GUIDANCE NOTES
GD007-2025

INTERNATIONAL SHIP CLASSIFICATION

GUIDELINES FOR DIRECT CALCULATION OF STRUCTURAL STRENGTH UNDER ICE LOADS

2025

Effective from 1 April 2025

CONTENTS

CHAPTER 1 GENERAL

Section 1 General Requirements

1.1.1 The Guidelines is applicable to the direct calculation and assessment of structural strength of the primary supporting members of ship applying for the class notations of Polar Class (PC 1-7), Icebreaker and Icebreaker * under ice loads. The Guidelines can also be used as a reference for other ships subjected to ice loads.

1.1.2 The structural strength of the primary supporting members (including decks, transverse bulkheads, etc.) of the ship under ice loads are to meet the linear or nonlinear analysis requirements provided in the Guidelines.

Section 2 Definitions

1.2.1 The definitions in ISC Rules for Classification of Sea-going Steel Ships (hereinafter referred to as the Rules) and Rules for Heavy Icebreakers are applicable to the Guidelines.

1.2.2 **Design Ice load P_{avg}**: means the average pressure evenly distributed on a rectangular load patch (height *b* and width *w*), see 13.2.3.4, Section 2, Chapter 13, PART EIGHT of the Rules.

1.2.3 **Height of ice load patch *b***: see 13.2.3.3, Section 2, Chapter 13, PART EIGHT of the Rules.

1.2.4 **Width of ice load patch *w***： see 13.2.3.3, Section 2, Chapter 13, PART EIGHT of the Rules.

1.2.5 **Hull area factor *AF***: reflects the relative magnitude of the load expected in each hull area, see 13.2.3.5, Section 2, Chapter 13, PART EIGHT of the Rules and 2.2.5, Section 2 of the Rules for Heavy Icebreakers.

1.2.6 **Ice pressure － deformation curve**: means a curve that characterizes the relationship between ice pressure load and structural deformation.

1.2.7 **Lateral deformation**: means the bending deformation of a structural member in its plane under the action of ice loads.

1.2.8 **Out-of plane deformation**：the deformation of a structural member that deviates from its plane under the action of ice loads.

1.2.9 **Plastic strain**: also known as permanent strain, means the strain that remains in a structural member after all stresses have disappeared.

Section 3 Plans and Information

1.3.1 The direct calculation report is to be submitted to ISC for information.

1.3.2 The linear direct calculation report is at least to include the followings:

(1) List of plans used;

(2) Detailed description of the structural finite element model;

(3) Structural model and related attribute graphics;

(4) Detailed description of boundary conditions;

(5) Detailed information of the applied load, including the calculation process of ice loads, the size of the load patch, the load diagram, etc;

(6) Graphics and results of the structural model response related to the loads, as well as the summary of compliance results according to strength standards, buckling analysis and results of the panels, etc;

(7) Proposed modification plans for structure, if necessary, including the assessment results after modification.

1.3.3 The non-linear direct calculation report is at least to include the followings:

(1) 1.3.2(1) ~ (5);

(2) Explanation of the constitutive relationship of the materials used;

(3) Description of graphics and results of the structural model response (deformation, stress, plastic strain, etc.) related to the loads;

(4) Ice pressure - deformation curve diagram of structural members;

(5) Summary of compliance results according to strength standards;

(6) Proposed modification plans for structure, if necessary, including the assessment results after modification.

Section 4 Structural Scantlings

1.4.1 Unless otherwise specified, the scantlings of structural member models in the Guidelines, are to be calculated using the gross offered thickness, which is defined in 1.2.2, Section 2, Chapter 3, PART 9-1 in the Rules.

CHAPTER 2 DIRECT CALCULATION OF LINEAR STRENGTH

Section 1 General Requirements

2.1.1 This Chapter provides specific requirements for direct calculation of the linear strength of the primary supporting members of hull under ice loads, assuming that the material is linearly elastic.

2.1.2 The primary supporting members to be assessed are to include:

(1) Transverse members: transverse bulkheads, transverse webs, web frames and other transverse plate structures;

(2) Longitudinal members: decks/platforms, side stringers and other longitudinal plating structures;

(3) The primary supporting structures within the stem area (for ships navigating in both directions, the assessment of the stern area can refer to the requirements of the stem area).

Section 2 Structural Modeling

2.2.1 Scope of modeling

2.2.1.1 The scope of structural modeling is to avoid the influence of boundary conditions.

2.2.1.2 Local structural member models or global segment models can be used for strength analysis of the target position.

2.2.1.3 The local structural member model is generally to be centered around a specific analysis target position, and its scope of modeling is to be at least as follows (see Figure 2.2.1.3 for a typical schematic diagram of local structural member model):

(1) Vertical: 1 level side stringer (or deck platform) + 1 level side stringer (or deck platform) + 1 level side stringer (or deck platform);

(2) Longitudinal: 2 level web frames + 1 level web frame + 2 level web frames;

(3) Transverse: from the ship side to the 2 level deck stringers or to the inner shell, longitudinal bulkhead, etc. For ships with ice class of PC5 and above, it is to be extended to the longitudinal line of the ship.

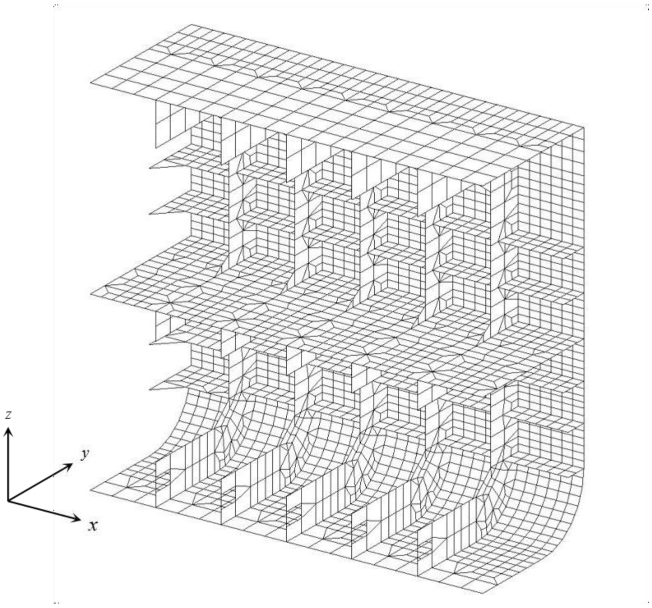


Figure 2.2.1.3 Schematic diagram of local structural member model

2.2.1.4 If the scope of the local structural member model is large enough to reflect multiple specific analyzed targets and ensure the avoidance of boundary effects, the local structural member model can also be used to calculate multiple analyzed targets.

2.2.1.5 When calculating multiple analyzed targets using the global segment model, the scope of modeling is at least to be as follows (see Figure 2.2.1.5 for a typical global segment calculation model):

(1) Vertical: from the bottom to the main deck;

(2) Longitudinal: When the analyzed target is a web frame, it is to be extended vertically at least 2 web frames before/after the position of the analyzed target. When the analyzed target is a transverse bulkhead, it is to be extended longitudinally at least 0.5 segment forward and afterward from the transverse bulkhead;

(3) Transverse: the full width.

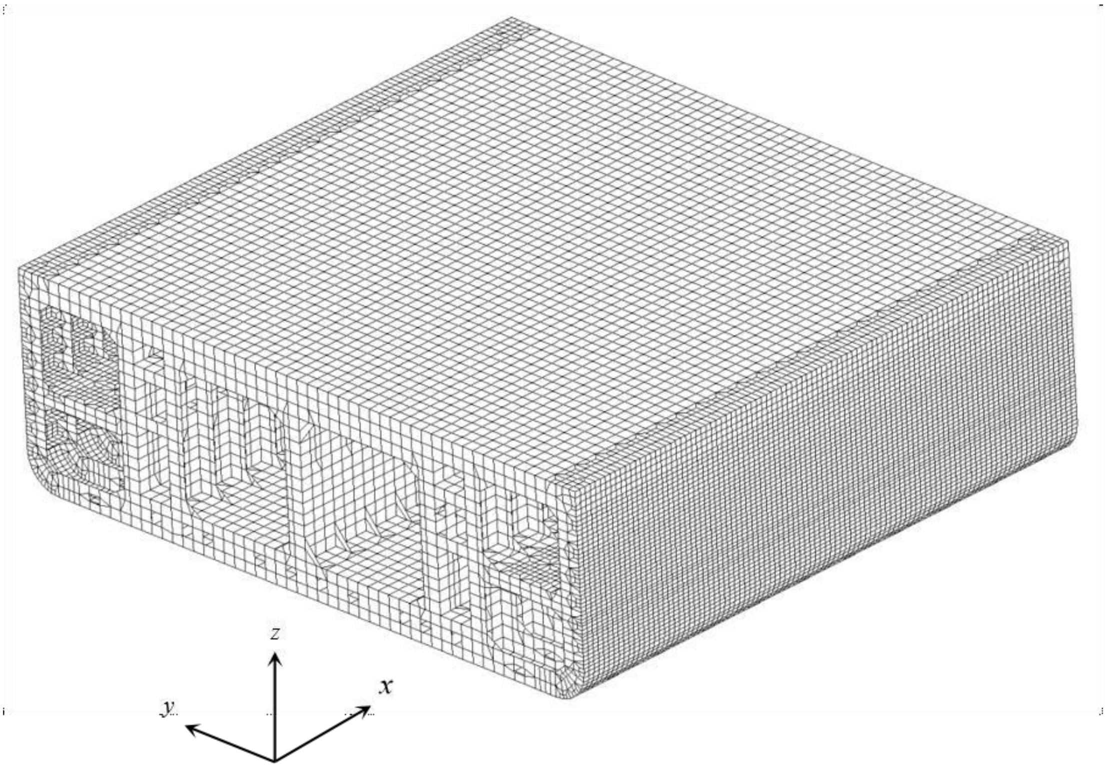


Figure 2.2.1.5 Typical global segment calculation model

2.2.1.6 Within the contraction area of the stem and stern lines, the scope of model can be expanded on the basis of 2.2.1.3 and 2.2.1.5 with the approval by ISC.

2.2.2 Modeling requirements

2.2.2.1 The element type and size are to comply with the requirements of 1.5.6.3, Section 5, Chapter 1, PART TWO of the Rules, and the element type is generally to be selected based on the following principles:

(1) The direct calculation of linear strength is generally to be checked using a coarse mesh model;

(2) The webs of web frames and stringers are to be simulated by using shell elements, and the mesh size of the shell elements is generally to be based on the frame spacing. The web frames and stringers are generally to have no less than 3 elements along their height direction, and for those with smaller web heights, 2 elements can be used for modeling;

(3) The face plates on the primary supporting members can be simulated by using beam elements or shell elements;

(4) The cast steel stem can be simulated by using solid elements.

2.2.2.2 The method for processing the openings (including manholes) on web plates of primary supporting members is to be in accordance with the requirements of Table 2.2.2.2.

Processing of openings on webs of primary supporting members

Table 2.2.2.2

Criterion	Modeling
$h_0/h < 0.5$ and $g_0 < 2.0$	Modeling not needed for openings
$h_0/h \geq 0.5$ or $g_0 \geq 2.0$	Modeling need for openings, by means of removing the appropriate elements in way of openings

Where：

$$g_0 = \left(1 + \frac{l_0^2}{2.6(h - h_0)^2}\right)$$

0: The opening length perpendicular to height of web plates, in m, see Figure 2.2.2.2(1); where the space d_0 of continuous openings is less than 0.25 h, l_0 is to be taken as the length across the openings, see Figure 2.2.2.2(2);

h_0: The opening height parallel to height of web plates, in m, as shown in Figure 2.2.2.2 (1) and (2).

h: The height of web plates in way of openings, in m, as shown in Figure 2.2.2.2 (1) and (2).

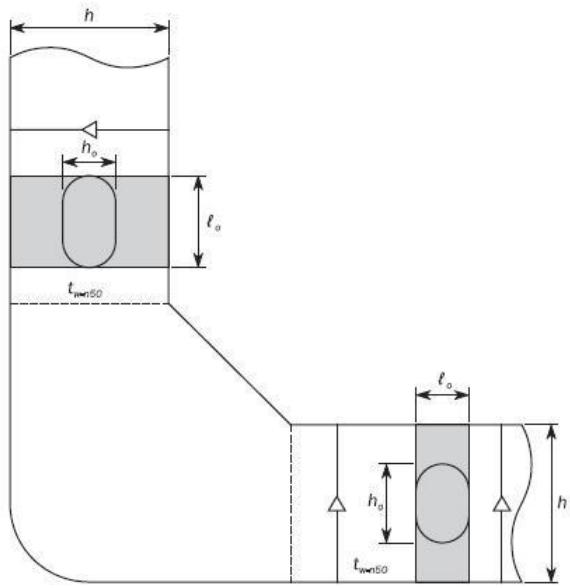


Figure 2.2.2.2(1) Openings of web plates

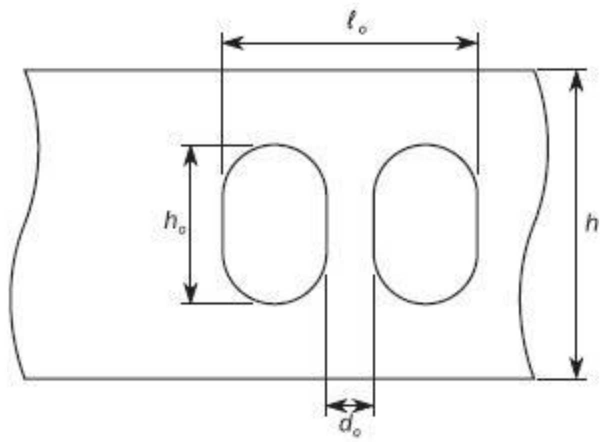


Figure 2.2.2.2(2) Length l_0 for space of continuous openings d_0 < 0.25 h

2.2.3 Boundary conditions

2.2.3.1 When using a local structural member model, the boundary constraints are shown in Table 2.2.3.1 and Figure 2.2.3.1.

Model boundary constrains **Table 2.2.3.1**

Position	Translation			Rotation		
	δx	δy	δz	θx	θy	θz
Forward and afterward						
Cross section	Fixed	—	Fixed	—	Fixed	Fixed
Longitudinal position/longitudinal line						
Longitudinal section	—	Fixed	—	Fixed	—	Fixed
Water plane (if required)	—	Fixed	Fixed	Fixed	Fixed	—
Note 1：[—] means no constraints to be applied (freedom).						

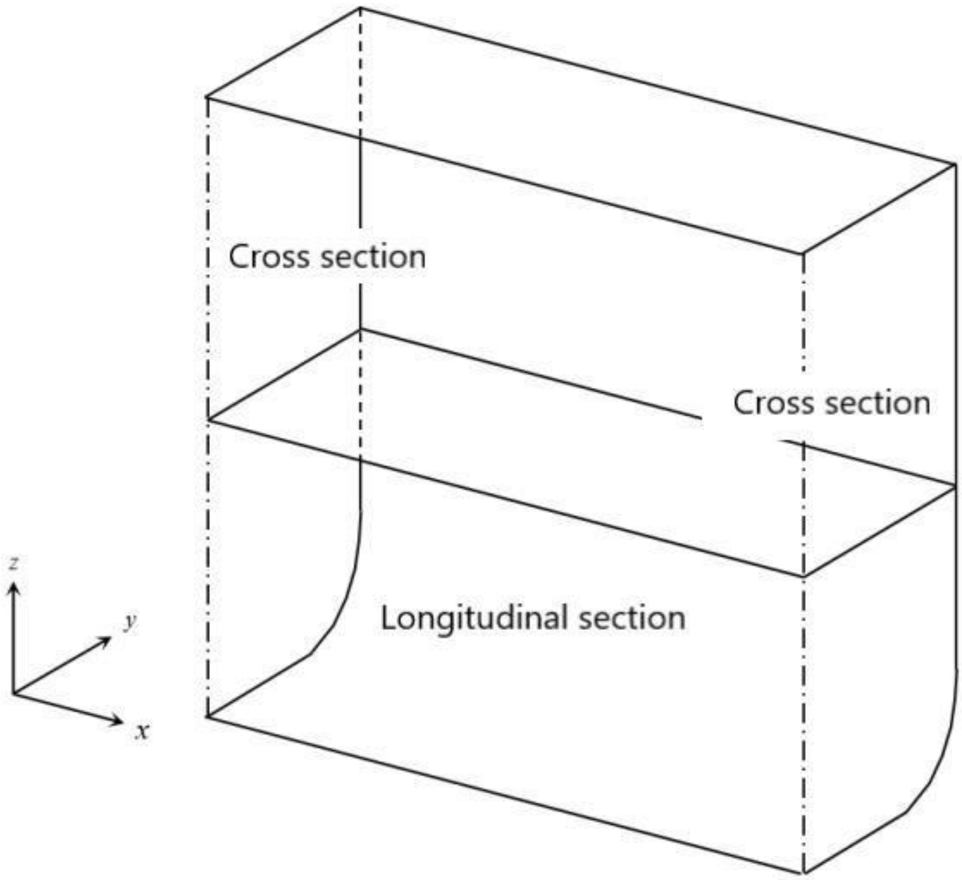


Figure 2.2.3.1 Boundary constraints of local structural member model

2.2.3.2 When using the global segment model, the boundary constraints of the front and rear ends of the model are rigidly fixed, as shown in Figure 2.2.3.2.

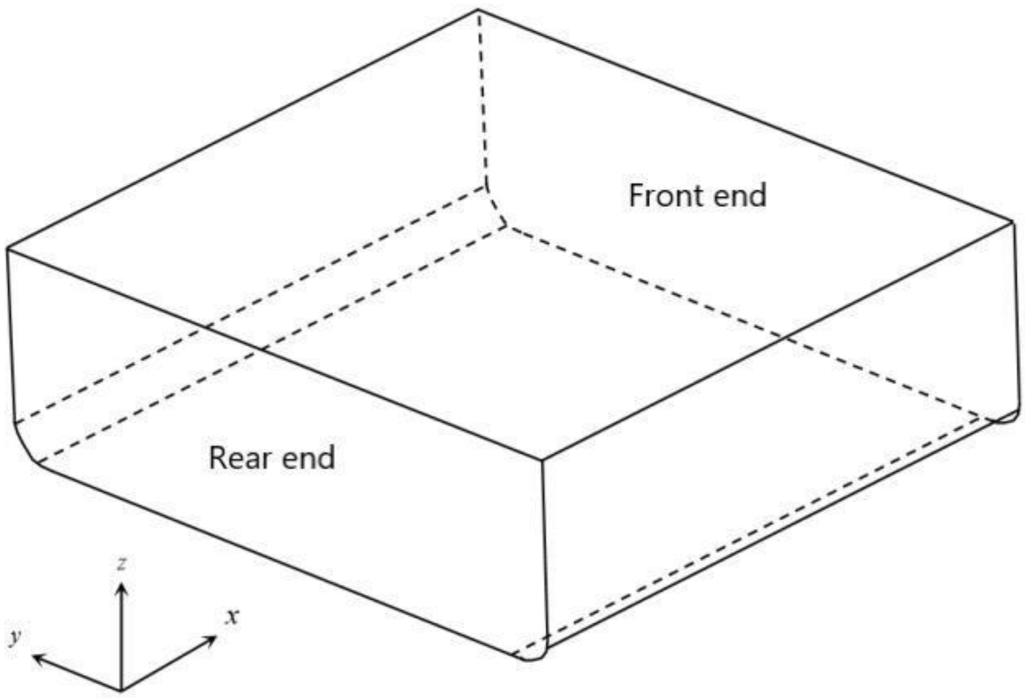


Figure 2.2.3.2 Boundary constraints of global segment model

Section 3 Load Application and Loading Conditions

2.3.1 Loads are to be applied to the finite element model in the form of an ice load patch. When the size of the ice load patch is not consistent with that of the model mesh, the ice pressure can be applied to the closest load patch size as needed, and the ice pressure can be adjusted to remain the total force on the adjusted load plate consistent.

$$P_{adj} = \frac{AF \cdot P_{avg} wb}{w_{mesh} b_{mesh}}$$

Where：P_{adj} —— ice pressure after adjustment, in MPa;

P_{avg}—— mean ice pressure, in MPa, see 1.2.2;

w —— width of load patch, in m, see 1.2.4;

b —— height of load patch, in m, see 1.2.3;

AF—— hull area factor, see 1.2.5;

w_{mesh} —— mesh boundary width closest to the width of the load patch, in m;

b_{mesh}—— mesh boundary height closet to the height of the load patch, in m.

2.3.2 Only the ice loads are to be applied for the direct calculation of structural strength, without the need to superimpose other loads, such as hydrostatic load, hydrodynamic load, hull girder load, etc.

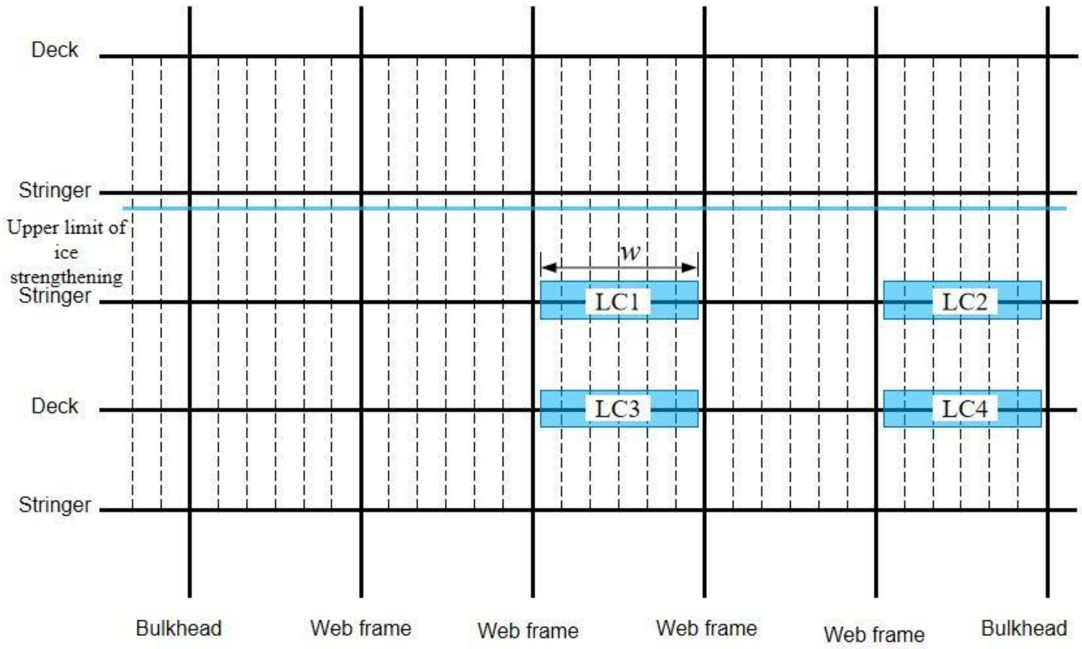
2.3.3 The load patch is to be loaded on the weakest part of the structural member subject to the combined action of bending and shear forces, and is to be as far away from the constraint boundary as possible.

2.3.4 If the structural types within the analyzed area are similar, the analyzed targets can select the typical structures or the weakest structures within the analyzed area.

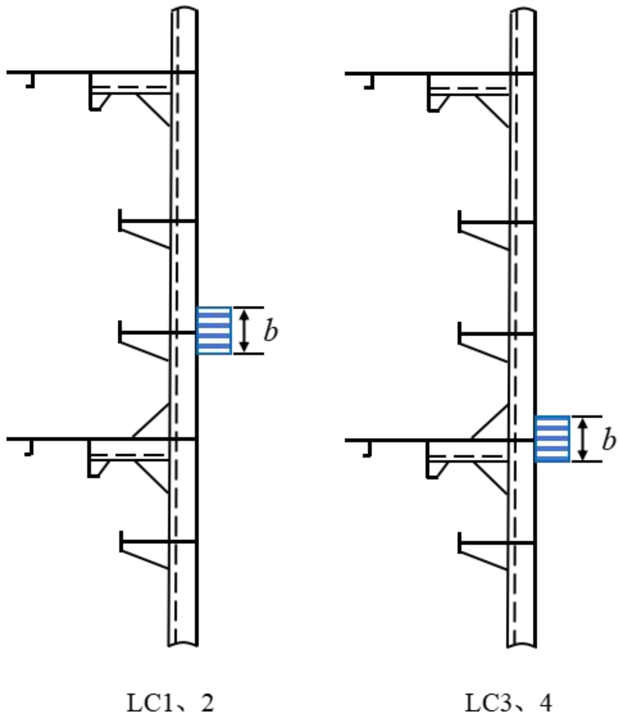
2.3.5 According to different analyzed targets, the ice load positions that require special attention are shown in Table 2.3.5.

Loading conditions **Table 2.3.5**

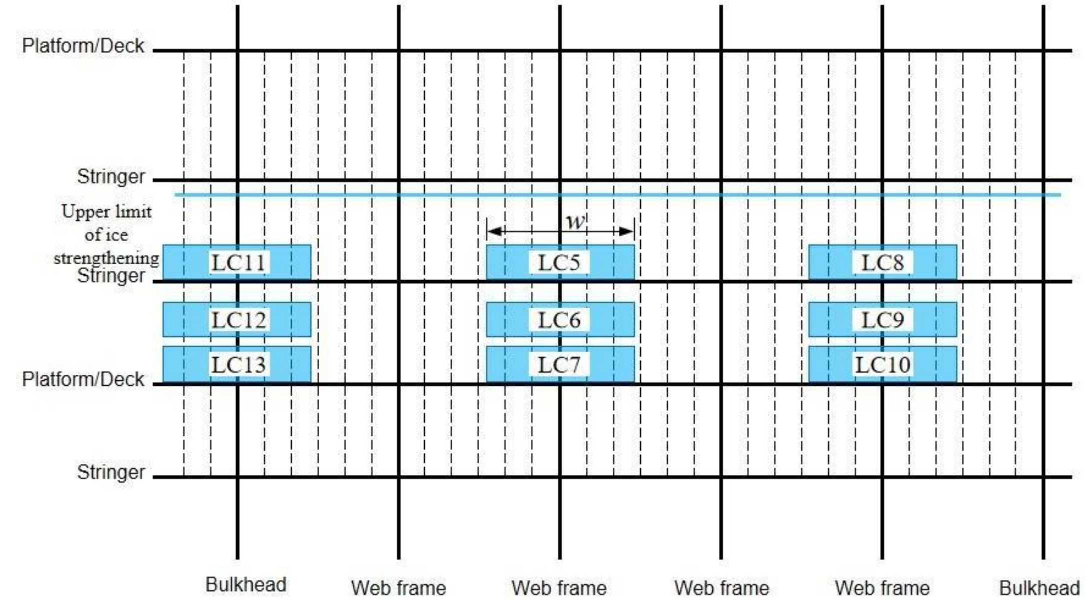
Loading condition	Position	Application object	Remark
LC1	The load patch is located on the side stringer in the middle of the cargo hold	Side stringer (between the web frames)	See 2.3.5(1)a, 2.3.5(2)a
LC2	The load patch is located on the side stringer close to the transverse bulkhead	Side stringer (close to the transverse bulkhead)	
LC3	The load patch is located on the deck of the middle cargo hold	Deck (between the web frames)	
LC4	The load patch is located on the deck close to the transverse bulkhead	Deck (close to the transverse bulkhead)	
LC5	The longitudinal position of the center of load patch is located at the structural member, and the vertical position is located above the side stringer (if any) at the end of span of structural member.	Web frame/transverse diaphragm (between the web frames)	See 2.3.5(1)c, 2.3.5(2)c
LC6	The longitudinal position of the center of load patch is located at the structural member, and the vertical position is located above the side stringer (if any) at the end of span of structural member.	Web frame/transverse diaphragm (close to the transverse bulkhead)	
LC7	The longitudinal position of the center of load patch is located at the structural member, and the vertical position is located between the spans of structural members.	Web frame/transverse diaphragm (between the web frames)	
LC8	The longitudinal position of the center of load patch is located at the structural member, and the vertical position is located between the spans of structural members.	Web frame/transverse diaphragm (close to the transverse bulkhead)	
LC9	The longitudinal position of the center of load patch is located at the structural member, and the vertical position is located above the deck (if any) at the end of span of structural member.	Web frame/transverse diaphragm (between the web frames)	
LC10	The longitudinal position of the center of load patch is located at the structural member, and the vertical position is located above the deck (if any) at the end of span of structural member.	Web frame/transverse diaphragm (close to the transverse bulkhead)	
LC11	The longitudinal position of the center of load patch is located at the structural member, and the vertical position is located above the side stringer (if any).	Transverse bulkhead	
LC12	The longitudinal position of the center of load patch is located at the structural member, and the vertical position is located in side stringer/deck room.	Transverse bulkhead	
LC13	The longitudinal position of the center of load patch is located at the structural member, and the vertical position is located above the deck (if any)	Transverse bulkhead	
LC14	The load patch is longitudinally located at the stem and vertically located at a typical position of the stem structure.	primary supporting members within the stemarea	See 2.3.5(3)
Note 1: Although as shown in Figure 2.3.5, if there is significant structural weakening in other positions, it is also to be included in the analyzed targets. Note 2: If the structural arrangement and size of the target area are similar, typical locations can be selected for analysis. Note 3: The number of analysis targets is to be increased at the contraction of the stem and stern lines. Note 4: The bottom structures (i.e.: BI_b, M_b, S_b in the hull areas) are to be applied according to Figure 2.3.5(1), i.e.: the height direction b of the load patch is parallel to the direction of the frame.			



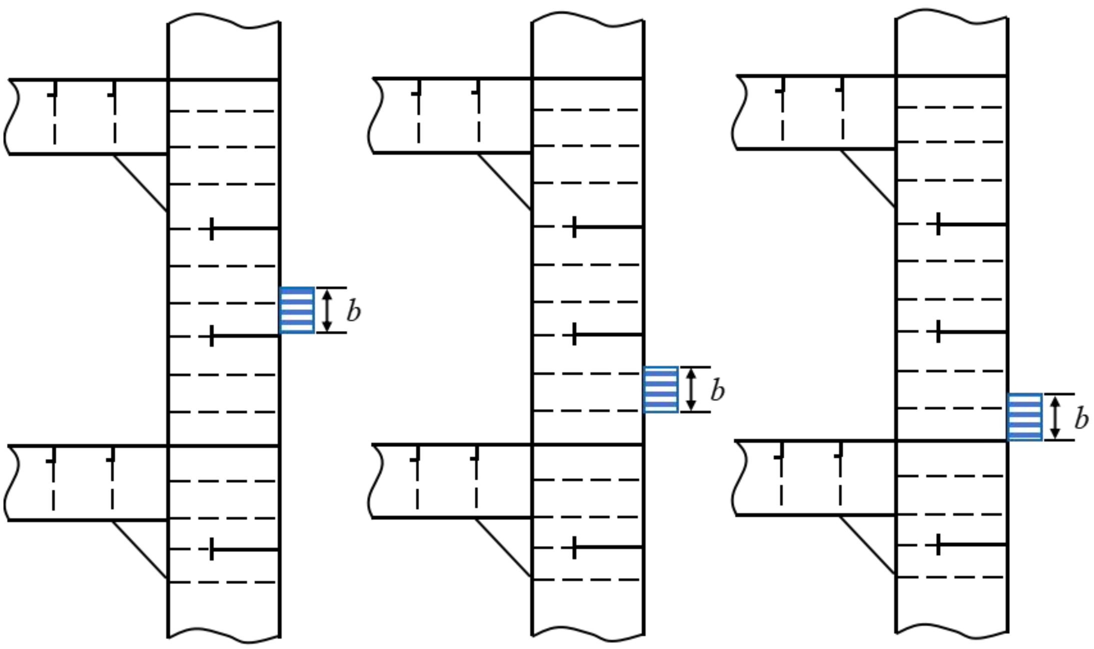
(a) Longitudinal member



(b) Side stringer/deck

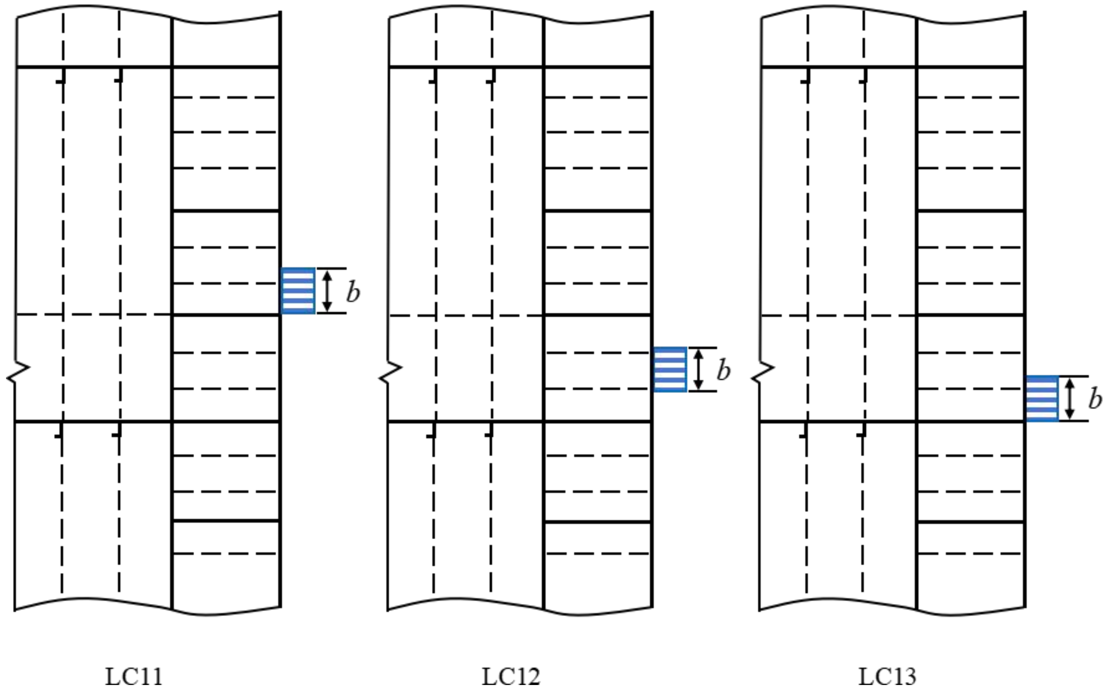


(c) Transverse member



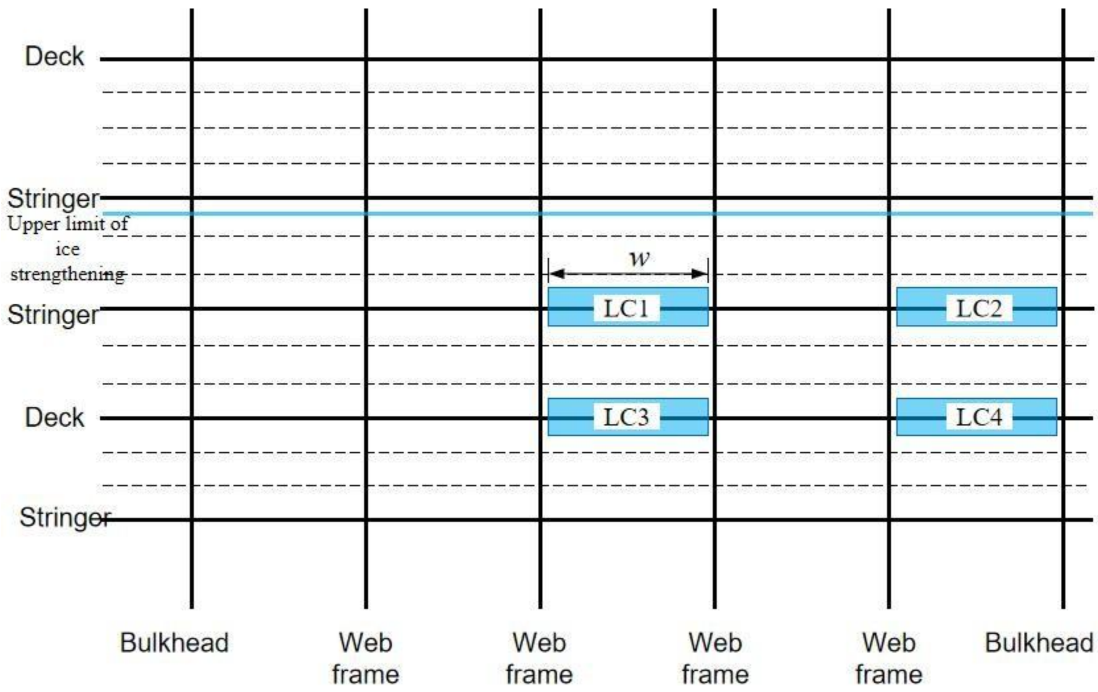
LC5、8 LC6、9 LC7、10

(d) Web frame/transverse diaphragm

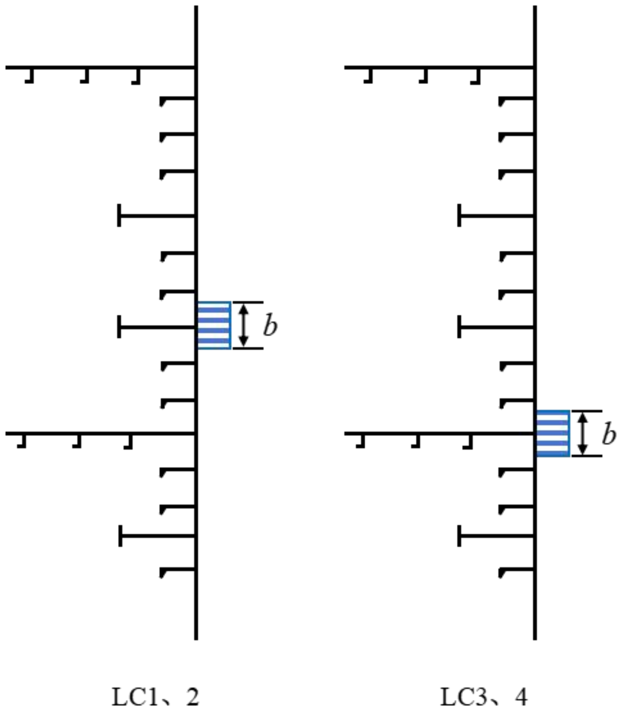


(e) Transverse bulkhead

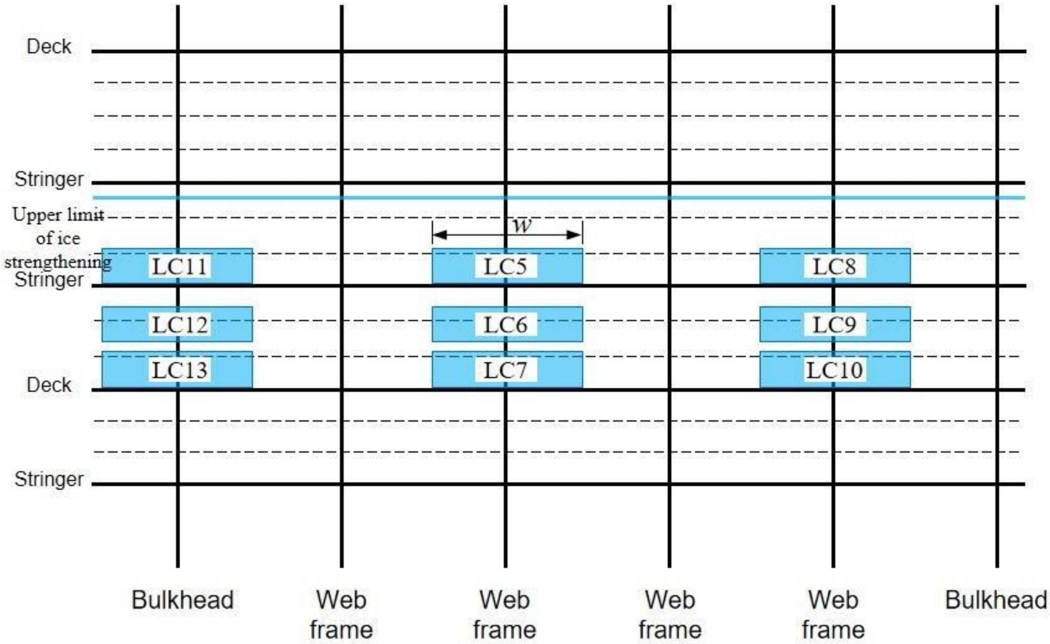
Figure 2.3.5(1) Typical loading position applied on load patch (transverse frame type)



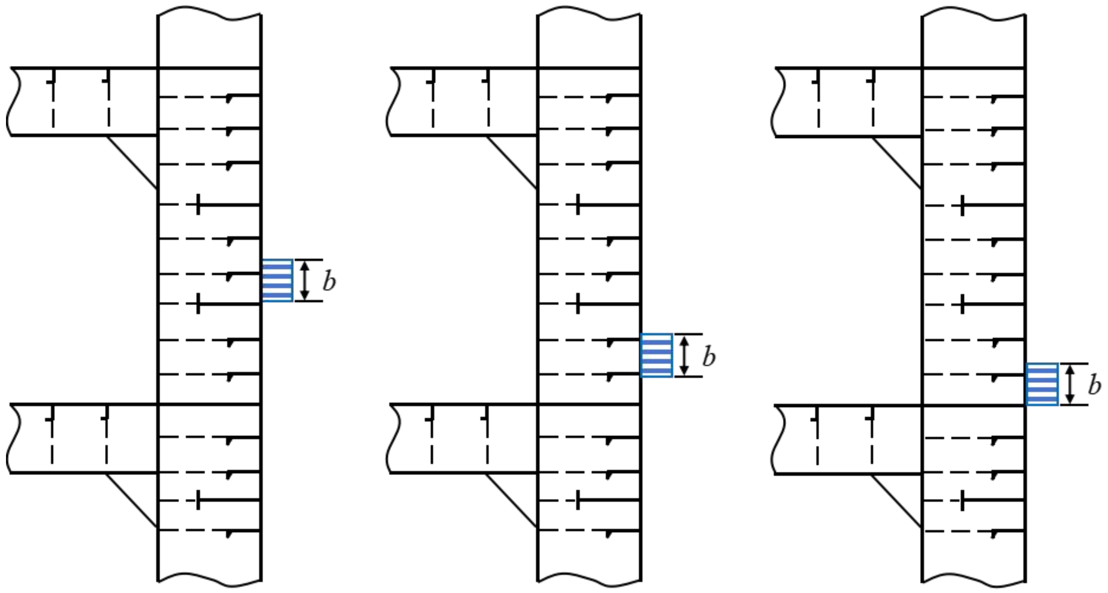
(a) Longitudinal member



(b) Side stringer/deck

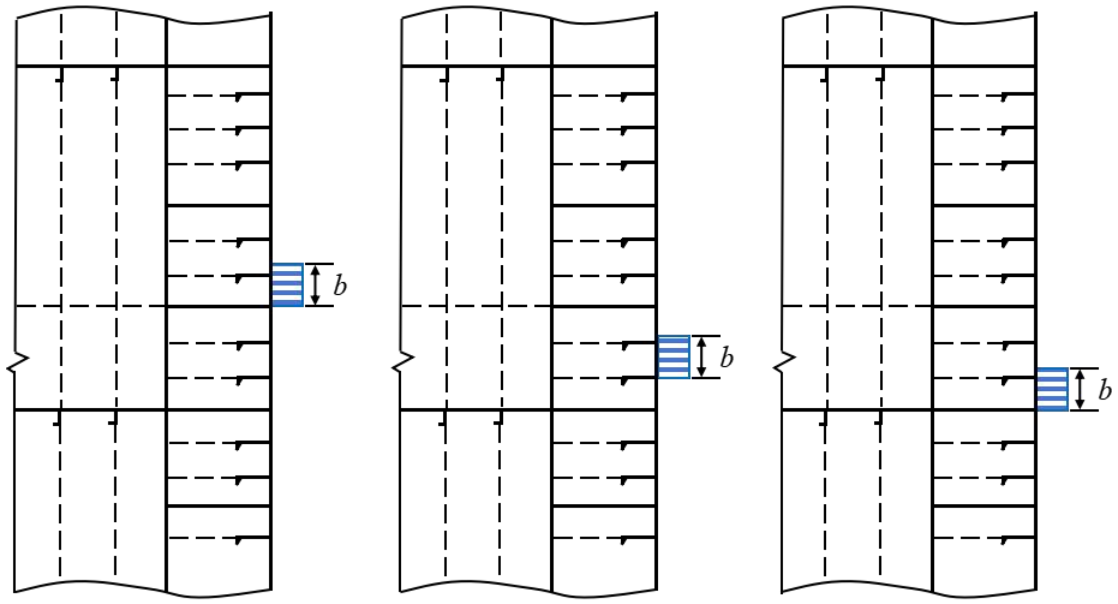


(c) Transverse member



LC5、8　　　　LC6、9　　　　LC7、10

(d) Web frame/transverse diaphragm



LC11　　　　LC12　　　　LC13

(e) Transverse bulkhead

Figure 2.3.5(2)　Typical loading position applied on load patch (longitudinal frame type)

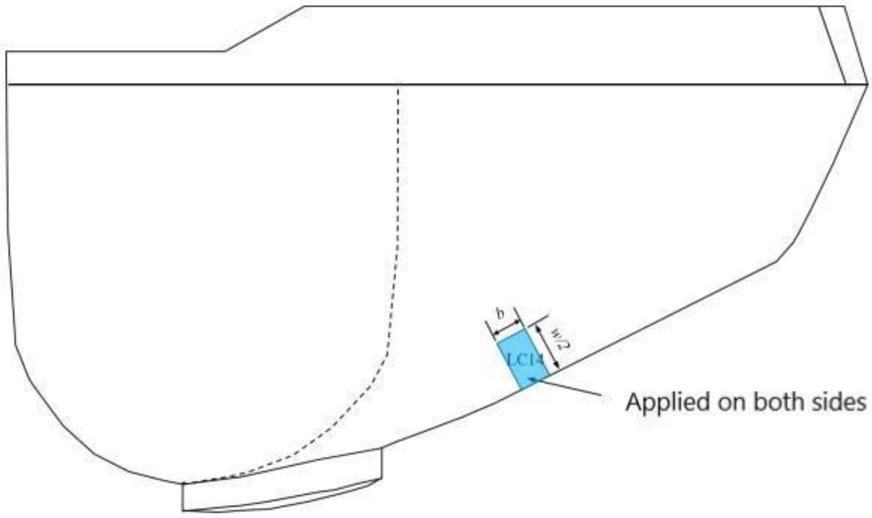


Figure 2.3.5(3) Typical loading position applied on load patch (stem)

Section 4 Yield Strength

2.4.1 The yield strength of primary supporting structures is to meet the following criterion:

(1) The nominal shear stresses of web plates, bulkhead plates, and deck plates are not to be greater than $_H/ \sqrt{3}$;

(2) The nominal Von Mises stresses of the web frame plates and stringer plates are not to be greater than 1.15_H.

Section 5 Buckling Strength

2.5.1 Buckling strength are to be assessed for the primary supporting members subject to ice loads on the side of polar ships, as well as the transverse bulkhead plates, deck plates and other plating structures that serve as supporting frames, are to be assessed for buckling strength.

2.5.2 The scope of assessment for plating structures, such as transverse bulkhead, platform/deck, etc., is to be taken the greater of the followings:

(1) The height of the web plate adjacent to and parallel to web frame or stringer;

(2) 2.5 times the height of the frame structural member intersecting with the plating structure.

2.5.3 In the assessment of buckling strength, biaxial pressure stress and shear stress are to be considered, and the mid-plane stress of the plating is to be used for buckling strength assessment.

2.5.4 The buckling strength is to be assessed based on the net scantling, all corrosion addition t_c are to be deducted from the model, and is not be less than the corrosion/abrasion addition t_s, for details, see 13.2.11.2 and 13.2.11.3, Section 2, Chapter 13, PART EIGHT of the Rules.

2.5.5 Buckling strength assessment is to be carried out after thickness correction is to be corrected for the working stress, the corrected working stress is to be calculated according to the following formula:

$$\sigma_A = \frac{t\sigma}{t - t_c} \quad \text{MPa}$$

Where : σ_A—— corrected working stress;

σ—— calculated working stress;

t—— plate thickness of model;

t_c—— corrosion addition.

2.5.6 In addition to the requirements in this Section, buckling strength assessment is to be conducted in accordance with the relevant requirements of Section 4, Appendix 5, Chapter 2, PART TWO of the Rules. The buckling strength is to meet the following criteria:

$$\eta_{act} = \frac{W_{act}}{W_U} = \frac{1}{\gamma_c} \le \eta_{all}$$

Where: W_{act}—— equivalent stress to be applied, for detail, see Section 4, Appendix 5, Chapter 2, PART TWO of the Rules.

W_U—— equivalent buckling capability, for detail, see Section 5, Appendix 5, Chapter 2, PART TWO of the Rules.

γ_c—— stress multiplier factor at failure;

η_{all}—— allowable buckling utilization factor, taken as 1.0.

CHAPTER 3 DIRECT CALCULATION OF NON-LINEAR STRENGTH

Section 1 General Requirements

3.1.1 This Chapter provides specific requirements for direct calculation of the non-linear strength of the primary supporting members of hull under ice loads.

3.1.2 The non-linear direct calculation of structural strength in this Chapter takes into account material non-linearity and is to consider the following:

(1) The analysis method is to be able to reliably simulate the buckling and plastic deformation of the structures;

(2) The criterion are to ensure sufficient margin to prevent significant stiffness loss caused by fracture, buckling and yielding;

(3) The permanent lateral deformation and out of plane deformation of the structural members are to be the smaller values compared to the relevant structural scantlings.

3.1.3 The primary supporting members to be assessed are to include:

(1) Transverse structural members: transverse bulkheads, transverse webs, web frames and other transverse plating structures;

(2) Longitudinal structural members: decks, side stringers and other longitudinal plating structures;

(3) The primary supporting structures within the stem area (for ships navigating in both directions, the assessment of the stern area can refer to the requirements of the stem area).

Section 2 Structural Models

3.2.1 When using non-linear methods for direct strength analysis, in addition to the special requirements of this Section, relevant provisions in Section 2, Chapter 2 of the Guidelines are also to be followed.

3.2.2 Fine mesh is to be used within the assessment area, and the scope of the fine mesh model is to consider the size of the ice load patch and the arrangement of the supporting structures, generally including the following:

(1) Longitudinal: 2 level web frames + 1 level web frame + 2 level web frames;

(2) Vertical: 1 level side stringer (or deck platform) + 1 level side stringer (or deck platform) + 1 level side stringer (or deck platform);

(3) Lateral: from the side of the ship to the inner shell, longitudinal bulkhead, or longitudinal line.

3.2.3 Structural modeling

3.2.3.1 The plating and stiffeners within the assessment area are generally to be modeled using 4-node shell elements, and triangular elements are to be avoided as much as possible at stress concentration points, such as toe ends and knuckles.

3.2.3.2 The mesh size is to be able to reasonably represent the local deformation and stress changes of the structures. Usually, the element size is not to be greater than 1/8 of the spacing between stiffeners.

3.2.3.3 For critical areas with high stress, the finite element mesh is to be sufficiently fine, generally taken as 50 mm × 50 mm.

3.2.3.4 When the mesh size of the assessment area is greater than the requirements of 3.2.3.2, a mesh sensitivity analysis for typical loading conditions is to be submitted and confirmed by ISC.

3.2.3.5 Coarse mesh modeling can be used outside the assessment area and is to meet the relevant requirements of Chapter 2.2.2 of the Guidelines. Smooth transition of mesh density between refined mesh and coarse mesh is to be remained.

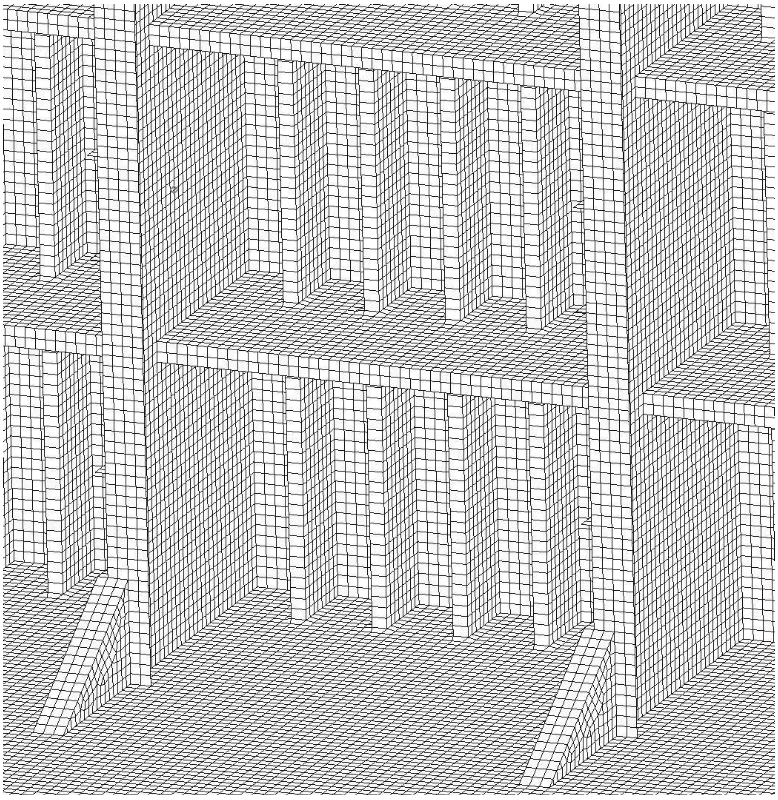


Figure 3.2.4 Schematic diagram of fine mesh model

3.2.4 For the boundary conditions, see 2.2.3, Chapter 2 of the Guidelines.

Section 3 Material Models

3.3.1 Material models are typically to be able to reflect the non-linear behavior of the structures. Generally, ideal elastoplastic materials with bilinear stress-strain curve can be used, as shown in Figure 3.3.1, where AB is the linear elastic stage and the slope is the elastic modulus *E*. BC is the elastic-plastic stage, with a slope of 1/1000 of the elastic modulus *E*. Other non-linear material model, if any, is to be submitted to ISC for confirmation.

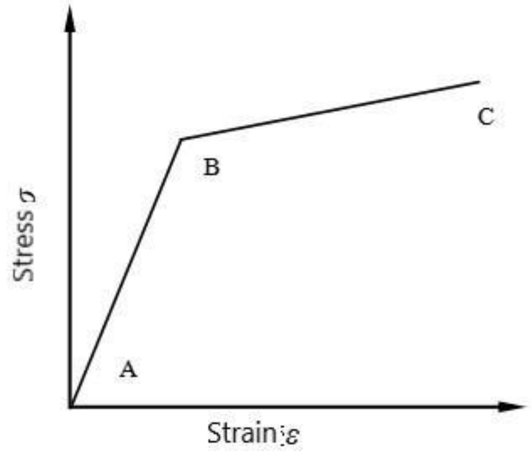


Figure 3.3.1 Bilinear stress-strain curve

Section 4 Non-linear Analysis

3.4.1 Structural strength assessment is to be carried out based on the ice pressure - deformation curve obtained through non-linear calculations. As shown in Figure 3.4.1, the ice load is loaded using incremental method, and unloaded after reaching the target value P_e (see 3.4.4), so as to obtain the permanent deformation δ_p of the structure.

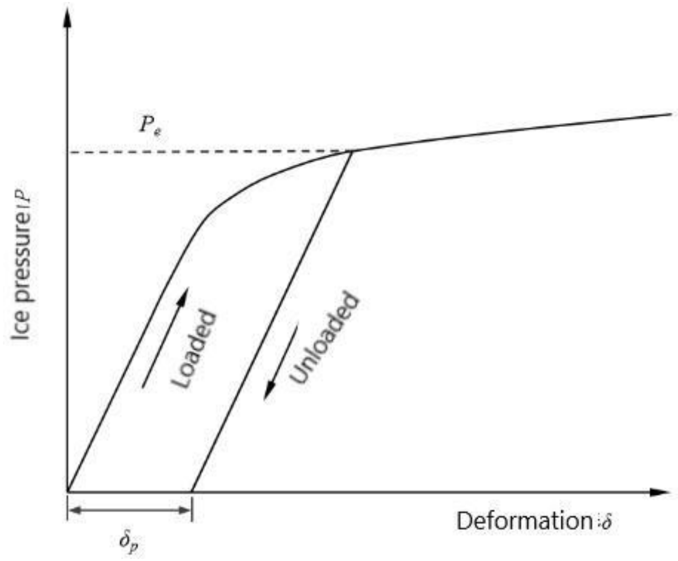


Figure 3.4.1 Ice pressure - deformation curve

3.4.2 To be facilitate to the subsequent strength analysis, the range of ice pressure - deformation curve is at least to cover P_e.

3.4.3 The lateral deformation is to be measured perpendicular to the direction of the shell plate at the point of maximum deformation of the structural member. The out of plane deformation is to be measured perpendicular to the original plane of the structural member at the point of maximum deformation.

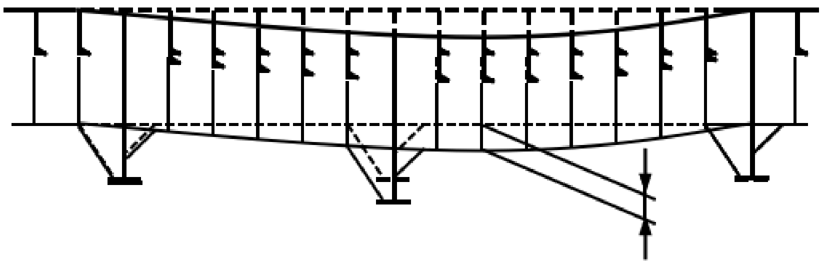


Figure 3.4.3(1) Measurement of displacement for lateral deformation

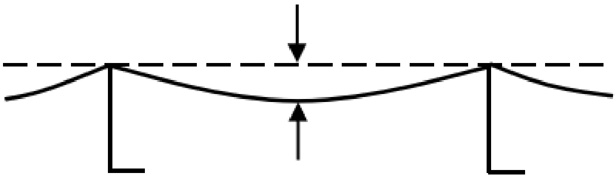


Figure 3.4.3(2) Measurement of displacement for out of plane deformation

3.4.4 The ice load P_e used to obtain permanent deformation and plastic strain of the structure is to be calculated according to the following formula:

$$P_e = CF_O \cdot AF \cdot P_{avg}$$

Where: CF_O— overload factor, see Table 3.4.4.

AF— hull area factor, see 1.2.5.

P_{avg}— design ice load, see 1.2.2.

Overload factor **Table 3.4.4**

Ice class	CF_O	
	Permanent deformation	Plastic strain
PC1~PC3	1.1	1.5
PC4~PC5	1.15	1.5
PC6~PC7	1.2	1.5

3.4.5 The permanent deformation of the structure can be calculated based on the ice pressure - deformation curve using the following formula:

$$\delta_p = \delta - \frac{P}{k}$$

Where: P— ice load;

δ — Structural deformation corresponding to ice load P;

k— slope of the elastic stage of the ice pressure - deformation curve relative to the deformation axis.

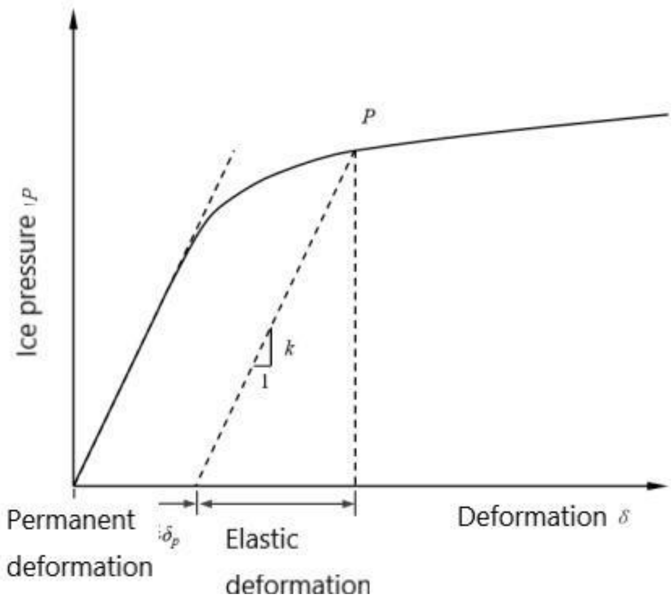


Figure 3.4.5 Elastic deformation calculation

Section 5 Load Application and Loading Conditions

3.5.1 The load patch is to be placed at the weakest bearing capacity of the structural members within the ice strengthened range under the combined action of bending and shear forces. Special attention is to be paid to lightening holes and openings in the structural strengthened areas. For the main loading conditions, see Table 3.5.1.

Loading conditions **Table 3.5.1**

Loading condition	Position	Application object	Deformation	Remark
LC1	The load patch is located on the side stringer in the middle of the cargo hold	Side stringer (between the web frames)	Lateral, out of plane	See 2.3.5(1)a, 2.3.5(2)a
LC2	The load patch is located on the side stringer close to the transverse bulkhead	Side stringer (close to the transverse bulkhead)	Lateral, out of plane	
LC3	The load patch is located on the deck of the middle cargo hold	Deck (between the web frames)	Lateral, out of plane	
LC4	The load patch is located on the deck close to the transverse bulkhead	Deck (close to the transverse bulkhead)	Lateral, out of plane	
LC5	The longitudinal position of the center of load patch is located at the structural member, and the vertical position is located above the side stringer (if any) at the end of span of structural member.	Web frame/transverse diaphragm (between the web frames)	Lateral, out of plane	See 2.3.5(1)c, 2.3.5(2)c
LC6	The longitudinal position of the center of load patch is located at the structural member, and the vertical position is located above the deck (if any) at the end of span of structural member.	Web frame/transverse diaphragm (close to the transverse bulkhead)	Lateral, out of plane	

LC7	The longitudinal position of the center of load patch is located at the structural member, and the vertical position is located between the spans of structural members.	Web frame/transverse diaphragm (between the web frames)	Lateral, out of plane	
LC8	The longitudinal position of the center of load patch is located at the structural member, and the vertical position is located between the spans of structural members.	Web frame/transverse diaphragm (close to the transverse bulkhead)	Lateral, out of plane	
LC9	The longitudinal position of the center of load patch is located at the structural member, and the vertical position is located above the side stringer (if any) at the end of span of structural member.	Web frame/transverse diaphragm (between the web frames)	Lateral, out of plane	
LC10	The longitudinal position of the center of load patch is located at the structural member, and the vertical position is located above the deck (if any) at the end of span of structural member.	Web frame/transverse diaphragm (close to the transverse bulkhead)	Lateral, out of plane	
LC11	The longitudinal position of the center of load patch is located at the structural member, and the vertical position is located above the side stringer (if any).	Transverse bulkhead	Out of plane	
LC12	The longitudinal position of the center of load patch is located at the structural member, and the vertical position is located in side stringer/deck room.	Transverse bulkhead	Out of plan	
LC13	The longitudinal position of the center of load patch is located at the structural member, and the vertical position is located above the deck (if any)	Transverse bulkhead	Out of plane	
LC14	The load patch is longitudinally located at the stem and vertically located at a typical position of the stem structure.	Primary supporting members within the stem area	Lateral, out of plane	See 2.3.5(3)
Note 1: Although as shown in Figure 2.3.5, if there is significant structural weakening in other positions, it is also to be included in the analyzed targets. Note 2: If the structural arrangement and size of the target area are similar, typical locations can be selected for analysis. Note 3: The number of analysis targets is to be increased at the contraction of the stem and stern lines. Note 4: The bottom structures (i.e.: BI_b, M_b, S_b in the hull areas) are to be applied according to Figure 2.3.5(1), i.e.: the height direction b of the load patch is parallel to the direction of the frame.				

3.5.2 When the size of the load patch is inconsistent with the mesh size of the model, the load patch can be applied to the model according to the requirements of 2.3.1.

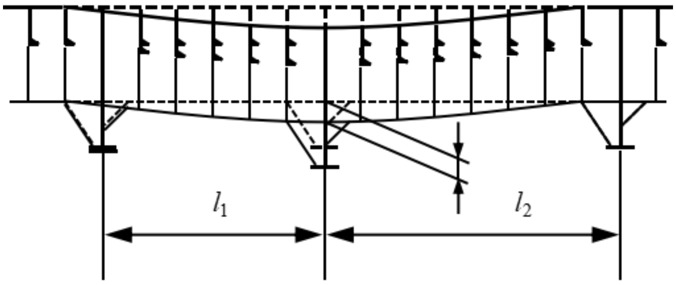
Section 6 Criterion

3.6.1 The primary supporting members are to meet the requirements of 3.6.2 and 3.6.3.

3.6.2 Permanent deformation

3.6.2.1 The lateral permanent deformation of structural members loaded to P_e by the ice load patch is not to be greater than 0.3% of the spacing l between its supporting structural members. When the maximum deformation is located at the supporting structural member, the spacing l

between the supporting structural members is to be taken as the maximum spacing between adjacent supporting structural members on both sides, and the value is not to be less than 3m.

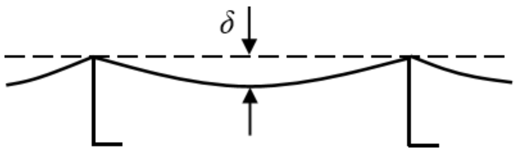
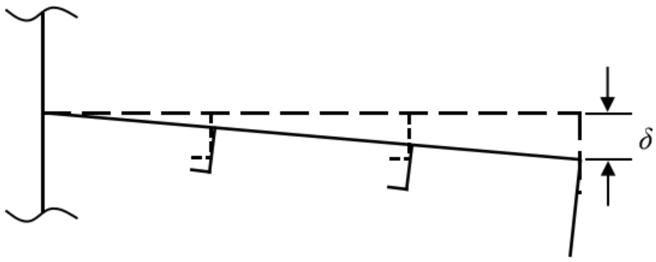
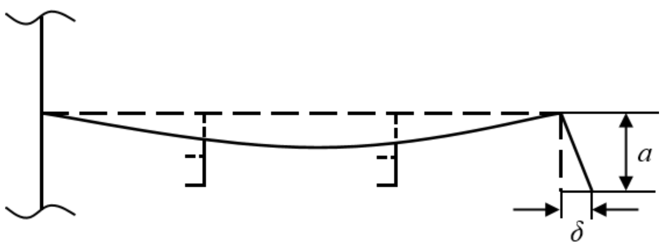


$l=\max(l_1, l_2)$

Figure 3.6.1.1 Measurement of span

3.6.2.2 The out of plane permanent deformation of the structural member loaded to P_e by ice load patch is not to be less than the allowable out of plane permanent deformation in Table 3.6.2.2.

Allowable out of plane permanent deformation **Table 3.6.2.2**

Structural member	**Schematic diagram**	**Allowable out of plane permanent deformation**
Side stringer web plate Web frame plate Transverse diaphragm Deck Transverse bulkhead		8 *mm*
Side stringer web plate Web frame plate		$l^{(1)}/400$
Side stringer face plate Web frame face plate		$3a^{(2)}/100$

Note： (1) *l*: span of structural members, not considering bracket reduction.

(2) *a*：width of face plate.

3.6.3 Plastic strain

3.6.3.1 The plastic strain of the primary supporting members loaded to P_e by ice load patch is not to be greater than 0.05.