Guide for Assessing Hull-Girder Residual Strength for Tankers

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1.0 GENERAL

This Guide provides guidelines and assumptions for facilitating an assessment of structural redundancy and hull-girder residual strength at an early design stage. After damage sustained by a ship hull from the hypothetical accidents specified in 2.0, a minimum hull-girder residual strength, as specified in 5.0, is to be maintained with regard to preventing, or at least substantially reducing, the risk of a major oil spill or loss of ship due to a post-accident collapse or disintegration of the hull during tow or rescue operations.

2.0 TYPES OF ACCIDENTS TO BE CONSIDERED

The following types of accidents should be considered for examining the residual strength:

- grounding on rocky sea bed with considerable rupture of the double-bottom structures, as specified in 3.0.
- collision, when another ship strikes a tanker on one side, which results in extensive rupture of the double-side structure, as specified in 4.0.

3.0 LOCATION AND EXTENT OF DAMAGE DUE TO GROUNDING

The damaged bottom structure is assumed to be in the most unfavorable location anywhere on the flat bottom within the fore part of the hull between 0.5L and 0.2L aft from F.P. At least one location should be examined.

Bottom structures are assumed to be damaged over a considerable length and the damaged members should be excluded from the hull-girder. The following members are assumed to be damaged and excluded, completely or partially, from the hull girder section modulus calculation (see Fig. 1).

- bottom shell plating for a width of 4 m or B/6, whichever is greater, where B is the ship breadth as defined in 3/1.3 of the Rules.
- double-bottom girders attached to the damaged shell plating are assumed to be damaged and ineffective up to the following percentage of the girder's height:

25% - for girders situated within 1 meter marginal zones of the damaged plating as shown in Fig. 1.

75% - for girders situated between the marginal zones.

- all of the bottom longitudinals within the damaged bottom shell and the longitudinal stiffeners within the damaged parts of girders.

4.0 LOCATION AND EXTENT OF DAMAGE DUE TO COLLISION

The damaged side structure is assumed to be in the most unfavorable location on the freeboard anywhere between 0.15L aft from F.P. and 0.2L forward from the A.P. At least two locations should be examined; one within the midship region and another at the region of high shear forces. The collision damage is assumed to be located at the upper part of the side shell, down from (and including) the stringer plate of the strength deck. The following members should be assumed to be damaged and excluded totally or partially, from the hull girder section modulus calculation (see Fig. 2).

- side shell plating for the vertical extent of 4 m or D/4, (designated as "h" in Fig. 2), whichever is greater, down from the upper edge of the shear strake, where D is the ship depth as defined in 3/1.5 of the Rules.
- strength of deck plating including the stringer plate extending from the side shell to the inner skin.
- side stringers and platforms, within the damaged zone extending for 75% of the double-side width, 3/4 b as shown in Fig. 2.
- all deck and side longitudinals and longitudinal stiffeners attached to the damaged plating.

5.0 RESIDUAL STRENGTH ASSESSMENT

The assessment is to demonstrate that the appropriate residual longitudinal strength of the hull girder after an accident as specified in 2.0 is in compliance with the strength criteria given in 7.0 for a single trip from the site of accident to a repair yard under load conditions as specified in 6.0. The residual hull girder section modulus may be calculated using either a finite element model or a simplified method based on the assumed damage, as given in 3.0 or 4.0.

The residual bending strength should be analyzed both for collision and grounding situations. The residual shearing strength should be checked for collision, but need not be analyzed for grounding.

6.0 LOAD CRITERIA

Residual strength of the damaged hull-girder should be assessed based on the total longitudinal bending moments, M_t, and shear forces, F_t, given as follows:

$$M_t = K_{us} M_s + K_{uw} M_w \qquad \text{kN-m (tf-m, Ltf-ft)}$$

$$F_t = K_{us} F_s + K_{uw} F_w \qquad \text{kN (tf, Ltf)}$$

where

M_s, F_s = maximum still-water bending moment (hogging and/or sagging) and shear force (positive and/or negative), in intact condition.

M_w, F_w = wave-induced vertical longitudinal bending moments (hogging and sagging) and shear forces (positive and negative), calculated in accordance with 3/6.3.3 of the Rules.

K_{us} and K_{uw} are given in the following table.

		Grounding	Collision
Hogging	K_{us}	1.1	1.0
	K_{uw}	0.5	0.7
Sagging	K_{us}	0.9	1.0
	K_{uw}	0.5	0.7

Both hogging and sagging conditions are to be considered. Local loads for secondary and tertiary bending need not be taken into consideration.

7.0 RESIDUAL STRENGTH CRITERIA

7.1 Residual Bending Strength Criterion

The residual section moduli of the damaged hull-girder, calculated in accordance with 5/2A4.2.1 of the Rules excluding the nominal design corrosion values and the damaged members as specified in 3.0 and 4.0, are not to be less than the nominal section modulus:

$$SM_r = 0.9\ M_t/f_p \qquad cm^2 - m(in.^2 - ft)$$

where

M_t is the total longitudinal bending moment as specified in 6.0.

f_p is the nominal permissible bending stress as specified in 3/6.3.4 of the Rules.

7.2 Residual Shearing Strength Criterion

The shear stresses, f_{sr}, in the side shell plating, after damage due to a collision, are not to be greater than that given by the formula:

$$f_{sr} = n_1\ n_2\ F_t\ m_r/(I_r t_s) \leq 1.1\ f_s \qquad kN/cm^2(tf/cm^2, Ltf/in.^2)$$

where

F_t = total shear force as specified in 6.0

t_s = thickness of side shell plating in cm (in.)

f_s = permissible shear stress specified in 5/2A4.2.3 of the Rules.

m_r and I_r are the first moment, in cm^3 (in^3), and moment of inertia, in cm^4 (in^4), of the "net" hull-girder damaged due to a collision at the station being considered.

$n_1 = A_{sr}/2(A_{sd} + A_b + 0.5A_i)$

$n_2 = D/(D-h)$

A_{sr} = residual shell plating area of the damaged side, in cm^2 (in^2).

A_{sd} = total plating area of one side shell (outer skin), in cm^2 (in^2).

A_b = total plating area of one outermost longitudinal bulkhead (inner skin), in cm^2 (in^2).

A_i = total plating area of all other longitudinal bulkheads between the inner skins, in cm^2 (in^2).

D and h are as defined in Fig. 2.

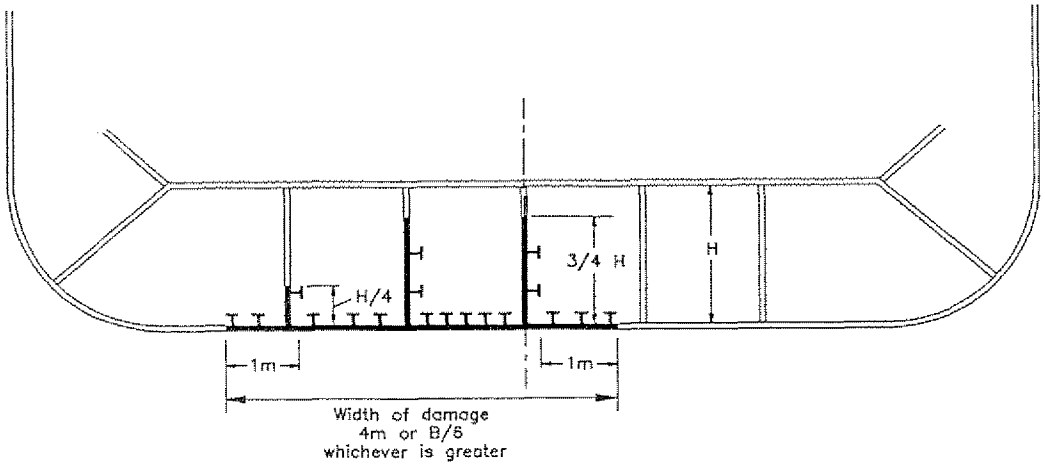

Figure 1

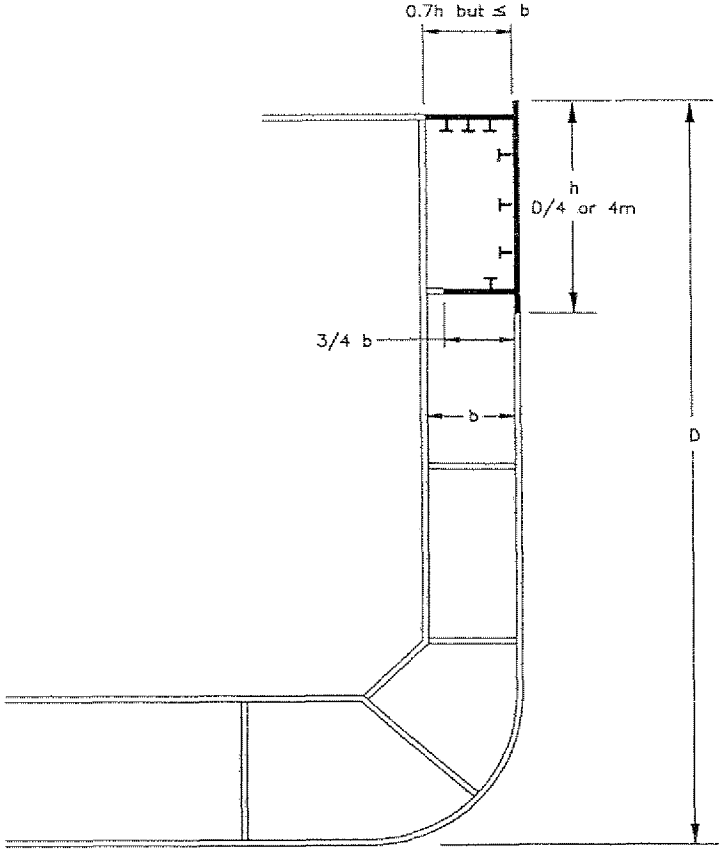

Figure 2