

# SECTION 2 HULL GIRDER AND CROSS DECK

## 1 Hull girder of monohull and catamaran

### 1.1 General

1.1.1 The global loads are to be taken into account for the review of hull girder of monohull and catamaran and for the cross deck of catamaran in the cases listed in Ch 6, Sec 1, [1.3].

1.1.2 The design review of hull girder structure consists in:

- checking that global stresses are less than the admissible values given in Ch 4, Sec 3, Tab 2 and Ch 4, Sec 3, Tab 4 as appropriate ( $\sigma_{glam}, \tau_{glam}$ )
- checking that the actual safety factors for buckling of plating and stiffeners contributing to longitudinal hull girder strength are more than the admissible values given in Ch 4, Sec 3, Tab 2 and Ch 4, Sec 3, Tab 4, as appropriate (SF).

1.1.3 The calculation of global stresses is carried out on basis of:

- the combination of global loads (bending moments) as indicated in Ch 6, Sec 4,
- the actual strength characteristics of the hull girder as indicated in Ch 4, Sec 4

1.1.4 The buckling strength of structural members contributing to the longitudinal hull girder strength is checked on basis of:

- relevant requirements of Ch 8, Sec 3 for plating
- relevant requirements of Ch 8, Sec 4 for stiffening members.

1.1.5 As a rule, the checking of the hull girder strength is to be carried out for monohull yachts and for catamarans yachts.

## 2 Cross deck of catamaran

### 2.1 Estimation of stiffness of cross deck

2.1.1 The design review of the main structure of the cross deck of catamarans under global wave torque may be checked by means of a beam model analysis, as shown on Fig 1. Any other justified checking method may be considered.

This design review consists in:

- checking that global stresses in floats are less than the admissible values given in Ch 4, Sec 3, Tab 2 and Ch 4, Sec 3, Tab 4 as appropriate ( $\sigma_{glam}, \tau_{glam}$ )
- checking that local stresses in cross connecting structure (cross beams or transverse bulkheads) are less than the admissible values given in Ch 4, Sec 3, Tab 2 and Ch 4, Sec 3, Tab 4 as appropriate ( $\sigma_{locam}, \tau_{locam}$ ).

2.1.2 The purpose of the present calculation is to determine the loads distribution in the cross deck between floats, versus flexural and shear stiffnesses of the primary structure of the cross deck.

2.1.3 Each resisting transverse member between floats is modeled as a beam, taking account of:

- flexural inertia about an horizontal axis, depending mainly on the web height of the transverse cross beam or bulkhead, the roof deck thickness or the float deck thickness and the thickness of the underside of the cross deck (wet deck)
- vertical shear inertia, depending on the web height of the transverse cross beams or bulkheads and their thickness
- their span between inner side shell of floats.

Figure 1 : Cross deck of catamarans - Model principle

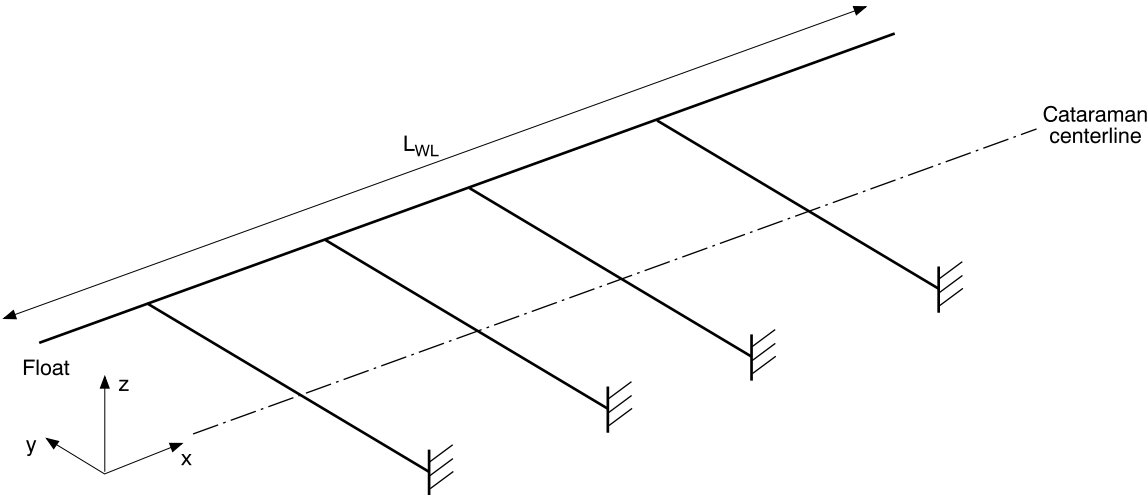
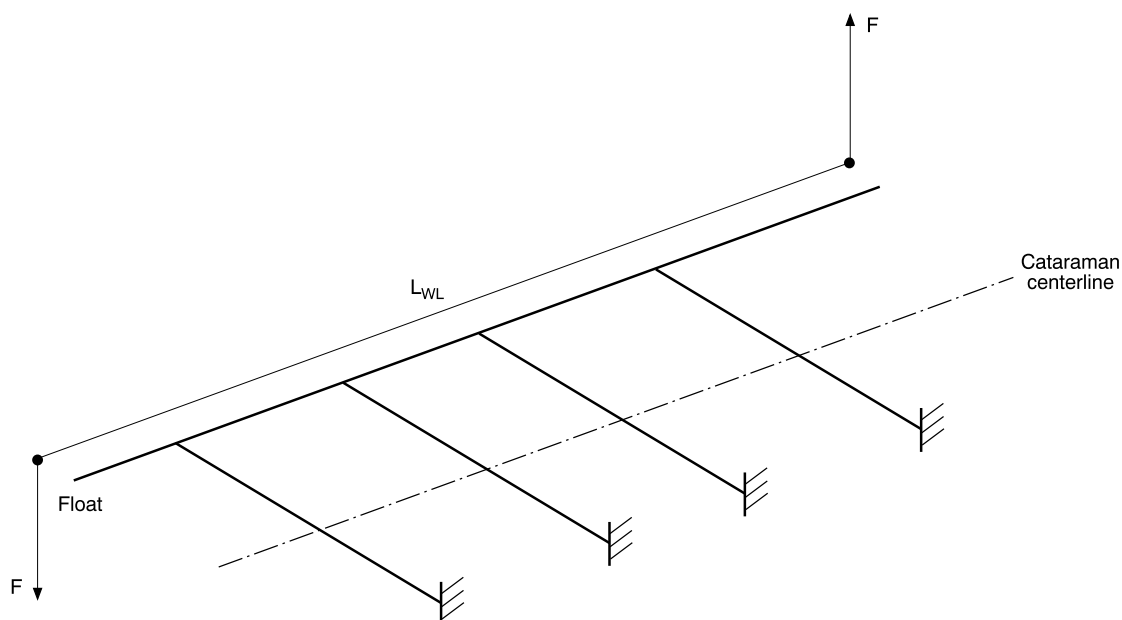


Figure 2 : Application of wave torque in beam model



**2.1.4** As far as possible, the beam model of the float is to have:

- vertical and horizontal inertias close to the actual one of the float
- a shear inertia close to the actual one of the float
- a torsional inertia about longitudinal float axis close to the actual one of the float.

The second float is not described as a beam in the beam model. Instead, the transverse cross beams in the beam model are fully fixed at their intersection with this float.

#### 2.1.5 Wave torque model

The wave torque moment exerted on the cross deck may be represented by 2 vertical forces  $F$ , equal in magnitude and opposite in direction, as shown on Fig 2. The magnitude of the force  $F$ , in kN, is to be taken equal to:

$$F = M_{WT} / L_{WL}$$

where:

$M_{WT}$  : Wave torque moment, in kN.m, calculated according to Ch 6, Sec 2, [2.3.2]

$L_{WL}$  : Length of the float at full load waterline, in m, as described in the beam model (see Fig 1).

#### 2.1.6 Digging in loading model

The loading due to digging in, as described in Ch 6, Sec 3, [3], may be satisfactorily taken into account in the beam model by applying a differential vertical loading  $F_V$  (difference between the vertical loads exerted on both floats) and a differential horizontal load  $F_H$  (difference between the horizontal loads exerted on both floats), as shown on Fig 3.

The linear loads to input in the beam model,  $F_V$  and  $F_H$ , in kN/m, are to be calculated as follows, with  $F'$  and  $F''$  calculated according to Ch 6, Sec 3, [3.2]:

$$F_V = \frac{F'/3}{L_{WL}/4}$$

$$F_H = \frac{F''/3}{L_{WL}/4}$$

#### 2.1.7 Rig torque

For catamaran sailing yacht, the torque exerted by standing rigging may be represented by 2 vertical forces  $F_{RIG}$ , equal in magnitude and opposite in direction, as indicated in [2.1.5]. The magnitude of the force  $F$ , in kN, is to be taken equal to:

$$F_{RIG} = M_{RIGT} / L_{WL}$$

where:

$M_{RIGT}$  : Rig torque, in kN.m, calculated according to the method given in Ch 6, Sec 3, [2.4]

$L_{V1}'$ ,  $L_{D1}'$ ,  $L_p'$ : Distances, in m, between various chain plates of the standing rigging and the center of rotation of the cross deck, measured according to Fig 4.

The longitudinal position of the center of rotation of the cross deck is estimated from the results of the beam model analysis specified in [2.1.5].

#### 2.1.8 Combination of loadings

The two loading cases to be considered are defined in Ch 6, Sec 4 and are reminded below for information:

- wave torque loading combined with 70 percent of the rig torque
- digging in torque combined with 70 percent of the rig torque.

### 2.2 Floats structure

**2.2.1** The structure of each float is to be checked as indicated in [1], considering the vertical bending moments and the vertical shear forces coming from the beam model analysis performed to check the cross deck structure, as shown on Fig 5.

Figure 3 : Application of digging in loads in beam model

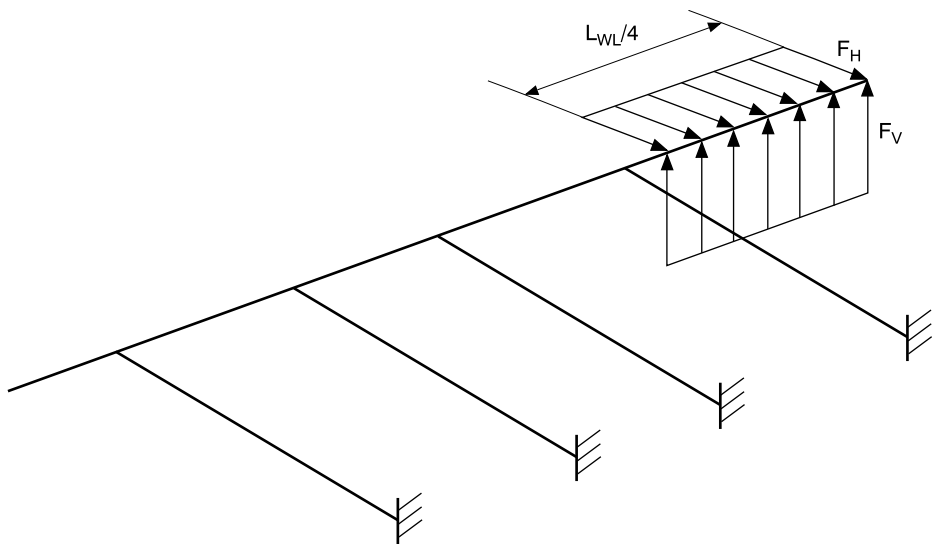
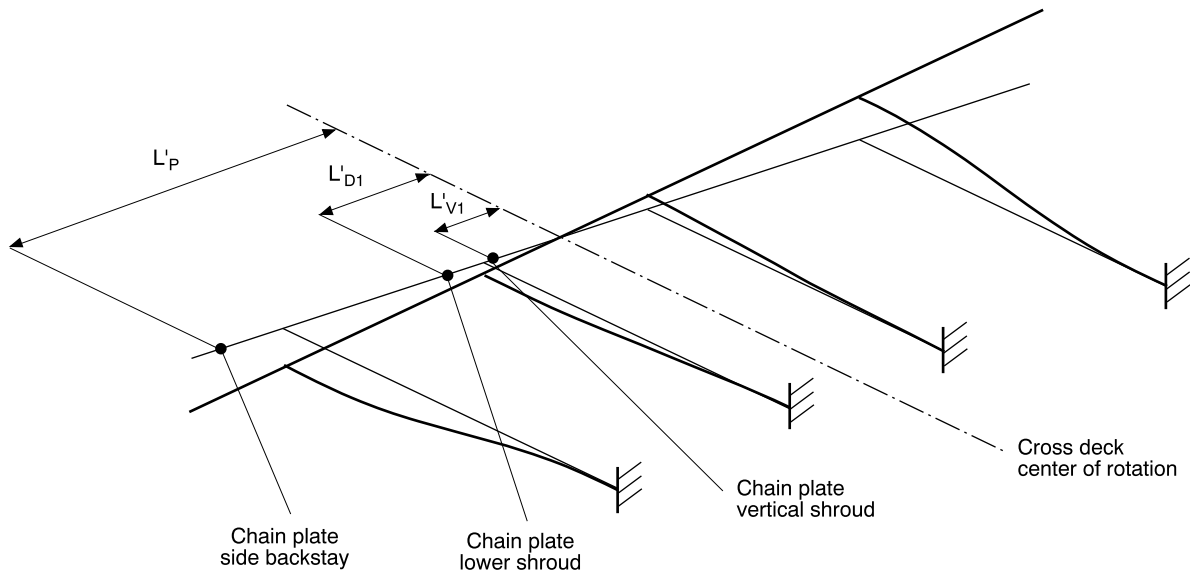


Figure 4 : Rig lever arm inducing rig torque



**2.2.2** The geometrical characteristics of the float may be determined using Bureau Veritas Rule software “MARS”, as indicated in Ch 1, Sec 4, [2.3], or any other equivalent mean.

The transverse sections to be considered are to take into account all the longitudinal continuous members (plates and longitudinal stiffeners) in the areas shown on Fig 6:

- $b_R$  : Breadth equal to 10% of the roof length
- $b_{WD}$  : Breadth equal to 10% of the cross deck length.

**2.3 Primary transverse structure between floats**

**2.3.1** Each resisting transverse cross member between floats (cross beams, bulkheads) is checked against flexural and shear strength, taking account of the bending moments and shear forces resulting from the beam model analysis described in [2].

The values of bending moments and shear forces to consider are the one calculated in the transverse beams of the beam model, in way of the modeled float.

The transverse distribution of vertical bending moments and vertical shear force is indicated in Fig 7.

**2.3.2** Particular attention is to be paid to:

- shear buckling check of transverse bulkheads
- compression/bending buckling check of wet deck and cross deck plating in areas where the bending moment is maximum.

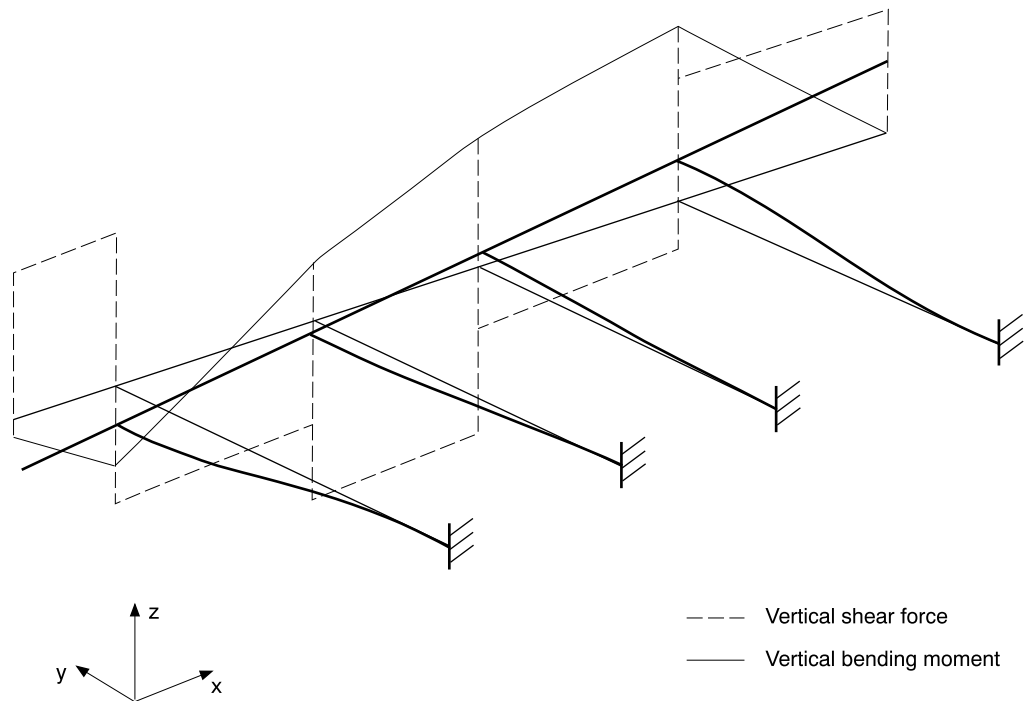
**2.3.3** For catamarans sailing yachts, the cross beam supporting the mast is to be checked as indicated in [2.3.1] and

[2.3.2], with added effect of loads induced by mast on this particular cross beam.

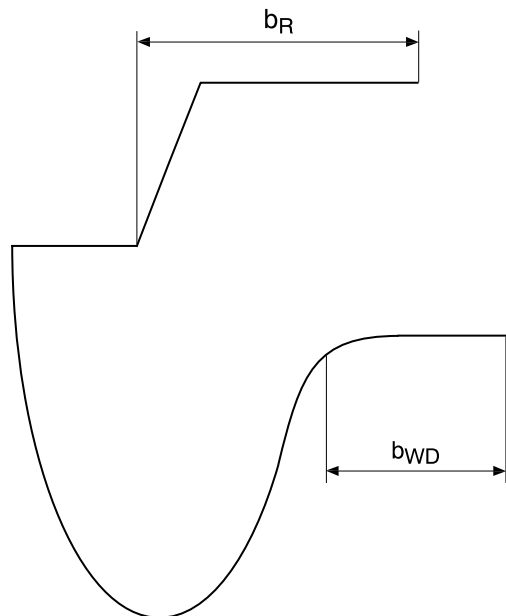
This cross beam may be considered as fixed in way of inside side plating of floats and loaded by the mast (considered as a concentrated force).

The mast compressive load, as given by the Shipyard or the Designer, is to be considered with a contribution factor 0,7.

**Figure 5 : Overall loads in the float**



**Figure 6 : Area to take into account for continuous members (plates and stiffeners) for hull girder strength**



**Figure 7 : Transverse distribution of bending moment and shear force**

