
**Small craft — Hull construction and
scantlings —**

Part 7:
**Determination of loads for multihulls
and of their local scantlings using
ISO 12215-5**

Petits navires — Construction de la coque et échantillonnage —

*Partie 7: Détermination des charges des multicoques et de leur
échantillonnage local en utilisant l'ISO 12215-5*

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ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 188, *Small craft*.

A list of all parts in the ISO 12215 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

The reason underlying the preparation of this document is that standards and recommended practices for loads on the hull and the dimensioning of small craft differ considerably, thus limiting the general worldwide acceptability of boat scantlings. This document has been set towards the minimal requirements of the current practice.

The dimensioning according to this document is regarded as reflecting current practice, provided the craft is correctly handled in the sense of good seamanship and operated at a speed appropriate to the prevailing sea state in a safe and responsible manner, having due cognisance of the prevailing conditions.

Implementation of this document allows to achieve an overall structural strength that ensures the watertight and weathertight integrity of the craft. This document is intended to be a tool to determine the scantlings of a craft as per minimal requirements. It is not intended to be a structural design procedure.

The mechanical property data supplied as default values in this document make no explicit allowance for deterioration in service nor provide any guarantee that these values can be obtained for any particular craft.

Like the other parts of ISO 12215, this document was developed to assess the structure of recreational craft up to 24 m L_H , but it can also be used, where relevant, for non-recreational craft, workboats or yachts with an IMO load line length of up to 24 m, with the necessary critical mind.

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Small craft — Hull construction and scantlings —

Part 7:

Determination of loads for multihulls and of their local scantlings using ISO 12215-5

1 Scope

This document defines the dimensions, local design pressures and global loads acting on multihull craft with a hull length (L_H) or load line length of up to 24 m (see Note). It considers all parts of the craft that are assumed watertight or weathertight when assessing stability, freeboard and buoyancy in accordance with ISO 12217 (all parts). Scantlings corresponding to the local design pressures are then assessed using ISO 12215-5.

NOTE The load line length is defined in the OMI "International Load Lines Convention 1966/2005", it can be smaller than L_H for craft with overhangs. This length also sets up at 24 m the lower limit of several IMO conventions.

This document is applicable to multihulls built from the same materials as in ISO 12215-5, in intact condition, and of the two following types:

- recreational craft, including recreational charter vessels;
- commercial craft and workboats.

It is not applicable to multihull racing craft designed only for professional racing.

This document is applicable to the structures supporting windows, portlights, hatches, deadlights and doors.

For the complete scantlings of the craft, this document is intended to be used in conjunction with ISO 12215-8 for rudders, ISO 12215-9 for appendages of sailing craft and ISO 12215-10 for rig loads and rig attachment in sailing craft. ISO 12215-6 can be used for additional details.

Throughout this document, unless otherwise specified, dimensions are in (m), areas in (m^2), masses in (kg), forces in (N), moments in (Nm), Pressures in (kN/m^2) ($1 kN/m^2 = 1 kPa$), stresses and elastic modulus in (N/mm^2) ($1 N/mm^2 = 1 MPa$).

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 8666:2020, *Small craft — Principal data*

ISO 12215-5:2019, *Small craft — Hull construction and scantlings — Part 5: Design pressures for monohulls, design stress, scantlings determination*

ISO 12215-8:2009, *Small craft — Hull construction and scantlings — Part 8: Rudders*

ISO 12215-9:2012, *Small craft — Hull construction and scantlings — Part 9: Sailing craft appendages*

ISO 12215-10:2020, *Small craft — Hull construction and scantlings — Part 10: Rig loads and rig attachments in sailing craft*

ISO 12217-1:2015, *Small craft — Stability and buoyancy assessment and categorization — Part 1: Non-sailing boats of hull length greater than or equal to 6 m*

ISO 12217-2:2015, *Small craft — Stability and buoyancy assessment and categorization — Part 2: Sailing boats of hull length greater than or equal to 6 m*

ISO 12217-3:2015, *Small craft — Stability and buoyancy assessment and categorization — Part 3: Boats of hull length less than 6 m*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <http://www.electropedia.org/>

3.1 multihull
craft with two or more hulls with a connecting *wet deck* (3.8)/crossbeams above the loaded waterline, as opposed to a tunnel boat or scow

Note 1 to entry: See Clause 6 and [Figure 2](#) for the main dimensions of a multihull.

3.2 design categories
description of the sea and wind conditions for which a craft is assessed to be suitable

Note 1 to entry: The design categories are defined in ISO 12217 (all parts).

Note 2 to entry: The definitions of the design categories are in line with the European Recreational Craft Directive 2013/53/EU.

[SOURCE: ISO 12215-5:2019, 3.1.]

3.3 loaded displacement
 m_{LDC}
mass of water displaced by the craft, including all appendages, when in fully loaded ready for use condition

Note 1 to entry: The fully loaded ready for use condition is further defined in ISO 8666.

[SOURCE: ISO 12215-5:2019, 3.2.]

3.4 mass in minimum operating conditions
 m_{OC}
mass of the craft in minimum operating condition

Note 1 to entry: The minimum operating condition is further defined in ISO 8666.

3.5 sailing craft
craft for which the primary means of propulsion is wind power

Note 1 to entry: It is further defined in ISO 8666.

Note 2 to entry: In this document, non-sailing craft are considered as motor craft.

[SOURCE: ISO 12215-5:2019, 3.3.]

3.6 beam of hull

B_H
beam across the outer hulls

Note 1 to entry: The measurement of the beam of hulls is specified in ISO 8666.

3.7 chine beam

B_C
beam at chine of planing hulls

Note 1 to entry: It is further characterized in 6.1.2.

3.8 wet deck

underside area of the structure connecting hulls with an area greater than 5 % $L_H B_H$

Note 1 to entry: Some *multihulls* (3.1) have no wet deck but just crossbeams, i.e. connecting beams.

3.9 craft speed

V
for motor craft, maximum speed in calm water and m_{LDC} condition that is declared by the manufacturer, expressed in knots

[SOURCE: ISO 12215-5:2019, 3.6.]

3.10 displacement craft

motor craft whose speed is such that $V < 5\sqrt{L_{WL}}$

[SOURCE: ISO 12215-5:2019, 3.7, modified - the definition is reworded.]

3.11 displacement mode

mode of running of a motor craft in the sea such that its mass is mainly supported by buoyancy forces

Note 1 to entry: This is the case where the actual speed in a seaway in m_{LDC} condition is such that its speed/length ratio makes the craft behave as a *displacement craft* (3.10).

[SOURCE: ISO 12215-5:2019, 3.8, modified - in the definition, "craft" is replaced with "motor craft".]

3.12 planing craft

motor craft whose speed is such that $V \geq 5\sqrt{L_{WL}}$

Note 1 to entry: This speed/length ratio limit has been arbitrarily set up in this document, but it can vary from one craft to another according to hull shape and other parameters.

[SOURCE: ISO 12215-5:2019, 3.9, modified - the definition is reworded.]

3.13 planing mode

mode of running of a motor craft in the sea such that a significantly part of its mass is supported by forces coming from dynamic lift due to speed in the water

Note 1 to entry: A *planing craft* (3.12) in calm water runs in planing mode, but it can be obliged to significantly reduce its speed when the sea gets worse, running in that case in *displacement mode* (3.11).

[SOURCE: ISO 12215-5:2019, 3.10, modified - the definition slightly reworded and "craft" replaced with "motor craft".]

3.14 non-walking area

area of the craft comprising those areas defined in the owner's manual as being both outside of the working deck and where people are not liable to stand or walk in normal or emergency operation, and those of the working deck of a *multihull* (3.1) with an inclination of more than 25° against the horizontal in the longitudinal and transverse directions

Note 1 to entry: All other areas of the working deck, cockpit bottom and superstructures are deemed to be walking areas.

4 Symbols

Unless specifically otherwise defined, the symbols shown in Table 1 are used in this document. The symbols are shown by group type and in alphabetical order.

Unless otherwise specified, all dimensions, measured in m_{LDC} condition, are according to ISO 12217.

Table 1 — Symbols, dimensions, factors, parameters

Symbol	Unit	Designation/Meaning of symbol	Reference/ Clause concerned
General dimensions and data			
B_{BH}	m	Beam between hulls as defined in Table 4	6.1, Fig 2 & Annex D
B_C	m	Chine beam at 0,4 L_{WL} from the origin used for k_{DYNM1} and $P_{BMUP\ BASE}$	6.1.1, Fig 1 & Table 7
B_{CB}	m	Beam between centres of buoyancy	6.1, 12.5 & Fig 2
B_{CP}	m	Beam between upper shrouds chainplates	Annex B
B_{WDx}	m	Beam at the inside of wet deck/beam connection with hulls at section x	6.1.3 & Fig 2
B_H	m	Beam of hull according to 3.6	6.1 & Fig 2
B_{nOHi}	m	Beam at overhang root, n = F(fwd) M(mid), A(Aft), and i = H(Hull), F(Float)	Table 11, Fig 9
L_{nOHi}	m	Length of overhang, n = F(fwd) M(mid), A(Aft), and i = H(Hull), F(Float)	Table 11, Fig 9
D_{ROH}	m	Depth of hull at overhang root	Table 11, Fig 9
D_{WL}		Design Waterline plan or section	6.1.3, Figure 2
h_{SIDEx}	m	Height of mid panel of cockpit side or stiffener below overflow level	Table 5 it. 10
H_{SUPx}	m	Height of mid panel or stiffener above the lesser of Z_{SDTMx} or Z_{SDAMx}	Table 5 it. 10
L_{Ci}	m	Length of crossbeam i	Table 11, Fig 9
L_{BB}	m	Length between main beams centre of inertia	Annex B & C
L_H	m	Length of hull	1
L_{FLOAT}	m	Length of a trimaran float	9.4 & Fig 9
L_{WL}	m	Length of waterline	Fig 2
m_{LDC}	kg	Mass of craft in fully loaded condition	3.3, 9
m_{MO}	kg	Mass in minimum operating condition	3.4, 11
T_C	m	Max canoe body draught (see Figure 2)	Fig 2, 9.3
V	Knots	Craft maximum speed in m_{LDC} condition	3.9, Table 5 it. 2
Panels, stiffeners and local dimensions and data			
A_D	m ²	Panel or stiffener supported area	Table 5 it. 9

Table 1 (continued)

Symbol	Unit	Designation/Meaning of symbol	Reference/ Clause concerned
b	mm	Small unsupported dimension of panel plating	Table 5 it. 9
l	mm	Large unsupported dimension of panel plating	Table 5 it. 9
s	mm	Stiffener spacing (small unsupported dimension of stiffener)	Table 5 it. 9
l_u	mm	Stiffener length: long unsupported dimension of stiffener (frame/stringer)	Table 5 it. 9
Q_x		Point at section x where the pressure is assessed	Figures 2 & 3
T_x	m	Local canoe body draught at section x (see Figure 2)	Fig 2
x	m	Distance of a section x from aft of L_{WL}	Fig 2, 9.3
Z_{Qx}	m	Height of point Q_x above D_{WL} at section x	Fig 2, 9.3
Z_{Tx}	m	Height of local canoe body above D_{WL} at section x (usually <0)	Fig 2, 9.3
Z_{Cx}	m	Height of local hard chine above D_{WL} at section x for planing craft	Fig 2, 9.3
Z_{SDAFx}	m	Height of actual side/deck limit for trimaran float at section x	Fig 2, Table 4
Z_{SDTMx}	m	Height above D_{WL} of the theoretical side/deck limit at section x	Fig 2, Table 3
Z_{SDAMx}	m	Height above D_{WL} of the actual side/deck limit at section x	Fig 2, Table 3
Z_{WDTx}	m	Height above D_{WL} of the theoretical wet deck height at section x	Fig 2, 9.3
Z_{WDAx}	m	Height above D_{WL} of the actual height of wet deck at section x	Fig 2, 9.3
$\alpha_{LSx}, \alpha_{TSx}$	Degree	Longitudinal and transverse angle of superstructure at section x	Fig 2, Table 5
α_{LWDx} α_{LDx}	Degree	Longitudinal slope angle against horizontal of wet deck or deck/cross-beam at section x	Fig 8, Table 5 it 9
β_x	Degree	Deadrise at section x , of planing craft, not to be taken $<30^\circ$ nor $>60^\circ$	Fig 2, 9.3
$\beta_{0,4}$	Degree	Deadrise of planing craft at section $x/L_{WL} = 0,4$,	Fig 2, 9.3
Calculation data, factors, etc.			
k_{AR}	1	Area pressure distribution factor	Table 5 it. 9
k_{BWD}	1	Wet deck transverse pressure distribution factor	Table 5 it. 6
k_{DC}	1	Design category factor	Table 5 it. 1
k_{DRx}	1	Deadrise pressure reduction factor for planing multihulls in planing mode	Table 5 it. 8
k_{DYNM}	g's	Dynamic load factor for multihulls, see Figure 4	Table 5 it. 2
k_{LDMx}	1	Deck longitudinal pressure distribution factor for multihulls	Table 5, Fig 4
k_{LMx}	1	Side longitudinal pressure distribution factor for multihulls	Table 5, Fig 3
k_{LMTx}	1	Side longitudinal pressure distribution factor for trimaran float	9.4.1
k_{DLMTx}	1	Deck longitudinal pressure distribution factor for trimaran float	9.4.1
k_{LWDx}	1	Wet deck longitudinal pressure distribution factor	Table 5, Fig 5
k_{SUPx}	1	Superstructure/deckhouse pressure distribution factor for multihulls	Table 5 it. 10
k_{Sx}	1	Slope factor respectively k_{SDx} or k_{SDx} for deck and wet deck, see Figure 8	Table 5 it. 11
k_{ZDMx}	1	Vertical pressure correction for deck where $Z_{SDAMx} < Z_{SDTMx}$	Table 6 it. 1
k_{ZMIx}	1	Inner side/bottom vertical pressure correction factor in way of wet deck for sail and displacement multihulls	Table 6 it. 3
k_{ZMOx}	1	Outer and inner side/bottom vertical pressure correction factor clear of wet deck for sail and displacement multihulls	Table 6 it. 2
k_{ZPMIx}	1	Inner side/bottom vertical pressure correction factor in way of wet deck for planing multihulls in planing mode	Table 7 it. 3
k_{ZPMOx}	1	Outer and inner side/bottom vertical pressure correction factor clear of wet deck for planing multihulls in planing mode	Table 7 it. 2
k_{ZWDx}	1	Wet deck vertical pressure correction factor	Table 5 it. 7

Table 1 (continued)

Symbol	Unit	Designation/Meaning of symbol	Reference/ Clause concerned
Design pressures for sailing and displacement motor multihulls			
$P_{BMU\text{ BASE}}$	kN/m ²	Base pressure for sailing and displacement catamarans and trimarans central hull	Table 6 it. 1
P_{BMUx}	kN/m ²	Design pressure at lowest point of section x	Table 6 it. 1
P_{WDx}	kN/m ²	Design wet deck/crossbeam bottom design pressure at section x	Table 6 it. 1
$P_{DMU\text{ BASE}}$	kN/m ²	Base design pressure for deck and cockpit bottom	Table 6 it. 1
P_{DMUx}	kN/m ²	Design pressure for deck and cockpit bottom at section x	Table 6 it. 1
P_{HMUIx}	kN/m ²	Inner design pressure in way of wet deck/crossbeam at section x	Table 6 it. 3
P_{HMUOx}	kN/m ²	Outer and inner design pressure clear of wet deck/crossbeam at section x	Table 6 it. 2
P_{SUPMx}	kN/m ²	Superstructure and cockpit side design pressure at section x	Table 6 it. 4
Design pressures for planing multihulls in planing mode			
$P_{BMUP\text{ BASE}}$	kN/m ²	Base bottom design pressure for planing multihulls in planing mode	Table 7 it. 1
P_{HMUIPx}	kN/m ²	Inner design pressure in way of wet deck/crossbeam for planing multihulls in planing mode at section x	Table 7 it. 1
P_{HMUOPx}	kN/m ²	Outer and inner design pressure for planing multihulls in planing mode clear of wet deck/crossbeam at section x	Table 7 it. 2
Design pressures for trimaran floats			
$P_{TRF\text{ BASE}}$	kN/m ²	Base bottom pressure for trimaran float (same as for central hull)	Table 8
P_{TRFx}	kN/m ²	Bottom/side design pressure for trimaran floats at section x	Table 8
Stresses, shear forces and moments			
σ_d, τ_d	N/mm ²	Design stress for global loads	Table 12
q	N/mm	Shear flow such as $\tau = q/t$	Tables C.1, C.3
M_B	Nm, kNm	Bending moment, design or ultimate	Annex D
M_T	Nm, kNm	Torsional moment, design or ultimate	Table 14
F	N, kN	Force, shear force	Tables 14, 15

5 Application of this document

5.1 Materials

The materials considered in this document are the main modern building materials listed in [Clause 1](#) and Table 17 of ISO 12215-5:2019. This document may be used with other materials, including new fibres and resins, provided that they show similar cohesion, durability, resistance to marine environment and elongation at break as the ones quoted in Table 17 of ISO 12215-5:2019.

5.2 Limitations

The shape of multihulls entails that significant deflexions are observed without rupture of structural elements. In contrast, non-structural elements (i.e. accommodations) are sometimes stiffer, but not necessarily stronger, than the structural elements and can suffer from this difference of behaviour. This is not considered in this document provided the structural elements are strong enough. The strength and arrangements of non-structural elements are left to the responsibility and experience of the manufacturer.

On multihulls, the value of the loaded displacement m_{LDC} has a greater influence on the loads than for monohulls. Exceeding the m_{LDC} value can cause significant load increase which can transform a craft

meeting the requirements of this document into a non-conform craft, for example a lower wet deck clearance induces a much greater pressure. Overloading shall therefore be avoided, and a caution information shall be included in the owner's manual, see [15.2](#).

5.3 Overall procedure for the application of this document

[Table 2](#) describes, by steps, the overall procedure of this document for scantlings determination.

Table 2 — Overall procedure for scantlings determination

Step N°	Subject	Clause N°
1	Main dimensions, data and areas	6
2	Dimensions of panels and stiffeners under local loads	7
3	Local pressure adjustment factors	8
4	Local design pressures	9
5	Further analysis of structural elements subject to local loads	10
6	Multihull rudders, appendages and their wells	11
7	Multihull global loads	12
8	Structural arrangements for supporting global loads	13
9	Multihulls used as commercial craft and workboats	14
10	Information to be included in the owner's manual	15

6 Main dimensions, data and areas

6.1 Dimensions and data

6.1.1 General

The dimensions are usually the same as in ISO 12215-5:2019, many of them being as defined in ISO 8666, see [Table 1](#) and [Figures 1](#) and [2](#). The figures show sections at any longitudinal coordinate x , measured from aft of D_{WL} and some values like B_{WD} , B_{BH} , etc. shall be taken as the average values of B_{WDx} , B_{BHx} , etc. For clarification, data that vary with length x are followed by index x .

6.1.2 Bottom deadrise of the hulls β_x and chine beam B_{Cx} of planing multihulls

[Figure 1](#) explains local chine beam B_{Cx} and deadrise determination for planing craft at any section x :

- where the bottom hulls sections of planing multihulls are approximately straight lines, the deadrise is the actual deadrise β_x [see [Figures 1](#) a), b) and d) and at right part of [Figure 2](#) c)], and
- where the bottom has round bilges, the deadrise β_x shall be measured as the angle between lowest point of the hull bottom (hull centreline) and the point where the bottom is tangent to a line angled 50° from horizontal [see [Figure 1](#) c) and at right part of [Figure 2](#) c)].

For planing multihulls that reach speeds allowing them to progress in planing mode ([3.13](#)), the chine beam B_C and corresponding deadrise angle $\beta_{0,4}$, measured at $x = 0,4 L_{WL}$ from their aft end, are used for the determination of k_{DYNM1} and bottom pressure of planing multihulls $P_{BMU\text{BASE}}$.

Where the bottom of a planing catamaran is not symmetrical, as in [Figure 2](#) g), the bottom has an angle β_{x0} on the outer side and β_{xi} on the inner side. In the inner side, the deadrise factor k_{DR} defined in item 8 of [Table 5](#) lowers significantly the design pressure.

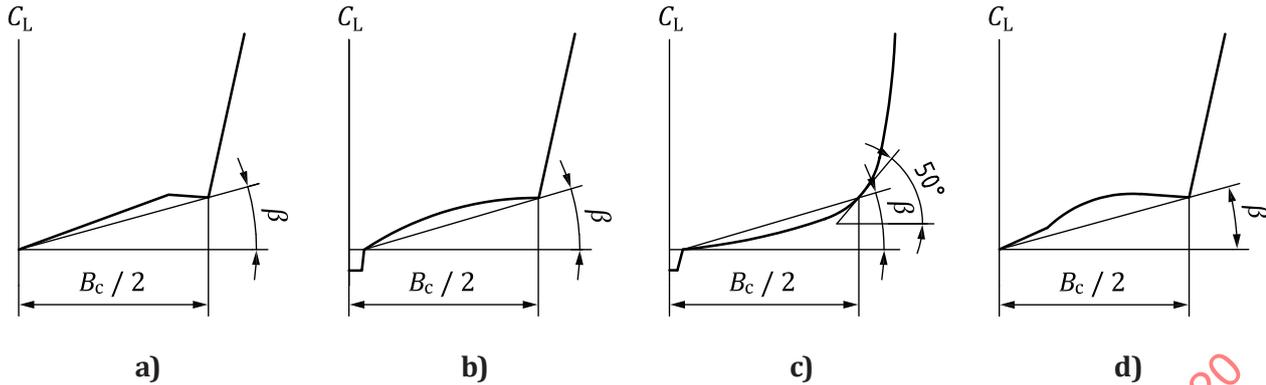


Figure 1 — Measurement of chine beam B_{Cx} and deadrise angle β_x

6.1.3 Wet deck bottom

See definitions of wet deck in [Table 4](#).

For catamarans: the actual local height of the wet deck Z_{WDAx} at section x is its height above D_{WL} , see [Figure 2 b](#)). Where the wet deck bottom height is not constant, it shall be taken as the average height of 80 % of its width inside the limits of its connection with the hull plating B_{BWDx} . Where there are parts with a width greater than 0,33 B_{WDX} and with a height differing by more than 10 % from Z_{WDAx} , each of these panels shall be assessed as a specific panel. B_{WDX} is the beam of the wet deck, averaged if variable, inside the angle or fairing/connection with the hulls, it is used for the calculation of k_{BWD} in item 6 of [Table 5](#).

Where different from horizontal, the angles of the wet deck bottom α_{WDLx} against the horizontal increase the wet deck pressure of the wet deck or crossbeams, see item 11 of [Table 5](#) and corresponding figure.

For sailing trimarans, the wet-deck height is measured perpendicular to a sloped plan angled from D_{WL} , cutting it a C_L and at $x = 0,5 L_{WL}$ and the float axis at key point 17 of [Figure 2 d](#)) to e) at the height Z_{WDT} above its bottom; see left part of [Figure 2 d](#)). This point 17 needs not be taken higher than the point at which the float is dipped in the water in sail configuration S_{C1} of ISO 12215-10 (apparent wind speed where the full sail area begins to be reduced).

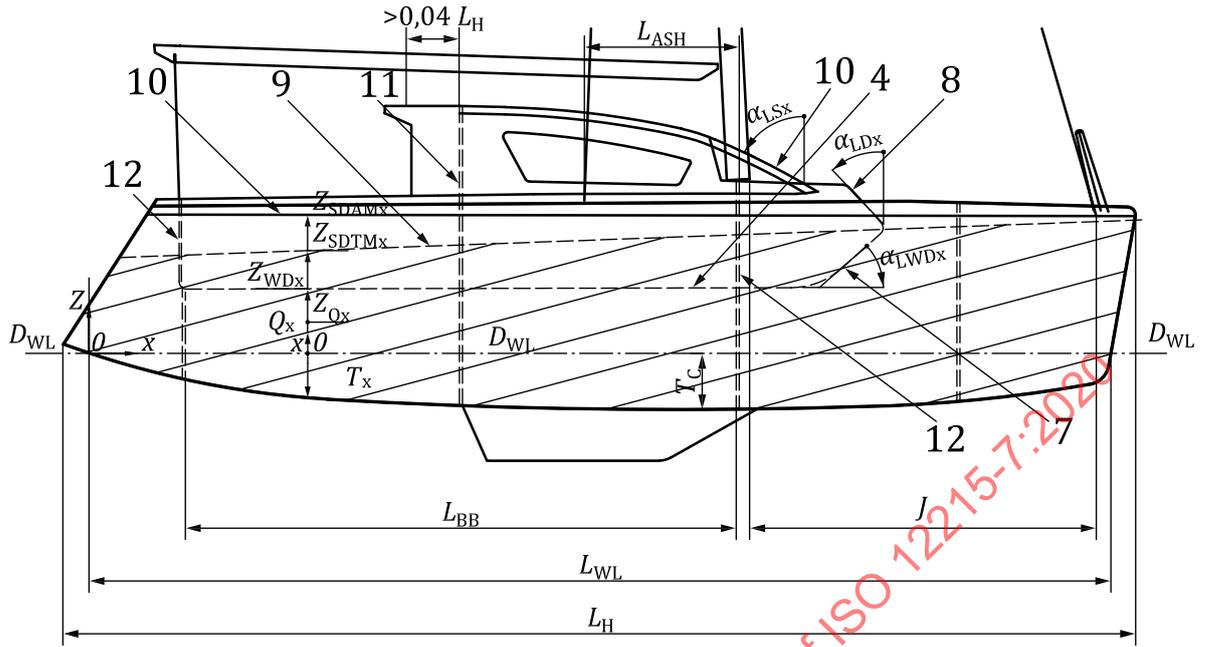
For motor trimarans, the wet-deck height is measured perpendicular to the same sloped plan as for sailing trimarans but angled so that point 17 is taken at a height $0,5 Z_{WDT}$ above the float's bottom.

NOTE This sloped plan for trimarans considers the "envelope" of the waterline both when the craft heels when beating upwind and when it is close to upright when running.

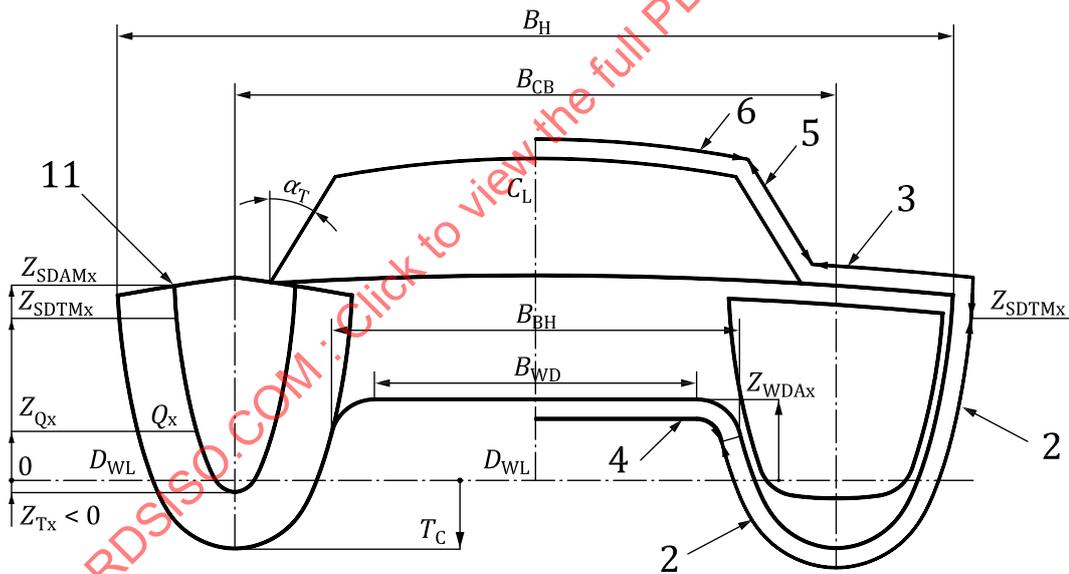
6.1.4 Crossbeams

Crossbeams for catamarans and trimarans are defined in [Table 4](#).

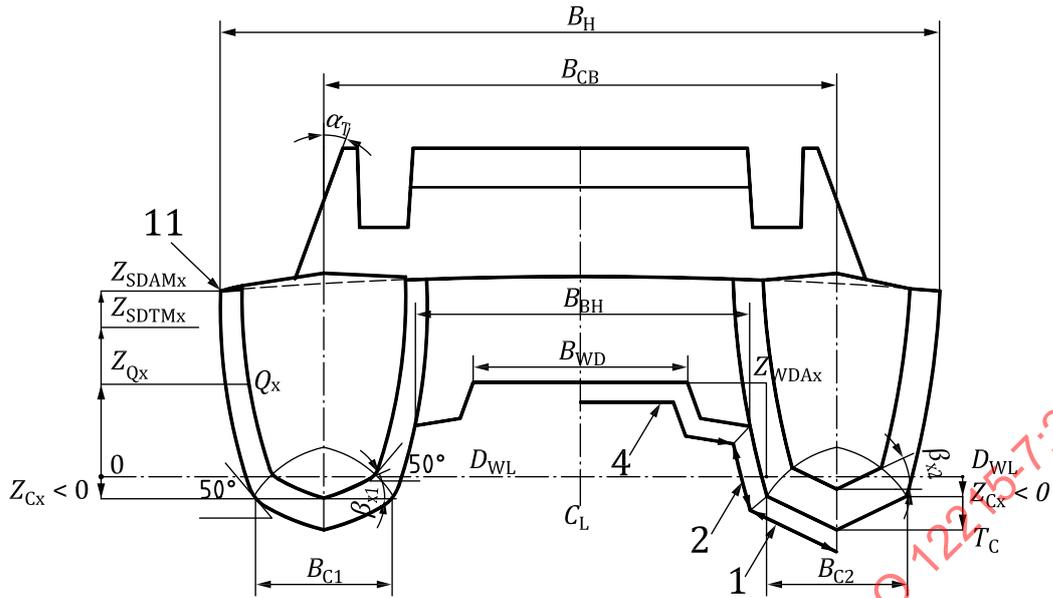
For local loads, the front and bottom parts of crossbeams lower than Z_{WDTx} are considered as part of the wet deck bottom, and the parts above are considered side or deck whether they are below or above Z_{SDTMx}



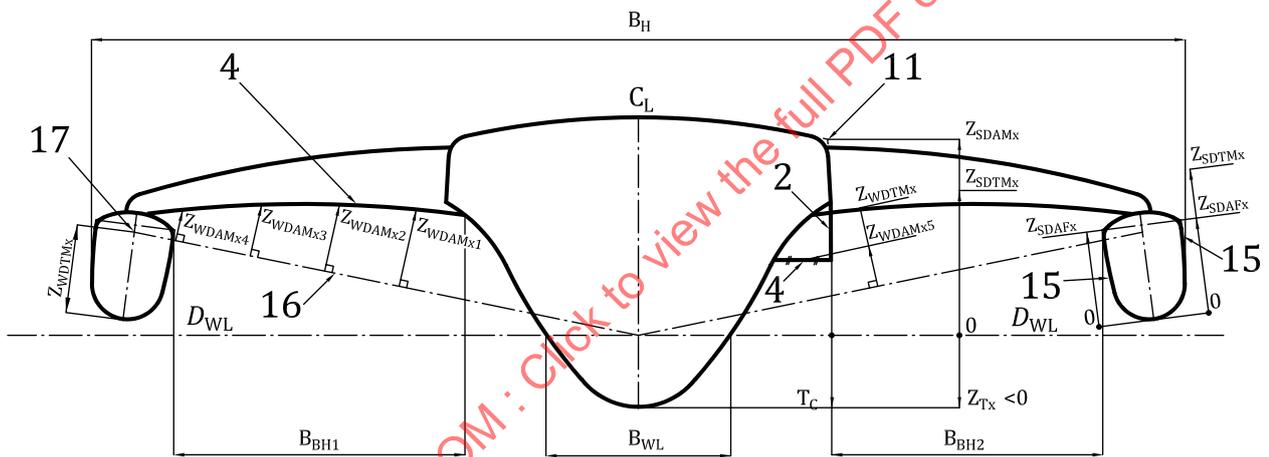
a) Typical sailing catamaran, side view



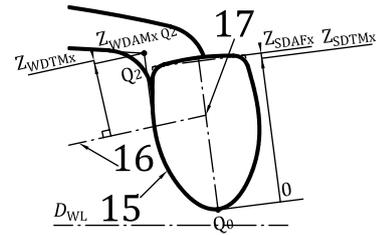
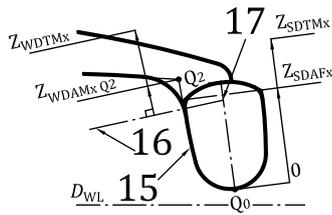
b) Typical sailing catamaran, view at main section and any section x



c) Typical motor catamaran, view at main section and any section x (round bilge/hard chined)

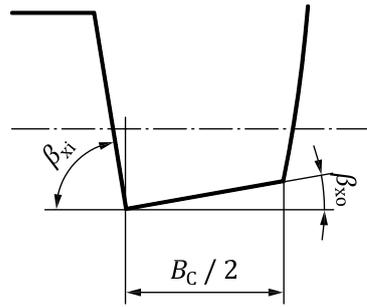


d) Typical sailing trimaran, view at mid-section $x/L_{WL} = 0,5$



e) Trimaran with merging crossbeam, end 1

f) Trimaran with merging crossbeam, end 2



g) Non-symmetrical planing hull section

Keys

1	bottom area (planing)	10	Z_{SDTMx} theoretical limit side/deck
2	bottom/side area (non planing)	11	Z_{SDAMx} actual limit side/deck
3	deck area	12	protected aft bulkhead/superstructure (if $\geq 0,04 L_H$, see Table 5 , item 10)
4	wet deck/crossbeam bottom area	13	mainsheet bulkhead/crossbeam (sailing multi)
5	superstructure side area	14	mast bulkhead/cross beam (sailing multi)
6	superstructure top area	15	side of trimaran float
7	bottom front of wet deck (angle α_{LWDx})	16	sloped plan between C_L at 0 and height Z_{WDTM} along float C_L at section $x/L_{WL} = 0,5$
8	front of deck (angle α_{LDx})	17	point defining the end of the sloped plan
9	front of superstructure (angle α_{SL})		

Figure 2 — General dimensions of a multihull

6.2 Areas

The hull, deck and superstructure are divided into various areas: bottom/side, wet deck/crossbeams, deck and cockpit bottom, cockpit sides and superstructure, see [Figure 2](#).

The "theoretical" hull/deck connection height Z_{SDTMx} is defined in item 1 of [Table 3](#). Above this height, the side pressure is considered to be the deck pressure to avoid penalizing the structure of craft with a high freeboard. In contrast, below Z_{SDTMx} the deck pressure and side pressure are increased as more prone to be submerged or subject to wave shocks, see [Tables 6](#) and [7](#). The hatched area in [Figure 2](#) a) represents the outer plating subject to bottom/side pressure P_{BHMUX} .

[Figure 2](#) b) shows a section of a typical sailing catamaran, whereas [Figure 2](#) c) shows a section of a typical motor multihull, the right part is the one of a typical, hard-chined planing catamaran and the left part, a section with round bilges. The bottom/side pressure P_{HMU0x} or P_{HMUOPx} (in displacement or

planing mode) applies up to the Z_{SDTMx} line, i.e. the hatched area in [Figure 2 a\)](#). This applies to the outer plating or the inner plating not in way of the wet deck/crossbeams.

NOTE According to the multihull design, the Z_{SDTMx} line for the theoretical side/deck limit can be above or below the actual height. Z_{SDTMx} [Figure 2 a\)](#) shows a cruising catamaran with $Z_{SDAMx} > Z_{SDTMx}$.

The "theoretical" wet deck height Z_{WDTx} line is defined in item 2 of [Table 3](#). Above this height, the pressure lowers slowly with freeboard and below this height, the pressure raises quickly when wet deck height is closer to the waterline, see k_{ZWD} in [Table 5](#).

Table 3 — Height of theoretical hull deck connection and wet deck connection according to L_{WL} and x/L_{WL}

1- Theoretical height of hull/deck connection									
$Z_{SDTMx} = (0,028\ 6 \times L_{WL} + 0,115) x/L_{WL} + 0,057\ 1 L_{WL} + 0,229$ (m)									
L_{WL} (m)	8	10	12	14	16	18	20	22	24
	Values of Z_{SDTMx} at section x according to L_{WL} and x/L_{WL}								
x/L_{WL} 0,00	0,69	0,80	0,91	1,03	1,14	1,26	1,37	1,49	1,60
0,50	0,86	1,00	1,14	1,29	1,43	1,57	1,71	1,86	2,00
1,00	1,03	1,20	1,37	1,54	1,72	1,89	2,06	2,23	2,40
2- Theoretical height of hull/wet deck connection									
$Z_{WDTx} = (0,018\ 6 \times L_{WL} + 0,074\ 8) x/L_{WL} + 0,037\ 1 L_{WL} + 0,148\ 9$ (m)									
L_{WL} (m)	8	10	12	14	16	18	20	22	24
	Values of Z_{WDTx} at section x according to L_{WL} and x/L_{WL}								
x/L_{WL} 0,00	0,45	0,52	0,59	0,67	0,74	0,82	0,89	0,97	1,045
0,50	0,56	0,65	0,74	0,84	0,93	1,02	1,11	1,21	1,30
1,00	0,67	0,78	0,89	1,00	1,11	1,23	1,34	1,45	1,56

[Table 4](#) defines the various areas of a multihull:

Table 4 — Definition of bottom/side, transom, wet deck and crossbeams deck, cockpit and superstructure areas

1-Sailing craft and motor catamarans in displacement mode, see Figure 2 b) and 2 c)	
Area	Definition
Bottom/ side + transom	Outside wet deck/crossbeam area, anywhere from lower limit of T_{Cx} up to Z_{SDTMx} the "theoretical limit" side/deck connection, or actual side deck connection Z_{SDAMx} , whichever the lower. In way of wet deck/crossbeams: from lower limit of T_{Cx} up to actual wet deck/crossbeam bottom connection/fairing or Z_{WDTx} , whichever the lower.
Deck and cockpit bottom	Lower horizontal or near horizontal area of the craft structure located above hull side. If there are several deck levels, it is the lower one at the considered section. Where $Z_{SDA} \leq Z_{SDT}$ it is subject to bottom/side/transom pressure, otherwise it is subject to deck pressure (see Tables 6 and 7).

Table 4 (continued)

Wet deck/ crossbeams	<p>Area between the intersection of inner bottom/side with centre hull of trimaran or other hull of catamaran, where not permanently below D_{WL} at actual height Z_{WDAx} or average height if differences of height. Also, any area with an angle $<15^\circ$ from the horizontal protruding more than 0,2 m from the inner side of a catamaran or trimaran float or central hull shall be considered subject to the wet deck pressure. Other such areas with another angle or less and protruding less than 0,2 m are part or inner hull sides or trimaran centre hull.</p> <p>B_{WD} is the beam of the wet deck, averaged if variable, inside the angle or fairing connection with the hulls.</p> <p>B_{BH} is the beam of the wet deck at its connection with the hulls, averaged if variable, i.e. outside the angle or fairing connection with the hulls. If there is not fairing or connection $B_{WD} = B_{BH}$.</p>
2-Motor catamarans in planing mode, see Figure 2 b)	
Area	Definition
Bottom	<p>Where $\beta_x \leq 20^\circ$ and where local chine is below D_{WL}: up to local chine Z_{Cx}.</p> <p>Where $\beta_x > 20^\circ$ and/or where local chine is above D_{WL}: up to D_{WL}. This is the case for the bottom/side plating on the inside in Figure 2 g).</p>
Side+ transom	Above the local chine Z_{Cx} or D_{WL} , whichever the lower.
Deck and cockpit bottom	Same definition as for sailing and motor displacement multihulls.
Wet deck/ crossbeams	Same definition as for sailing and motor displacement multihulls.
3-Sailing and motor trimarans, see Figure 2 d) to 2 f)	
Area	Definition
Main hull: bottom, side and transom	Same as for catamarans (item 1 for sailing/displacement and item 2 for planing) and measured with the craft upright. See Note a in Table 7 defining B_c for trimarans.
Wet deck/ crossbeams	<p>For sailing trimarans Z_{WDAx} is measured perpendicular to a sloped plan defined in 6.1.3, see Figure 2 d) right.</p> <p>For motor trimarans Z_{WDAx} is measured perpendicular to the waterline, craft upright.</p> <p>For trimarans, B_{BH} is as defined for catamarans, except that it is measured between the main hull and the floats, whichever the greatest value being chosen, where not symmetrical, and considering possible main hull bulges, see Figure 2 d).</p>
Trimaran floats	<p>For the outer sides and inner side of floats outside of wet deck/crossbeams area, the actual height of the intersection between side/bottom and deck, see key 4 in Figure 2 c), is called Z_{SDAFx} (height of actual float side/deck limit) and is measured along the float axis perpendicularly from float bottom.</p> <p>Where the bottom of the wet deck/crossbeams bottom does not merge with the inner sides of floats, the pressure of the inner side of floats is considered as for the outer sides.</p> <p>Where the bottom of the wet deck/crossbeams bottom merges with the inner sides of floats, the inner float pressure is calculated as P_{HMUIx} or P_{HMUIPx} in Table 6 or 7.</p> <p>Figure 2 e) and f) show details of calculation of the heights (and therefore pressure) of the inner side of float where the wet-deck/crossbeams merge with the inner plating of floats. Point Q_2 is the intersection of the extension of the wet-deck/crossbeam before the fairing radius with a line parallel to the float axis extending the float plating. This point defines the height $Z_{WDAMQx2}$ where the wet deck/inner plating pressure is calculated, as per Tables 6 and 8.</p>
CAUTION — As the hull/float pressure increases in way of wet deck/crossbeams areas, the scantlings shall vary progressively longitudinally forward or aft the wet deck/crossbeam limit.	

Table 4 (continued)

4-Cockpit and superstructure of catamarans and trimarans (see 3.14 for the definition of non-walking areas and item 10 of Table 5)		
Area	Walking area	Non-walking area
Cockpit bottom, bench top	Yes	No
Cockpit side	No	Yes
Superstructure front	Depends on angle, see 3.14	Depends on angle, see 3.14
Superstructure side	Depends on angle, see 3.14	Depends on angle, see 3.14
Superstructure top including upper tiers	Yes, unless specified in the owner's manual	No, unless specified in the owner's manual

7 Dimensions and pressure for panels and stiffeners under local loads

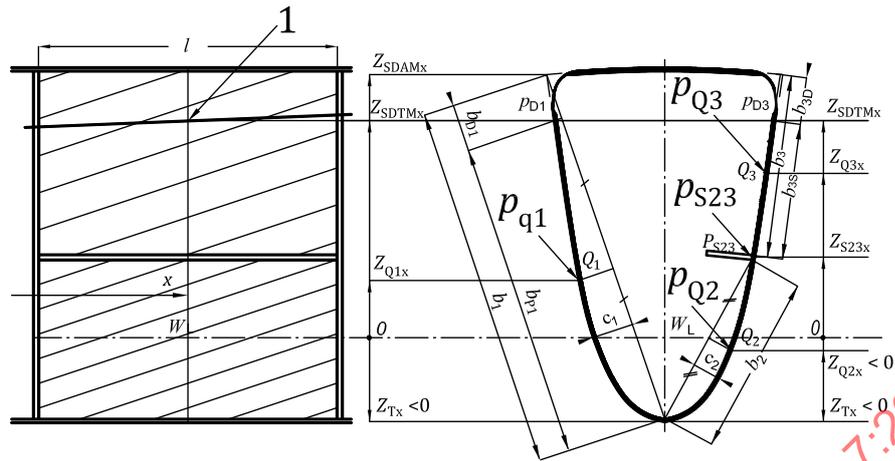
7.1 General

Apart from specific details between monohulls and multihulls (e.g. presence of wet deck), the dimensions of panels and stiffeners shall be determined according to ISO 12215-5:2019. Same for natural stiffeners and pressure determination, except that for multihulls the pressure varies constantly from the bottom at hull/float centreline to side/deck actual limit, i.e. there is no sharp variation between bottom and side at waterline or chine. The pressure applied to a panel follows the logic of ISO 12215-5:2019 and particularly its Clause A.7 (panel across several areas) and is based on several possible methods: weighted average pressure and constant panel thickness, or variable pressure with variable panel thickness, FEM, etc. The same approach is used for a stiffener whose loading is proportional to the pressure of the area it supports.

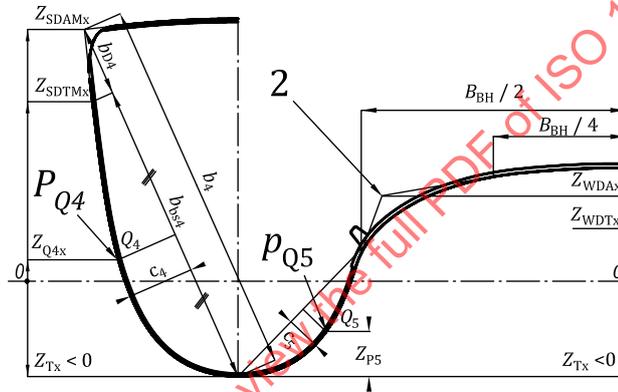
7.2 Example of application on multihulls

7.2.1 Sections

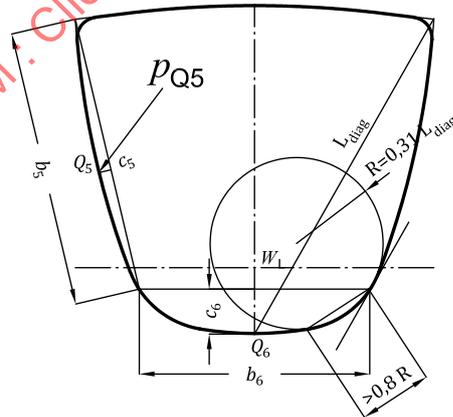
Figure 3 shows examples of panel section analysis for sailing and displacement multihulls; details and comments are given in 7.2.2.



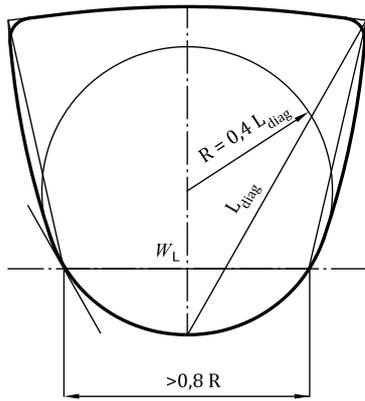
a) Section clear of wet deck



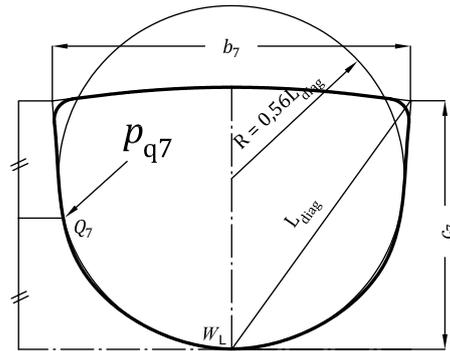
b) Section in way of catamaran wet deck



c) Two natural stiffeners plus side deck/angles



d) One natural stiffener plus side/deck angles



e) No natural stiffener except side/deck angles

Key

- 1 theoretical hull deck limit defined in [Table 3](#)
- 2 Z of hull/wet deck intersection taken at the intersection of the tangent to the hull at B_{BH} and the tangent to the wet deck at $B_{BH}/4$ from C_L

Figure 3 — Example of panel assessment for sailing and displacement multihulls

7.2.2 Details on panel assessment and dimensions

The pressure on a panel or its stiffener is not constant, even if it is only in one area, as the pressure varies with its size (k_{AR}), longitudinal position (k_{LMx}), and vertical position (k_z), with additional corrections for wet deck beam (k_{BWD}) or longitudinal angle (k_{Sx}). Where a panel or stiffener extends over several areas, its final design pressure and corresponding scantlings may be determined by several possible methods.

7.2.3 The constant averaged pressure method

The "constant averaged pressure" method determines a constant pressure over the entire design area, calculated as a weighted average between the pressures, as explained in the following examples:

In [Figure 3](#) b left: first of all, determine x , the distance of the mid-section from the aft end of L_{WL} , then the distance from flotation of the following points:

- Z_{SDTMx} height of the theoretical side/deck limit
- Z_{SDAMx} height of the actual side/deck limit
- Z_{Tx} height (negative) of the bottom at centreline
- Z_{bs4x} height of the outer intersection of the wet deck with the hull of a perpendicular to the chord b_{s4} at its middle. This chord is the part of the chord b_4 inside the side/bottom area, the other part of the chord b_{D4} is in the deck area, above theoretical side/deck limit. The pressure is calculated according to [Table 6](#) at point S_4 .

The final plating pressure P_{L4} on the outer side is $P_{L4} = \frac{(P_{LS4} \times b_{s4}) + (P_{LD4} \times b_{D4})}{b_4}$ with $b_4 = b_{s4} + b_{D4}$, where

P_{PLS4} is the plating pressure on side/bottom plating and P_{PLD4} is the deck plating pressure. Same method for the left side of [Figure 3](#) a).

As explained in ISO 12215-5:2019, the scantling of the panel b_4 may be determined from the pressure P_{P4} considering the curvature correction for camber c_4 for the whole panel b_4 ;

The right side of [Figures 3 a\)](#) and [b\)](#) shows examples with a stringer, and how to calculate the pressure of the panel or its stiffener with the same averaged pressure method.

The height of the connection between the wet deck and the hulls is normally its actual connection height or, the intersection of the tangents to the hulls and wet deck, see [Figure 3 b\)](#). Where there is no clear intersection or tangents as in [Figure 3 b\)](#), it shall be taken as the outer intersection of the wet deck with the hull with the tangent to the wet deck at $B_{BH}/4$ from C_L .

NOTE The disadvantage of this method is that it is conservative for the upper part of the hull structure and non-conservative for the rest.

7.2.4 Other assessment and dimensioning methods

A possible alternative solution is to calculate first the scantlings of the whole panel as if it was below waterline, then the scantlings of the whole panel if it was above D_{WL} or above Z_{SDTMx} . Then use the bottom scantlings below waterline and lower scantling in the upper parts (playing, for example, on skin thickness), ensuring that the pressure at any point is not lower than required by [Tables 6](#) or [7](#). This method is explained in A.7.3 of ISO 12215-5:2019.

More developed methods such as FEM (Finite elements methods), as explained in Clause 11 of ISO 12215-5:2019 may also be used to determine the final panel scantlings with variable pressure.

7.2.5 Panels acting as "natural" stiffeners

The analysis is the same as explained in Clause A.5 of ISO 12215-5:2019 where a part of the section corresponds to the inscribed circle with a radius $R \leq 0,4$ times L diagonal, with an inscribed chord $> 0,8 R$. This section can therefore be considered as a "natural" stiffener, the curve(s) or chine(s) acting as "natural" stiffener(s).

[Figure 3 c\)](#) shows a section with two such "natural" stiffeners. [Figure 3 d\)](#) shows a limit case with only one natural stiffener, for relatively narrow section. [Figure 3 e\)](#) shows a "squat" section where the radius is too large to act as a natural stiffener, and the panel shall be calculated as section with chord b_7 and camber c_7 . The large value of camber c allows a small value of the curvature correction factor k_C , defined in ISO 12215-5:2019.

NOTE The hull/deck or hull/wet deck connections are usually considered as natural stiffeners as they fulfil the requirements of this subclause.

7.3 Other topics on panel or stiffener dimensions

For other topics on panel or stiffener assessment, e.g. rectangular grid, non-rectangular panels, natural stiffeners, etc. see ISO 12215-5:2019.

8 Local pressure-adjusting factors

The final local design pressure is adjusted by a set of factors, adjusting the base pressure according to design category, boat type, location, etc. as defined in [Table 5](#):

- The design category factor k_{DC} is the same as in ISO 12215-5:2019, see item 1.
- The dynamic load factor for multihulls k_{DYNM} has the same purpose and logic as in ISO 12215-5:2019 but has been adapted to multihulls, see item 2; it has a direct influence on the bottom pressure of sailing and motor craft, and it has an indirect influence on all pressures as the values of its k_{Lx} for hull and deck are connected to it.
- The longitudinal pressure-adjusting factors k_{LMx} , k_{LDMx} , and k_{LWDx} defined in items 3, 4 and 5, consider the variation of pressure loads due to location in the craft, respectively for hull, deck,

and wet deck. The fore and aft overhangs have the same value as k_L of ISO 12215-5:2019 at their respective end of the waterline but are extended outside of D_{WL} . Figures 4, 5, and 6 show computed values of these factors.

- The transverse and vertical pressure-adjusting factors for wet deck k_{BWD} and k_{ZWD} consider the vertical pressure variation on wet deck or crossbeam bottom. For the effect of k_{ZWD} , see 6.2.
- The deadrise pressure-adjusting factor k_{DR} considers that deadrise reduces the pressure when a planing multihull slams without heeling. k_{DR} applies at any section x and is a function of the bottom deadrise angle β_x , measured according to Figure 1. It lowers the bottom pressure if $\beta_x > 30^\circ$ and is equal to 0,5, its lower limit is for $\beta_x = 60^\circ$; see item 8.
- The superstructure pressure is adjusted from the deck pressure by k_{SUP} , see item 10.
- The pressure in front of deck is adjusted by the front slope factor k_{SX} , see item 11.
- The pressure in the front of wet deck is adjusted by k_{SDX} , probably with a different angle, see item 11.

NOTE 1 The deadrise pressure-adjusting factor is not applied in ISO 12215-5:2019 as monohulls move in a seaway while heeling whereas multihulls are considered to pitch without heeling.

NOTE 2 For clarity, the factors and dimensions that vary with x have an index x .

Table 5 — Values of pressure-adjusting factors

Remark: All dimensions are defined in Table 1.				
1-Design category factor k_{DC}				
Design category as defined in 3.2	A	B	C	D
Values of k_{DC}	1,0	0,8	0,6	0,4
2-Dynamic load factor k_{DYNM} for sailing and motor multihulls in displacement or planing mode				
Definition	Formulas/specifications			
Sailing multihulls	$k_{DYNM} = \frac{2,5 \times L_{WL}^2}{m_{LDC}^{0,66}}$ that shall not be taken <1 nor >2			
Displacement motor multihulls	$k_{DYNM} = 1$			
Planing motor multihulls in planing mode	$k_{DYNM1} = 0,32 \left(\frac{L_{WL}}{10 \times B_C} + 0,084 \right) \times (50 - \beta_{0,4}) \times \frac{V^2 \times B_C^2}{m_{LDC}}$ where B_C is, for catamarans, taken as the sum of the chine beams for both hulls and $\beta_{0,4}$ is the value of β for $x/L_{WL} = 0,4$, not to be taken less than 10° nor more than 30° , or			
k_{DYNM} shall be taken as: ^a — $k_{DYNM} = k_{DYNM1}$ where $k_{DYNM1} \leq 3$, or — $k_{DYNM} = k_{DYNM2}$, where $k_{DYNM1} > 3$	$k_{DYNM2} = \frac{0,5 \times V}{m_{LDC}^{0,17}}$ where $k_{DYNM1} \geq 3$ but not to be taken > 6			
^a The value of k_{DYNM} is considered to not be higher than 6: when running in rough sea, the crew usually limits the speed to keep the slamming accelerations within acceptable comfort and safety limits. This limit of 6 may be surpassed for "heavy duty" workboats, see Annex J of ISO 12215-5:2019.				

Table 5 (continued)

3-Longitudinal pressure distribution factor for side/bottom k_{LMx}, see Figure 4	
General formula for k_{LMx}	$k_{LMx} = (1,667 - 0,222 \times k_{DYNM}) \times \frac{x}{L_{WL}} + 0,133 \times k_{DYNM}$ but not taken >1 , where $\frac{x}{L_{WL}}$ shall be taken <0 for aft overhangs and >1 for front overhangs, even if k_{LMx} is ≤ 1
For sailing and displacement motor multihulls	Use formula above with $k_{DYNM} = 3$ ($k_{LMx} = 0,4$ for $x/L_{WL} = 0$)
For planing multihulls in planing mode	Use formula above with $3 \leq k_{DYNM} < 6$ according to k_{DYNM} calculation
4-Longitudinal pressure distribution factor for deck k_{LDMx}, see Figure 5	
Motor craft	k_{LDMx} same as k_{LM} for displacement craft using $k_{DYNM} = 3$
Sailing craft	For $\frac{x}{L_{WL}} < 0,6$; $k_{LDMx} = 0,4 + \frac{x}{L_{WL}}$ For $\frac{x}{L_{WL}} \geq 0,6$; $k_{LDMx} = 1 + 2,5 \times (k_{DYNM} - 1) \times \left(\frac{x}{L_{WL}} - 0,6 \right)$ where $\frac{x}{L_{WL}}$ taken <0 for aft overhangs and >1 for front overhangs, see Figure 5.
5-Longitudinal pressure distribution factor for wet deck/crossbeams k_{LWDx}, see Figure 6	
Value of k_{LWDx}	$k_{LWDx} = 0,416 \frac{x}{L_{WL}} + 0,5$ for $\frac{x}{L_{WL}} < 0,6$ and $k_{LWDx} = 1,25 \frac{x}{L_{WL}}$ for $\frac{x}{L_{WL}} \geq 0,6$ with k_{LWDx} not to be taken $>1,25$
6-Transverse pressure distribution factor for wet deck and crossbeams k_{BWD}	
$k_{BWD} = 1,3 B_{BH} / L_{WL} + 0,39$ where, B_{BH} is defined in Table 4 and Figure 2.	
7-Vertical pressure distribution factor for wet deck and crossbeams k_{ZWDx}, see Figure 7	
For k_{ZWD} , use the formulas or Figure 7 with interpolation between values	where $\frac{z_{WDAx}}{z_{WDTx}} \geq 1$ $k_{ZWDx} = \max \left[\left(\frac{z_{WDTx}}{z_{WDAx}} \right)^{0,8} ; 0,5 \right]$ and where $\frac{z_{WDAx}}{z_{WDTx}} < 1$ $k_{ZWDx} = \min \left[\left(\frac{z_{WDTx}}{z_{WDAx}} \right)^{1,5} ; 2 \right]$
where z_{WDAx} and z_{WDTx} are respectively the actual and theoretical wet deck height defined in Table 3 and Figure 2	

Table 5 (continued)

8-Deadrise pressure reduction factor k_{DRx} , see Figure 1		
$k_{DRx} = \frac{90 - \beta_x}{60}$ with $0,5 < k_{DRx} \leq 1$, i.e. $30 < \beta_x \leq 60$ where β_x is defined in Figure 1 as the transverse deadrise angle at section x.		
CAUTION — k_{DRx} Only applies for bottom of planing multihulls.		
9-Pressure reduction factor due to area k_{AR}		
General formula for k_{AR}	$k_{AR} = \frac{k_R \times 0,1 \times m_{LDC}^{0,15}}{A_D^{0,3}}$ not to be taken < 0 nor > 1 CAUTION — k_{AR} is different for plating and stiffeners.	
Values of k_R		
For bottom side and deck plating and stiffeners of planing motor craft in planing mode	$k_R = 1$	
For bottom side and deck plating of sailing craft, displacement motor craft and planing motor craft in displacement mode	$k_R = 1,5 - 3 \times 10^{-4} \times b$	
For bottom side and deck stiffeners of sailing craft, displacement motor craft and planing motor craft operating in displacement mode	$k_R = 1 - 2 \times 10^{-4} \times l_u$	
Values of design area A_D (m ²)		
For plating	$A_D = (l \times b) \times 10^{-6}$ not to be taken $> 4b^2 \times 10^{-6}$	
For stiffeners	$A_D = (l_u \times s) \times 10^{-6}$ but need not be taken $< 0,33 l_u^2 \times 10^{-6}$	
Where b and l (mm) are respectively the small and large dimensions of a panel, and s and l_u (mm) are respectively the stiffener spacing and unsupported length, see ISO 12215-5:2019.		
NOTE This document considers that the local pressure diminishes when the area of a panel increases, as the panel is subject to an average of high slamming loads on small areas and lower sea loads on larger areas. This approach is based on usual practice which is not valid for panels with a large aspect ratio, i.e. $l/b > 4$. In case of large aspect ratio, the pressure and scantlings can be smaller than acceptable in terms of safety, particularly for planing craft, unless A_D is taken = $4 b^2 \times 10^{-6}$.		
10-Superstructure, cockpit and deckhouses pressure reduction factor k_{SUPx}		
Position of panel	Value of k_{SUPx} motor and sail	
	Walking area	Non-walking area
Front of superstructures	$\max \left(1 - \frac{0,3 H_{SUPx}}{\cos \alpha_{LSx} \times Z_{SDTMx}}; 0,67 \right)$	$\max \left(1 - \frac{0,3 H_{SUPx}}{\cos \alpha_{LSx} \times Z_{SDTMx}}; 0,5 \right)$
Side of superstructures	$\max \left(1 - \frac{0,4 H_{SUPx}}{\cos \alpha_{TSx} \times Z_{SDTMx}}; 0,67 \right)$	$\max \left(1 - \frac{0,4 H_{SUPx}}{\cos \alpha_{TSx} \times Z_{SDTMx}}; 0,5 \right)$
Side of "open" cockpit	0,67	0,5
Side of "closed" cockpit	Use k_{SUPx} 0,67 or 0,5 as above and check that the cockpit pressure is $\geq 10 \times 2/3 \times h_{SIDE}$,	
Top of superstructures, including upper tiers	$\max \left(1 - \frac{0,5 H_{SUPx}}{0,067 L_{WL}}; 0,50 \right)$	$\max \left(1 - \frac{0,5 H_{SUPx}}{0,067 L_{WL}}; 0,35 \right)$
Non-protected aft side of superstructures, including upper tiers ^b	Not relevant - see ^b	$\max \left(1 - \frac{0,6 H_{SUPx}}{0,067 L_{WL}}; 0,35 \right)$
Protected ^a aft side of superstructures, including upper tiers ^b	Not relevant - see ^b	$\max \left(1 - \frac{0,7 H_{SUPx}}{0,067 L_{WL}}; 0,35 \right)$

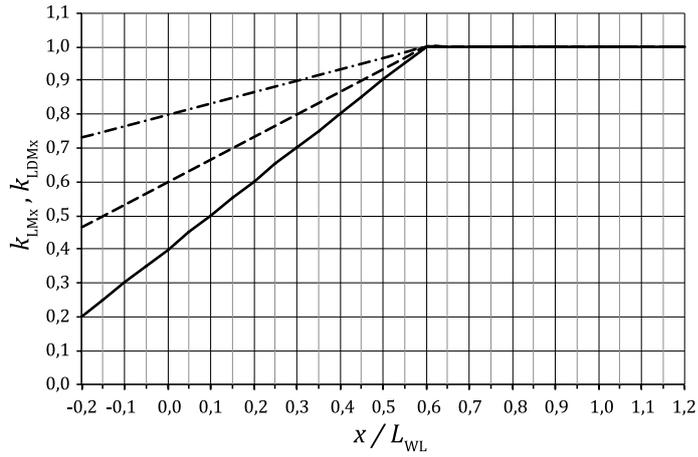
Table 5 (continued)

<p>where</p> <p>H_{SUPx} (m) is the height of mid panel above the lesser of actual side /deck limit Z_{SDAMx} or theoretical value Z_{SDTMx} (see Table 3);</p> <p>h_{SIDEx} (m) is the height of the middle of cockpit side panel below overflow level, see Figure 6 a) of ISO 12215-5:2019.</p> <p>Angles α_L and α_T are respectively the longitudinal and transverse angles of the faces (or their tangent when curved) against vertical (see Figure 1).</p> <p>a Protected means "protected from full force of waves" by permanent top, awning, etc. whose vertical projection extends at least outside the bottom of the panel, and $\geq 0,04 L_H$ outside the top of the panel., see Figure 1.</p> <p>b Panel on non-walking areas.</p>	
<p>11-Slope factor k_{Sx} for deck and wet deck/crossbeam, see Figures 2 a), 8 and sketch below</p>	
<p>$k_{SDx} = \min [1/\cos (\alpha_{LDx}); 1,5]$ for $\alpha_{Lx} > 0$ or < 0 for deck/crossbeam top,</p> <p>$k_{SWDx} = \min [1/\cos (\alpha_{LWDx}); 1,5]$ for $\alpha_{Lx} > 0$ or < 0 for wet deck or crossbeam bottom.</p> <p>where α_{Lx} is either α_{LDx} for deck/crossbeam top or α_{LWDx} for wet deck/crossbeam bottom, the local longitudinal angle measured from the horizontal, see sketch below.</p> <p>This coefficient applies to any longitudinal angle in the deck/wet deck and increases the deck or wet deck pressure where different from horizontal, whether upwards or downwards.</p> <p>For simplicity k_{SDx} or k_{SWDx} shall not be measured/applied where $\alpha_{Lx} < 10^\circ$ and k_{Sx} reaches its upper limit at 40°.</p> <p>Where the local bottom is a curve the angle shall be the one of the chord between two adjacent horizontal stiffeners against horizontal, see figures below.</p> <p>For front of superstructure see k_{SUPx} in item 10 of Table 5 for angle α_{LS}.</p>	
	<p>Key</p> <p>1 front of wet deck angle α_{LWDx}</p> <p>2 front of deck angle α_{LDx}</p> <p>3 top of deck angle $\alpha_{LDx} \approx 0$</p> <p>4 front of superstructure angle α_{LSx}</p> <p>5 top of superstructure angle $\alpha_{LSx} \approx 0$</p>

NOTE 3 The concept of limiting k_{DYNM} (i.e. the vertical acceleration due to craft speed in moderate sea state) recognizes that on motor craft running in rough sea, the helmsman usually limits the speed to keep the slamming accelerations within acceptable comfort and safety limits for the crew. See 15.5.

NOTE 4 Figures 3 and 4 only represented 3 sets of values of k_{DYNM} . For other values k_{LMx} or k_{LDMx} are determined either by calculation, according to the respective formulas of items 3 or 4 of Table 5, or by interpolation in Figures 3 or 4.

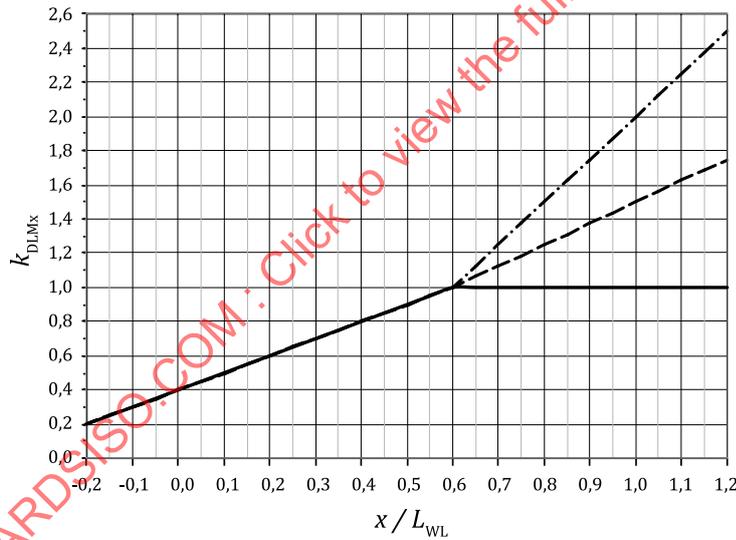
NOTE 5 Like for monohulls, k_{DYNM} has an influence on the longitudinal distribution one bottom/side pressure for fast motor craft that can jump on a wave and land in any position, increasing thus the aft pressure. Sailing craft with a high value of k_{DYNM} , also has a "dynamic" behaviour and can dig the front deck and stem into the water explaining the increased value of k_{LDMx} in that case.



Key

- $k_{DYNM} = 6$
- $k_{DYNM} = 4,5$
- $k_{DYNM} = 3$

Figure 4 — Value of k_{LDMx} for bottom/side of all multihulls and k_{LDMx} for deck of motor multihulls according to k_{DYNM} and as a function of x/L_{WL}



Key

- $k_{DYNM} = 2$
- $k_{DYNM} = 1,5$
- $k_{DYNM} = 1$

Figure 5 — Value of k_{LDMx} for deck of sailing multihulls according to k_{DYNM} as a function of x/L_{WL}

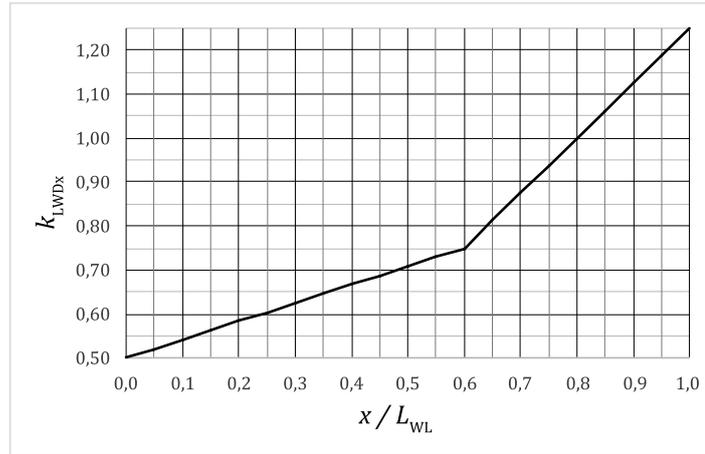


Figure 6 — Value of k_{LWDx} as a function of x/L_{WL}

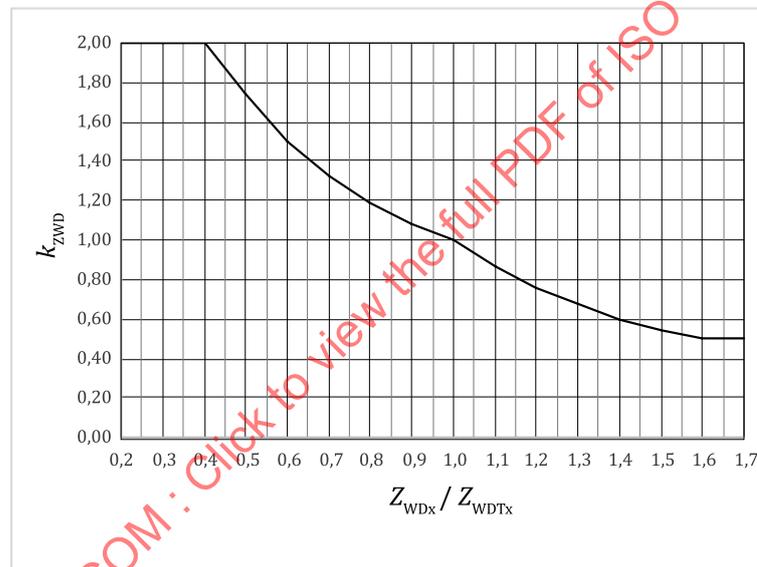


Figure 7 — Value of k_{ZWD} as a function of Z_{WD}/Z_{WDT}

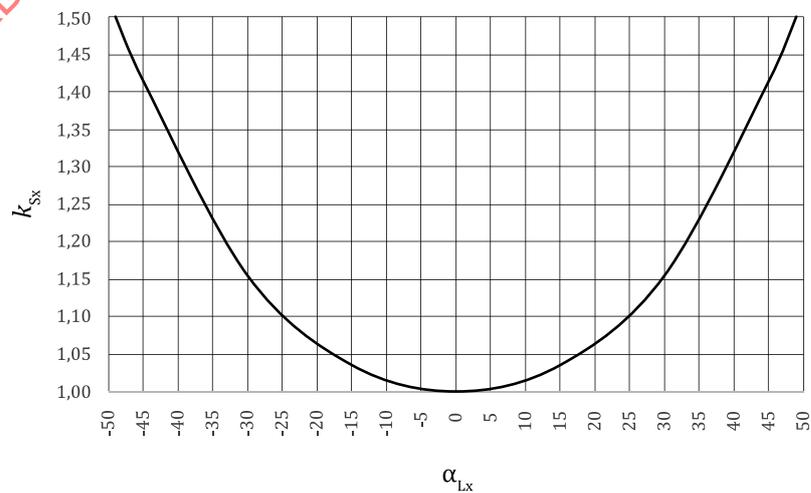


Figure 8 — Value of k_{Sx} as a function of α_{Lx}

9 Local design pressures

9.1 General

For sailing and displacement multihulls, the bottom/side/transom design pressures for catamaran hull and trimaran main hull and floats are linearly interpolated, using k_{ZMU0x} , or k_{ZMUIx} , factors, with height between the pressure at local deepest point Z_{Tx} of the canoe body and the deck pressure at theoretical hull/deck limit Z_{SDTMx} . Like for T_c , the deepest point T_x excludes appendages. Where there is an appendage (skeg, keel) the measurement of bottom of T_x shall be measured as the prolongation of the hull sides (least tangent as in ISO 8666.)

For planing multihulls in planing mode, the bottom pressure for catamaran hull and trimaran main hull and floats is constant up to chine Z_c or D_{WL} , whichever the lower. Above that limit the side pressure is interpolated between 40 % of the bottom pressure and deck pressure at theoretical hull/deck limit Z_{SDTMx} .

In a given transverse section the deck pressure is a function of k_{LMx} , k_{LDMx} , k_{ZDMx} and k_{DSx} , whereas the bottom/side is multiplied by k_{LMx} . This document calculates separately P_{BMUx} , P_{WDX} , P_{DMUx} and then interpolates the final inner or outer bottom/side pressure P_{HMU0x} or P_{HMUIx} using k_{ZMOx} and k_{ZMUIx} .

The connection/fairing of wet deck/crossbeams with the hull sides is subject to wet deck/crossbeams pressure.

9.2 Limits of areas

The deck/cockpit bottom pressure is mostly due to waves, green water or people mass and applies to the lowest horizontal areas exposed to weather, which is above the upper limit line between side pressure and deck pressure located at theoretical side/deck limit Z_{SDTMx} , defined in [Table 3](#). Where the actual side/deck limit Z_{SDAMx} is above this limit, the side pressure applies, adversely where $Z_{SDAMx} < Z_{SDTMx}$, the deck pressure is increased, see [Tables 7](#) to [9](#). For cockpit bottom, Z_{Qx} need not be taken less than Z_{SDAMx} at the same section.

Superstructure, deckhouse and cockpit side pressures apply for other areas than deck, their pressure correspond to the adjacent deck pressure multiplied by k_{SUP} , or minimal pressure according to item 10 of [Table 5](#).

9.3 Tables defining the local design pressures for multihulls

All local design pressures are expressed in kN/m^2 .

[Table 6](#) defines the bottom/side and wet deck pressure of

- sailing catamaran hulls and central hulls of sailing trimarans, or
- motor catamarans and central hulls of motor trimarans in displacement mode.

[Table 6](#) also applies to planing motor catamarans and central hull of trimarans when sailing in category A and B conditions, as the helmsman needs to slow down to progress in the seaway in displacement mode without excessive shocks.

[Table 7](#) defines the bottom/side and wet deck pressure of motor catamarans and central hulls of motor trimarans in planing mode.

The bottom and side pressure of planing multihulls of design categories A and B shall be taken as the greater of the ones for planing and displacement mode. This applies to hull(s) and, where relevant, floats of trimarans.

[Table 8](#) defines the bottom/side pressure of trimaran floats, sail or motor.

Once the pressures are defined according to [Tables 6 to 8](#), the average or interpolated pressure on a panel or stiffener shall be calculated according to [Clause 7](#), and the local scantlings assessed according to [Clause 10](#).

Table 6 — Design pressures for sailing and motor displacement catamarans and for central hulls of trimarans (kN/m²)

Sailing and motor displacement catamarans and central hulls of trimarans	
Pressures with index x are calculated at section x, pressures without index are base pressures or general minimum pressure, which are independent of the position in the craft.	
1-Base pressure for bottom/side, deck and cockpits	
Design pressure at lowest point of section x of bottom/side or transom P_{BMUx}	$P_{BMUx} = \max (P_{BMU\text{ BASE}} \times k_{AR} \times k_{DC} \times k_{LMx}; P_{BMUx;MIN})$ with $P_{BMU\text{ BASE}} = (2 m_{LDC}^{0,33} + 18) \times k_{DYNM}$, and $P_{BMUx\text{ MIN PLT}} = \max [(0,3 m_{LDC}^{0,33} + 0,66 L_{WL} \times k_{DC}) \times k_{LMx}; 10T_C; 7]$ for plating $P_{BMUx\text{ MIN STF}} = \max (0,85 P_{BMUx\text{ MIN PLT}}; 5)$ for stiffeners
Design pressures for wet deck/crossbeams bottom P_{WDx}	$P_{WDx} = \max (P_{BMU\text{ BASE}} \times k_{AR} \times k_{DC} \times k_{LWDx} \times k_{ZWD} \times k_{BWD} \times k_{SWDx}; P_{WDx;MIN})$ where $P_{WDx\text{ MIN PLT}} = \max [(0,3 m_{LDC}^{0,33} + 0,66 L_{WL} \times k_{DC}) \times k_{LMx}; 7]$ for plating, and $P_{WDx\text{ MIN PLT}} = \max [(0,85 P_{WDx\text{ MIN PLT}}; 5)]$ for stiffeners
Base and design pressures for deck and cockpit bottom P_{DMUx}	$P_{DMUx} = \max [(P_{BMU\text{ BASE}} \times k_{LMx} - (P_{BMU\text{ BASE}} \times k_{LMx} - P_{DMU\text{ BASE}} \times k_{LDMx}) \times k_{ZDMx}] \times k_{AR} \times k_{DC} \times k_{SDx}; P_{DMU\text{ MIN}}$ with $P_{DMU\text{ BASE}} = (0,375 m_{LDC}^{0,33} + 9)$ and $k_{ZDMx} = \min [(Z_{Qx} - Z_{Tx}) / (Z_{SDTMx} - Z_{Tx}); 1]$ and; $P_{DMU\text{ MIN}} = 5$ for walking areas, and 3,5 for non-walking areas for plating and stiffeners For cockpit bottom, Z_{Qx} need not be taken less than Z_{SDAMx} at same section
CAUTION — In the following calculations of P_{BMUox} or P_{BMUIx} for a panel/stiffener, the calculations of P_{BMUx} and P_{DMUx} shall be made with the k_{AR} value of this panel/stiffener and not the ones of the actual deck or bottom panels.	
2-Outer and inner design pressure clear of wet deck at a point Q_x of section x and $Z = Z_Q$	
Interpolated between pressure at bottom of local canoe body T_x and deck pressure at Z_{SDTMx}	
Design pressure for outer and inner side/transom Clear of wet deck or cross-beam P_{HMUox}	$P_{HMUox} = [P_{BMUx} - (P_{BMUx} - P_{DMUx}) \times k_{ZMOx}]$ with $k_{ZMOx} = \min [(Z_{Qx} - Z_{Tx}) / (Z_{SDTMx} - Z_{Tx}); 1]$ and where _{MIN} values apply, where relevant, for P_{BMUx} or P_{DMUx}
3-Inner design pressure in way of wet deck at a point Q_x of section x and $Z = Z_Q$	
Interpolated between pressure at bottom of local canoe body T_x and wet deck pressure	
Design pressure for inner bottom/side/transom In way of wet deck or cross-beam P_{HMUIx}	$P_{HMUIx} = [P_{BMUx} - (P_{BMUx} - P_{WDx}) \times k_{ZMIx}]$ with $k_{ZMIx} = \min [(Z_{Qx} - Z_{Tx}) / (Z_{WDAX} - Z_{Tx}); 1]$ and where _{MIN} values apply, where relevant, for P_{BMUx} or P_{WDx} Valid up to beginning of connection/fairing with wet deck; P_{WDx} applies above.
4-Superstructure and cockpit side design pressure	
Superstructures and cockpit side design pressure P_{SUPMx}	$P_{SUPMx} = \max ([P_{DMUx\text{ BASE}} \times k_{AR} \times k_{DC} \times k_{LDMx} \times k_{SUP}; P_{SUP\text{ MIN}}])$ where ; k_{SUP} is defined in item 10 of Table 5 , and; $P_{SUP\text{ MIN}} = 5$ for walking areas and 3,5 for non-walking areas, for plating and stiffeners
See Figures 1 and 2 and Table 4 for the definitions of Z_{ix} i.e. Z_{Qx} , Z_{SDTMx} , Z_{SDAMx} , Z_{Tx} , Z_{WDTx} , Z_{WDAX} . Z_{Qx} is the height of point Q at mid-panel or stiffener above waterline or chine, see Figure 2 . Z_{Cx} is the height of the chine above waterline, and Z_{SDTMx} and Z_{SDAMx} are respectively the height of actual and theoretical hull deck limit above waterline (see Figure 2 and Table 4), all values considered at distance x from aft of L_{WL} .	

Table 7 — Design pressures for planing catamarans and central hulls of trimarans in planing mode (kN/m²)

Planing motor catamarans and central hulls of trimarans in planing mode	
CAUTION — For planing multihulls in design categories A and B, the design pressure for side, bottom, wet deck and deck shall be taken as the greater of planing (this table) or displacement (Table 6) as in these conditions the craft needs to progress in the seaway in displacement mode.	
Pressures with index x are calculated at section x, pressures without index are base pressures or general minimum pressure, which are independent of the position in the craft.	
1-Base and design pressure for bottom, wet deck/crossbeams and deck of planing multihulls in planing mode	
Bottom planing design pressure at section x P_{BMUPx} Applies up to Z_{Cx}	$P_{BMUPx} = \max (P_{BMUP\ BASE} \times k_{AR} \times k_{LMx} \times k_{DR}; P_{BMUx\ MIN})$ with $P_{BMUP\ BASE} = \frac{0,1 m_{LDC}}{L_{WL} \times B_C} \times \left(1 + k_{DC}^{0,5} \times k_{DYNM} \right)^a$ $P_{BMUx\ MIN\ PLT} = \max [(0,3 m_{LDC}^{0,33} + 0,66 L_{WL} \times k_{DC}) \times k_{LMx}; 10F_C; 7]$ for plating $P_{BMUx\ MIN\ STF} = \max (0,85 P_{BMUx\ MIN\ PLT}; 5)$ for stiffeners
Base and design pressures for wet deck/crossbeams bottom P_{WDx}	$P_{WDx} = \max (P_{BMU\ BASE} \times k_{AR} \times k_{DC} \times k_{LWDx} \times k_{ZWDx} \times k_{BWD} \times k_{SWDx}; P_{WDx\ MIN})$ where $P_{WDx\ MIN\ PLT} = \max [(0,3 m_{LDC}^{0,33} + 0,66 L_{WL} \times k_{DC}) \times k_{LMx}; 7]$ for plating, and $P_{WDx\ MIN\ STF} = \max [(0,85 P_{WDx\ MIN\ PLT}; 5)]$ for stiffeners
Base and design pressures for deck and cockpit bottom P_{DMUx}	$P_{DMUx} = \max [(P_{BMU\ BASE} \times k_{LMx} - (P_{BMU\ BASE} \times k_{LMx} - P_{DMU\ BASE} \times k_{LDMx}) \times k_{ZDMx}] \times k_{AR} \times k_{DC} \times k_{SDx}; P_{DMU\ MIN})$ with $P_{DMU\ BASE} = (0,375 m_{LDC}^{0,33} + 9)$ and $k_{ZDMx} = \min [(Z_{Qx} - Z_{Tx}) / (Z_{SDTMx} - Z_{Tx}); 1]$ and; $P_{DMU\ MIN} = 5$ for walking areas, and 3,5 for non-walking areas for plating and stiffeners For cockpit bottom, Z_{Qx} need not be taken less than Z_{SDAMx} at same section
For planing multihulls P bottom is constant up to chine or D_{WL} , whichever is the lower.	
CAUTION — In the following calculations of P_{BMUOx} or P_{BMUIx} for a panel/stiffener, the calculations of P_{BMUx} and P_{DMUx} shall be made with the k_{AR} value of this panel/stiffener and not the ones of the actual deck or bottom panels.	
2-Outer and inner side/bottom clear of wet deck/crossbeam at a point Q_x of section x interpolated between 0,4 bottom planing pressure at chine height Z_{Cx} and deck pressure at Z_{SDTMx}	
Design pressure for outer and inner bottom/side/transom Clear of wet deck or crossbeam P_{HMUOP}	$P_{HMUOPx} = [0,4 P_{BMUPx} - (0,4 P_{BMUPx} - P_{DMUx}) \times k_{ZPMOx}]$ with $k_{ZPMOx} = \min [(Z_{Qx} - Z_{Cx}) / (Z_{SDTMx} - Z_{Cx}); 1]$ and where $_{MIN}$ values apply, where relevant, for P_{BMUPx} or P_{DMUx} where Z_{Cx} is the local chine height defined in Figures 1 and 2 and Table 4
3-Inner side/bottom design pressure in way of wet deck crossbeam at a point Q_x of section x and $Z = Z_Q$	
Design pressure for inner bottom/side/transom In way of wet deck or crossbeam P_{HMUIPx}	$P_{HMUIPx} = [0,4 P_{BMUPx} - (0,4 P_{BMUPx} - P_{DMUx}) \times k_{ZPMIx}]$ with $k_{ZPMIx} = \min [(Z_{Qx} - Z_{Cx}) / (Z_{WDTx} - Z_{Cx}); 1]$ and where $_{MIN}$ values apply, where relevant, for P_{BMUPx} or P_{DMUx} where Z_{Cx} is the local chine height defined in Figures 1 and 2 and Table 4 Valid up to beginning of connection/fairing with wet deck; P_{WDx} applies above.
4-Superstructure and cockpit side design pressure	
Design pressure for superstructures and cockpit side P_{SUPMx}	$P_{SUPMx} = \max (P_{DMU\ BASE} \times k_{AR} \times k_{DC} \times k_{LDMx} \times k_{SUP}; P_{SUPMx\ MIN})$ with $P_{SUPM\ MIN} = 5$ for walking areas and 3,5 for non-walking areas for plating and stiffeners

Table 7 (continued)

See Figures 1 and 2 and Table 4 for the definitions of Z_{ix} i.e. Z_{Qx} ; Z_{STDMx} ; Z_{Tx} ; Z_{WDx} .
Z_{Qx} is the height of point Q at mid-panel or stiffener above waterline (W_L or chine see Figure 2), Z_{Cx} is the height of the chine above waterline, and Z_{SDTMx} and Z_{SDAMx} are respectively the height of actual and theoretical hull deck limit above waterline (see Table 4 and Figure 2), all values considered at distance x from aft of L_{WL} .
^a For the purpose of this formula, $B_C = B_{C1} + B_{C2}$ for catamarans and $B_C = B_{CCH} + 0,5B_{FL}$ for trimarans (B_C of centre hull + $\frac{1}{2}$ beam of one float) even if this may differ from ISO 8666.

9.4 Design pressure for trimaran floats P_{TRFx}

9.4.1 Pressure reduction factors

- The pressure reduction factors k_{LMTx} and k_{DLMxT} for trimaran floats shall be determined respectively like k_{LMx} and k_{DLMx} but replacing x/L_{WL} of hull by x/L_{FLOAT} , where L_{FLOAT} is the length of the float, see [Figure 9c](#)) and d).
- The pressure assessment explained in [6.1.3](#), [Table 4](#) and [Figures 3](#) d), e) and f) shall be performed depending whether Point 17 of these figures is above or below Z_{SDTMx} when the float is immersed according to item 3 of [Table 4](#).

9.4.2 Pressure

The design pressures for trimaran floats are defined in [Table 8](#).

Table 8 — Design pressures for trimaran floats (kN/m²)

Trimaran floats Displacement/planing bottom/side/transom base and design pressures	Sail and displacement craft
	Same pressure P_{HMUPx} for sides and P_{WDx} for wet deck/crossbeams bottom as for sail/motor displacement catamarans, but with Z_{WDTx} , Z_{WDAx} , Z_{SDTx} , Z_{SDATx} , as defined in Table 4 and Figure 2 d) to f), i.e. where the wet deck/crossbeams intersect or not the float sides
	Planing craft in planing mode
	Same pressure P_{HMUPx} for bottom, P_{HMUPx} for sides and P_{WDx} wet deck/crossbeams bottom as for planing catamaran in planing mode, but with Z_{Cx} , Z_{WDTx} , Z_{WDAx} , Z_{SDTx} , Z_{SDATx} , as defined in Table 4 and Figure 2 c) to f), i.e. where the wet deck/crossbeams intersect or not the float sides
CAUTION — As the hull/float pressure increases in way of wet deck/crossbeams areas, the scantlings shall vary progressively longitudinally forward or aft the wet deck/crossbeam limit.	
For all other data and calculations, Tables 6 or 7 apply, where relevant.	

9.5 Design pressure on watertight bulkheads and integral tanks

The design pressure on watertight bulkheads and integral tanks is according to ISO 12215-5:2019.

10 Further treatment of structural elements subject to local loads

Once the local pressures are defined, ISO 12215-5:2019 shall be used to check the structural elements subject to local loads, i.e. plating, stiffeners, etc. This includes the modification of b , A_D , k_{AR} and pressures for hard chined sections using Annex A of ISO 12215-5:2019.

The design stresses and design analysis of structural elements subject to local loads are those of ISO 12215-5:2019; optional recommended minimum single skin or sandwich thickness are those of Annex I of ISO 12215-5:2019.

The design stresses and design analysis of rudders and appendages are specified in [Clause 11](#), those of rig elements and their connection to the structure are specified in ISO 12215-10.

Where the global loads defined in this document increase the stresses in structural elements subject to local loads, these stresses shall be combined and still comply with design local stresses defined in ISO 12215-5:2019.

11 Assessment of multihulls rudders, appendages and their wells

The loads on rudders, centreboards and non-ballasted appendages shall be assessed according to ISO 12215-8 with the modifications defined in [Table 9](#).

Table 9 — Rudder and appendages loads and their wells

1-Rudder load on sailing multihulls
ISO 12215-8 shall be applied, except that the rudder force shall be modified as follows: $F_{1MS} = 23 \times L_{WL} \times k_{SEA} \times k_{LD}^2 \times k_{GAP} \times k_{USE} \times A$, with k_{LD} modified as follows: $k_{LD} = L_{WL} / \left(\frac{m_{MO}}{1025} \right)^{1/3}$ NOTE m_{MO} is used instead of m_{LDC} , because in minimum operating condition, the speed of multihulls is larger than on monohulls and is the criterion for rudder scantlings.
2-Rudder load on motor multihulls
ISO 12215-8 shall be applied.
3-Non-ballasted appendage loads on sailing multihulls
ISO 12215-9 shall be applied except that, if the speed is not known, it shall be taken as $V = 3,2 \times L_{WL}^{0,5} \left(\frac{k_{LD}}{6,15} \right)$ with k_{LD} as modified above. This also applies to foils.
4-Centreboards or foil wells
The design pressure below D_{WL} of centreboard wells shall be at least $10 T_C$. For sliding/daggerboard type centreboards or foils it is a good practice to reinforce the aft bottom of well/hull to avoid damage in case of longitudinal shock on the appendage, e.g. floor, extra laminate, UD belt, crash box, etc.

12 Multihull global loads

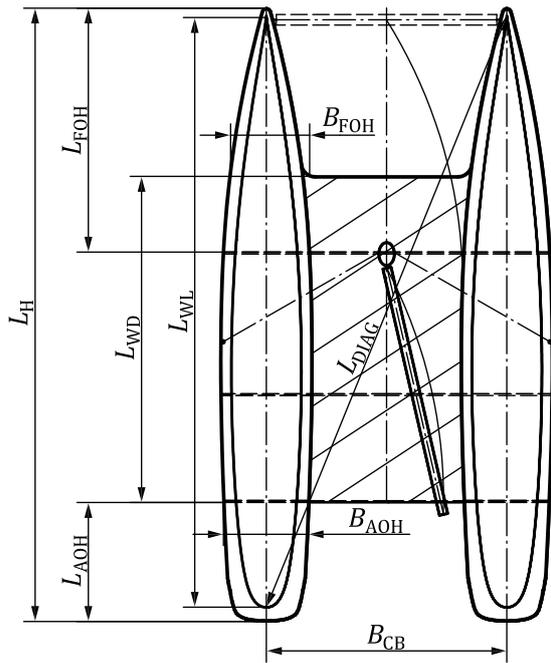
12.1 General

The ISO 12215 series has been developed with the idea to keep structural analysis and scantlings assessments as simple as possible, considering that, for small craft, the loads to be assessed are mainly local loads. However, the assessment of a multihull needs a structural analysis of global loads.

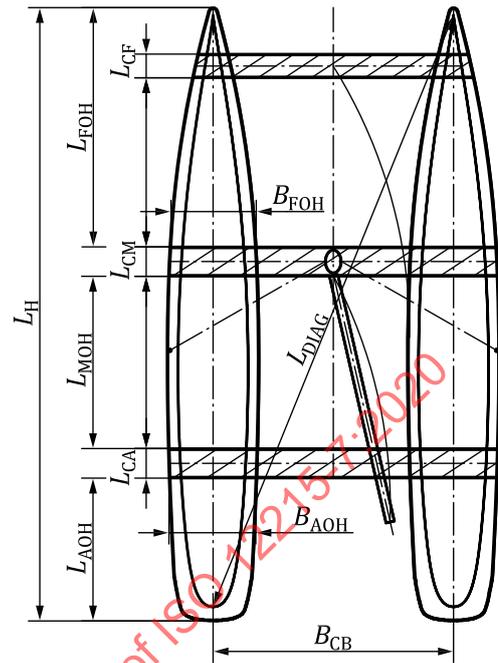
NOTE The application of global loads depends from the craft's program(s) and structural arrangement.

12.2 Typical structural arrangements

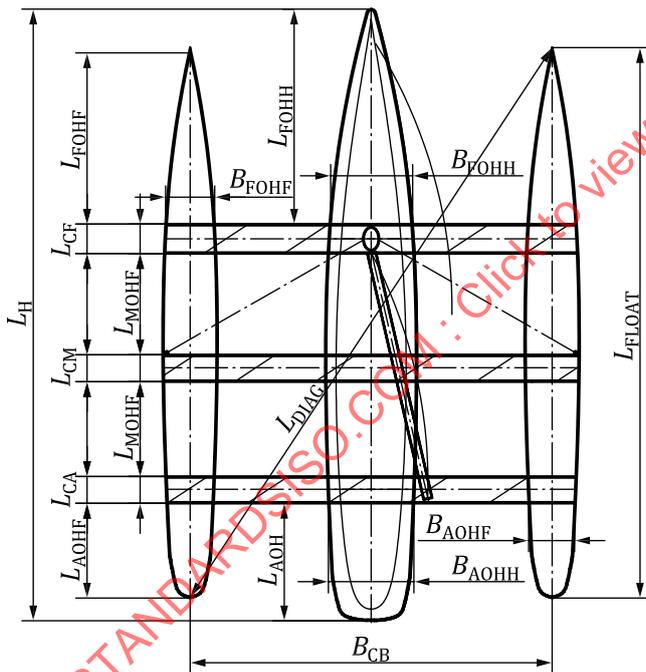
The "typical" structural arrangements as defined by this subclause only apply to recreational craft, charter vessels and light duty workboats are represented in [Figure 9](#). The global loads to be assessed depend on the multihull type, i.e. sail or motor, and on its structural arrangements, i.e. wet deck plus crossbeams, or independent crossbeams.



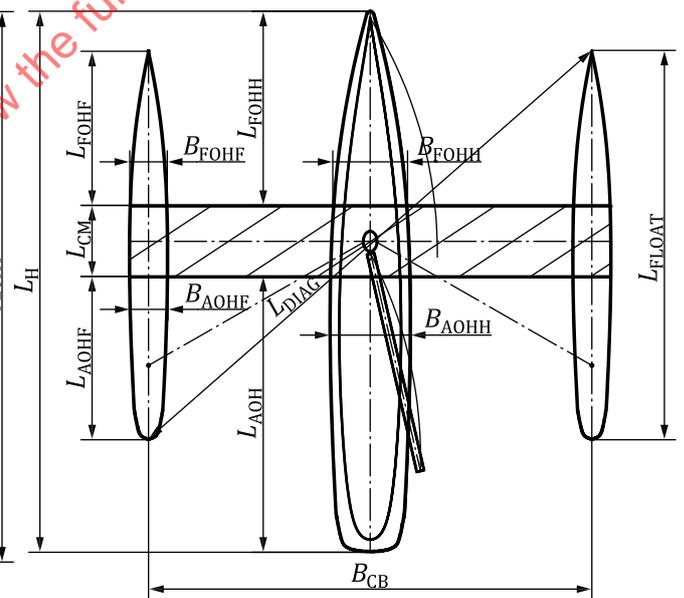
a) Catamaran with wet deck and crossbeams



b) Catamaran with 2 or more crossbeams



c) Trimaran with 2 or more crossbeams



d) Trimaran with only one crossbeam

Figure 9 — Typical multihulls structural arrangements for global loads

NOTE In Figure 9, sailing multihulls are represented with rig but the same arrangements without rig are valid for motor multihulls. See Tables 1, 10 and 11 for explanations of the dimensions.

12.3 Global load assessment

12.3.1 General

This document requires to assess global loads with one of the following methods:

- the simplified method defined in [12.3.2](#), to be considered as a basic assessment approach for “typical” structures arrangements as defined in [12.2](#);
- the enhanced method defined in [12.3.3](#) which provides a more accurate analysis and results, and which is applicable to any structural arrangement, typical or non-typical.

12.3.2 The simplified method

The simplified method consists in applying the relevant global load cases listed in [Table 10](#);

- used as specified in [Table 11](#);
- with resulting stresses complying with [Table 12](#).

For this purpose, an analytical method, a FEM method, or a mixing of both shall be used.

[Table 11](#) gives the global load cases to be checked, considering that very wide structural elements for lateral loads and bending moments or very high elements for vertical loads and bending moments are strong enough and do not need to be checked.

12.3.2.1 Global loads for the simplified method

[Table 10](#) lists the main individual global loads that are considered in this document. Other global loads can also be significant, e.g. foils, appendages, connected structural elements, etc. and shall be considered with an appropriate method.

Table 10 — Main individual global loads to be checked, where relevant

Global load case (GLC)	Definition	Craft type	Defined in
GLC 1	Diagonal loads GLC 1 in quartering sea	Sail and motor	12.5
GLC 2	Rig load GLC 2	Sail	12.6
GLC 3	Asymmetric broaching loads GCL 3	Sail	12.8
GLC 4	Longitudinal broaching/Pitchpoling GLC 4	Sail and motor	12.9
GLC 5	Longitudinal force/shock on one hull GLC 5	Sail and motor	12.10
GLC 6	Bending on crossbeams of motor multihulls GLC 6	motor	12.11

[Table 11](#) provides the method to be used to check the global load cases of [Table 10](#) with the simplified method, individually or combined according to boat type and dimensions of structural elements.

NOTE This analysis only deals with strength issues, and the analysis of deflexion, stress concentration in the long term are better analysed with the enhanced method.

Table 11 — Conditions where loads are considered to need assessment

Structural arrangement of Figure 9	GLC 1 Quartering sea	GLC 2 ^d Rig loads	GLC 3 ^{a,d} Asymmetric broaching	GLC 4 ^a Longitudinal broaching	GLC 5 ^b Longitudinal force	GLC 6 Free standing
Figure 9 a)	On motor multihulls no rig loads Quartering sea to be checked in Design categories A and B sail and motor For sailing multihulls, GLC1 and GLC2 combined according to ^c		Hull/floats if $L_{nOH_i} > 4 B_{nOH_i}$	Hull/floats if $L_{nOH_i} > 4 D_{nOH_i}$	Wet deck if $L_{WD} \leq 0,4 L_H^b$	Usually only relevant for motor
Figures 9 b) and c)		Crossbeams hull/floats if $L_{nOH_i} > 4 B_{nOH_i}$	Crossbeams hull/floats if $L_{nOH_i} > 4 D_{nOH_i}$	Crossbeams if $\Sigma L_c \leq 0,4 L_H^b$		
Figure 9 d)		Crossbeams hull/floats if $L_{nOH_i} > 4 B_{nOH_i}$	Crossbeams hull/floats if $L_{nOH_i} > 4 D_{nOH_i}$	Crossbeams if $L_{ic} \leq 0,4 L_H^b$		

^a L_{nOH_i} is the length of overhang or between supports with $n = F(\text{fwd}), A(\text{aft})$ and $M(\text{mid})$ and $i = H(\text{hull})$ of $F(\text{Float})$
 B_{nOH_i} is the beam at overhang root or between supports with $n = F(\text{fwd}), A(\text{aft})$ and $M(\text{mid})$ and $i = H(\text{hull})$ of $F(\text{Float})$
 D_{nOH_i} is the depth at overhang root or between supports with $n = F(\text{fwd}), A(\text{aft})$ and $M(\text{mid})$ and $i = H(\text{hull})$ or $F(\text{Float})$.

^b L_{WD} is the length of the wet deck and L_{Ci} the lengthwise dimension of crossbeam i .

^c Combine 0,5 GLC1 + GLC2 or GLC1 + 0,5 GLC2 whichever the greater.

^d Only for sailing multihulls.

See [Figures 9](#) to [14](#).

NOTE The wish to simplify calculations and the limited bending moments due to small overhangs or distance between supports, and hulls/floats with large beam or depth are the basis for the exemption of checking.

12.3.3 The enhanced method

This method analyses as follows the craft through a modelisation of the loads exerted when moving in a seaway.

a) Sailing multihulls:

- 1) When sailing upwind, the loads from the rig (given by ISO 12215-10 or equivalent) induce longitudinal and transverse forces and moments on the craft, which are balanced by forces and moments from the hulls and appendages. The resulting loads on the structure are similar to load cases GLC 2 to GLC 4 defined in [12.4](#) but adjusted so that the whole system is globally balanced (zero final forces and moments).
- 2) When sailing in waves or swell in a quartering sea, the loads of indent 1) shall be combined with GLC 1.
- 3) When sailing downwind, the loads of indent 1) shall be combined with GLC 5.

NOTE GLC 6 is usually not relevant, as less demanding than GLC 3 or GLC 4.

b) Motor multihulls:

All combinations of GLC 6 with GLC 1 and GLC 3 to GLC5 shall be assessed, or its worst combination.

c) Analysis method:

FEM analysis, using beam elements and/or full modelisation shall be applied.

The stresses shall not be greater than the ones defined in [Table 12](#).

The scale and method of meshing are quite sensible and need experience and specific expertise in the applied method compared to other methods.

12.4 Design stresses under global loads

The stresses (direct, shear, or buckling) deriving from single or combined global loads shall not be greater than the design stress for global loads defined in Table 12. When analysing stiffeners with an analytic method for global loads, such as crossbeams, beams (tubular or not), etc., there is no need to check deflection.

Table 12 — Design stresses for global loads

Material	Tensile/compressive design stress σ_d N/mm ²	Design shear stress τ_d N/mm ²	Design buckling stresses σ_{db}, τ_{db} N/mm ²
FRP	0,5 σ_{ut} and 0,5 σ_{uc} ^a	0,5 τ_u	0,4 $\tau_{buckling}$ 0,5 $\sigma_{buckling}$
Aluminium alloys	0,7 σ_{yw} ^b	0,7 σ_{yw} ^b	
Steel	0,8 σ_y	0,45 σ_y	
Laminated wooden frames	0,45 σ_{uf} ^c	0,45 τ_u	
Solid stock wooden frames	0,4 σ_{uf} ^c	0,4 τ_u	
Plywood on edge frames	0,45 σ_{uf} ^c	0,45 τ_u	
NOTE These design stresses also apply for the attached plating of the stiffener, according to its material, determined according to ISO 12215-5:2019.			
^a σ_c is considered where stressed in compression (usually the stiffener top flange) and σ_t is considered where stressed in tension (usually the plating); both verifications need to be calculated.			
^b For welded stiffeners. If aluminium stiffeners are not welded, i.e. riveted, glued, etc. the non-welded properties shall be used.			
^c σ_{uf} for laminated wooded stiffeners and σ_{uf} for solid stock shall be taken from Table E.1 of ISO 12215-5:2019: For plywood, σ_{uf} shall not be taken from Table E.2 but from Tables E.3 or E.6 of ISO 12215-5:2019.			
NOTE The design stresses are the same as in ISO 12215-5:2019 for stiffeners, and this relatively high value (or low safety factor) is connected to the use, where relevant, of k_{DYNM} in load formulas.			

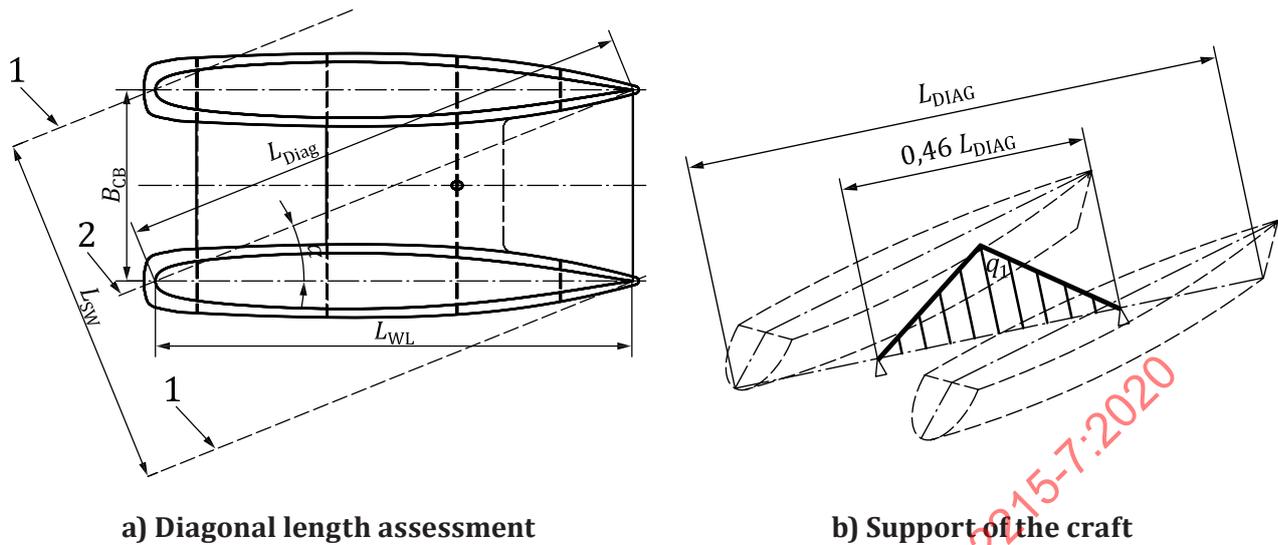
12.5 Global load case GLC1: Diagonal load in quartering sea

The loads considered are those induced when a catamaran is supported by the two adjacent crests of a swell of wave one at the aft of the port hull, the other at the front of the starboard hull. Similar situation for a trimaran, replacing the port hull by the port float. The design torsional moment under quartering waves and parameters are defined in Table 13 and Figure 10.

Table 13 — Global load GLC1 — Design torsional moment in quartering sea (see Figure 10)

Torsional moment M_{TD} around transversal axis	$M_{TD} = k_{DC}^{0,5} \times \frac{m_{LDC}}{1000} \times (9,81 \times k_{DYNM}) \times 0,076 L_{DIAG}$ (kNm) where
Diagonal length for catamarans	$L_{DIAG} = \frac{L_{WL}}{\cos \alpha} = \sqrt{L_{WL}^2 + B_{CB}^2}$ (m) where $\alpha = \text{Atan} \frac{B_{CB}}{L_{WL}}$ (degree)
Diagonal length for trimarans	Diagonal between the aft end of the port float and the fore end of the starboard float, not to be taken $>1,4 L_{WL}$
NOTE 1 The factor 0,076 corresponds to a symmetrical triangular loading on a beam simply supported ($q_1 L^2/12$) with a distance between supports of $0,46 L_{DIAG}$. The symmetrical triangular loading corresponds to a load greater in the middle (more accommodation) than at the ends. See Figure 10 b).	

The formula for torsional moment is a proposed default value, but it may be replaced by any documented value, including a full calculation derived from the buoyancy calculated from the intersection of the hull with a sinusoidal swell, with the masses distributed according to a detailed bill of masses.

**Key**

- 1 crest of swell or wave
- 2 through of swell or wave

Figure 10 — Sketches explaining how load case LC1 is defined

12.6 Global load case GLC 2: Rig loads

The rig loads acting on the craft's structure shall be according to ISO 12215-10, meeting, where relevant, the heel and trim conditions defined therein. They shall be balanced with the other loads, such as buoyancy, hydrodynamic forces and moments and masses. The load increase due to dynamic effect shall be considered.

Established practice recommendations for global load assessment and reporting are given in informative [Annex B](#).

12.7 Combination of diagonal load GLC 1 and rig load GLC 2 for sailing multihulls

Generally, the loads from rig can be considered as point loads (mast compression, shroud or mainsheet pull). When a load is not directly applied to a crossbeam, it can be decomposed into its fraction directly applied to the crossbeam plus a torsional moment.

When combining GLC 1 and GLC 2, one shall consider $0,5 \text{ GLC } 1 + \text{GLC } 2$ or $\text{GLC } 1 + 0,5 \text{ GLC } 2$ whichever the greater.

12.8 Global load case GLC 3: Asymmetric broaching loads in sailing multihulls

Asymmetric broaching of a sailing catamaran occurs when it digs both front ends with horizontal transverse pressure corresponding to the lateral resistance of the hulls/float profile. For a trimaran, the force is applied on the leeward float and the hull, see [Figure 11](#). The force is applied at mid-hull/float depth.

It is considered that the front leeward part of hulls and floats are loaded as shown in [Figure 11](#) and [Table 14](#). The pressure is a linear pressure varying from zero at the foremost transversal bulkhead or crossbeam connecting the two hulls, to a maximum pressure at the stem. This force is therefore acting at $2/3$ of the distance between fore bulkhead/crossbeam to stem.

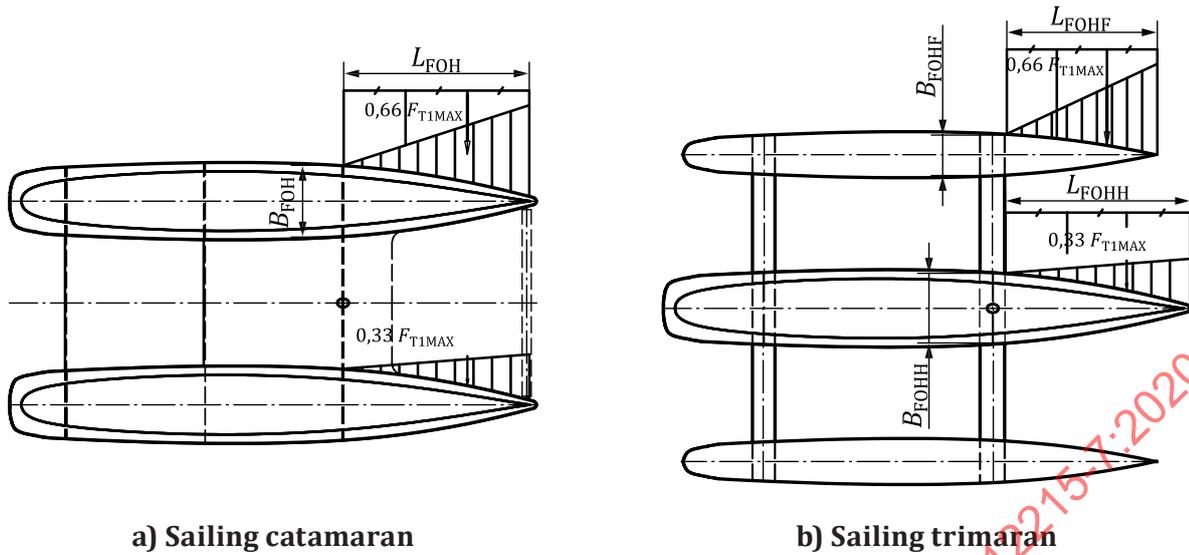


Figure 11 — Asymmetric broaching loads (sailing multihulls only)

Table 14 — Global load GLC 3 — Asymmetric broaching (see Figure 11)

Definition	Value
Total resultant transverse force directed windward	F_{T1MAX} (N)
Resultant force on leeward hull/float fore overhang	$a \times F_{T1MAX}$ at $0,67 L_{FOH}$ (catamaran) or L_{FOHF} (trimaran)
Resultant force on windward hull/float fore overhang	$(1-a) \times F_{T1MAX}$ at $0,67 L_{FOH}$ (catamaran) or L_{FOHF} (trimaran)
Where	
F_{T1MAX} is the maximum value of the transverse forces (N) exerted by the sail plan in sail configuration 1 of ISO 12215-10, and;	
$a = 0,67$ where there is no crossbeam between hulls or floats; and;	
$a = 0,5$ where there is a crossbeam between hulls or floats.	
Where there is no front crossbeam, the strength of the front of each hull or float shall be assessed as a cantilever longitudinal beam under the resultant force, Same assessment for catamarans with transverse front crossbeam, but for trimarans, a specific calculation considering the different stiffness/strength of hull and float is needed.	

12.9 Global load case GLC 4: Longitudinal broaching/pitchpoling

12.9.1 General

A multihull, sail or motor, broaches when digging the stem of a hull/float into a wave which causes a deceleration force corresponding to the longitudinal loads defined below. The longitudinal dynamic energy is usually absorbed by a longitudinal righting moment called pitchpoling.

The shear force and bending moment in the hull /floats and in the crossbeams resulting from the vertical buoyancy shall be checked, so that the resulting stresses are not greater than the design stresses defined in Table 12.

To simplify, this checking need not be performed for hull/floats when $L_{OH_i} \leq 4 D_{OH}$,

where, see Figure 12;

- L_{OH_i} is the relevant distance between supports or overhangs = L_{FOH} , L_{AOH} , L_{OFH} , L_{FOH} for hulls L_{FOF} , L_{AOF} , L_{FOF} for floats, and

- D_{OH} is the local depth at the root of the hull/float at overhang (point of max bending moment) either forward D_{FOH} or aft D_{AOH} .

The loading may also be assessed by one of the methods given in [12.9.2](#).

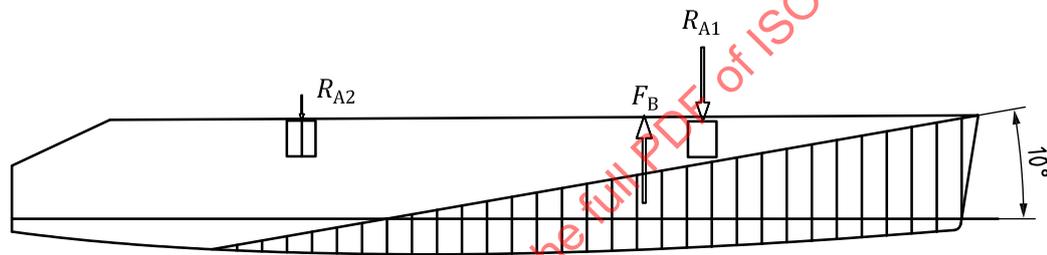
12.9.2 Full method of analysis of the buoyancy load when the craft pitchpoles

This method normally corresponds to the earlier occurrence of the following situations:

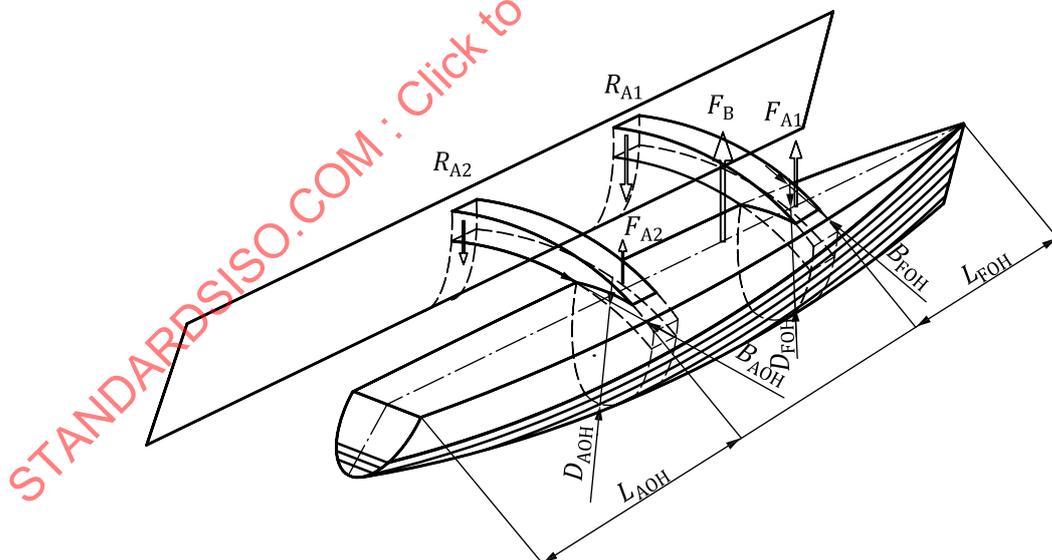
- either bow down trim angle of 20° , or
- immersion of the deck at the stem (main hull for trimarans).

Additionally, for sailing craft:

- the rig load and corresponding angle of heel/trim shall be according to ISO 12215-10;
- for more information, one may use the pitchpoling condition of ISO 12217-2:2015 but using the loaded displacement m_{LDC} (ISO 12217 uses minimum operation condition m_{M0}).



a) Buoyancy force F_B and reactions of crossbeams where the deck at stem is immersed before 20°



b) General dimensions of hull or float and sketch of forces and reactions in crossbeams

Figure 12 — Sketch of vertical forces and reactions on crossbeams when pitchpoling

[Figure 12](#) shows the front and aft forces F_{A1} and F_{A2} or the total buoyancy force F_B and the values of L_{FOH} , B_{FOH} and D_{FOH} or L_{AOH} , B_{AOH} and D_{AOH} for respectively the front and aft overhangs, beam and depth as defined in [Table 11](#) and shown in [Figure 12](#) b).

[Annex D](#) gives examples of the determination of F_B and of the EI products of each crossbeam.

Where the enhanced method of 12.3.3 is used, the leeward hulls are asymmetrically loaded, as in GLC 3, and the leeward hull usually supports a higher loading than the windward one.

12.10 Global load case GLC 5: Longitudinal force on one hull

12.10.1 General

This load case considers the longitudinal force, defined in Table 15 and occurring either when hitting a floating object/whale or a steep wave. The resulting shear force and bending moment in the crossbeams or wet deck shall be checked, so that the resulting stresses are not greater than the design stresses defined in Table 12.

To simplify, this checking need not be performed, as required in Table 11, where:

- the length of the wet deck $L_{WD} > 0,4L_H$ for structural configuration a),
- the sum of the lengths of the crossbeams $\Sigma L_{Ci} > 0,4L_H$ for structural configurations b) and c),
- the length of the main crossbeam $L_{CM} > 0,4L_H$ for structural configuration d).

12.10.2 Longitudinal force

Figure 13 shows the crossbeams and the beam between hulls B_{BHi} for a multihull with 3 crossbeams, and Table 15 gives the longitudinal forces on hulls and crossbeams.

Table 15 — Global load LC5 — Longitudinal force (see Figure 13)

1-Direct longitudinal force on hulls	
Longitudinal force on stem of catamaran hull F_{LC}	$F_{LC} = \min (2,5 m_{LDC}; 2,5 m_{HULL})$ (kN)
Longitudinal force on stem of trimaran float F_{LT}	$F_{LT} = \min (5 m_{LDC}; 5 m_{FLOAT})$ (kN)
Where m_{HULL} and m_{FLOAT} are respectively the mass of one catamaran hull or one of the trimaran floats.	
NOTE 1 These forces respectively correspond to about 0,25 g and 0,5 g decelerations.	
2-Resulting longitudinal force on crossbeams	
Longitudinal force F_{Li} acting on crossbeam i	$F_{Li} = F_L \times \left(\frac{EI}{B_{BHi}^3} \right)_i / \sum \left(\frac{EI}{B_{BHi}^3} \right)_i$ (N), see Annex D, with $F_L = F_{LC}$ or F_{LT} where relevant
Longitudinal bending moment about a vertical axis at the connection of the crossbeam with the hull	$M_{Li} = F_{Li} \times B_{Bi}$ (Nm)
NOTE 2 The EI value for each crossbeam is calculated about a vertical axis. (See Annexes C and D and ISO 12215-6).	

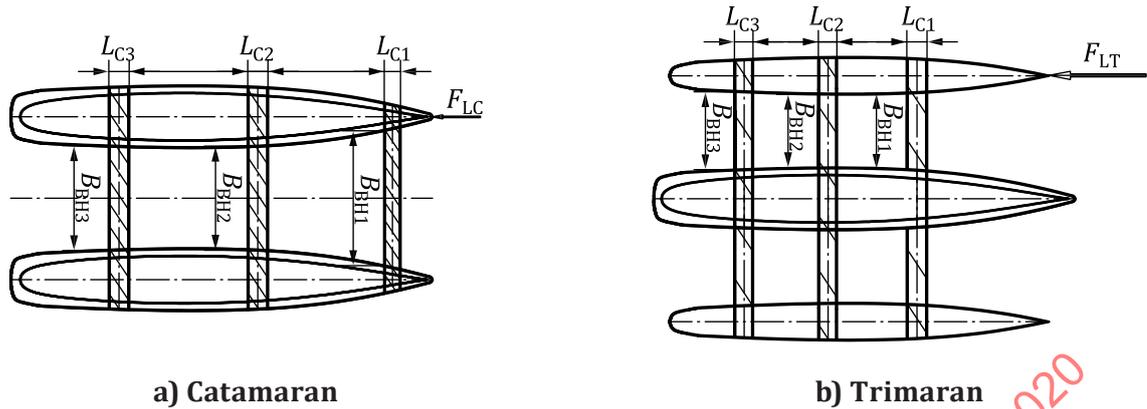


Figure 13 — Longitudinal force on hull of catamaran or float of a trimaran

12.11 Global load case GLC 6: Bending of crossbeams connecting hulls for motor catamarans.

Table 16 and Figure 14 give the shear force and bending moment on the crossbeams connecting hulls of motor catamarans. This bending moment may be shared by several crossbeams. This also applies where "classical" crossbeams are replaced by a continuous structure or a great number of small beams.

For motor trimarans, unless using another specific documented method, the shear force, and corresponding bending moment, shall be taken as the one exerted by the float considered fully immersed. This case is similar to the one shown in Figure 12 but only when heeling.

The resulting stresses shall not be greater than the design stresses defined in Table 12.

Table 16 — Global load LC6 — Design bending moment and shear force for motor catamarans

Total design Bending moment M_B on crossbeam(s)	$M_B = k_{DC}^{0,5} \times \frac{m_{LDC}}{1000} \times 9,81 \times k_{DYNM}^{0,5} \times \frac{B_{CB}}{8}$ (kNm)
Total design shear force F on crossbeam(s)	$F = 0,25 \times k_{DC}^{0,5} \times \frac{m_{LDC}}{1000} \times 9,81 \times k_{DYNM}$ (kN)

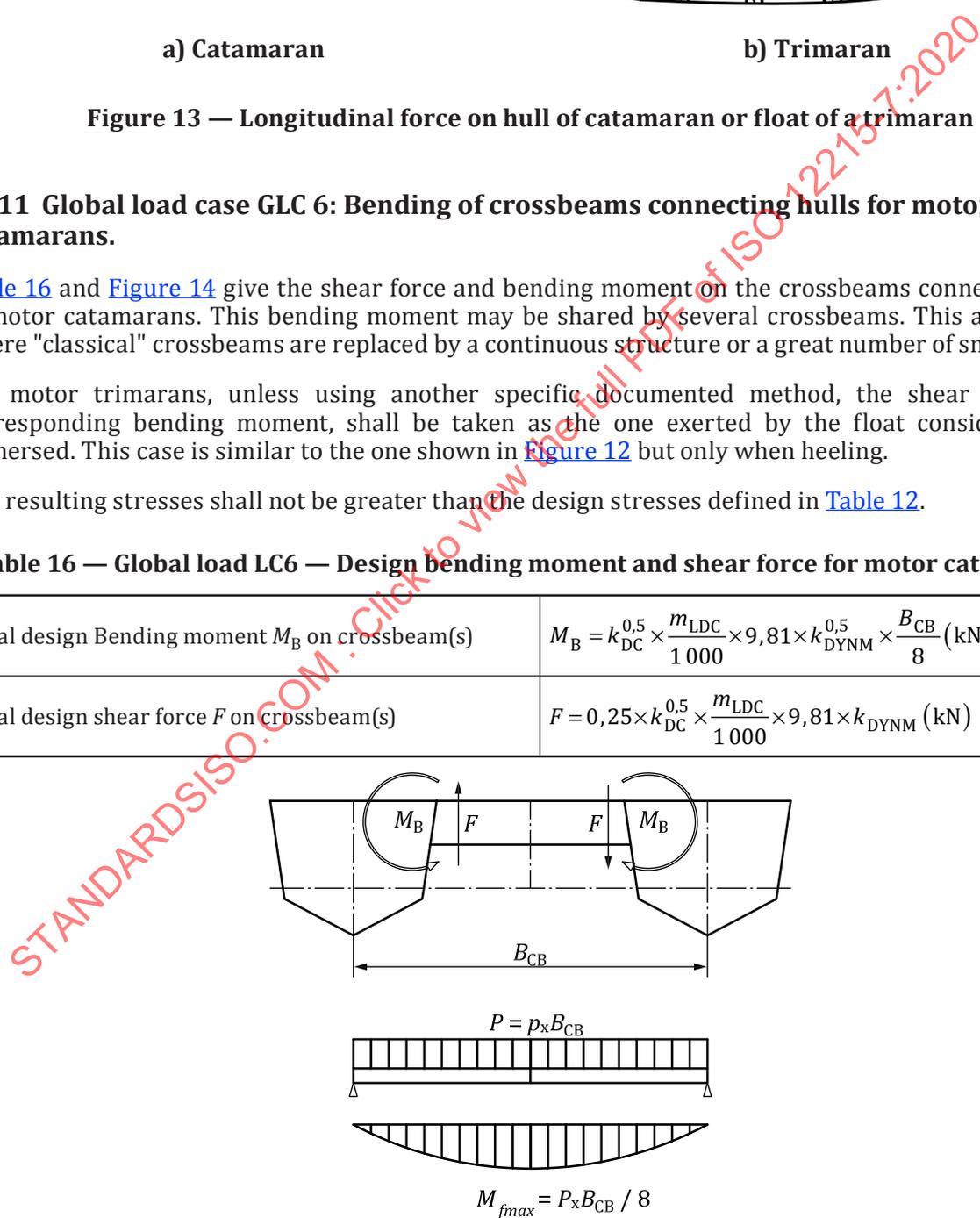


Figure 14 — Bending moments and shear forces in GLC 6

13 Structural arrangement for supporting global loads

The structural arrangement shall be able to support and/or transmit local and global loads, without exceeding the design or buckling direct or shear stress defined in [Table 12](#).

[Annexes C](#) and [D](#) give respectively examples of "established practice" or technical background calculation. [Annex B](#) gives "Established practice" recommendations for global loads assessment and reporting.

14 Multihulls used as commercial craft and workboats

For multihulls used as commercial craft and workboats, Annex J of ISO 12215-5:2019 shall be applied in conjunction with this document.

15 Information to be included in the owner's manual

15.1 General

The information specified in [15.2](#) and, where relevant, in [15.3](#) to [15.5](#) shall be included in the owner's manual.

15.2 Respect of maximum loaded displacement

The owner's manual shall include the following warning.

"CAUTION — The value of the maximum loaded displacement m_{LDC} for multihulls has a greater direct influence on the loads than it has for monohulls. Exceeding its design value can cause significant load increase, for example a lower wet deck clearance inducing much higher pressures. Overloading shall therefore be avoided."

15.3 Operational guidance

The owner's manual shall include the following warning.

"The owner is advised that he/she is responsible for ensuring that the normal mode of operation is maintained. This means that the speed of the craft needs to be matched to the prevailing sea state, and that the craft is used 'with good seamanship behaviour.'"

15.4 Information to take care of sandwich plating

Where sandwich outer skin is thinner or with lower fibre mass than the "good practice" values of Annex I of ISO 12215-5:2019, include the following information in the owner's manual, or any equivalent or more detailed information:

"CAUTION — The outer skin of your craft is strong enough to resist the design pressure but can suffer from local damage from hitting hard/sharp objects. If the outer skin is damaged, it shall be repaired immediately."

15.5 Information required by Annex J of ISO 12215-5:2019 - for commercial craft and workboat

Where relevant, include the information required by J.3 of ISO 12215-5:2019.

Annex A (informative)

Application sheet of ISO 12215-7

Type of multihull	Description	Tick valid cell or give value	
Type of multihull	Catamaran		
	Trimaran		
	Other, specify		
Type of propulsion functioning mode	Sail		
	Motor, displacement		
	Motor, planing		
Building material	Steel		
	Aluminium		
	Wood		
	FRP		
Craft main data (Table 1)	Symbol	Unit	Value
Length of hull	L_H	m	
Length waterline in maximum loaded condition	L_{WL}	m	
Beam of hull	B_H	m	
Chine beam at $x/L_{WL} = 0,4$	B_C	m	
Loaded displacement	m_{LDC}	kg	
Maximum speed in m_{LDC} condition (motor craft)	V	knots	
Maximum draught of canoe body	T_C	m	
Deadrise at $0,4 L_{WL}$ (planing craft only)	$\beta_{0,4}$	degree	
Design category (Table 5):	Description	k_{DC}	Tick cell
	A	1,00	
	B	0,80	
	C	0,60	
	D	0,40	
Type of usage Clause 14 and Annex J of ISO 12215-5:2019, where relevant	Description		Tick cell
	Recreational/Charter	Use Annex J of ISO 12215-5	
	Workboat light duty		
	Workboat heavy duty		
Analysis method of local loads	Use Annex L of ISO 12215-5:2019		

Analysis of global loads							enter Yes or No	
Is the structural arrangement “Typical” according to Figure 9 ?							enter Yes or No	
If the result is “No” the enhanced global load analysis needs to be performed and results produced								
If the result is “Yes” the simplified global load analysis needs to be performed but the simplified method may be used, and results produced, if this is the case click the simplified global load analysis performed								
Structural arrangement (Fig 9)	GLC 1	GLC 2	GLC 1 and 2	GLC 3	GLC 4	GLC 5	GLC 6	
a								
b and c								
d								

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Annex B (informative)

"Established practice" recommendations for global loads assessment using FEM methods and reporting

B.1 Examples of "Established practices"

Examples of established practice in global loads assessment include:

- for sailing multihulls, balancing the rig/buoyancy loads and masses;
- the simplified method for global load, GLC 4 (see [12.9](#));

B.2 Guidelines for reporting the structural analysis with FEM method

Any structural analysis report, whatever the numerical calculation method is used, submitted, where relevant, to notify body or approbation office, should include the following information:

Model description

- Reference units (of length, force, pressure, etc.) and geometric origin of the model
- Reference of plans (CAD, 2D drawing...) used, including dates and versions
- Numerical software used, including versions and dates
- Modelling assumptions
- Element types
- Mesh size
- Any deviation in geometry and arrangement of structure compared with plans
- Plot of complete model in 3D view
- Plot to demonstrate correct structural modelling
- Plot to demonstrate assigned properties
- Bill of material properties used in the model

Load and boundary conditions

- Details of boundary conditions
- Details of all load combination with calculated hull girder shear force, bending moment and torsional moment distributions
- Plot of applied loads in 3D view
- Sum of total load applied

Design criterion

- Summary of allowable deflexion

ISO 12215-7:2020(E)

- Summary of allowable stresses
- Details of selected composite failure criteria

For each load case result:

- Details of reaction at boundary conditions
- Plots and results to demonstrate correct behaviour of structural model under the applied load combination
- Summary and plots of global displacements
- Summary and plots of stresses to demonstrate that allowable stress are not exceeded anywhere in the structure
- Contour plots for:
 - Composite failure criteria
 - Ply stresses, when relevant

Analysis used

- Linear or non-linear static analysis
- Buckling analysis
- Other, if required: modal analysis, fatigue, etc.

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Annex C (informative)

"Established practice" details

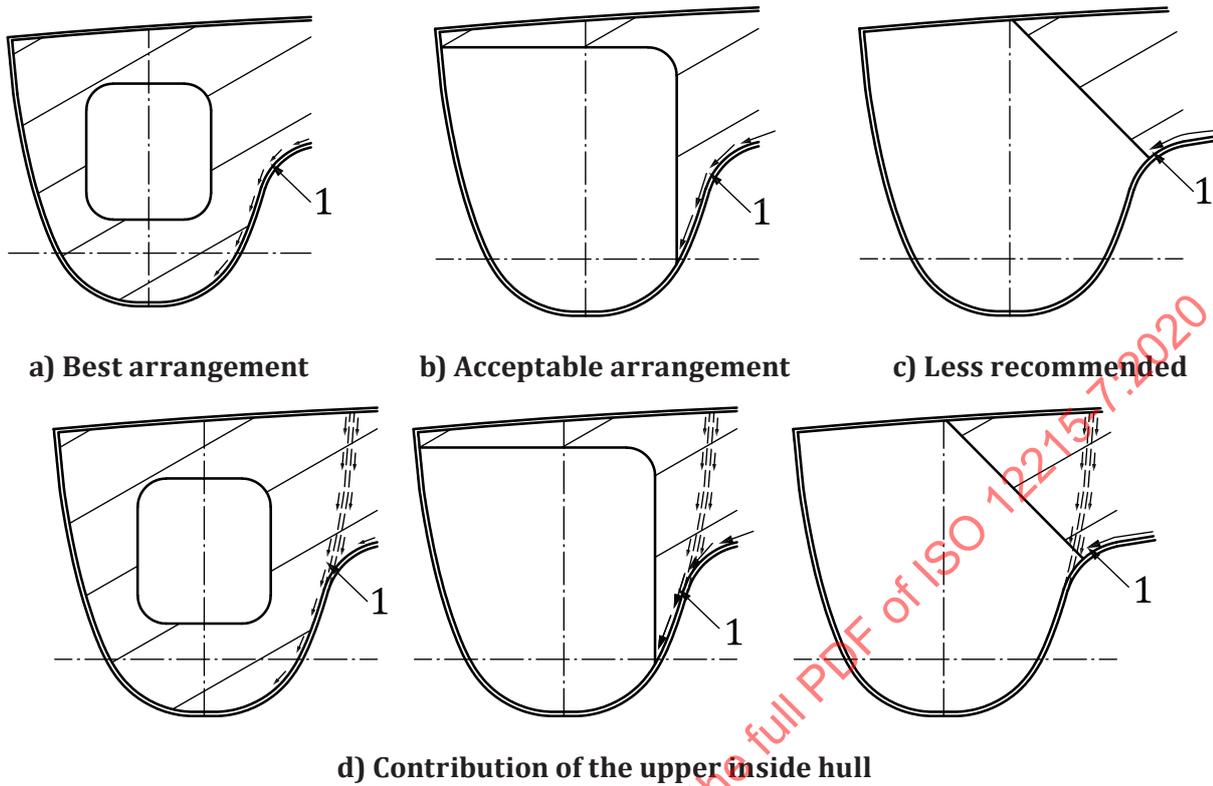
C.1 Details for the connection of crossbeams with the hulls

The connection between the crossbeams and the hulls transmits loads by shear flow (see the arrows in the drawings). This is mainly the case where the plating has an angle $<45^\circ$ with the direction of the shear force to be transferred, see ISO 12215-6 for more information. See [C.3.5](#) for details on shear flow.

[Figure C.1](#) shows 3 examples of connection between a structural bulkhead, mast or mainsheet and the hulls/floats.

- [Figure C.1](#) a) shows the best arrangement as the whole connection with the hull transfers the shear force with a small shear flow.
- [Figure C.1](#) b) shows an acceptable arrangement where the extension of the bulkhead is in the direction of the deck, to transfer transverse horizontal loads, and along the inner side of the hull, for vertical shear load (torsion and mainsheet pull) with a larger shear flow.
- [Figure C.1](#) c) shows a less recommended arrangement where the bulkhead can only transfer vertical shear forces on parts of the hull with some vertical projection to the hull structure, and stops abruptly. It is however acceptable if the shear force is low or transmitted by other means.

REMARK: The comments above become much less relevant where inner front part of the hull plating [dotted lines in [Figure C.1](#) d)] is connected to the bulkhead. In that case a significant part of the shear flow passes to the structure by this connection, and all the 3 cases can then be relevant.



Key
1 shear flow

Figure C.1 — Detailed arrangements of the connection between crossbeams and hulls

C.2 Design stresses

The design direct or shear stresses for local loads are taken from ISO 12215-5:2019 and the design direct or shear stresses for global loads from Table 12, including, where relevant, k_{DYN} . Where global loads combine with local loads their effect is combined.

Where the crossbeam webs are made out of plywood, the "plywood on edge" data in Annex E of ISO 12215-5:2019 may be used, unless other documented values are available. Plywood webs are sometimes made with plates oriented at $\pm 45^\circ$ from horizontal to benefit from higher design shear stress (generally double).

NOTE The shear stresses due to global loads, particularly the ones in elements working as shear web are "in-plane" or "intralaminar" shear stresses.

C.3 Analysis of beams

C.3.1 General

Table C.1 gives simplified results for web and flange scantlings. This method is not only applicable in the simplified method but is applicable to any crossbeam analysis when its shear force F and bending moment M are known. This method is more accurate if the beam is high, say $H > 3b_{ewd}$.

The assessment is made for each bulkhead/crossbeam, checking that the direct (tensile, compressive) or shear stresses are below the design stresses of [Table 12](#) for global loads, i.e.:

- direct compressive/tensile stresses in top and bottom flanges (analysed either with or without attached plating);
- shear stresses in webs analysed according to [Table C.1](#) and shear buckling stresses analysed in [C.3.4](#) and [Table C.2](#);
- increased direct and shear stresses from secondary bending moments from eventual cut-outs in the webs of crossbeams analysed according to [Table C.3](#);
- loads, and reactions defined in this Annex are correctly introduced by shear in the web;
- there is no abrupt discontinuity in the flanges and webs to avoid stress raisers, including the detailed recommendations of ISO 12215-6.

C.3.2 Method of analysis

The crossbeams are considered as I-beams, with the following simplifications:

For a "high" I-shaped crossbeam, the following assumptions are usually made:

- a) the shear force is only resisted by the web;
- b) the bending moment is only resisted by the upper and lower flanges, with eventual use of attached plating.

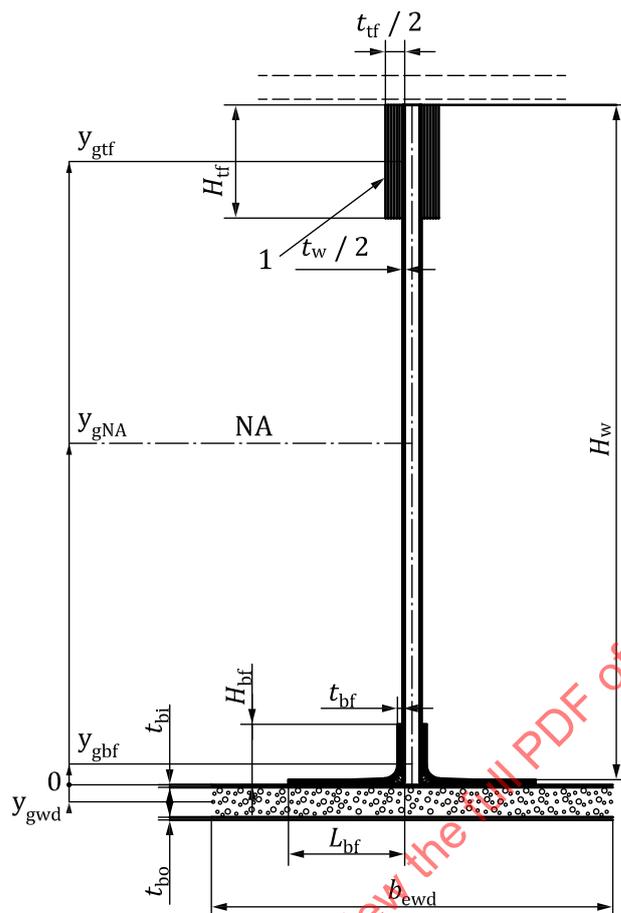
More sophisticated analysis methods can be applied provided that they use sound engineering.

C.3.3 Dimensions, sections, neutral axis

Where the deck is added at the end of the construction, the link between the bulkhead and the web may be not fully efficient, and some designers do not consider the deck as an attached plating (see [Figure C.2](#)). A conservative calculation therefore only considers the flange/reinforcement connected to the web and neglecting the attached plating effect of the deck (at top) and, where relevant, wet deck (at bottom).

The total section, position of y_G (neutral axis), second moment I , and section modulus are calculated, to verify that the tensile or compression design stress, whichever is the lesser, is not exceeded. Clause H.4 of ISO 12215-5:2019, explaining stiffener calculation, may be used, especially if different materials are used in the beam.

[Table C.1](#) gives, in contrast, an example of calculation for an I-shaped beam where deck and wet deck are part of the upper and lower attached plating.



Key

- 1 top reinforcement flange

Figure C.2 — Sketch of a bulkhead without considering the deck as an attached plating