



Rudder

User Guide

June 2021
DEV/UG/RUDDER/rev1

DISCLAIMER

The client acknowledges that the RUDDER software is used under her/his exclusive management, control and responsibility.

BUREAU VERITAS shall in no case be liable for any consequential damage due to software operation or contents.

This document is for information only.
Please contact us for specific advice.

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PURPOSE OF THIS DOCUMENT

This electronic document details the main elements of the RUDDER Software in order for a new user to handle an assessment from scratch or for a more experienced user to have a document of reference for clarifying her/his doubts.

In any case, the information contained in this document or in the RUDDER Software cannot be a substitute for the Rules or Surveyors decisions.

- ▶ Minimum screen resolution recommended: 1024 x 768
- ▶ Operating systems: Windows XP / VISTA / 7 / 10

 Please consider the environment before printing this document 

1. INTRODUCTION

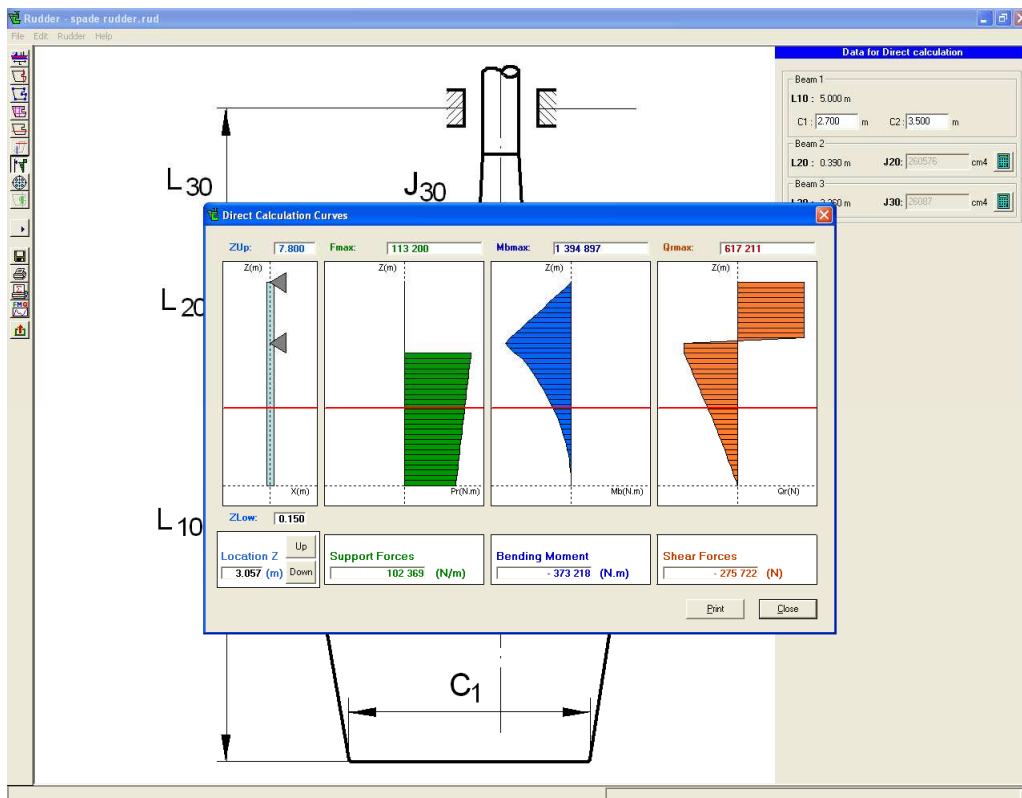
RUDDER allows checking the scantling of rudders according to the requirements of:

- ▶ BUREAU VERITAS Rules for the Classification of Steel Ships NR467
- ▶ BUREAU VERITAS Rules for the Classification of Inland Navigation Vessels NR217
- ▶ *IACS Common Structural Rules for Bulk Carriers (2012) – Chapter 10 Section 1*
- ▶ BUREAU VERITAS Rules for the Classification of Yachts NR500

RUDDER calculates:

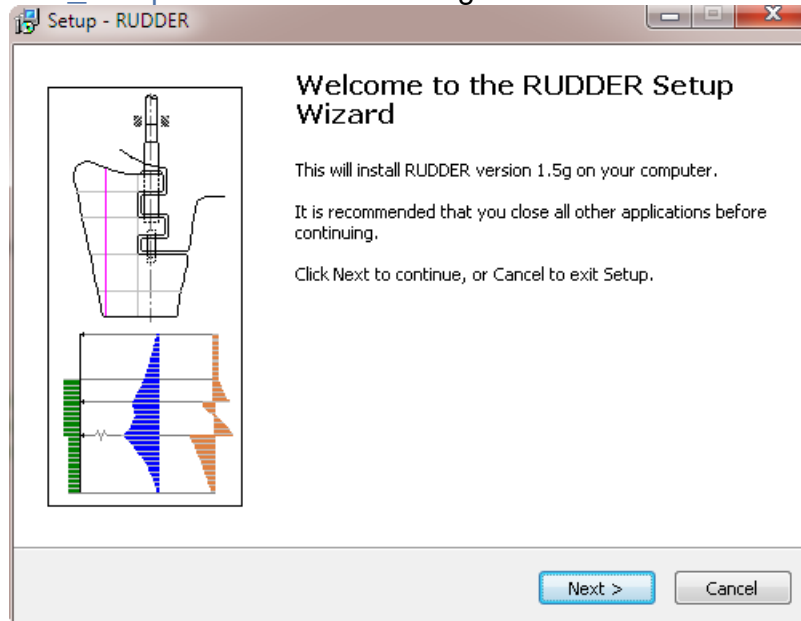
- The geometrical characteristics of rudder blades, forces and torques acting on the rudder,
- The scantlings of rudder stocks, rudder blades,
- The geometrical characteristics and the scantlings of rudder horns cross sections,
- The characteristics of the coupling between rudder blade and rudder stock, and also of pintles and bearings.

Inputs can be partial if only partial results are needed. How and what data to submit are detailed in the Part 4 “Data Input” of this document. Information on calculations and results are given in Part 5 “Rudder Calculation” and Part 6 “Rudder Results”.



2. INSTALL

Launch [Rudder_Setup.EXE](#) and follow the given instructions.



If the installation is successful, you will have access to the program by:

- ▶ Clicking on the RUDDER.EXE icon in the Program Folder you have defined
- ▶ Launching RUDDER via Start ⇒ All Programs ⇒ Bureau Veritas

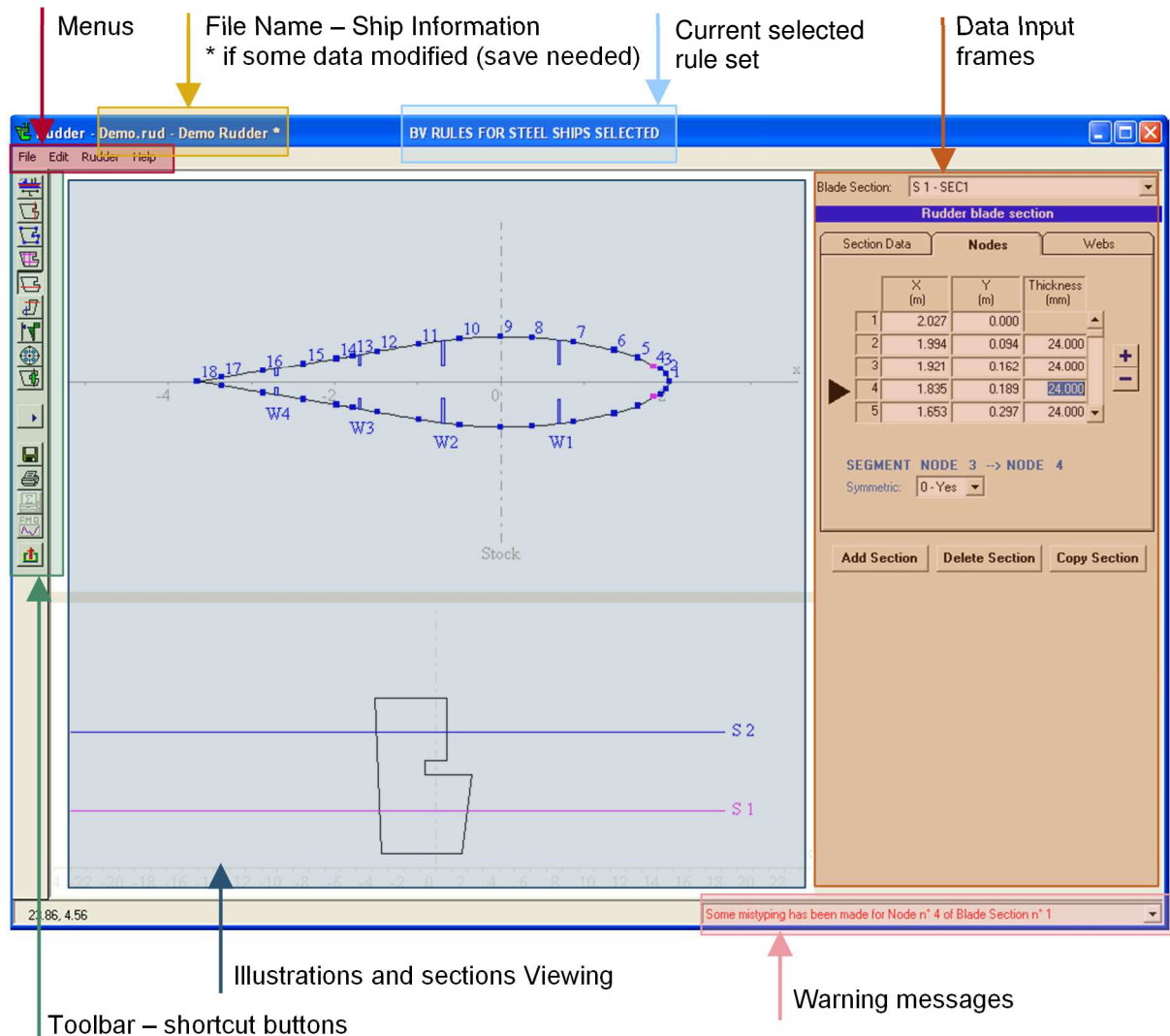


Rudder.exe
Scantling of rudders
Bureau Veritas

3. Main Features

3.1. General

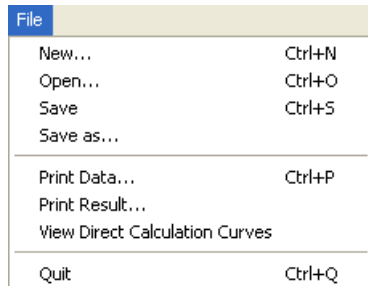
The RUDDER interface is organized as follows:



- ▶ Menus and Toolbar elements are described in Parts 3.2 and 3.3
- ▶ Viewing frame is interactive for:
 - Blade Geometry
 - Stiffening and Reinforcement
 - Rudder Blade Section
 - Horn Section
- ▶ Warning messages inform of possible problems.

3.2. Menus contents

Here is the list of menu items present in RUDDER:



New: Open new project

Open: Load existing database

Save: Save information of current database

Save As: Save current database with other file name

Print Data: Access to input data printing

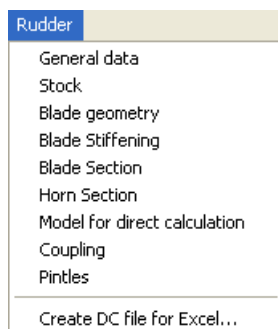
Print Result: Access to results printing (will be meaningful after compute)

View Direct Calculation Curves (DCC): Access to DCC window (available after calculations done)

Quit: Exit RUDDER software

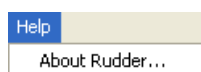


Undo: Restore value before last action

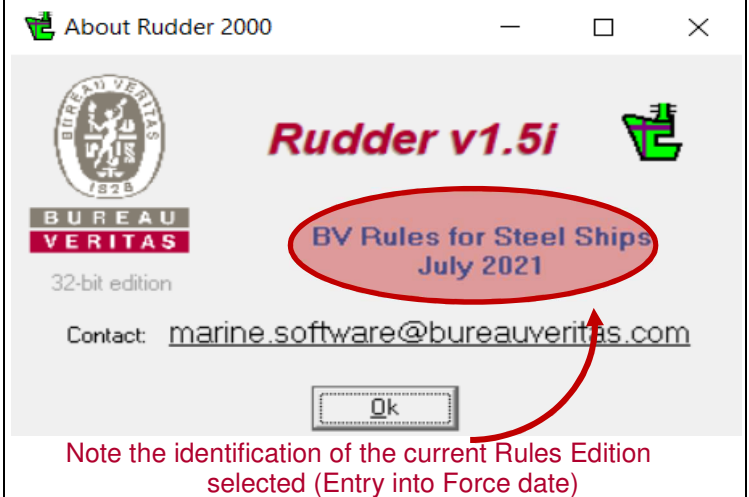


Access to the display where the corresponding information need to be input

Create DC file for Excel (tabulated text, available after calculations)

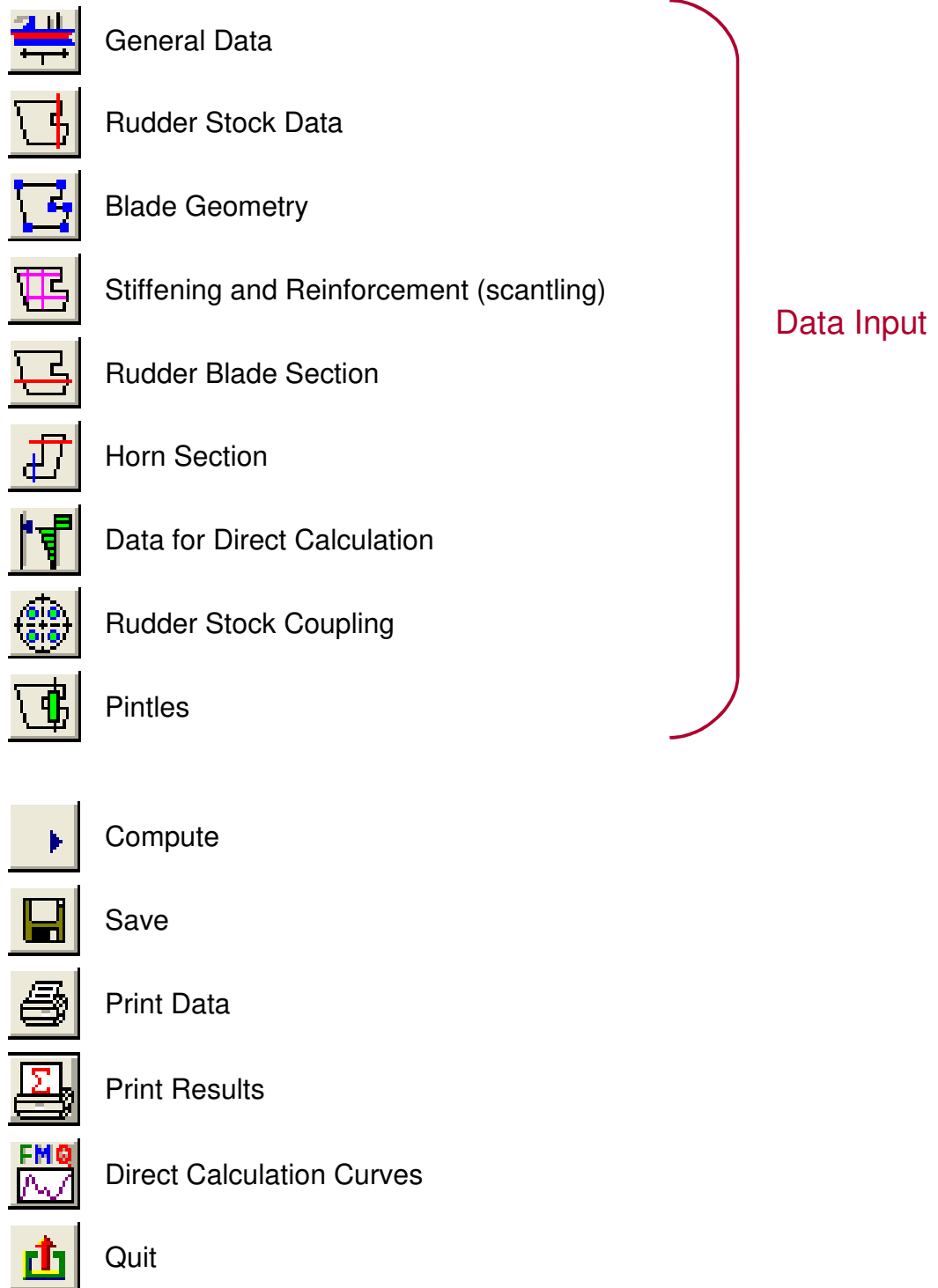


About Rudder: Access to the RUDDER general information



3.3. Toolbar elements

Here is the list of the shortcut buttons meaning:



Some detailed information is provided in Part 4 for Data Input and in Part 5 and 6 for calculations and results.

4. DATA INPUT

4.1. General Data

The General Data associated to a RUDDER project is divided in 3 types:

- ▶ Basic Ship Data
- ▶ Materials information
- ▶ Rudder principal characteristics

A detailed description of these data is provided in the following points.

4.1.1. Basic Ship Data

Ship identification

Ship main dimensions

BASIC SHIP DATA MATERIAL RUDDER

Identification

Ship Name: Semi-spade rudder

Builder:

Description (job): Demd

Main Data

Length: 214.650 m

Draught: 12.450 m

Maximum ahead service speed: 22.000 knots

Maximum astern speed: 11.000 knots

Notation

Service: Oil tanker (and easy chemical)

Navigation: Unrestricted navigation

Ice class: No ICE notation

Rule Set: BV Rules - Steel Ships

Graphical bounds

Height: 10.733 m

Breadth: 4.000 m

Service notation and Marks

Scale displays

The Basic Ship Data tab contains:

- ▶ The ship identifying information: the data input helps just to identify the project

► The Main Data:

- The ship rule *Length*
- The ship scantling *Draught*
- The *Maximum Ahead Service Speed*
- The *Maximum Astern Speed*

Note: RUDDER will check the minimum speed values according to the rules

► The Notations

- The ship *Service Notation* possible choices are:

Service Notations	
1	Cargo ship
2	Container ship
3	Ro-ro cargo ship
4	Ro-ro passenger ship
5	Passenger ship
6	Oil tanker
7	Bulk carrier
8	Bulk carrier CSR
9	Liquefied gas carrier
10	Chemical tanker
11	Tanker
12	Dredger
13	Hopper dredger/barge
14	Split hopper dredger/barge
15	Fishing vessel
16	Launch
17	Sea going launch
18	Yacht
19	Charter yacht
20	Tug
21	Supply vessel
22	Ore carrier
23	Combination carrier
24	Icebreaker

Note: This choice will automatically change the rule set

Assessment according to BV NR500 and NR467

Assessment according to BV NR527 – Classification of Ships Operating in Polar Waters and Icebreakers

Note: The list of service notation displayed with the rule set BUREAU VERITAS Rules for Inland Vessels, contains less elements (see “Note for

BV Inland” at the level of the rule set definition).

- The second notation to provide is the *Navigation Notation*. It specifies the type of navigation for which the ship is designed. For sea going ships (BUREAU VERITAS Rules for Steel Ships/ Rules for Yachts and *IACS CSR for Bulk Carriers*), the possible choices are:

Navigation Notations	
1	Unrestricted navigation
2	Summer zone
3	Tropical zone
4	Coastal area
5	Sheltered waters

← Forced choice for IACS CSR for Bulk Carriers

For inland vessels (BUREAU VERITAS Rules for Inland Vessels), the display varies:

Navigation m

Navigation Notations	
1	IN
2	IN(x ≤ 2)

- The third notation to provide for the BUREAU VERITAS rule sets is the possible presence of the additional *Ice Strengthening* to choose among:

Ice Class or *Polar Class* for Steel Ships rule set:

Ice Notations
No ice notation
ICE Class IA SUPER
ICE Class IA
ICE Class IB
ICE Class IC
POLAR CLASS 1 to 7

Assessment according to
BV NR467 – PtF Ch8 S2
6.1.1

Assessment according to
BV NR527 – S2 10.1.1

For ships with service notation Icebreakers:

Ice Notations
ICEBREAKER 1 to 7

For Inland Navigation vessels rule set:

<i>Ice Notations</i>
No ice notation
ICE
ICE-30
ICE-40
ICE-40+

Assessment according to
BV NR217 – PtD Ch2 S1
3.1.1

- The fourth element allows you to change the current **Rule Set**. There are 3 possible choices, the assessments will be done according to the selected rule set:

<i>Rule Set</i>	
1	BUREAU VERITAS Rules for Steel Ships
2	BUREAU VERITAS Rules for INLAND vessels
3	<i>IACS CSR Rules for Bulk Carriers</i>
4	BUREAU VERITAS Rules for Yachts

Note for BV Inland: In the case of the selection of BV Rules for Inland Vessels, equivalence is maintained by RUDDER between Steel Ships service notations and Inland service notations. This allows alternatively changing the rule set without losing the service notation information. The equivalence is done as follows:

<i>Inland Service Notations</i>	<i>Steel Ships Service Notations</i>
Cargo vessel	Cargo ship, Fishing vessel, Supply vessel, Icebreaker
Container vessel	Container ship
Ro-ro cargo vessel	Ro-ro cargo ship, Ro-ro passenger ship
Passenger vessel	Passenger ship
Tanker	Oil tanker (FLS Tanker), Combination carrier, Liquefied gas carrier, Chemical tanker, Tanker
Dredger	Dredger
Hopper dredger/barge	Hopper dredger/barge
Split hopper barge	Split hopper dredger/barge
Launch	Launch, Sea going launch
Tug & Pusher	Tug

- The **Graphical Bounds** (Height and Breadth) are used by the software to scale the displays. It is an optional input.

4.1.2. Materials

This tab allows presetting the characteristics of all the materials used in the current RUDDER project.

Note: at least one material need to be defined before running any calculation.

BASIC SHIP DATA		MATERIAL		RUDDER	
	Material type	Yield Stress (N/mm2)	Young Modulus (N/mm2)	Butt Weld Coefficient	Tensile Strength (N/mm2)
1	1 - Steel	235.000	206000.000		400.000
2	1 - Steel	310.000	206000.000		490.000
3					

For each material the following information is to be input:

- The *Material Type*: the possible choices are,

1	Steel
2	Stainless steel
3	Aluminum rolled
4	Aluminum extruded

- The Material following characteristics:

- The *Yield Stress*
- The *Young Modulus*
- The *Butt Weld Coefficient*
- The *Tensile Strength*

Note: For each material, only the active cells, in white, need to be completed. The input is validated by taping the ENTER key.

4.1.3. Rudder

To describe the rudder, it is necessary to provide the following information.

The screenshot shows the 'RUDDER' tab in a software interface. It contains several input fields and two diagrams. Annotations with arrows point to specific elements:

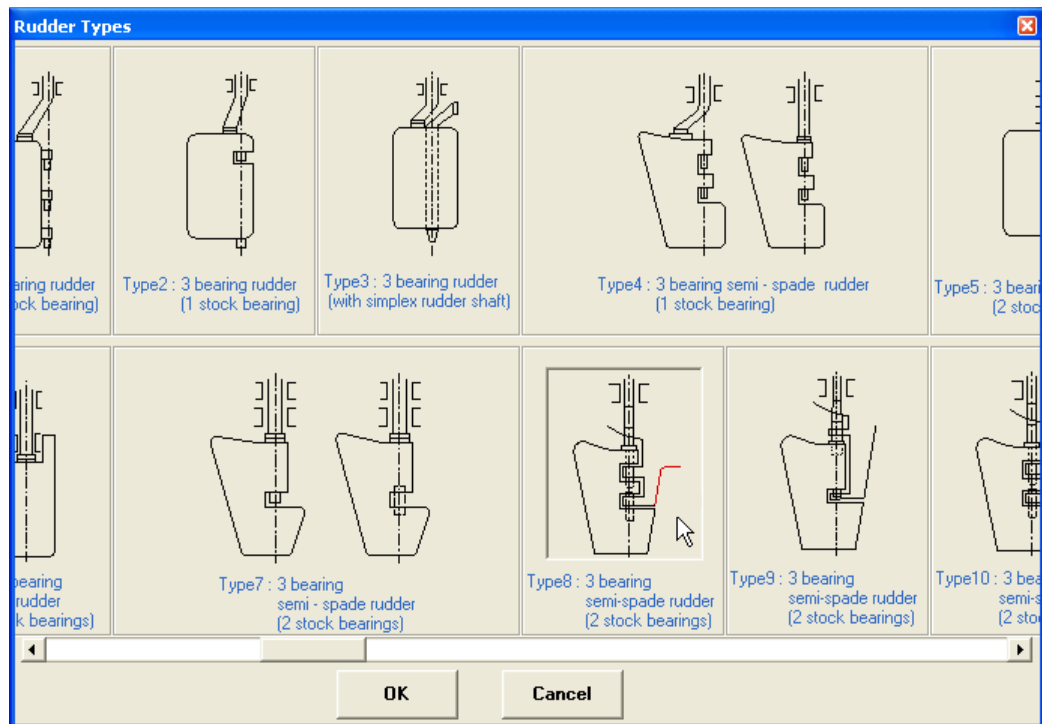
- Access button to all Rudder types:** Points to the information icon (i) next to the 'Rudder type' dropdown.
- Current Rudder type diagram:** Points to the diagram of a rudder with two stock bearings.
- Access button to all Blade profiles:** Points to the information icon (i) next to the 'Blade profile' dropdown.
- Current Blade profile diagram:** Points to the diagram of a NACA-00 Goettingen profile.

The form fields include:

- Rudder type:** 6 - 2 bearing spade rudder (2 stock bearings)
- Stock coupling:** 2 - Cone couplings
- Location of blade compared to propeller:** 3 - other case
- Blade type:** 1 - Double plated rudder
- Blade profile:** 1 - NACA-00 Goettingen profiles
- r2 (ahead):** [empty]
- r2 (astern):** [empty]
- Area of rudder post or rudder horn:** 0.000 m²

- The first data to provide is the *Rudder type* following the classification set by the Rules. There is 2 ways to establish the Rudder type:
 - By selecting the type in the list box
 - By accessing the type + diagram selection window via the "Information" button ⇒

In the case of using the Rudder Types window, the selection will be validated by clicking on the “OK” button.



Note: This list is an extended list of rudder types, check with the rules you are assessing your rudder with, to know which types are allowed by each rule set: if you choose a rudder type that is not in the rules, the scantlings check obtained are not to be considered as an approval and are given for an informative purpose only.

- The type of the Rudder *Stock Coupling* is the next data to set. The possible choices are:


1	Horizontal flange coupling
2	Cone coupling
3	Vertical flange coupling
4	Continuous rudder stock

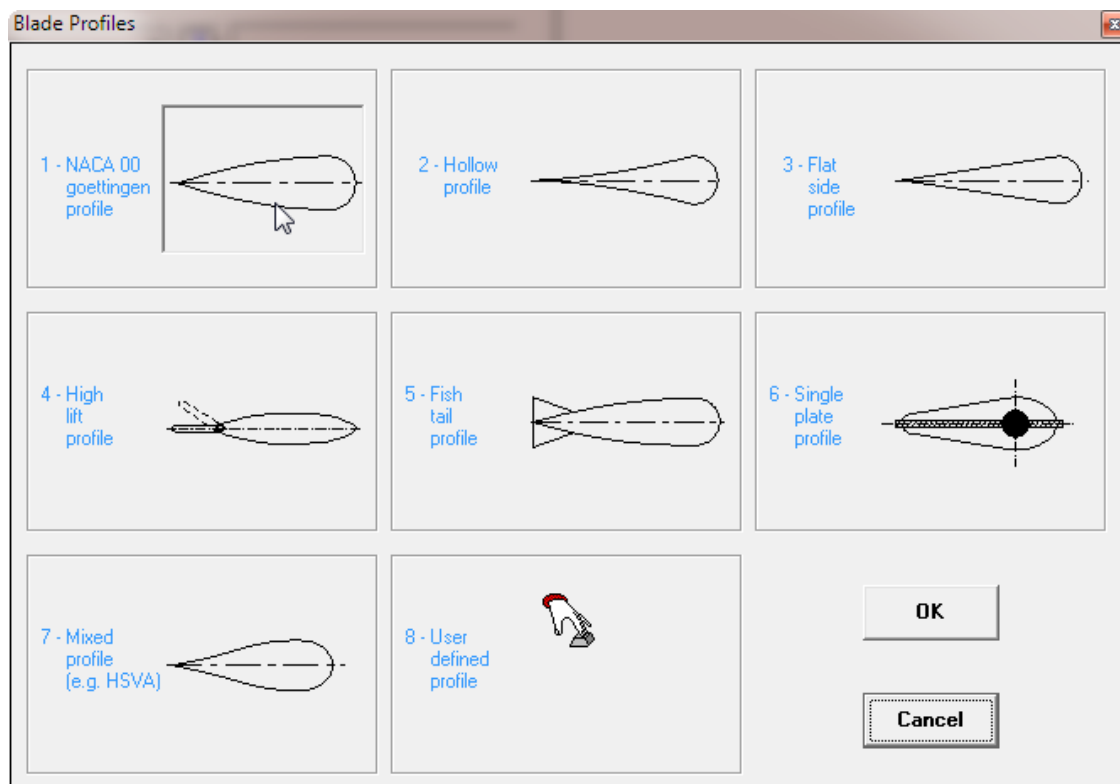
- The third input is the *position of the Rudder Blade with respect of the Propeller*. This is used to define the r3 coefficient. There are 3 cases distinguished:

1	Location outside the propeller jet
2	Location behind a fixed propeller nozzle
3	Other cases

- The *Blade Type* need to be input. The possible choices are:

1	Double plated rudder
2	Stiffened single plate rudder
3	Non-stiffened single plate rudder

- The next piece of information to set is the *Blade Profile* type. It is used to define the $r2$ coefficients. There are two ways to establish this input:
- By selecting the type in the list box
 - By accessing the type + diagram selection window via the “Information” button ⇒ 



If the “user defined profile” option is chosen, it is necessary to input the following data:

- coefficient $r2$ in *ahead* condition
 - coefficient $r2$ in *astern* condition
- Finally enter the sum of the *areas of the Rudder Post or/and the Rudder Horn*, if any, up to mean blade height.

4.2. Rudder Stock data

The Rudder Stock data is displayed according to the following form:

The screenshot shows the 'Rudder Stock' data entry form. It includes fields for the stock axis coordinate, stock material, and two bearing sections (Lower and Upper). Annotations with arrows point to specific fields: a red dashed box labeled 'Position of the Stock' encompasses the X coordinate, Z1, and Z2 fields; a blue arrow labeled 'Materials' points to the 'Material of stock' and 'Material of bearing' dropdowns.

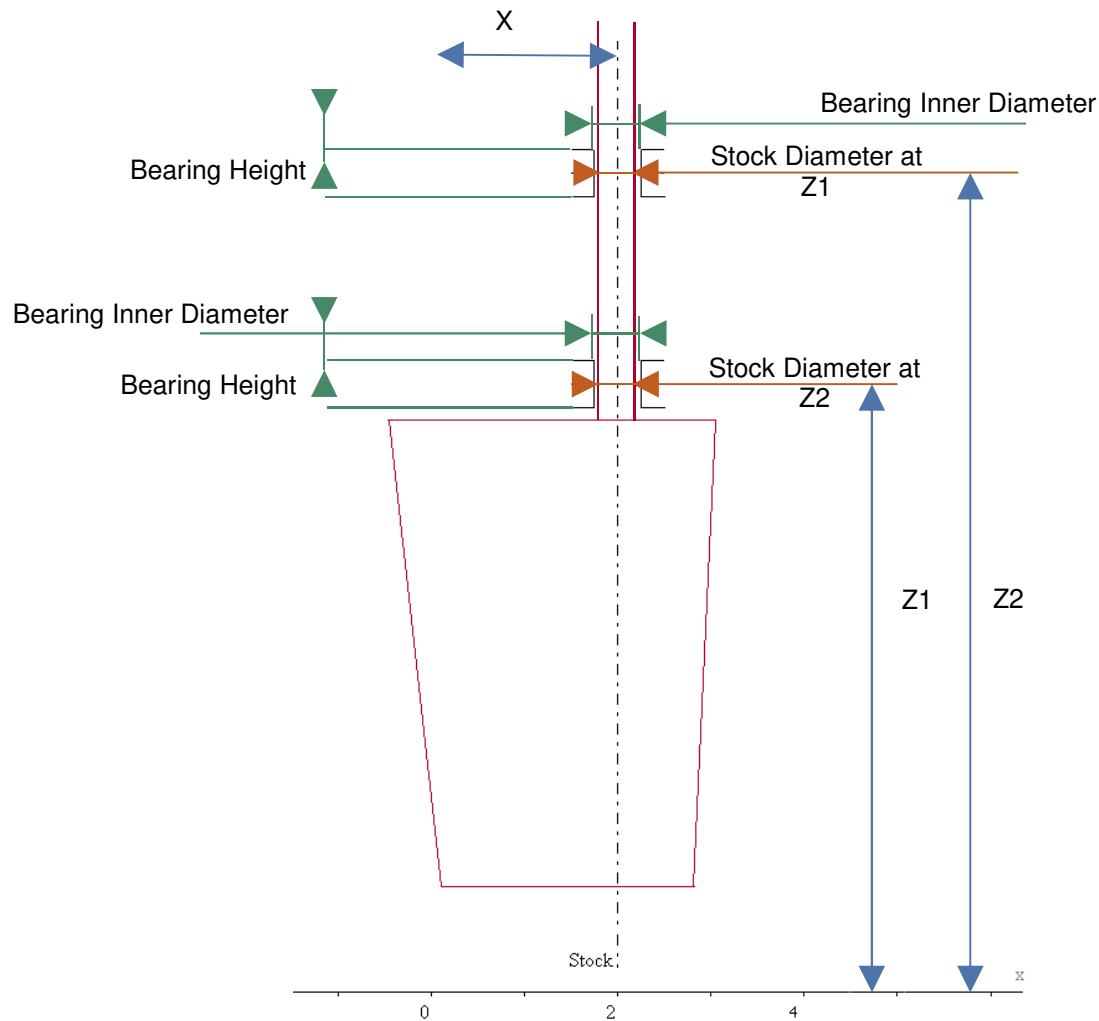
Rudder Stock	
X coordinate of the stock axis (*) :	0.000 m
Material of stock:	ST260
Lower rudder stock bearing	
Z1 at midspan (**):	10.525 m
Stock diameter at Z1:	0.620 m
Bearing height:	0.744 m
Bearing inner diameter:	0.620 m
(**) Z at mid-height of the upper rudder horn bearing	
Upper rudder stock bearing	
Z2 at midspan:	13.467 m
Stock diameter at Z2:	0.625 m
Bearing height:	0.470 m
Bearing inner diameter:	0.420 m
Material of bearing:	4 - Steel, bronze and hot-pressed bror
(*) in the user reference system	

- Position of the Stock information is composed of:
- *X coordinate of the stock axis* in the frame of reference that will be used in the RUDDER project (see also part 3.3 “Blade Geometry”)
 - *Z1 at midspan*, as the Z coordinate of the mid-height of the lower stock bearing
 - *Z2 at midspan*, as the Z coordinate of the mid-height of the upper stock bearing

Note: If the steering device has only one bearing, only the information associated to Z1 (lower stock bearing) need to be input for the calculations.

Note: If there are two bearings, Z2 must be set greater than Z1.

Note: The user is allowed to set her/his own frame of reference, that can be totally different from the ship reference co-ordinate system, as long as the coherence within that frame is kept all along the data input. This means particularly that the Z axis origin is not necessarily the ship baseline.

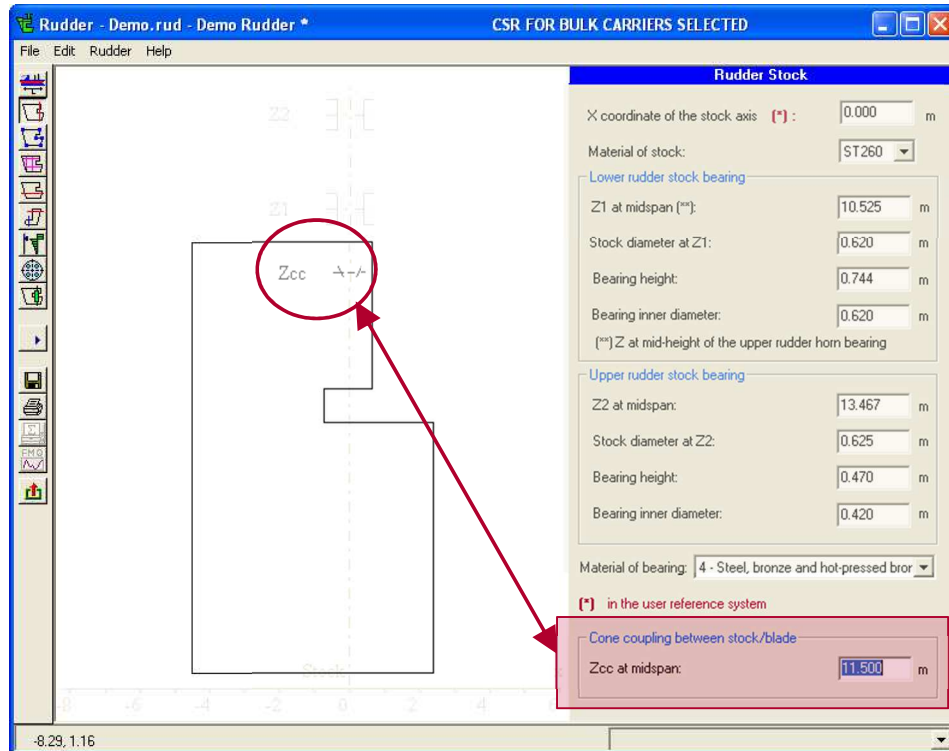


- ▶ The **Material of the Stock** must be chosen among the list reflecting the materials defined in the “General Data” - “Materials” tab (see Part 3.1.2).
- ▶ The actual **Diameter of the Stock** at the level of the bearing(s) needs to be input, as it is one of the principal part of the checking.
Note: If the steering device has only one bearing, only the information associated to Z1 (lower stock bearing) need to be input for the calculations.
- ▶ The **Bearing Height** and the **Bearing Inner Diameter** are to be entered.
- ▶ The **Material of the Stock Bearing** must be chosen among the following list:

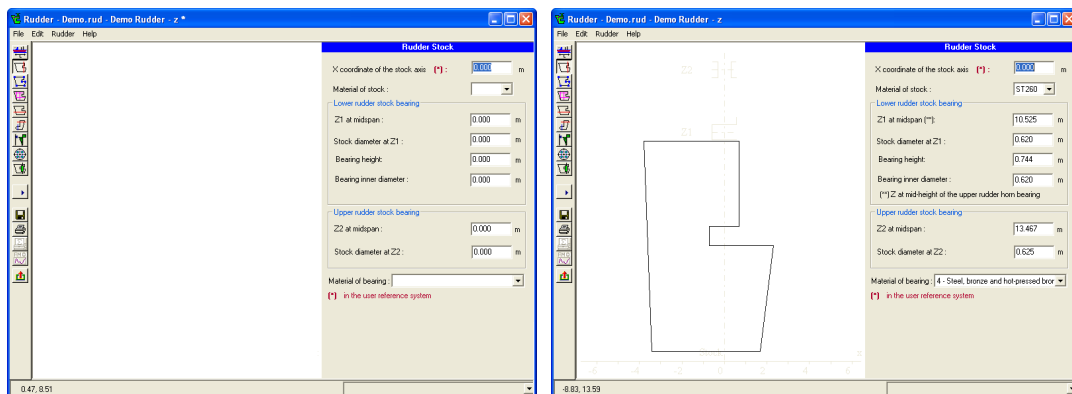
1	Lignum vitae
2	White metal, oil lubricated
3	Synthetic material with hardness greater than 60 Shore D
4	Steel, bronze and hot-pressed bronze-graphite metals

- ▶ For a rudder with cone coupling and with the BV rules for Steel Ships/ BV Rules for Yachts or *CSR rules for Bulk Carriers* being selected, the additional data **Zcc at midspan**, z coordinate of the middle of the cone

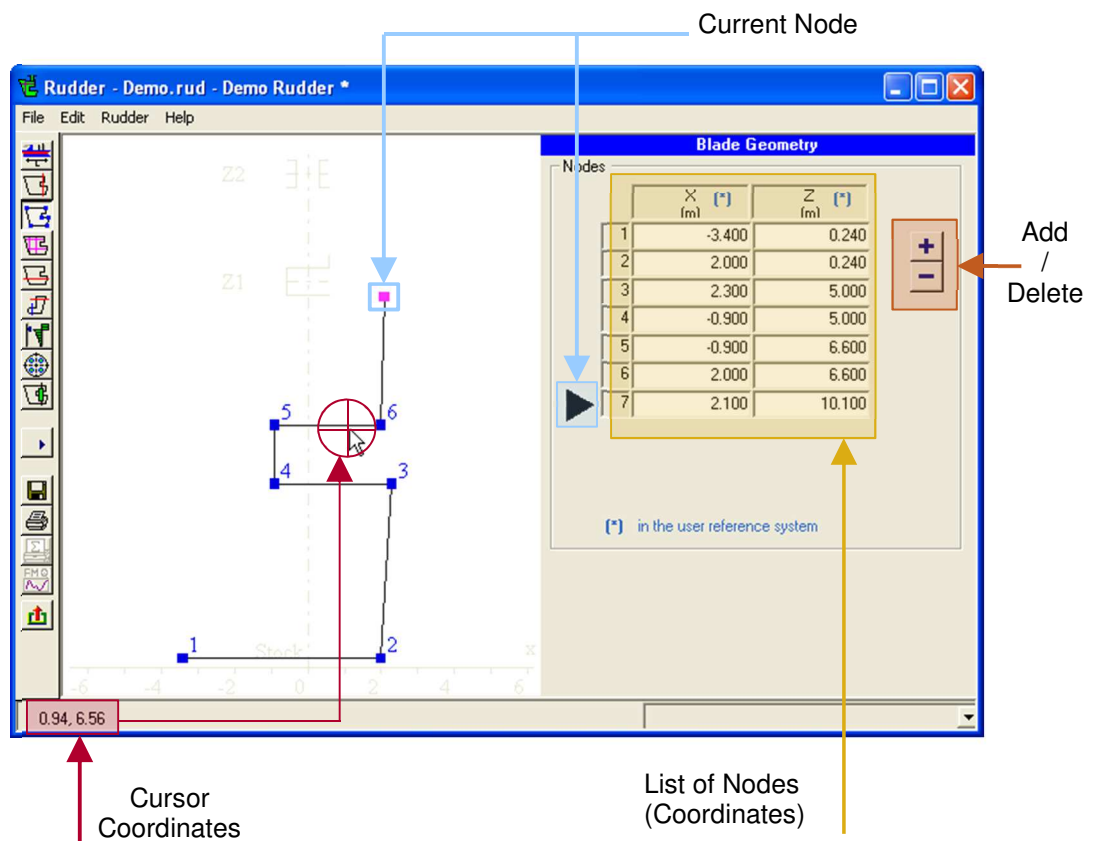
coupling length, has to be input (see Part 4.8.2 “Cone Coupling”).



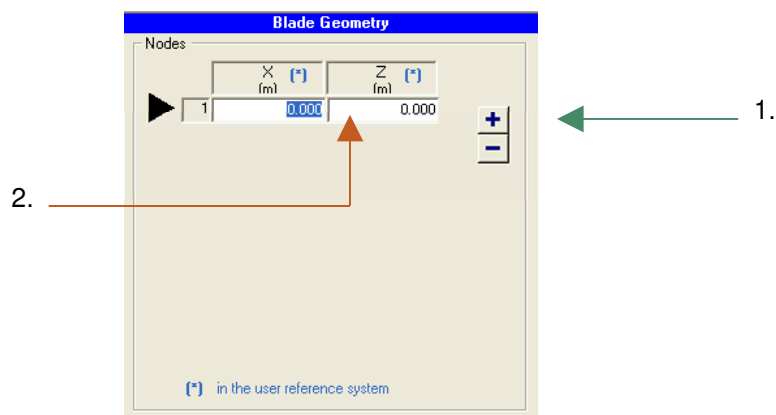
- Note: The related viewing is empty if no Blade Geometry has been entered yet, but displays the transverse section of the rudder if the geometry of the blade is already input (see Part 4.3 “Blade Geometry”).



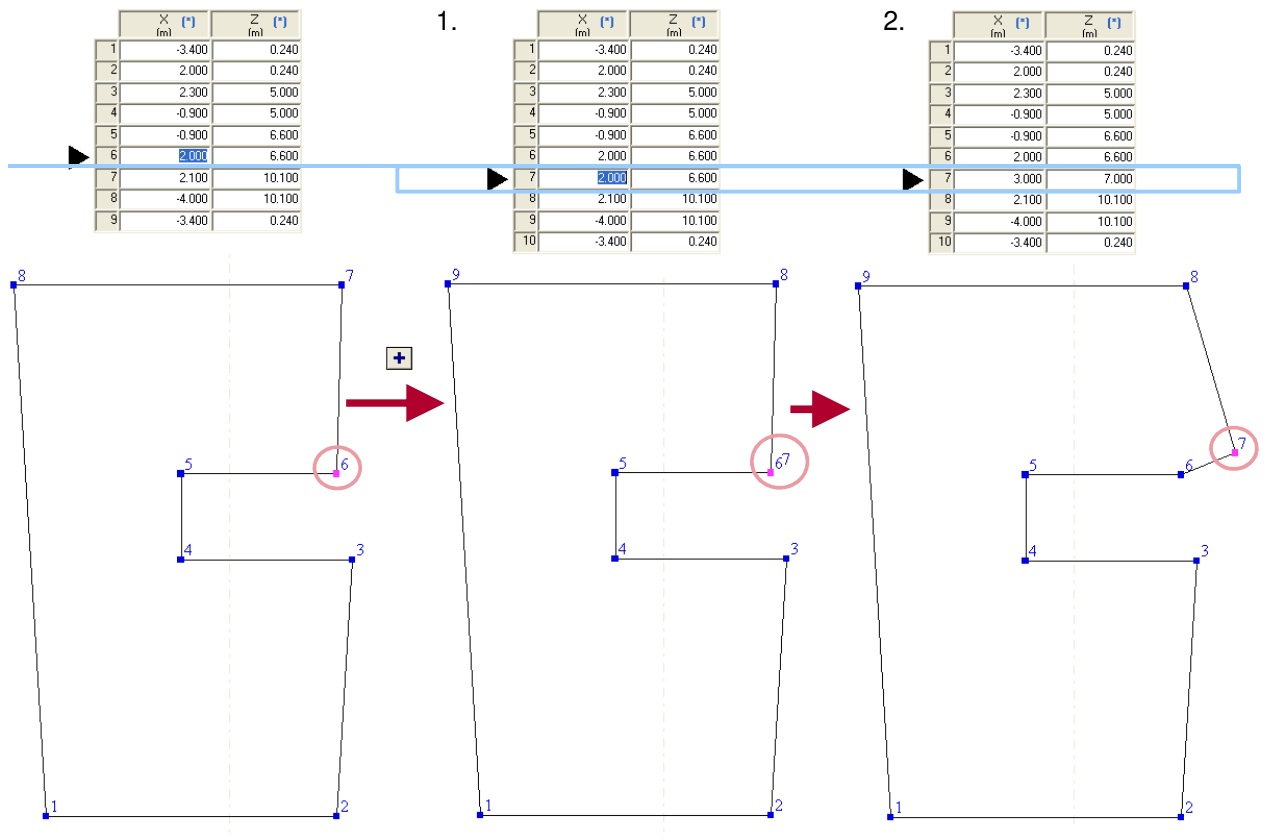
4.3. Blade Geometry



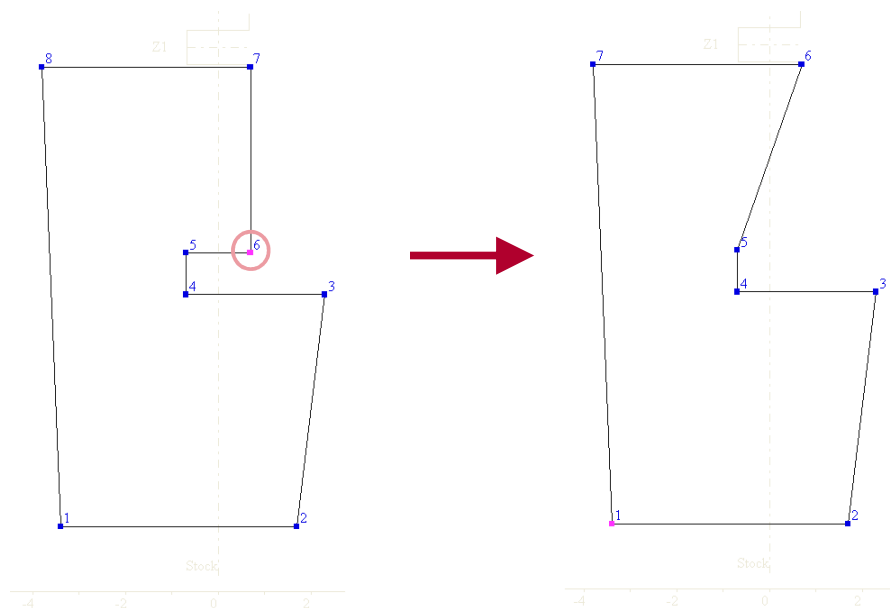
- This section allows defining the Rudder Blade geometry in the main elevation view.
- By clicking on the “Add” (+) button, a new line appears to enter the coordinates of the following node.



The new node will be added after the current one (if there is at least one node)

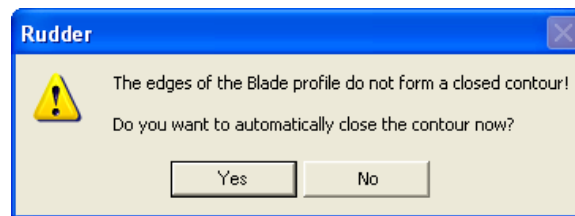


- It is possible to modify the coordinates of an existing node.
- By clicking on the “Delete” (-) button, the selected node of the list is deleted.

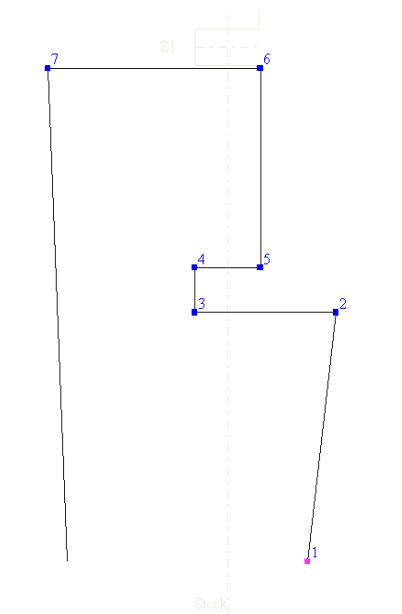


► Notes:

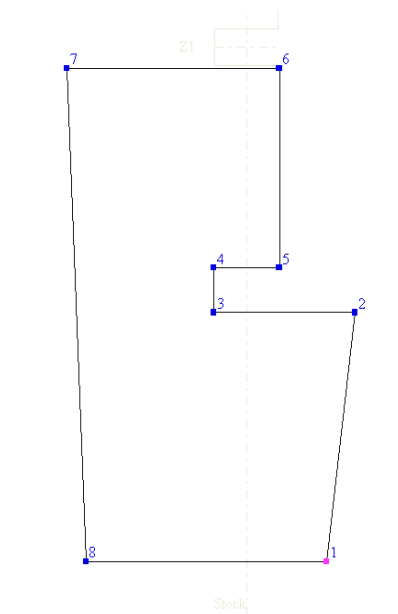
- The order in which the nodes are input, following a clockwise or a counter-clockwise definition, have no effect on the scantling results.
- The frame of reference is chosen by the user: the coordinates entered need only to be coherent with the coordinates of the stock axis entered in the “Rudder Stock Data” section (see part 4.2)
- The material of the Rudder Blade is input in the “Stiffening and Reinforcement” section (see part 4.4)
- No calculation will be allowed if the blade profile is let with less than 3 edge nodes.
- The software checks the closure of the blade profile contour previous to any calculation. If the encountered shape is open, the following warning will be displayed.



By clicking on the “Yes” button, RUDDER will automatically close the contour and proceed with the calculation.



Before computing (input)

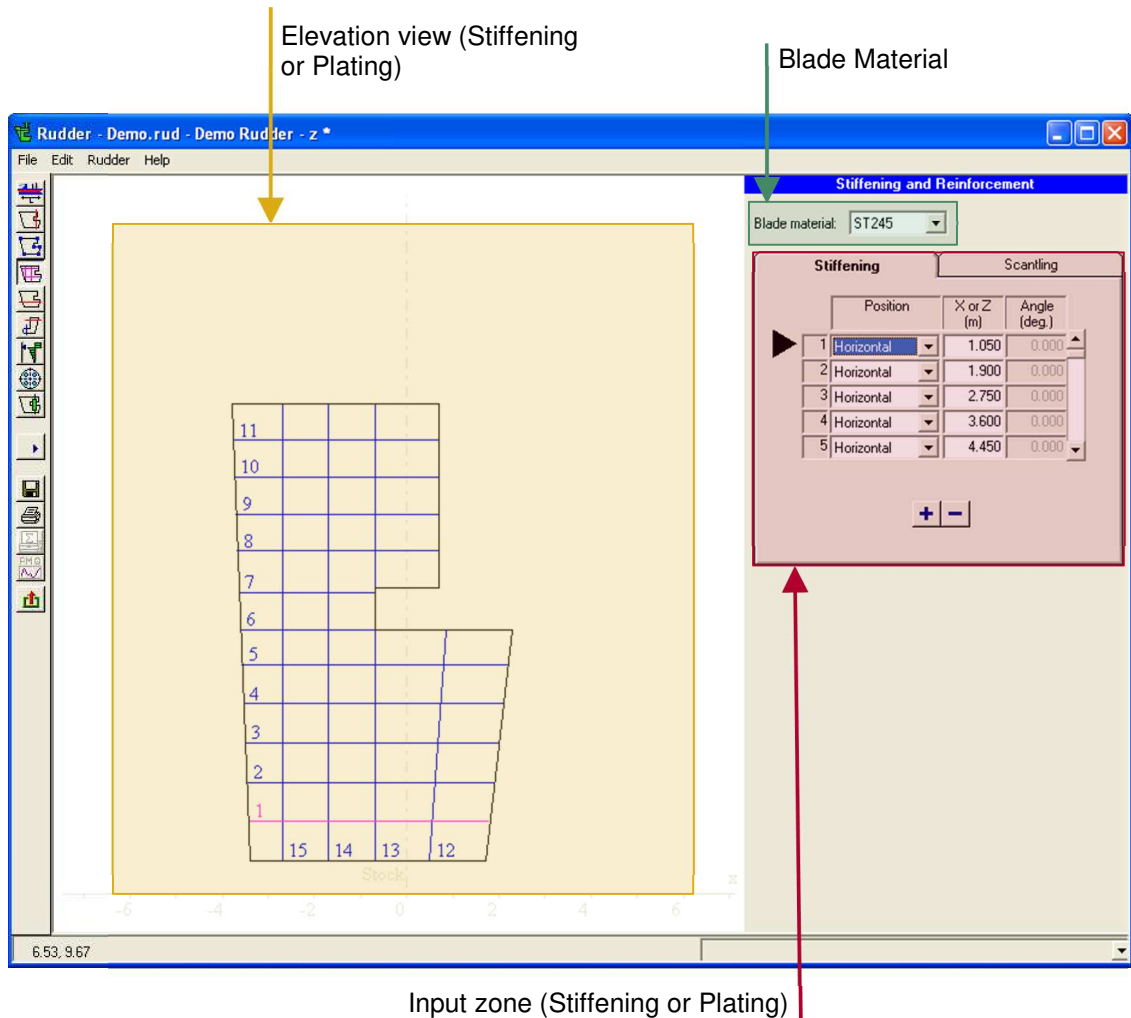


After computing

4.4. Stiffening and Reinforcement (Scantling)

There are 3 groups of data managed by this section:

- ▶ the Rudder Blade Material
- ▶ the definition of the Stiffening of the rudder blade
- ▶ the Scantling of the plates composing the rudder blade and their reinforcement



4.4.1. Rudder Blade Material

The material of the elements of the rudder blade is to be chosen among the list of the materials defined in the “General Data” section (see part 4.1.2).

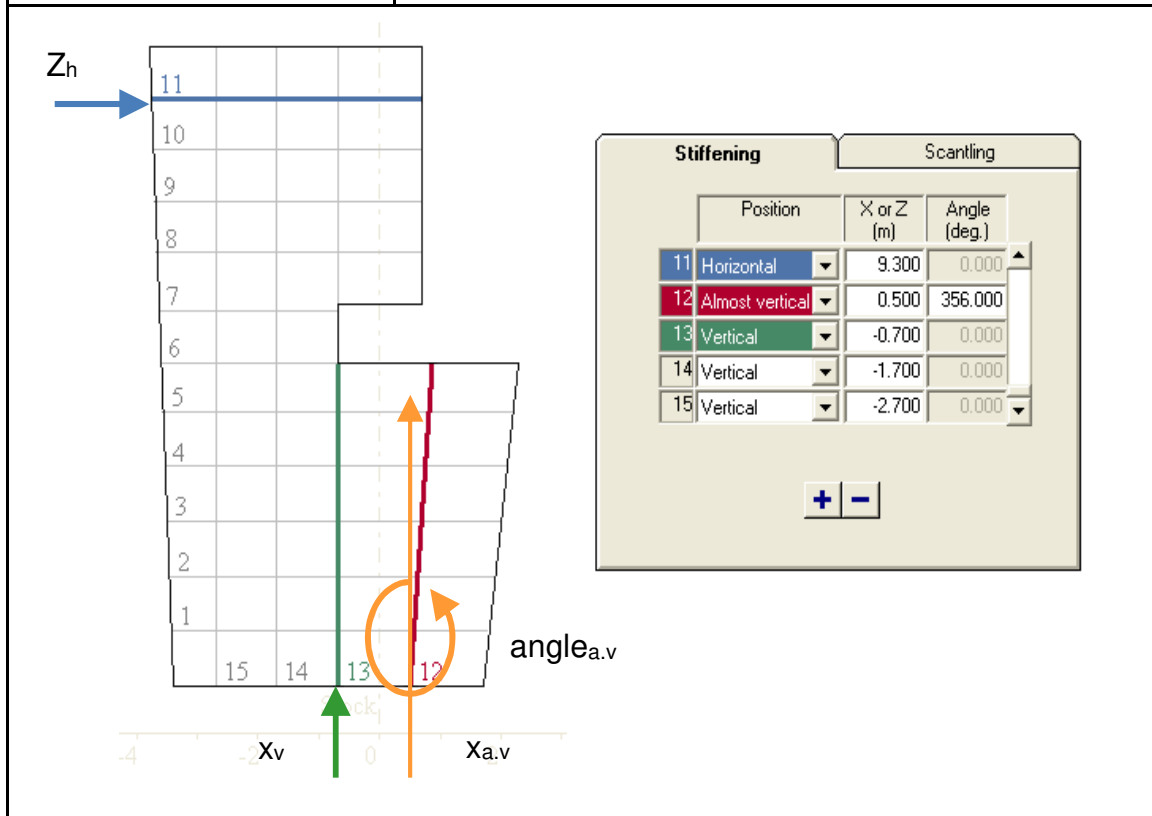
4.4.2. Rudder Blade Stiffening

The Stiffening tab is where to define the list of the stiffeners on the blade. Add as many stiffeners as needed with the Add “+” button.

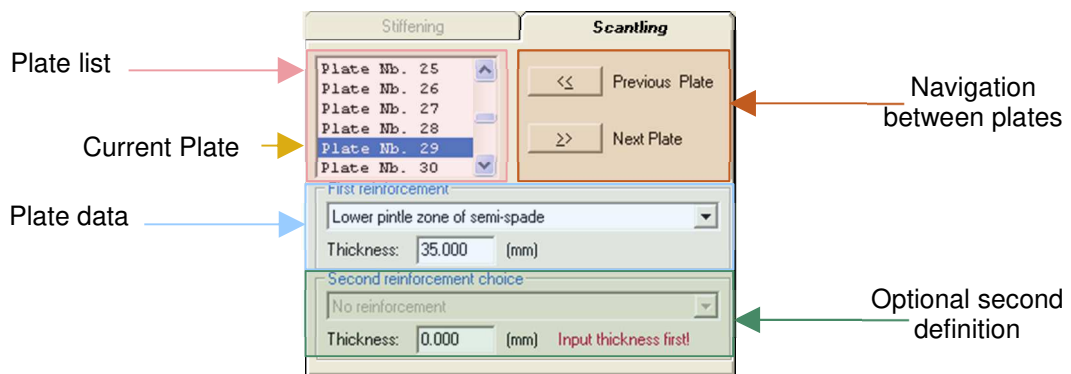
Once the stiffeners are defined it is always possible to delete any of them with the Delete “-” button, or to modify the input values if required.

The stiffeners are defined by their position. There are 3 possibilities:

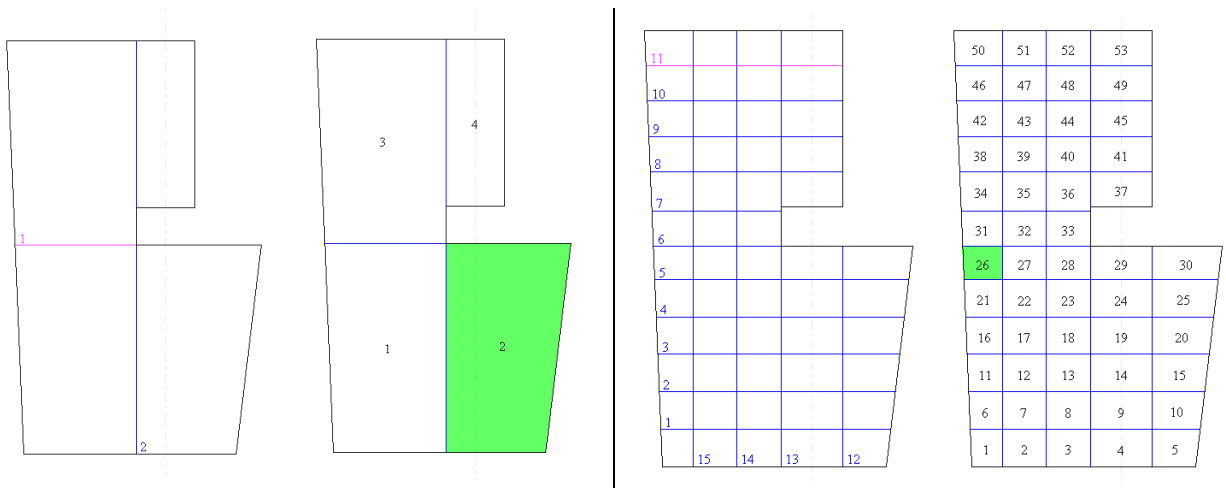
Stiffener type	Input
Horizontal stiffener	<ul style="list-style-type: none"> • z coordinate
Vertical stiffener	<ul style="list-style-type: none"> • x coordinate
Almost vertical stiffener	<ul style="list-style-type: none"> • x coordinate of intersection between the stiffener and the bottom edge of the blade • Angle between vertical axis and stiffener



4.4.3. Rudder Blade Scantling and Reinforcement



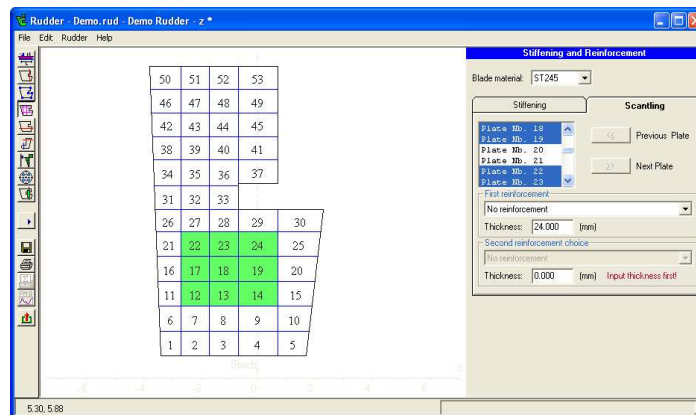
- The plates are automatically generated from the stiffening data. It is then necessary to define all stiffeners before the input of the plate data.



Automatically generated plates according to stiffeners definition

- For each plate (selection on view or in the list) or for each group of plates (selection in the list only) the following data is to be provided:
- The thickness of the plate
 - The reinforcement type. It is defined with respect of the area of the blade where the plate(s) is (are) located. The possible options are:

Rule reference of applied criteria ⇒		Steel Ships PtB Ch9 S1	Inland Vessels PtB Ch7 S1
1	No reinforcement	[7.3.1]	[6.2.1]
2	Lower pintle zone (semi-spade)	[7.3.6]	-
3	Rudder nose	[7.3.9]	[6.2.7]
4	Under the solid part /at boundary openings	[7.3.5] or [7.3.7] or [7.4.5] ⇒ T7	[6.2.5] or [6.3.5] ⇒ T4
5	Under the solid part /without openings		
6	Under the rudder coupling flange /at boundary openings	[7.3.5] ⇒ T7	[6.4.4] ⇒ T4
7	Under the rudder coupling flange /without openings		
8	Next to solid part linked to stock /at boundary openings	[7.4.4] horizontal webs & plating and [7.4.5] ⇒ T7 vertical webs	[6.3.4] horizontal webs & plating and [6.3.5] ⇒ T4 vertical webs
9	Next to solid part linked to stock /without openings		
10	Next to solid part linked to pintle /at boundary openings		
11	Next to solid part linked to pintle /without openings		
12	Main vertical web between upper part and pintle housing (semi-spade)	[7.3.7] main vertical web	-



- It is also possible to enter a second set of data with different values of plate thickness and reinforcement, if a plate belongs to several strakes (of different thickness) or if a comparison is needed between two alternative reinforcement zones.

In that case, the input of a non-null value of thickness allows choosing the reinforcement type and makes RUDDER consider this second optional calculation at computation time.

Second reinforcement choice

No reinforcement

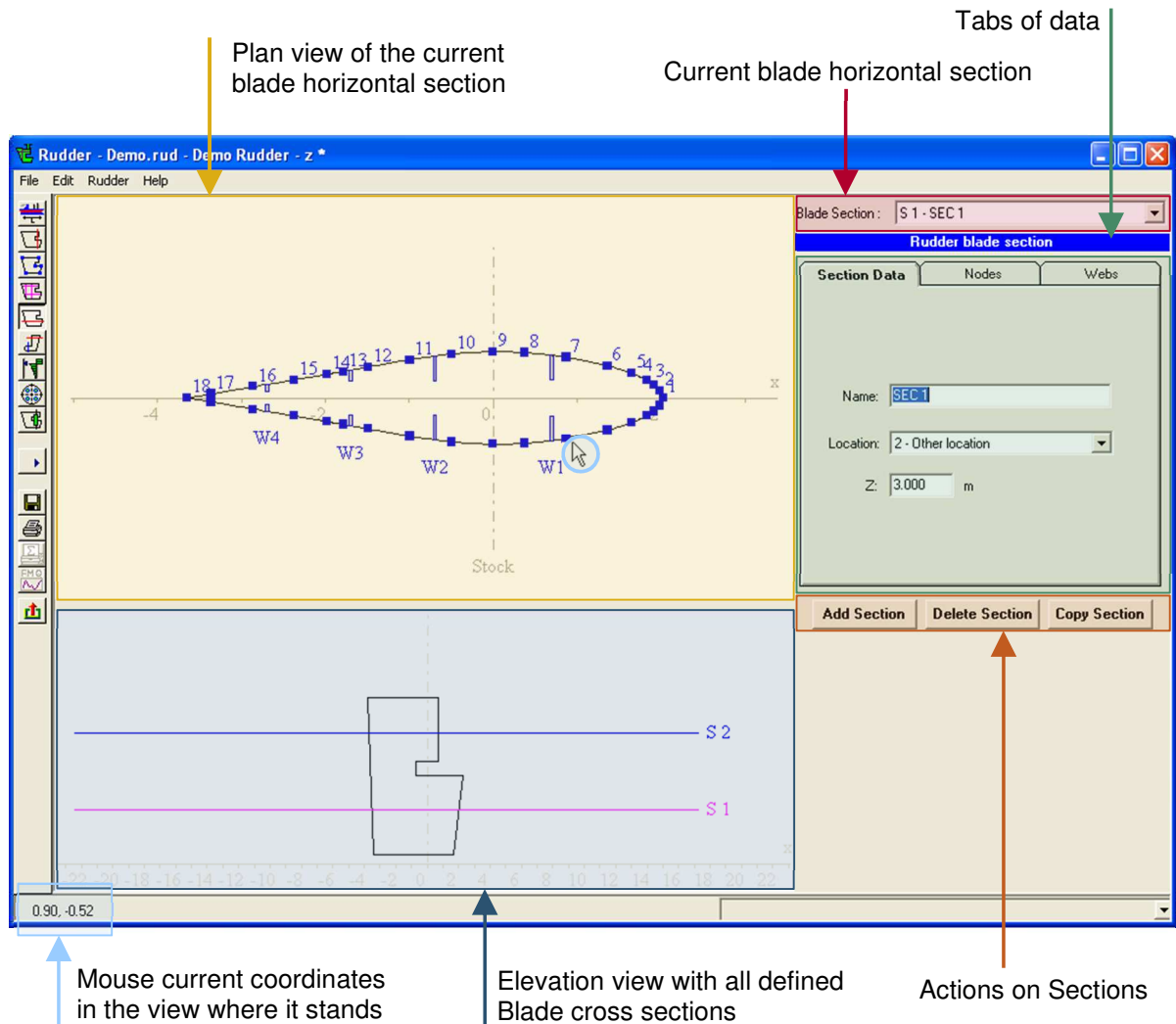
Thickness: 0.000 (mm) Input thickness first!

Second reinforcement choice

Under the solid part/without openings

Thickness: 30.000 (mm)

4.5. Rudder Blade Horizontal Sections



This part allows entering the definition of the rudder blade geometry in any plan required further in the calculations. This information is divided in 3:

- ▶ Plan definition (equivalent to blade [horizontal] sections)
- ▶ Nodes and thicknesses of the blade contour in a given plan (the selected horizontal cross section)
- ▶ Webs present in a given plan

4.5.1. Blade sections

- The first action is to add at least one section with the “Add Section” button.

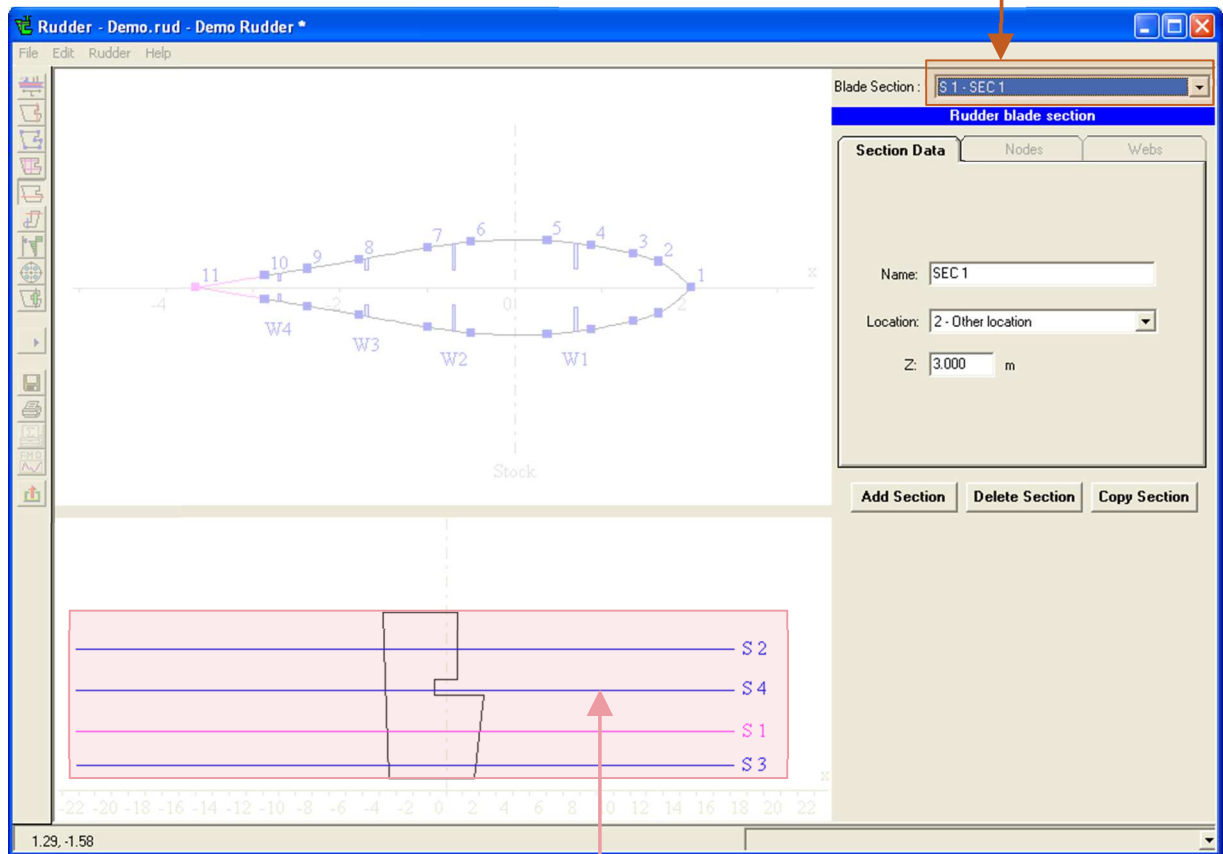
- For each added section, 3 elements characterize it:
 - The *Name*
 - The *Location*. It has no influence on the results but helps to identify the section. There are 2 or 3 possibilities:

Section around stock housing
In way of recess for rudder horn pintle
Other location

Only for assessment according to BV rules for Steel Ships and BV Rules for Yachts

- The *Z* coordinate of the plan being input: it is given in the reference frame chosen by the user (see part 4.2)
- For each added section, the blade geometry in the plan has to be defined by:
 - The nodes forming the contour (see part 4.5.2)
 - The webs inside the blade if any (see part 4.5.3)
- It is possible to:
 - Add as many horizontal sections as required (“Add Section” button)
 - Delete any section previously input (“Delete Section” button)
 - Copy any existing section (“Copy Section” button): the geometrical data (nodes and webs) of the copied section is transferred to a new section.
- To browse from one section to the other, in order to input/modify/see the associated data, there are 2 ways:
 - By selecting the proper section in the “Blade Section” list
 - By clicking directly on the corresponding cutting plane line in the elevation view

Browse through existing sections

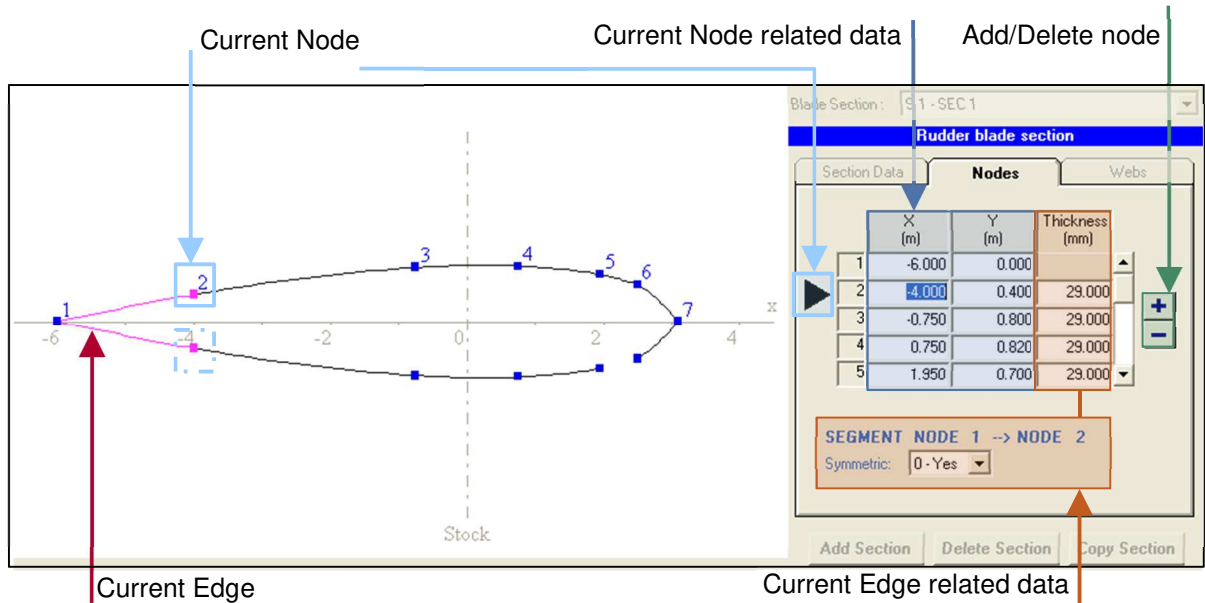


Click on cutting plane line to select another horizontal section

4.5.2. Nodes defining the section

This tab is for the input of the nodes forming the contour of the current horizontal blade section.

Sections are supposed to be symmetrical: only half the contour needs to be input.



- For each node, 4 inputs are asked:
 - The **X** coordinate of the node (in the frame of reference previously chosen)
 - The **Y** coordinate of the node

The current node and the previous node form an edge of the blade contour. This edge is characterized by 2 inputs that are associated with the current node:

- The **Thickness** of the -current- edge
- The **symmetric** information that is detailed below

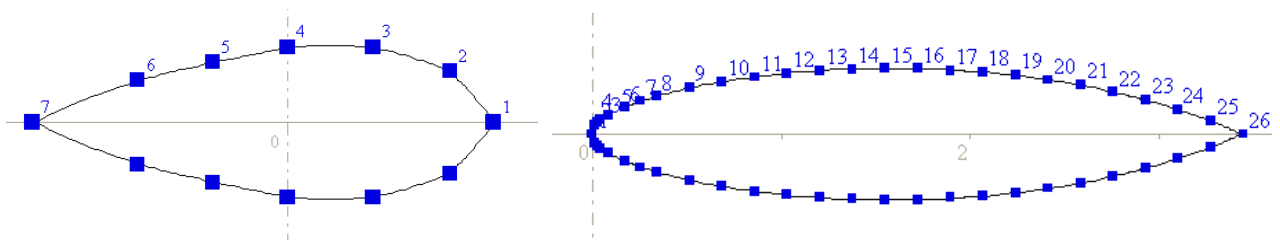
Note: Of course, the first node of the section is associated with no edge so the information linked to the segment is disabled.

- It is possible to add as many nodes as wanted with the Add “+” button. The added node is introduced just after the currently selected node. Once a node is added, it is always possible to modify the associated values. The current node can be deleted by clicking on the Delete “-” button.

- The number of nodes to input to define the contour depends on the degree of accuracy expected: The more points are defined, the more accurate is the contour but the greater the time spent for input.

Note: RUDDER calculates each edge as a quadratic curve between the 2 end nodes.

Note: The input order can be indistinctly from right to left or from left to right.

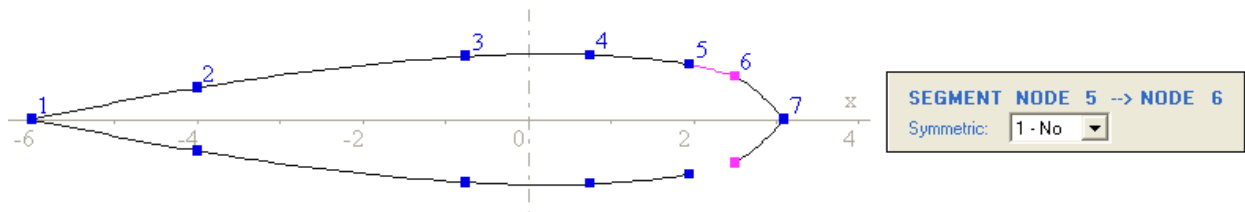


- The information labeled “Segment Node [n-1] → [n]” “Symmetric” gives

access to the choices:

0	Yes
1	No

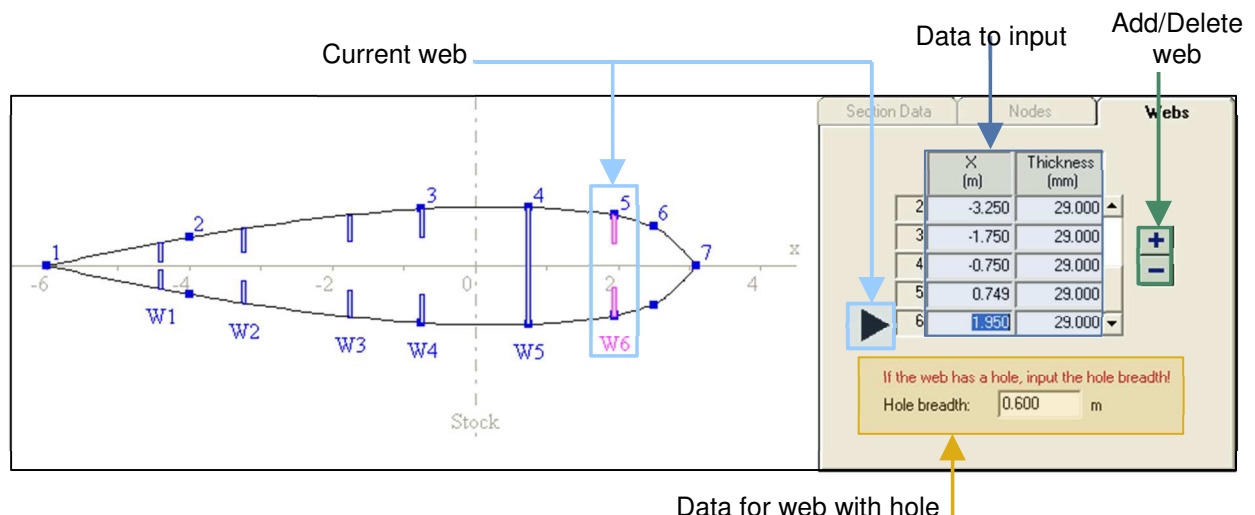
If the choice is “Yes”, RUDDER considers that the entered node and its associated edge have a symmetrical counterpart that will be automatically computed. If the choice is “No”, no node/edge counterpart is considered.



This data represents the existence of openings not closed by full penetration welded plate, as in the case of access to the rudder stock nut.

WARNING: CURRENTLY RUDDER DOES NOT HANDLE THE INPUT AND CALCULATION OF NON-SYMMETRICAL PROFILES.
PLEASE FOLLOW THE RELEASE OF FUTURE UPDATES ON THIS SUBJECT.

4.5.3. Webs present in the section



- For each web, the data to input is the following:
- The **X** coordinate of the web on plan (taken at mid-web)
 - The **thickness** of the web
 - The **hole breadth**, if the web has a central hole in the current horizontal section

Note: The Y coordinates of the web ends are computed automatically by RUDDER, as the intersection of the X line and the blade contour.

- It is possible to add or delete any number of webs and to modify the information associated with an existing web.

4.6. Horizontal Horn Section

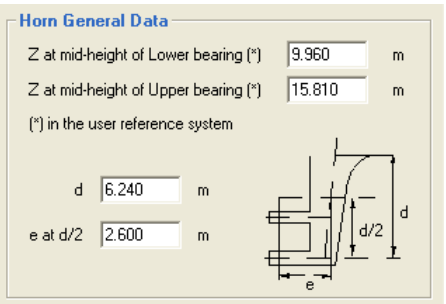
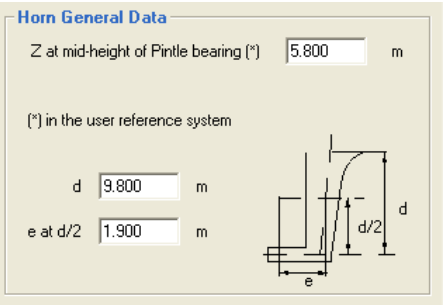
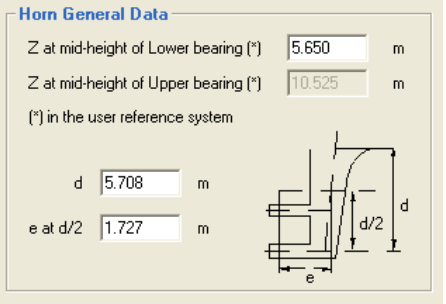
For Rudder systems having a horn, the information described in this part needs to be completed.

The screenshot displays the Rudder software interface with the following components and labels:

- Current Horn Section display:** Points to the plan view of the rudder horn in the main workspace, showing nodes 1 through 8 and a web labeled W1.
- Horn main data:** Points to the 'Horn General Data' panel on the right, which contains fields for:
 - Z at mid-height of Lower bearing (°): 5.650 m
 - Z at mid-height of Upper bearing (°): 10.525 m
 - (°) in the user reference system
 - d: 5.708 m
 - e at d/2: 1.727 m
- Horn Section list by names:** Points to the 'Horizontal horn section' panel, which shows a list of sections with 'S 1 - Section 1' selected.
- Horn Sections display (elevation):** Points to the elevation view at the bottom of the workspace, showing three sections labeled S 1, S 2, and S 3, with dimensions d=5.70 and e at d/2.
- Horn Section Management:** Points to the 'Add Section', 'Delete Section', and 'Copy Section' buttons at the bottom of the 'Section Data' panel.
- Current Horn Section Data:** Points to the 'Section Data' panel, which contains fields for:
 - Name: Section 1
 - Material: ST245
 - X origin of horn reference system: 0.000 m
 - Z location of section from the mid-height of lower bearing: 3.000 m

4.6.1. Horn General Data

The general Horn Data depends on the rudder type:

Rudder Type	Horn General Data
<p>Type 4:</p> <ul style="list-style-type: none"> Input the z coordinates of the 2 horn pintle bearings Input dimensions d and e at d/2 (according to figure) 	
<p>Type 7:</p> <ul style="list-style-type: none"> Input the z coordinate of the 1 horn pintle bearing Input dimensions d and e at d/2 (according to figure) 	
<p>Type 8, 9, 10:</p> <ul style="list-style-type: none"> Input the z coordinate of the lower horn bearing (pintle bearing) Input dimensions d and e at d/2 (according to figure) 	

4.6.2. Horn Sections

It is possible to input as many horizontal horn sections as requested or wanted. There are two ways of defining a horn section: by creating it from scratch (button "Add Section" ⇒ "Horizontal Horn Section") or by copying an already existing section (button "Copy Section").

WARNING: THE POSSIBILITY OF DEFINING VERTICAL HORN SECTION IS NOT AVAILABLE.

Each section will be characterized by:

- ▶ A set of general data
- ▶ A set of nodes describing the horn section contour (see 6.3)
- ▶ The set of webs present at the horn section level (see 6.4)

The image displays two screenshots of the 'Horizontal horn section' software interface. The left screenshot shows the 'Section Data' tab with fields for Name, Material, X origin of horn reference system, and Z location of section from the mid-height of lower bearing. The right screenshot shows the same interface with 'Section 1' selected, and the X origin set to 0.000 and Z location set to 3.000. Both screenshots show 'Add Section', 'Delete Section', and 'Copy Section' buttons at the bottom.

- ▶ The horn section main data are the following:
 - The *name* of the section, allowing to identify it
 - The *material* to be chosen among the list of materials defined in the “General Data”
 - The *X* coordinate of the *origin of the horn section reference system*: this reference system will be used to define Nodes and Webs coordinates
 - The *Z* coordinate, *location of the horn section from the mid-height of the lower bearing* of the horn. This will identify the position of the section along the horn.

4.6.3. Nodes defining the section

The horn section will be defined as a thin shell model with nodes and related thicknesses.

- ▶ The input of one node will automatically define the symmetric node regarding Ox axis.
- ▶ The contour between nodes will be deduced by curvilinear interpolation.
- ▶ The node coordinates are to be given with regard of the *X* origin defined in the main horn section data (*Y* origin being same as rudder reference system).
- ▶ The *thickness* associated to one node applies between the node and the previous one.
- ▶ Buttons “+” and “-” allow adding and deleting nodes. The adding will insert a new node after the current selected node. The Deleting will remove the currently selected node.

Note: The contour described by the nodes must follow the neutral axis of the horn thickness.

Click on nodes above Ox axis to select one

Currently selected

Horizontal horn section

Horn Section: S1 - S1-7690

	X (m)	Y (m)	Thickness (mm)
4	2.159	0.244	140.000
5	1.675	0.371	140.000
6	1.181	0.452	140.000
7	0.850	0.483	140.000
8	0.710	0.483	140.000

(*) in the horn reference system

Add Section Delete Section Copy Section

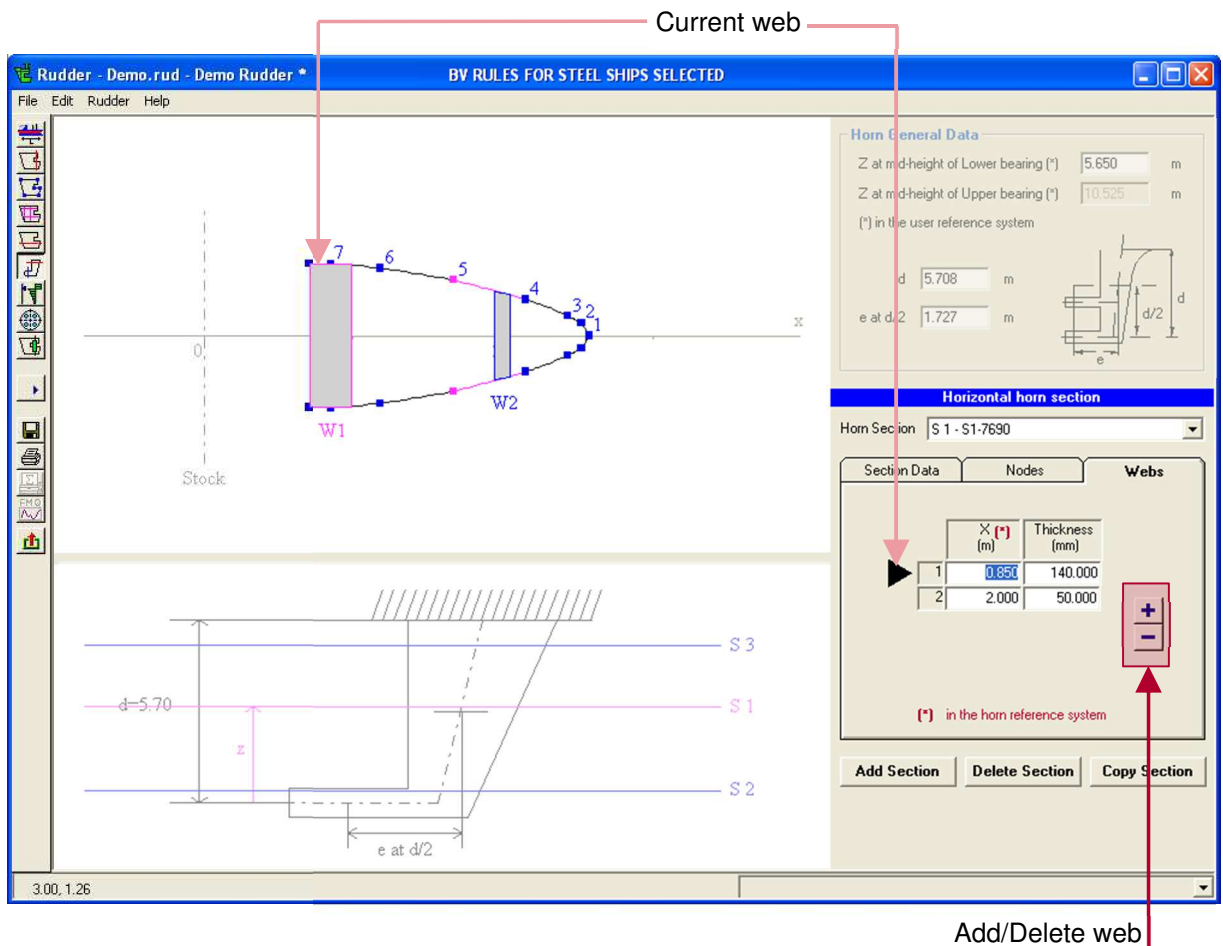
Currently selected horn section

Click on any value to change current node and modify value if necessary

Add/Delete node

4.6.4. Webs present in the section

- ▶ Internal webs are input by two values:
 - The **X** coordinate at mid-web with respect of the horn origin
 - The **thickness** of the web
- ▶ Manage the addition or deletion of webs with buttons “+” and “-”.



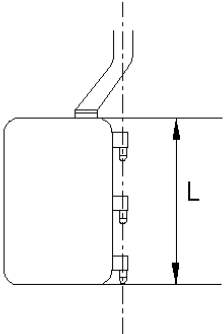
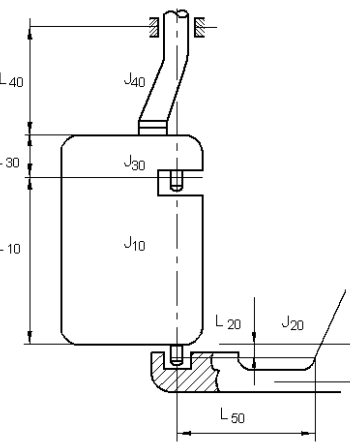
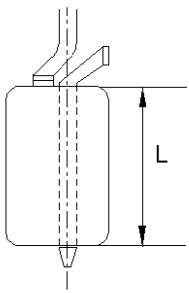
4.7. Data for Direct Calculation

The input of the Direct Calculation (DC) data is crucial for the correct assessment of the Rudder.

As some lengths are determined automatically by the RUDDER software, it is mandatory to correctly input stock and blade geometry data (see respectively Part 4.2 and Part 4.3 previous to the input of the DC information).

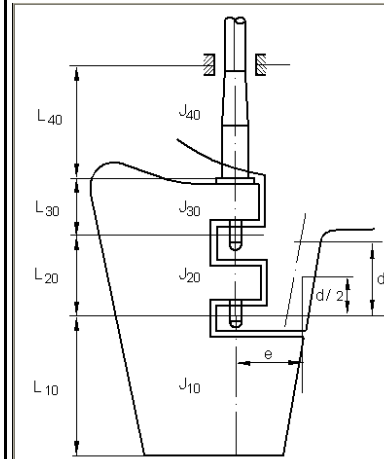
It is also highly recommended to input sections information for blade and horn (if present) to help in the definition of the DC related inertias (see below).

The following table summarizes the data that need to be input for each rudder type:

Rudder Type	DC Data Display
<p>Type 1:</p> <p>No input</p>	<div data-bbox="782 250 1165 736">  </div> <div data-bbox="1165 250 1489 736"> <p>Data for Direct calculation</p> <p>The rudder structure is to be calculated according to the approximate formulae given here below:</p> $M_b = 0$ $F_{a_1} = F_{a_2} = F_{a_3} = C_R / 3$ $F_{a_4} = 0$ </div>
<p>Type 2:</p> <ul style="list-style-type: none"> • Solepiece and solepiece pintle related lengths and inertias are to be input • Other lengths are automatically evaluated • Inertias J10 and J30 can be linked to blade sections • Inertia J40 can be linked to the diameter at the level of the rudder stock bearing 	<div data-bbox="782 754 1165 1211">  </div> <div data-bbox="1165 754 1489 1211"> <p>Data for Direct calculation</p> <p>Solepiece</p> <p>L50 <input type="text" value="1.500"/> m J50 <input type="text" value="5.071"/> cm⁴</p> <p>Beam 1 (Pintle)</p> <p>L20 <input type="text" value="0.190"/> m J20 <input type="text" value="5.153"/> cm⁴</p> <p>Beam 2</p> <p>L10 <input type="text" value="2.250"/> m J10 <input type="text" value="70.192"/> cm⁴</p> <p>Beam 3</p> <p>L30 <input type="text" value="1.000"/> m J30 <input type="text" value="70.192"/> cm⁴</p> <p>Beam 4</p> <p>L40 <input type="text" value="0.339"/> m J40 <input type="text" value="15.295"/> cm⁴</p> </div>
<p>Type 3:</p> <p>No Input</p>	<div data-bbox="782 1229 1165 1686">  </div> <div data-bbox="1165 1229 1489 1686"> <p>Data for Direct calculation</p> <p>The rudder structure is to be calculated according to the approximate formulae given here below:</p> $M_b = 0$ $F_{a_1} = F_{a_2} = C_R / 2$ $F_{a_3} = 0$ </div>

Type 4:

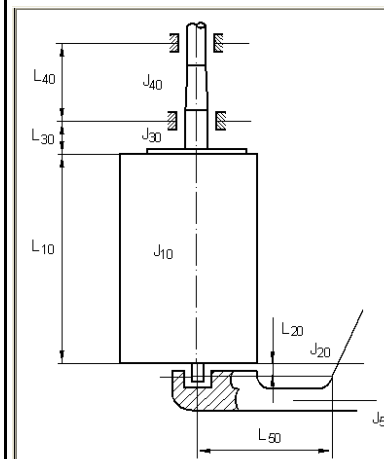
- Lengths are automatically evaluated
- Inertia J40 can be linked to the diameter at the level of the stock bearing
- Other inertias definition can be linked to blade sections
- Spring for one elastic support can be linked to horn sections (inertia)



Data for Direct calculation			
Beam 1			
L10	5.800 m	J10	3 705 854 cm ⁴
Beam 2			
L20	5.000 m	J20	3 705 854 cm ⁴
Beam 3			
L30	2.150 m	J30	3 705 854 cm ⁴
Beam 4			
L40	5.550 m	J40	1 125 626 cm ⁴
Horn			
Spring	138 944 500 N/m		

Type 5:

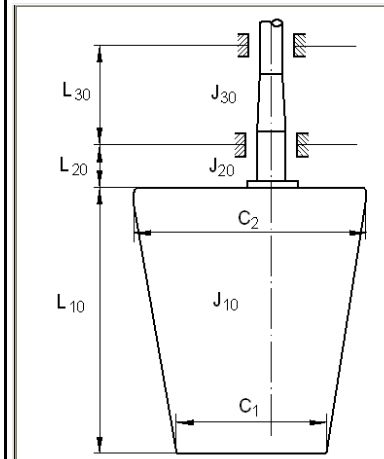
- Solepiece and solepiece pintle related lengths and inertias are to be input
- Other lengths are automatically evaluated
- Inertia J10 can be linked to blade sections
- Inertias J30 and J40 can be linked to the diameters at the level of the rudder stock bearings



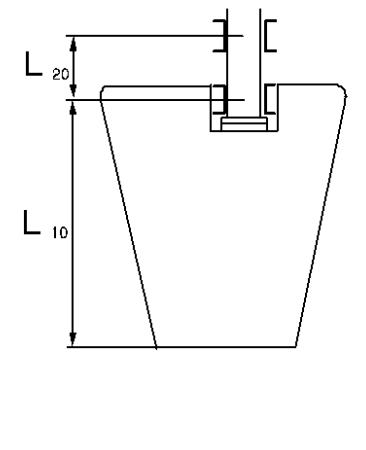
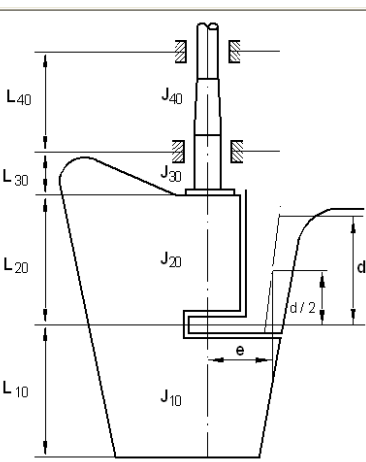
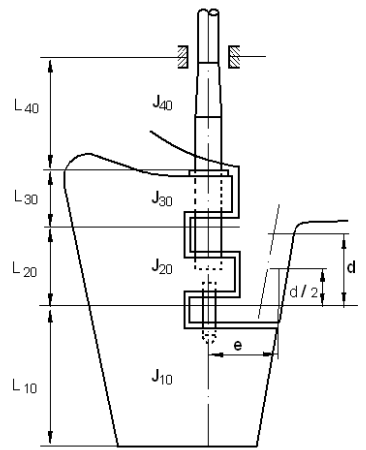
Data for Direct calculation			
Solepiece			
L50	0.800 m	J50	1 577 cm ⁴
Beam 1 (Pintle)			
L20	0.140 m	J20	531 cm ⁴
Beam 2			
L10	1.545 m	J10	46 cm ⁴
Beam 3			
L30	0.475 m	J30	531 cm ⁴
Beam 4			
L40	0.280 m	J40	531 cm ⁴

Type 6:

- Lengths are automatically evaluated
- Lengths C1 and C2 are to be input
- Inertias J20 and J30 definition can be linked to the diameters at the level of the rudder stock bearings

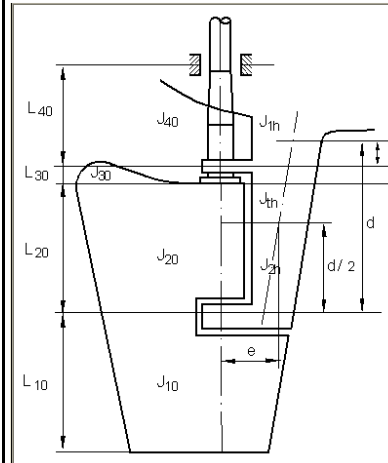


Data for Direct calculation			
Beam 1			
L10	2.886 m		
C1	1.874 m	C2	2.699 m
Beam 2			
L20	0.364 m	J20	306 796 cm ⁴
Beam 3			
L30	1.350 m	J30	54 765 cm ⁴

<p>Type 6 bis:</p> <p>No Input (Lengths automatically evaluated)</p>	 <div data-bbox="1181 168 1492 616"> <p>Data for Direct calculation</p> <p>Beam 1 L10 7.360 m</p> <p>Beam 2 L20 9.699 m</p> </div>
<p>Type 7:</p> <ul style="list-style-type: none"> Lengths are automatically evaluated Inertias J30 and J40 can be linked to the diameter at the level of the stock bearings Other inertias definition can be linked to blade sections Spring for one elastic support can be linked to horn sections (inertia) 	 <div data-bbox="1181 638 1492 1097"> <p>Data for Direct calculation</p> <p>Beam 1 L10 4.088 m J10 1 822 427 cm⁴</p> <p>Beam 2 L20 4.112 m J20 1 413 039 cm⁴</p> <p>Beam 3 L30 1.845 m J30 183 984 cm⁴</p> <p>Beam 4 L40 2.397 m J40 102 354 cm⁴</p> <p>Horn Spring 214 299 700 N/m</p> </div>
<p>Type 8:</p> <ul style="list-style-type: none"> Lengths are automatically evaluated Inertia J40 can be linked to the diameter at the level of the upper rudder stock bearing Other inertias definition can be linked to blade sections Spring for one elastic support can be linked to horn sections (inertia) 	 <div data-bbox="1181 1131 1492 1579"> <p>Data for Direct calculation</p> <p>Beam 1 L10 7.462 m J10 3 511 038 cm⁴</p> <p>Beam 2 L20 5.130 m J20 5 363 223 cm⁴</p> <p>Beam 3 L30 0.118 m J30 5 363 223 cm⁴</p> <p>Beam 4 L40 6.855 m J40 876 241 cm⁴</p> <p>Horn Spring 962 823 200 N/m</p> </div>

Type 9:

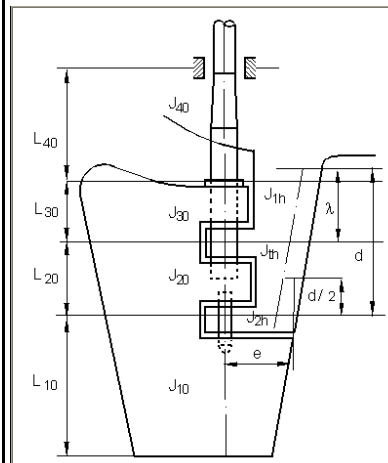
- Lengths are automatically evaluated
- Inertias J30 and J40 can be linked to the diameter at the level of the stock bearings
- Other inertias definition can be linked to respective blade sections or horn sections



Data for Direct calculation			
Beam 1			
L10	5.800 m	J10	3 007 087 cm ⁴
Beam 2			
L20	7.150 m	J20	4 831 403 cm ⁴
Beam 3			
L30	2.650 m	J30	1 125 626 cm ⁴
Beam 4			
L40	2.900 m	J40	1 125 626 cm ⁴
Horn			
Inertia J1h		10 113 930 cm ⁴	
Inertia J2h		10 113 930 cm ⁴	
Torsional stiffness factor Jth		35 646 600 cm ⁴	
$J_{th} = 4 F_T^2 / \sum (u_i / \theta_i)$			

Type 10:

- Lengths are automatically evaluated
- Inertia J40 can be linked to the diameter at the level of the upper rudder stock bearing
- Other inertias definition can be linked to respective blade sections or horn sections



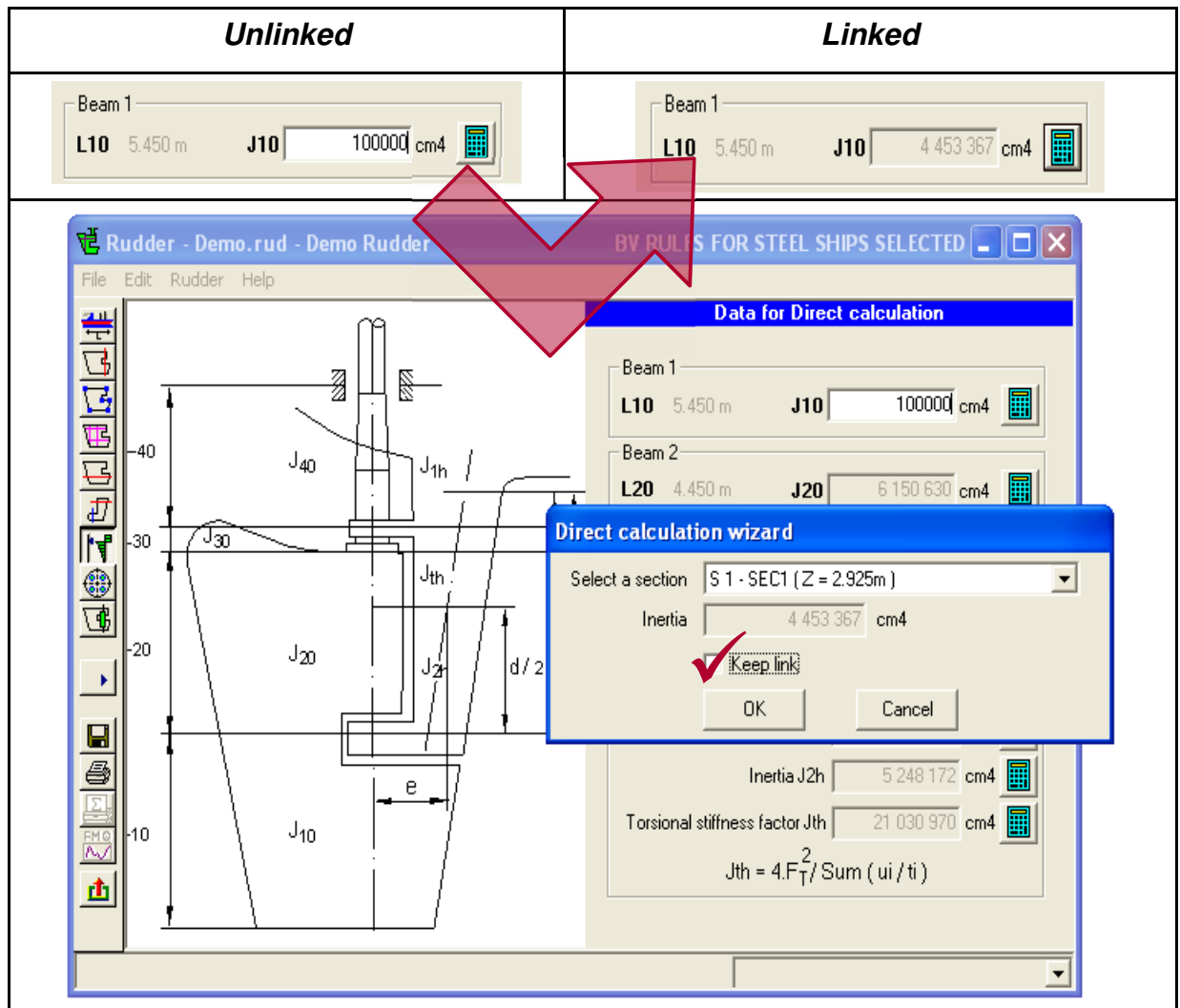
Data for Direct calculation			
Beam 1			
L10	7.462 m	J10	3 511 038 cm ⁴
Beam 2			
L20	5.130 m	J20	5 363 223 cm ⁴
Beam 3			
L30	0.118 m	J30	5 363 223 cm ⁴
Beam 4			
L40	6.855 m	J40	876 241 cm ⁴
Horn			
Inertia J1h		26 193 520 cm ⁴	
Inertia J2h		26 193 520 cm ⁴	
Torsional stiffness factor Jth		65 366 190 cm ⁴	
$J_{th} = 4 F_T^2 / \sum (u_i / \theta_i)$			

Any inertia can directly be input by the user or be automatically calculated by the software based on the selection of a previously defined section.

The automatic calculation is launched by accessing the “Wizard” button (button on the right side of the inertia input). Depending on the nature of each individual girder in the rudder system or beam, the content reached by clicking on the “Wizard” button associated to each beam’s inertia will be slightly different. The common principle is that, each time, the inertia will have to be defined as linked or not. Default choice is unlinked.

The “Link” defines how this automatic calculation will be performed.

If the “Keep Link” option is checked this means that the inertia will be re-computed each time and that the value will follow any change done in the section's geometry. A direct modification of the DC inertia value is not allowed. On the other hand, if the Wizard is used to get a section's inertia and the “Keep link” option is not checked, the section's inertia will be transferred to the corresponding DC data but as punctual action in time: no ulterior change in the section's geometry will be taken into account and a direct modification of the DC inertia value remains possible.



Inertia Wizard input will have the following aspect:

Beam/Girder type	Wizard Display
Inertia of a cylindrical part of the stock	
Blade inertia or Horn inertia	

Solepiece pintle inertia	<div> Direct calculation wizard </div> <div> Diameter : <input type="text" value="0.102"/> m Inertia <input type="text" value="531"/> cm4 </div> <div> <input type="button" value="OK"/> <input type="button" value="Cancel"/> </div>
+ Horn spring (one elastic support, calculation through inertia deduced from selected rudder horn section)	<div> Direct calculation wizard </div> <div> Select a section <input type="text" value="S 1 - middle height (z = 2.600m)"/> Spring <input type="text" value="1017 991 000"/> N/m <input checked="" type="checkbox"/> Keep link </div> <div> <input type="button" value="OK"/> <input type="button" value="Cancel"/> </div>

Finally, if a problem had occurred while inputting some geometrical value used for any of the automatically evaluated lengths, problem leading to a negative length value: the wrong length value will appear in red. Therefore if any of the length value is displayed in red, you must check the input of the geometry of the rudder (z coordinate of stock bearings, blade contour or z coordinate of horn pintles/bearings if exist).

Beam 1	L10	5.450 m	J10	<input type="text" value="4 453 367"/> cm4	
Beam 2	L20	4.450 m	J20	<input type="text" value="6 150 630"/> cm4	
Beam 3	L30	-7.100 m	J30	<input type="text" value="725 332"/> cm4	
Beam 4	L40	10.467 m	J40	<input type="text" value="749 014"/> cm4	

4.8. Rudder Stock Coupling

According to the “Stock Coupling” type defined in the “Rudder” tab of the General Data (see Part 4.1.3), the Stock Coupling data to input varies:

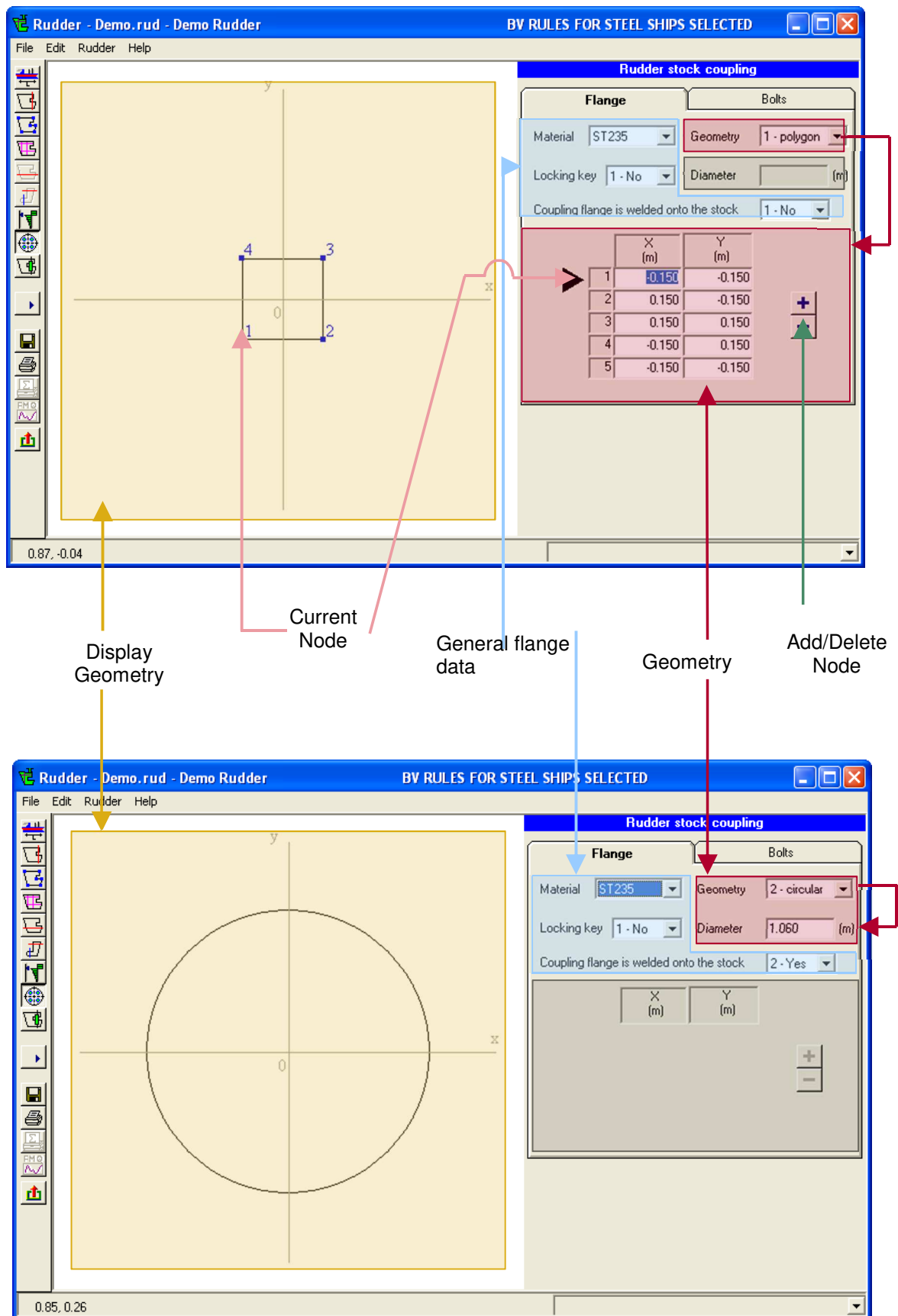
<i>Stock coupling type</i>		<i>For Input see...</i>
1	Horizontal Flange coupling	8.1. Flange Coupling
2	Cone Coupling	8.2. Cone Coupling
3	Vertical Flange coupling	- no input -
4	Continuous rudder stock	- no input -

WARNING: CURRENTLY RUDDER DOES NOT PROVIDE ANY REQUIREMENT CHECK FOR VERTICAL FLANGE COUPLINGS OR CONTINUOUS RUDDER STOCK.

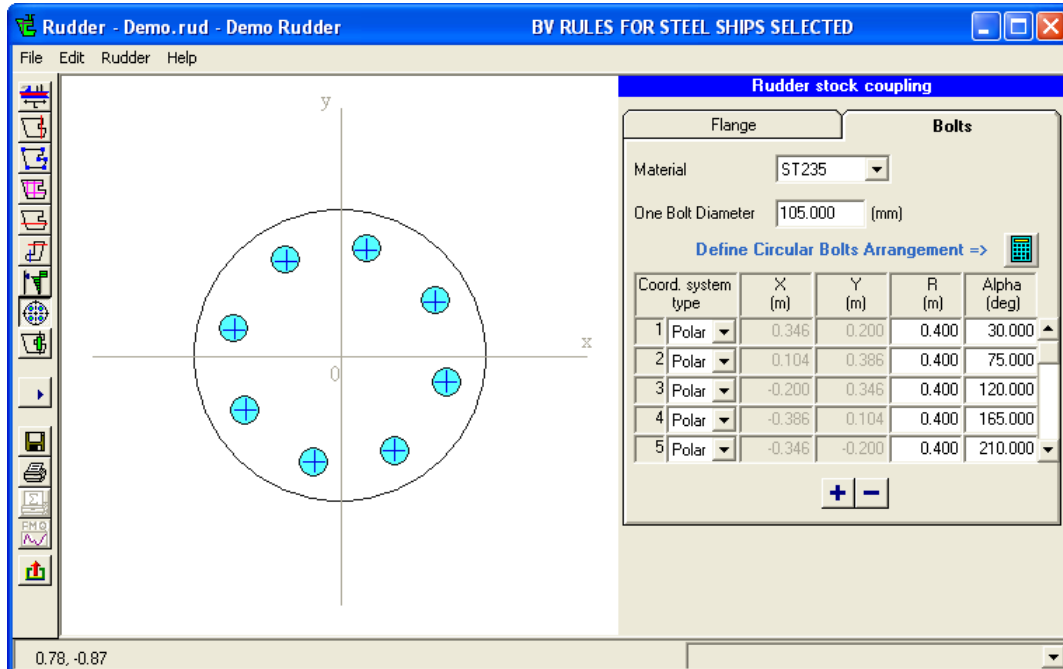
4.8.1. *Flange Coupling*

- ▶ The data to input for Flange Coupling can be divided into 3 categories:
 - General data
 - Geometry data
 - Bolts related data
- ▶ The elements of the general data category are the following:
 - The *material* of the flange, to be chosen among the user defined materials
 - The existence or not of a *locking key*
 - The fact that the *coupling flange is welded onto the stock* or not
- ▶ There are 2 types of *Geometry*, the choice of which changes the way the data input is to be made:

<i>Geometry</i>		<i>Input</i>
1	Polygonal	Nodes describing the shape of the flange
2	Circular	Diameter of the flange



- The Bolts related information to input is the following:
- The *material* of the bolts, to be chosen among the user defined materials
 - The diameter of the bolts (*one bolt diameter*), supposing that they have the same diameter (if this is not the case input the smallest diameter)
 - The position of each bolt on the flange

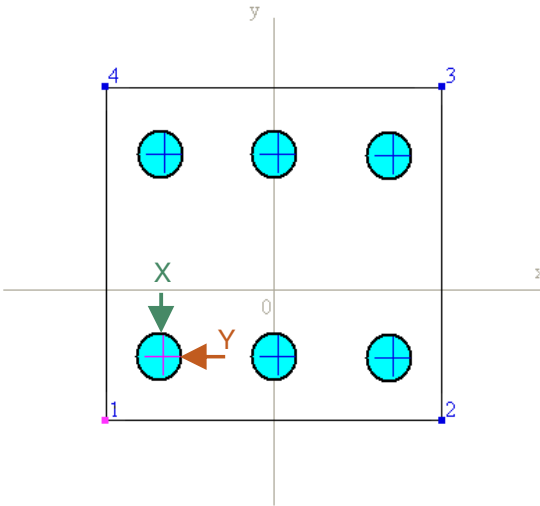
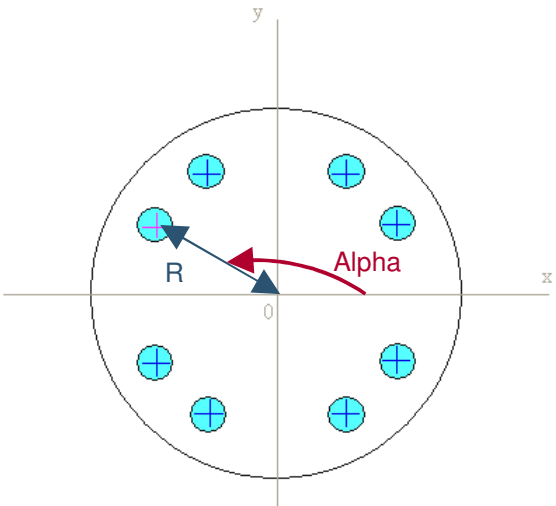


Depending on the actual bolt configuration there is a preferential way among 3 available methods.

For bolts in a rectangular configuration the suggested method is to define for each bolt the coordinates X and Y (flange references) with the Coordinate system type "XY" (Cartesian coordinates).

For bolts defined along a circular pattern, for each bolt input the radius and the Alpha angle between the bolt and the "0x" axis with the Coordinate system type "Polar".

Cartesian input					Polar input				
Coord. system type	X (m)	Y (m)	R (m)	Alpha (deg)	Coord. system type	X (m)	Y (m)	R (m)	Alpha (deg)
1 XY	-0.115	-0.115	0.163	225.000	1 Polar	0.346	0.200	0.400	30.000
2 XY	0.000	-0.115	-0.115	90.000	2 Polar	0.200	0.346	0.400	60.000
3 XY	0.115	-0.115	0.163	315.000	3 Polar	-0.200	0.346	0.400	120.000
4 XY	-0.115	0.115	0.163	135.000	4 Polar	-0.346	0.200	0.400	150.000
5 XY	0.000	0.115	0.115	90.000	5 Polar	-0.346	-0.200	0.400	210.000

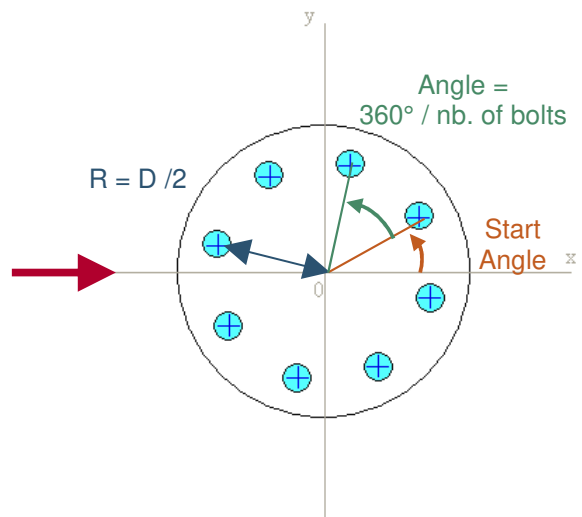
The third particular method is specific for bolts positioned along a circular pattern at equal interval. This method is accessible through the button pointed by the label “Define Circular Bolts Arrangement”. The following window will be displayed:

Circular Bolts Arrangement
✕

Number of bolts

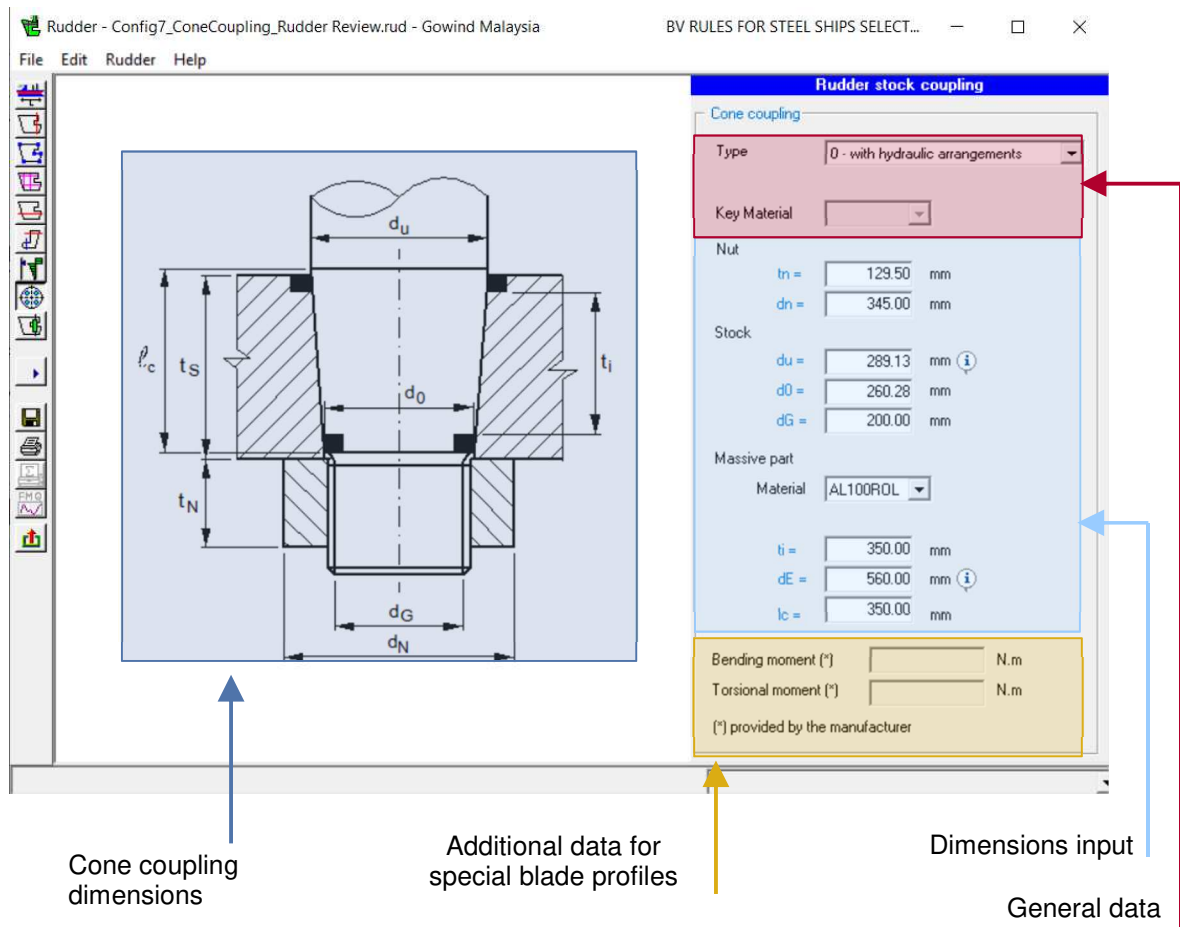
Start angle between the center of the first bolt and Ox axis (deg)

Bolts arrangement diameter (m)



By clicking on “OK”, as many bolts as the number of bolts will be added in the position listing, in polar coordinates, with angles and radius deduced from the input data. This action will also reset any previous input.

4.8.2. Cone Coupling



► The general data that need to be defined are:

- The *type* of the cone coupling:

0	With hydraulic arrangements
1	With key

- The choice of a *key material* is needed, in which case the list of user defined materials will be available.

► The following geometrical characteristics are to be input:

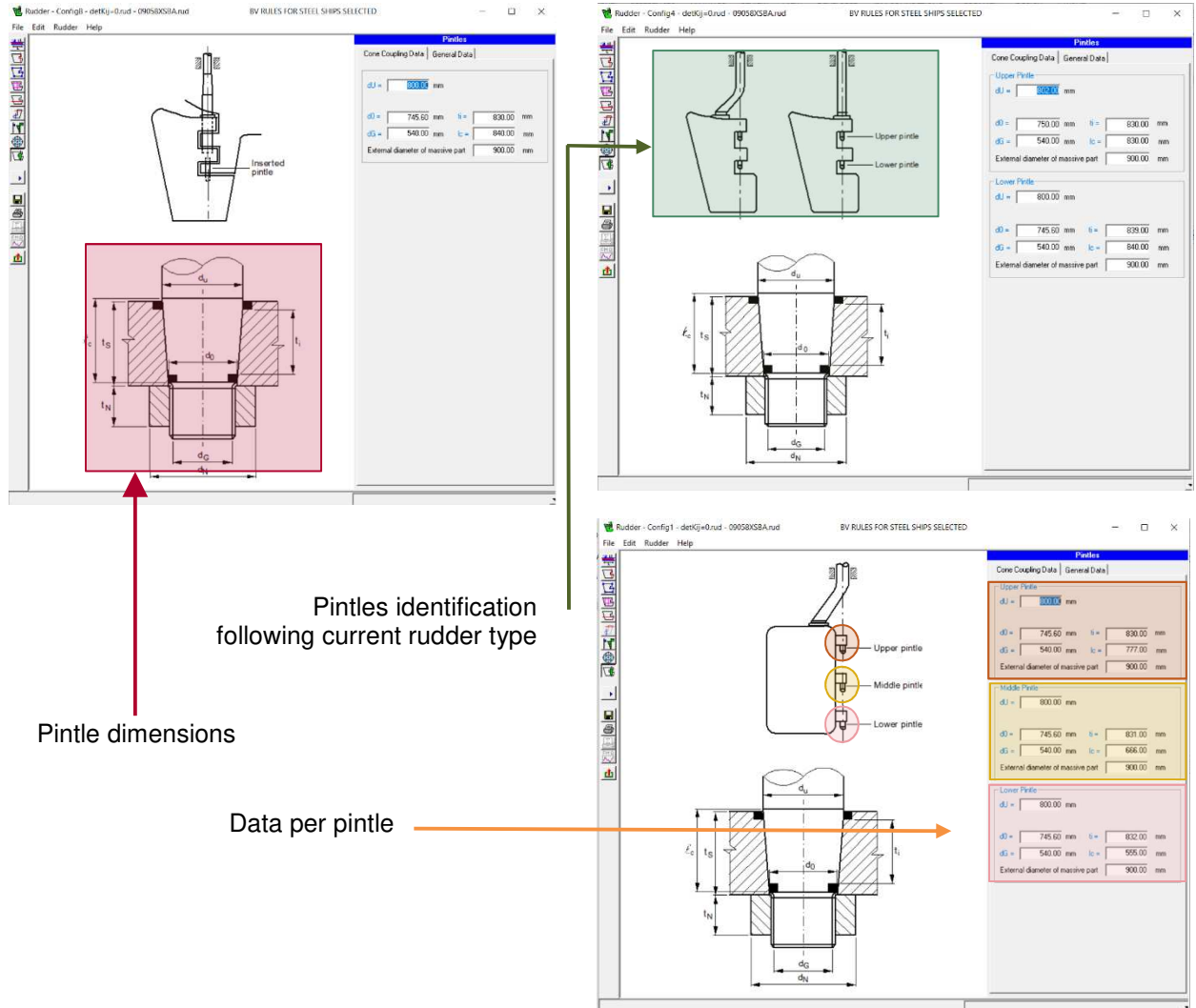
- t_N , d_N , dimensions of the nut
- d_U , stock diameter above cone coupling
- d_0 , smallest diameter of the cone
- d_G , core diameter of the threaded part
- The *material* of the massive part of the cone coupling, to be chosen among the user defined material list

- l_c , geometrical parameter of cone coupling (for BV RULES NR467, NR500 and NR217)
 - t_s , thickness / length of the cone housing (for CSR RULES for Bulk Carriers)
 - t_i , effective contact thickness of the cone housing, i.e. without sealing ring grooves and chamfers (for BV RULES NR467, NR500 and NR217)
 - d_E , external diameter of the massive part
- If the blade profile in the Rudder general data (see Part 4.1.3) has been defined of the types “High Lift” or “User defined”, the input of the *Bending moment* and the *Torsional moment* as provided by the manufacturer is required.

Bending moment (*)	<input type="text" value="0.00"/>	N.m
Torsional moment (*)	<input type="text" value="0.00"/>	N.m
(*) provided by the manufacturer		

4.9. Pintles data

There are as many pintle data sets as there are pintles in the rudder type selected. If several pintles exist, they are identified by their position: lower, middle, upper.



For each pintle the input is divided into two categories:

- ▶ Pintle general data (mostly materials)
- ▶ Pintle cone coupling data (geometrical dimensions)

4.9.1. Pintle general data

The general data associated to each pintle regroup:

- The pintle *material*, to be chosen among the user defined materials
- The pintle *bearing length*
- The *bearing material*, to be chosen among the specific material list
- The cone *coupling's massive part material*, to be chosen among the user defined materials

Pintles	
Cone Coupling Data	General Data
Upper Pintle	
Material	ST235
Bearing Length	825.00 mm
Bearing Material	3 - Synthetic material with hardness gre
Coupling's massive part (gudgeon) material	ST235
Lower Pintle	
Material	ST235
Bearing Length	825.000 mm
Bearing material	3 - Synthetic material with hardness greater than Shore D
Coupling's massive part (gudgeon) material	ST235

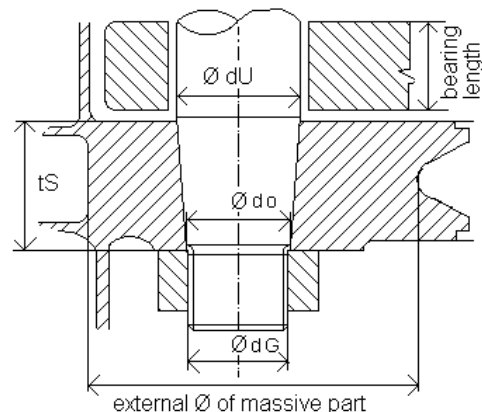
4.9.2. Pintle cone coupling data

The following geometrical characteristics are to be input:

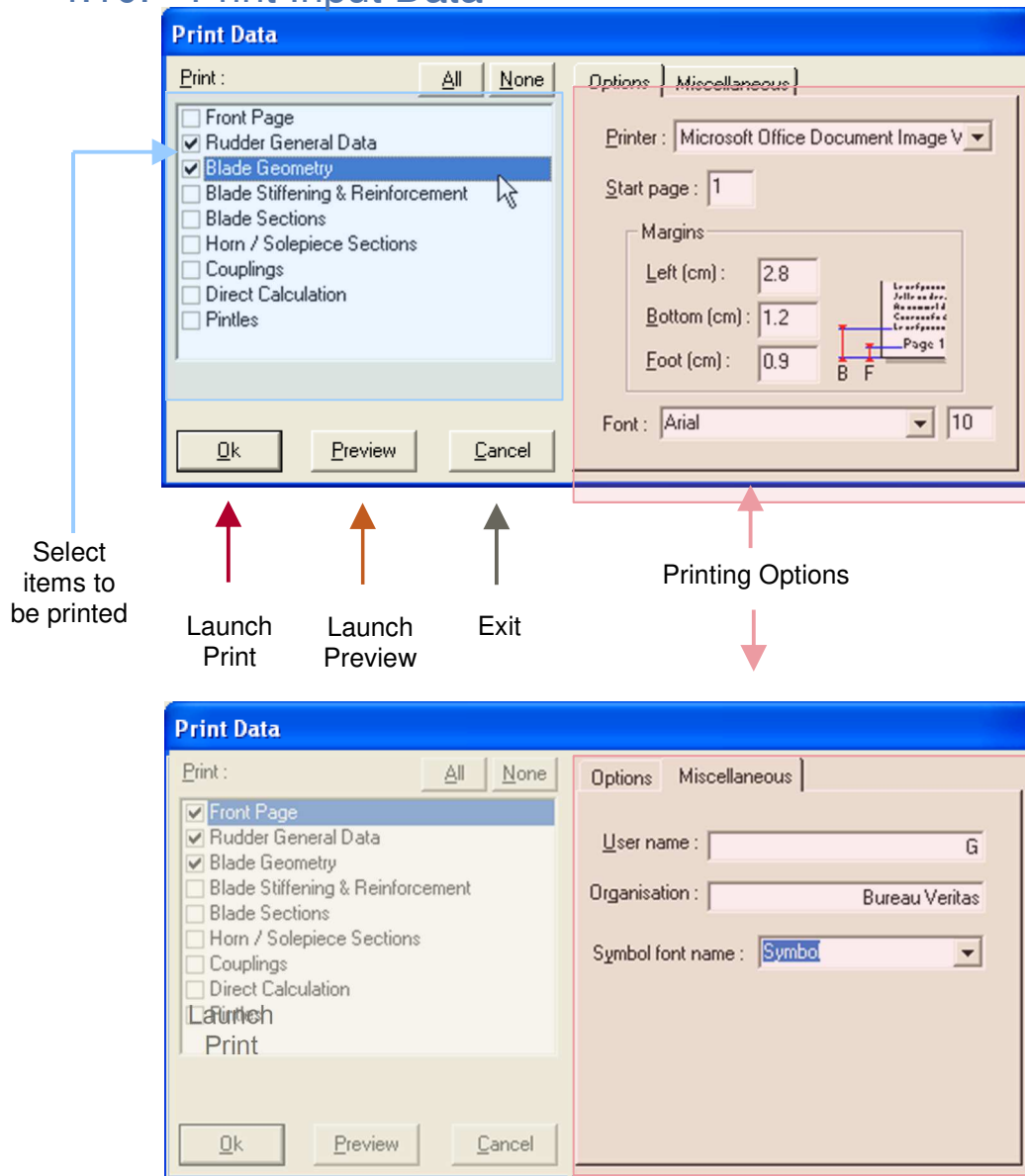
- d_U , greatest diameter in the pintle cone coupling
- d_0 , smallest diameter in the pintle cone coupling
- t_i , geometrical parameter of the pintle cone coupling (for BV RULES NR467, NR500 and NR217)
- t_s , length of the pintle housing (for CSR RULES for Bulk Carriers)
- l_c , geometrical parameter in the pintle cone coupling (for BV RULES NR467, NR500 and NR217)
- d_G , internal diameter of the nut
- The *external diameter of the massive part*

WARNING: THE DIAMETERS d_U AND d_0 ARE NAMED FOLLOWING BV RULES CONVENTION - CSR BULK CARRIERS NOTATIONS ARE NOT THE SAME.

Pintles	
Cone Coupling Data	General Data
Upper Pintle	
d_U =	802.00 mm
d_0 =	750.00 mm
t_i =	830.00 mm
d_G =	540.00 mm
l_c =	840.00 mm
External diameter of massive part	900.00 mm
Lower Pintle	
d_U =	800.00 mm
d_0 =	745.60 mm
t_i =	839.00 mm
d_G =	540.00 mm
l_c =	840.00 mm
External diameter of massive part	900.00 mm



4.10. Print Input Data



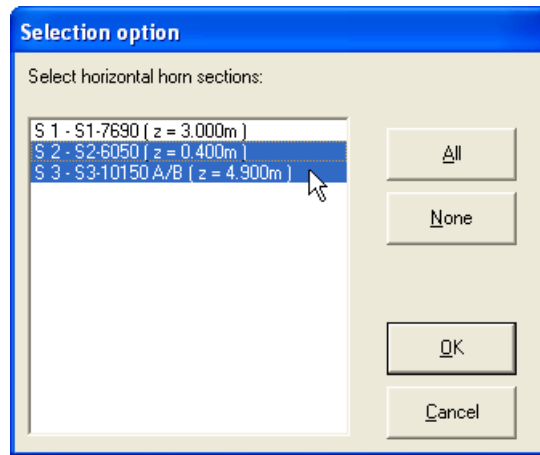
First choose the items you want to print: select a few elements in the selection list or use the “All” or “None” buttons to help you establish your selection. Then, if required, modify the printing options accordingly to your needs.

Notes:

- ▶ Printing settings are stored between uses of the RUDDER software
- ▶ Start page number is stored between prints and automatically increases with the number of printed pages
- ▶ Margins and fonts settings don't affect the preview mode

In the end, click either on the “OK” button to launch the print on the selected printer or on the “Preview” button to launch the preview mode.

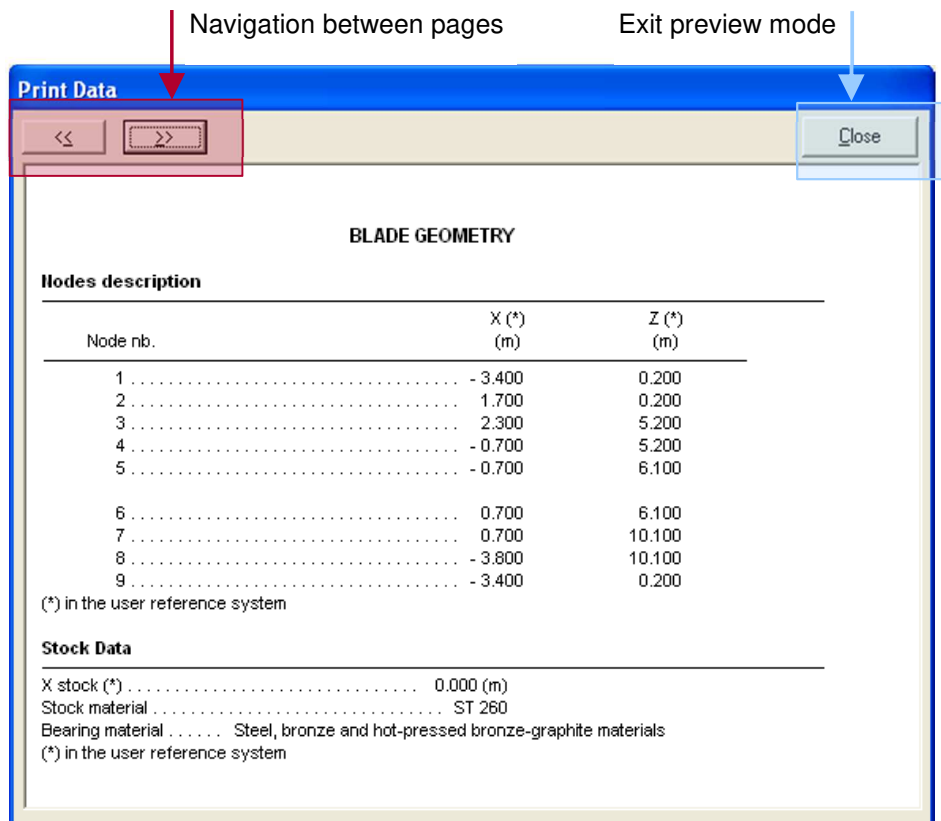
If several sections exist (either blade sections or horn sections being printed), an additional window will ask which sections should be printed or displayed.



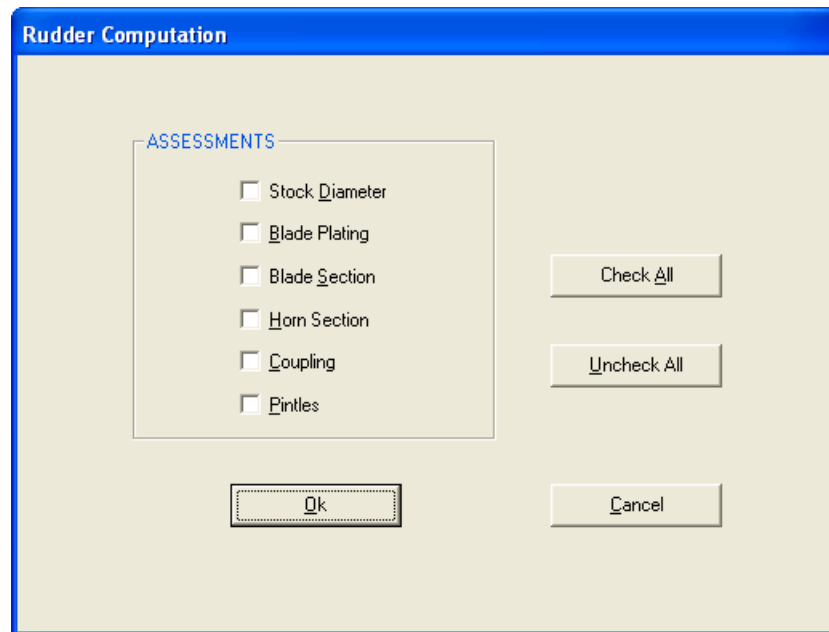
Elements will be printed or displayed with the same order as the print item list:

- Rudder general data
- Blade geometry data
- Blade plating (stiffening and reinforcement) data
- Blade sections data
- Horn sections data
- Coupling data
- Direct calculation data
- Pintle data

The preview mode allows browsing among the data directly on screen. Browse through the data thanks to the navigation buttons and exit by clicking on the “Close” button. Note that after closing the preview mode, nothing is sent to the printer.

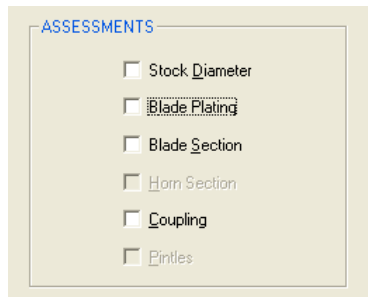


5. RUDDER CALCULATION

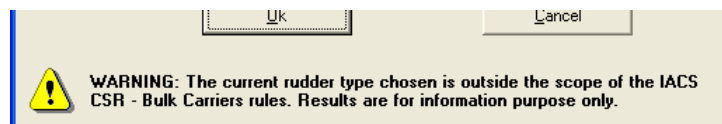


- Select the assessments to be made, and click on “OK” button to launch the calculations.

Note: Some options can be disabled if they have no meaning with respect of the current rudder type:



Note: A warning can appear at the bottom of the window, if the current rudder type is not mentioned in the currently selected rule set. In that case, the results based on the direct calculation will nonetheless be provided for information only and should not be considered as mandatory:



- Once the calculations are launched the outcome can be of 3 types:



No problem

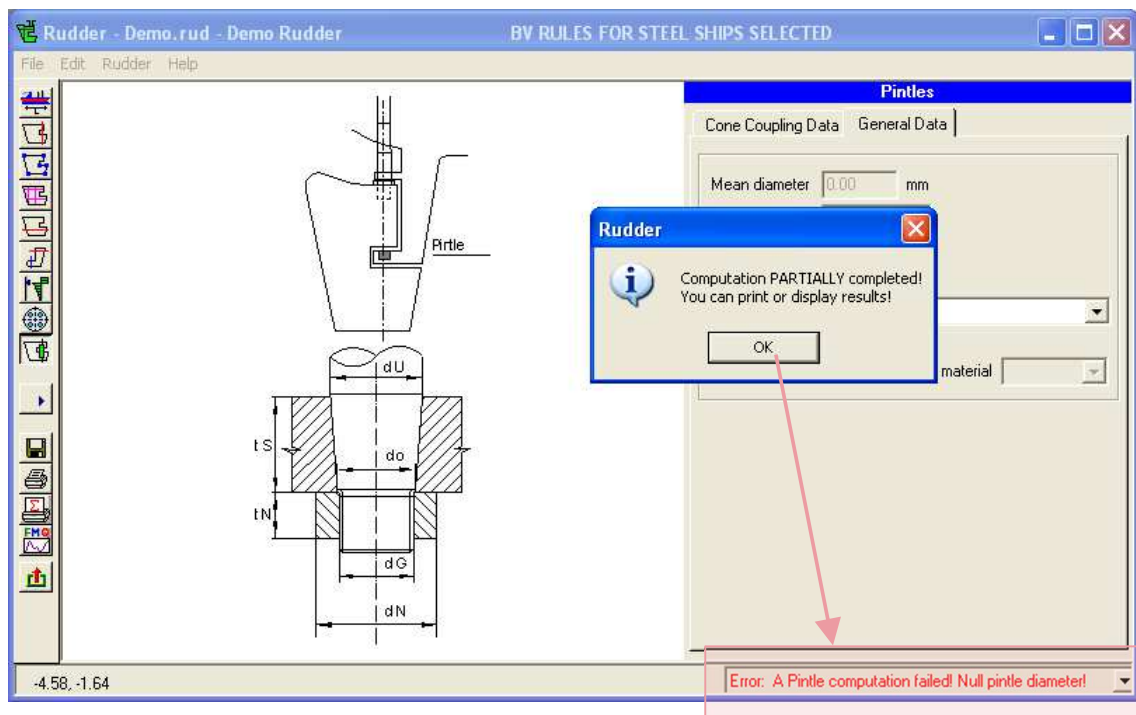


Some problem appeared: all the results might not be available.



Some problem appeared: no result is available

Computation fails due to some input problem; the Error Messages box provides some information on the origin of the problem. Try to complete or correct the input and launch the calculations again. If the problem persists do not hesitate in contacting us.



6. RUDDER RESULTS

Once the computation has been completed (see Part 5), the results are accessible under two categories:

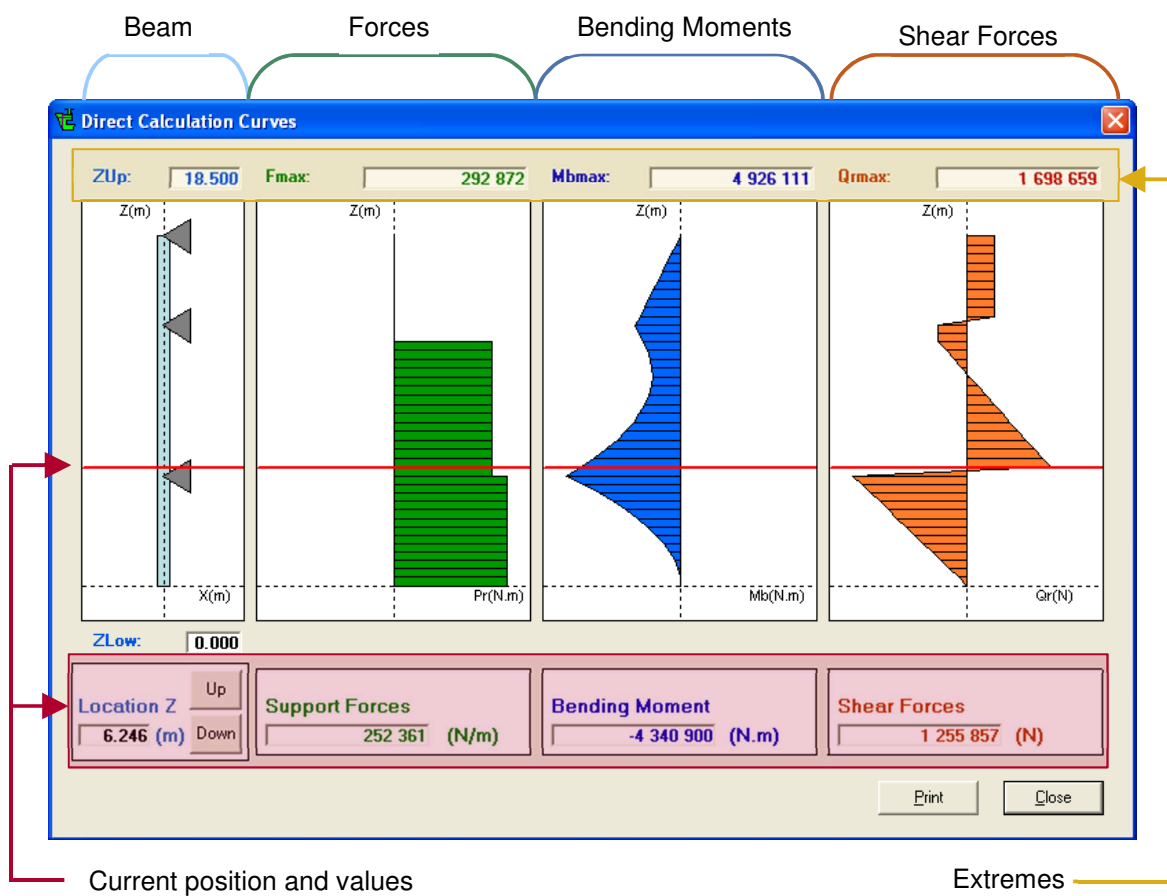


Requirements results (see Part 6.3)



Direct Calculation results (see Parts 6.1 and 6.2)

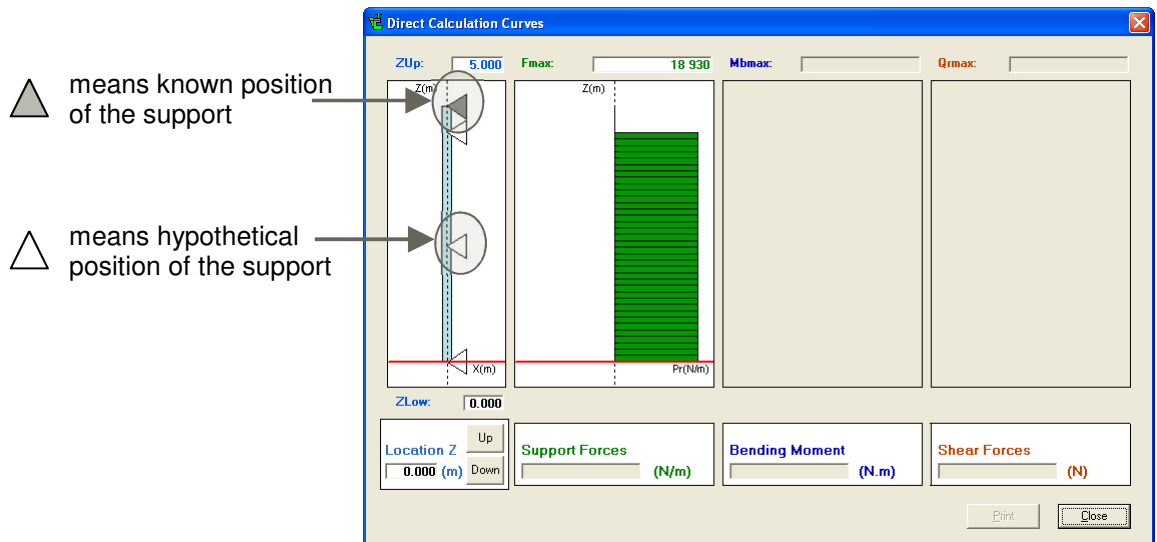
6.1. Direct Calculation curves



By clicking on the “Up” and “Down” buttons or by using the up and down arrows on the keyboard it is possible to navigate along the rudder beam. Current values are displayed at the bottom of the window.

The “Print” button allows printing a display of the curves.

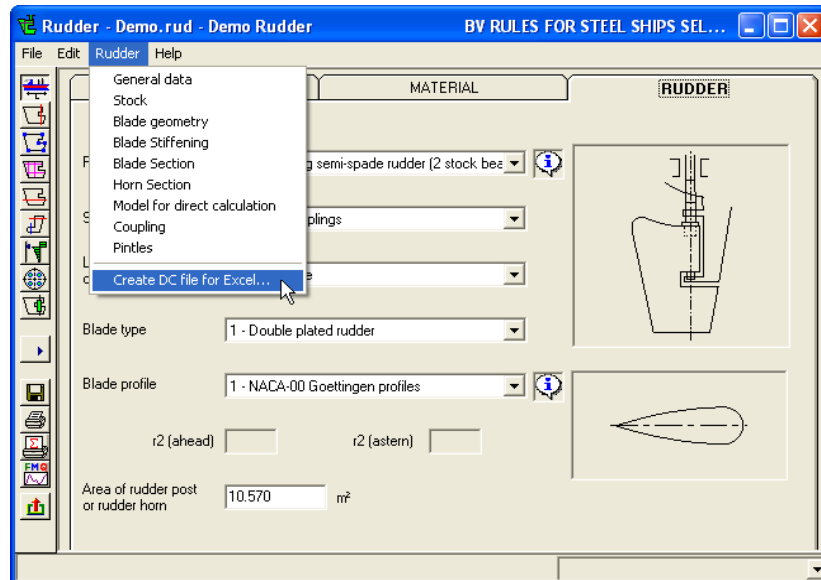
Note: For rudders of type 1 or 3 (see Part 4.1.3), only the beam and force distribution will be displayed.



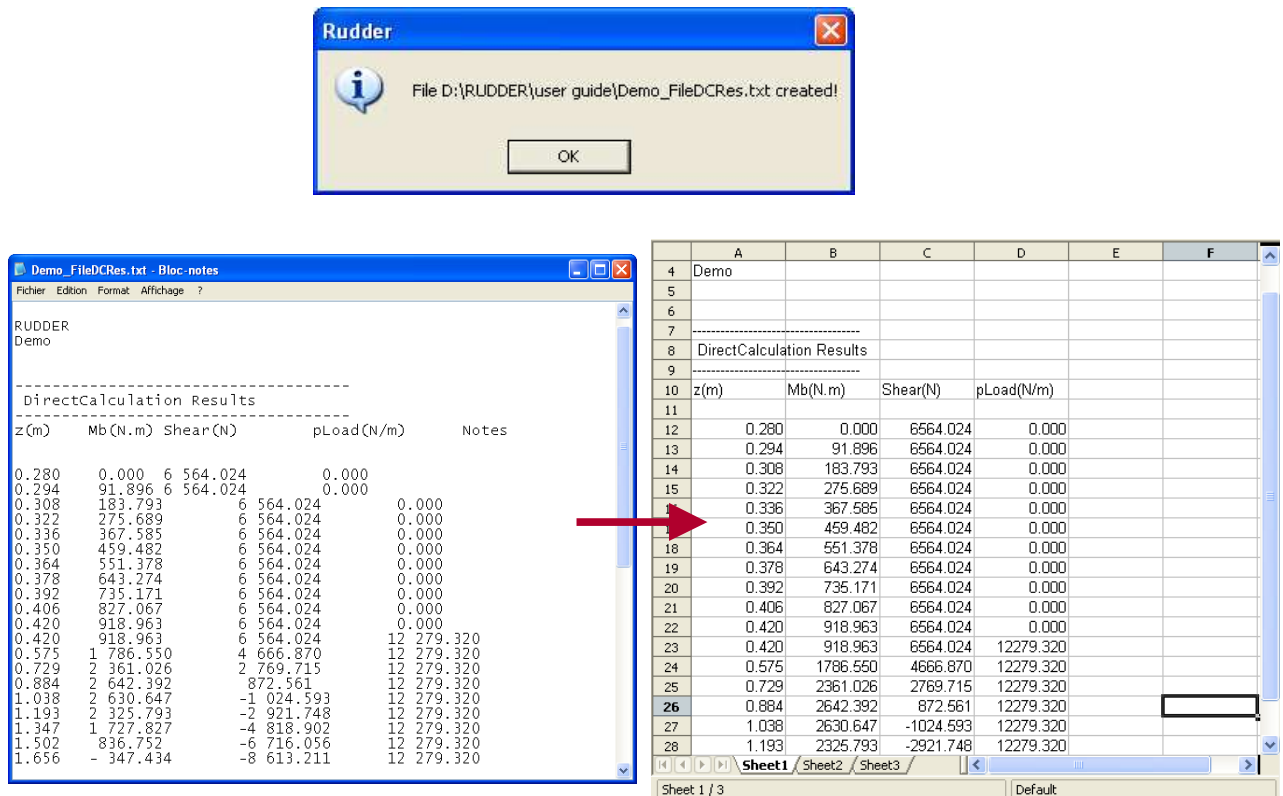
6.2. Exporting Direct Calculation results

It is possible to export a sample of the Direct Calculation results into a delimited text file (*.txt file using a tabulation separator between fields), which can be imported into most spreadsheet software.

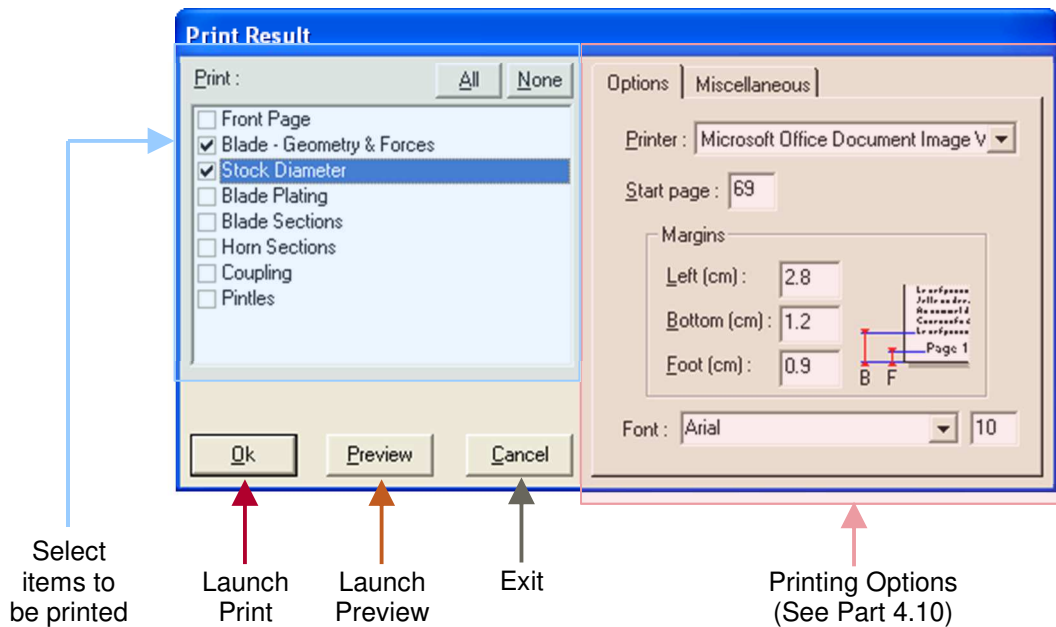
This feature is accessible once the calculations have been launched through Menu Rudder → Create DC File for Excel.



A file named “[name of the current Rudder database file]_FileDCRes.txt” will be created in the same folder as Rudder database file.



6.3. Results through prints

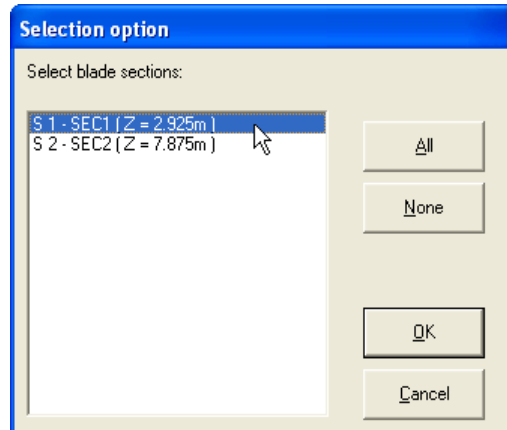


Select the items to be printed in the list.

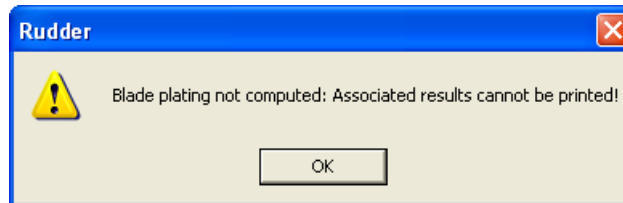
By clicking on the "OK" button, the print will be launched according to the selected options of the right part of the window (refer to Part 4.10 on how to establish the printing options).

By clicking on the "Preview" button, the results associated to the selected items will be displayed on screen.

If several sections (either blade sections or horn sections) exist, an additional window will ask which sections should be displayed.



If one selected item in the printing list has not been calculated, the following error message will appear. If the item is relevant to the rudder type, the corresponding calculation must be computed before any result display.



The results are printed in the same order of the printing list:

- Geometry of the blade and forces results
- Stock diameter and stock bearings criteria
- Blade plating criteria
- Blade section criteria
- Horn section criteria
- Coupling criteria
- Pintle criteria

Any result that is not allowable in regard of the current rule set, will be indicated by the presence of an asterisk *. The meaning of this * is usually reminded in the prints if at least a value is not allowable in a given result set.

The 'Print Result' dialog box has a title bar with the name 'Print Result'. It contains navigation buttons '<<' and '>>' on the left and a 'Close' button on the right. The main content area shows a table under the heading 'Dimensions massive part & slogging nut'. The table has three columns: a label, 'Actual thickness (mm)', and 'Rule thickness (mm)'. The data rows are as follows:

	Actual thickness (mm)	Rule thickness (mm)
IS	1 013.00	812.81
dG	345.00*	352.22
tN	250.00	207.00
dN	500.00*	561.60
dE	630.00*	826.87

Below the table, there is a red box containing the text '* not allowable'.



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