Parameters impermeable net

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Summary:
This document presents three new parameters for impermeable load formulations “Lice skirt” and “Closed compartment”, as well as the removal of the parameters “Bottom factor” and “Vacuum surface suction” previously used for the load formulation “General impermeable net”.

Consequently, the load formulation “General impermeable net” has been removed and all the capabilities of this load formulation have been separated out in the load formulations “Lice skirt”, “Closed compartment” and “Surface tarpaulin”, making “General impermeable net” obsolete.

The parameters used for the impermeable load formulations “Lice skirt” and “Closed compartment” are in the 2.20 version of AquaSim presented in an updated interface and are sorted more thematically.

Furthermore, a description of how these new parameters are presented in AquaView has been included in this document. Additionally, renaming of parameters from version 2.19 to 2.20 has been explained and descriptions have been updated.

1	09.12.2024	HNM	-	First revision
Revision no.	Date	Author	Verified by	Description

Content

1 Introduction

This document presents three new parameters for load formulations “Lice skirt” and “Closed compartment” in AquaSim and introduces an updated interface for presenting the analysis parameters in AquaEdit and the 2.20 version of AquaSim. Furthermore, a description of how these new parameters are presented in AquaView has been included.

2 Description of new parameters

In version 2.19 and earlier, the same scaling factor was applied both vertically and horizontally for the added mass and hydrodynamic damping using the parameters “Added mass coefficient / height” and “Hydrodynamic damping coefficient”.

For the inner watermass only the horizontal component of the mass was considered and could either be set explicitly for each element in the component-group to a defined value expressed in mH2O using “Horizontal radius inner watermass [mH2O]” or calculated automatically if “Horizontal radius inner watermass [mH2O]” was set to 0. The horizontal component of the mass could in turn be scaled using the parameter “Inner fluid mass scaling”.

The three new parameters that have been included enable separate adjustments of the horizontal and vertical component of the added mass, hydrodynamic damping and inner watermass.

The parameters enabling separate adjustment of the horizontal and vertical component of the added mass, hydrodynamic damping and inner watermass, are in version 2.20 denoted “Added mass coefficient horizontal”, “Added mass coefficient vertical”, “Hydrodynamic damping coefficient horizontal”, “Hydrodynamic damping coefficient vertical”, “Mass relative to radius following acceleration vertically” and “Mass following acceleration vertically [mH2O]”.

For the added mass and hydrodynamic damping, the horizontal and vertical factors are applied directly on the horizontal and vertical component, respectively.

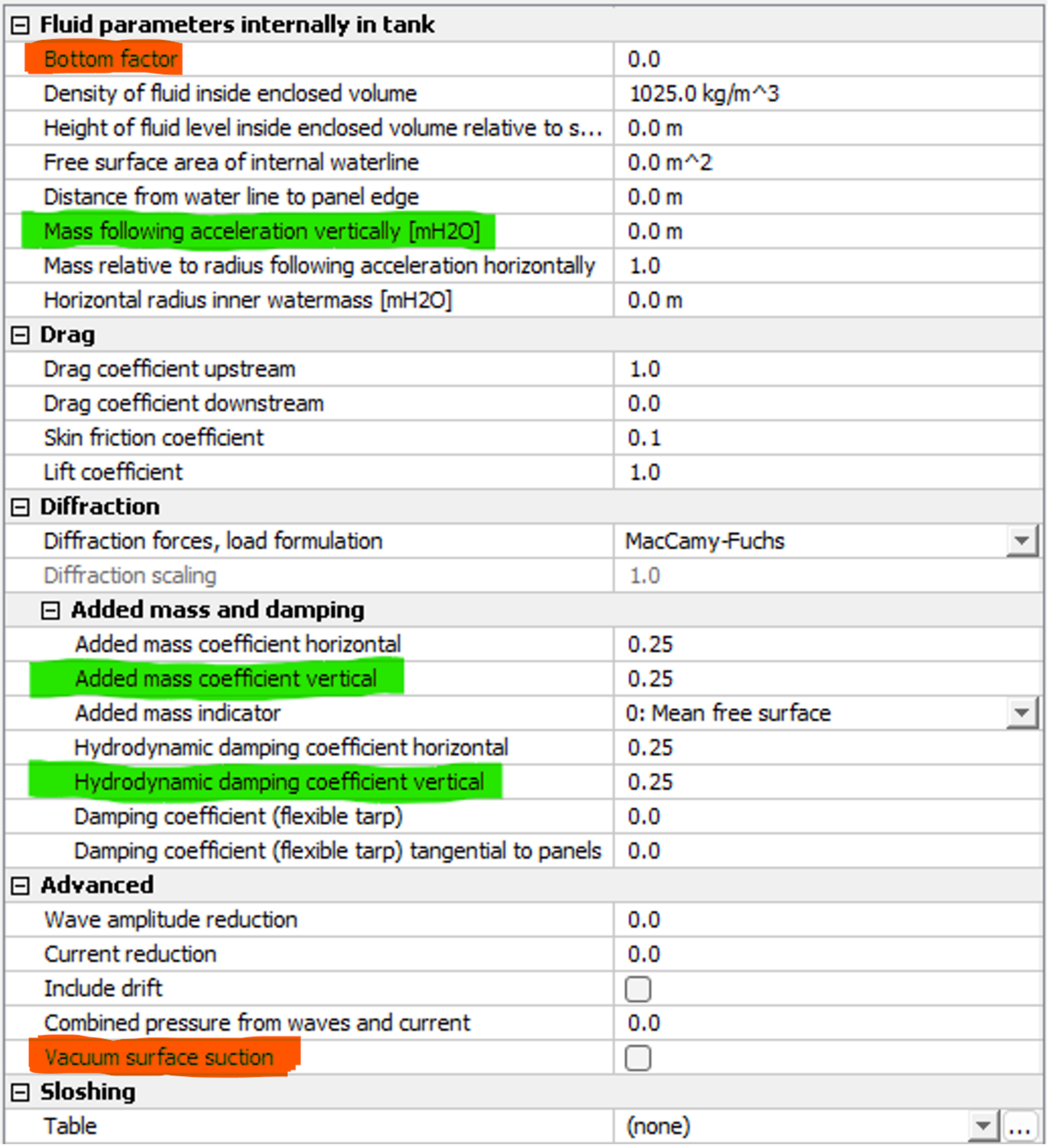
For the inner watermass, a vertical component of the inner watermass is introduced in the 2.20 version of AquaSim, and this value can be set explicitly for each element in the component-group to a defined value expressed in mH2O using “Mass following acceleration vertically [mH2O]”. For the horizontal component of the inner watermass, no change is made except that the parameter scaling the horizontal component of the inner watermass has changed name from “Inner fluid mass scaling” to “Mass relative to radius following acceleration horizontally”.

3 Parameters AquaEdit

The interface from version 2.19 of AquaSim, is shown in Figure 1. In version 2.20 of AquaSim, three new parameters have been introduced, and simultaneously the interface has been sorted as shown in Figure 2. It is noted that the parameters under the header "Thickness" in version 2.19, has been moved to "Material properties" in version 2.20.

⊟ Impermeable net load formulation	
Drag coefficient	1.0
Lift coefficient	2.4
Density of fluid inside tank	1025.0 kg/m^3
Height of fluid level inside tank relative to sea level	0.0 m
Added mass coefficient / height	0.25
Hydrodynamic damping coefficient	0.25
Bottom factor, 0 if water flow through bottom	0.0
Area top that water can penetrate over	0.0 m^2
Damping coefficient	0.02
Include drift	☐
Skin friction coefficient	0.1
Height of net edge	0.0
Inner fluid mass scaling	1.0
Horisontal radius inner watermass	0.0
Added mass indicator	0
Extra drag in front	0.0
Wave damping tangential to panels	0.1
Combined pressure from waves and current	0.0
Type of diffraction load	MacCamy-Fuchs
Diffraction scaling	1.0
Vacuum surface suction	☐
⊟ Thickness	
Thickness Y	1.2566E-4 m
Thickness Z	1.2566E-4 m
Thickness	2.5133E-4 m
⊟ Advanced	
Wave amplitude reduction	0.0
Current reduction	0.0
⊟ Sloshing	
Table	(none)

Figure 1 Parameters and interface "General impermeable net" in version 2.19 of AquaSim.



⊟ **Fluid parameters internally in tank**	
Bottom factor	0.0
Density of fluid inside enclosed volume	1025.0 kg/m^3
Height of fluid level inside enclosed volume relative to s...	0.0 m
Free surface area of internal waterline	0.0 m^2
Distance from water line to panel edge	0.0 m
Mass following acceleration vertically [mH2O]	0.0 m
Mass relative to radius following acceleration horizontally	1.0
Horizontal radius inner watermass [mH2O]	0.0 m
⊟ **Drag**	
Drag coefficient upstream	1.0
Drag coefficient downstream	0.0
Skin friction coefficient	0.1
Lift coefficient	1.0
⊟ **Diffraction**	
Diffraction forces, load formulation	MacCamy-Fuchs
Diffraction scaling	1.0
⊟ **Added mass and damping**	
Added mass coefficient horizontal	0.25
Added mass coefficient vertical	0.25
Added mass indicator	0: Mean free surface
Hydrodynamic damping coefficient horizontal	0.25
Hydrodynamic damping coefficient vertical	0.25
Damping coefficient (flexible tarp)	0.0
Damping coefficient (flexible tarp) tangential to panels	0.0
⊟ **Advanced**	
Wave amplitude reduction	0.0
Current reduction	0.0
Include drift	☐
Combined pressure from waves and current	0.0
Vacuum surface suction	☐
⊟ **Sloshing**	
Table	(none)

Figure 2 Parameters and interface "Closed compartment" in version 2.20 of AquaSim. The three new parameters are highlighted in green. The two old parameters highlighted in red have been removed and were previously used for load formulation "General impermeable net".

This document presents a modification of the table at page 36 in (Aquastructures, 2024a) and relevant changes from the original are described below. Please note that the notations from the 2.19 version of AquaSim is included in italics.

For updated descriptions and figures of the new interfaces for all the "Membrane" load formulations, see (Aquastructures, 2024d).

Properties	Description
Fluid parameters internally in tank	
Bottom factor - *Removed*	1.0 means that the inner volume is separated from the outer volume. 0.0 means that the inside and the outside fluids are connected, which is the case for lice skirts.
Density of fluid inside enclosed volume ***(Density of fluid inside tank)***	If the bottom factor is 0.0 (e.g., lice skirt), this parameter is a dummy. In this case the internal static pressure is set equal to the external pressure. If the bottom factor is 1.0, then this parameter is the density of the fluid inside the tank. The external pressure is calculated based on the density of seawater, 1025 kg/m^3
Height of fluid level inside enclosed volume relative to sea level ***(Height of fluid level inside tank volume relative to sea level)***	This parameter is a dummy if the bottom factor is 0.0. If the bottom factor is 1.0 then this value is the static water level of the fluid inside the tank, relative to the outside water level. Positive value means that the inside water level is higher than the outside water level. This and inner waterplane area gives the extra volume.
Free surface area of internal waterline ***(Area top that water can penetrate over)***	This parameter is a dummy if the bottom factor is 0.0. When an impermeable net, where the fluid on the inside is separated from the fluid on the outside, is deformed it will change volume. This area is then the area the fluid is assumed to be pushed through when volume is changed.
Distance from water line to panel edge ***(Height of net edge)***	Height of inside net, if 0.0 infinite height is set. If higher than 0.0 then the fluid inside can splash over the edge if it is compressed enough that it reaches over this set height.
Mass following acceleration vertically [mH2O]	mH2O of mass to be used as internal mass vibrating vertically.

Mass relative to radius following acceleration horizontally *(Inner fluid mass scaling)*	Part of inner water mass inside tank to be used as added mass horizontally in the analysis. If this parameter is: 1, then 100% of the enclosed water volume vibrates as added mass horizontally, 0.2, then 20% of the enclosed water volume vibrates as added mass horizontally, 0, then 0% of the enclosed water volume vibrates as added mass horizontally, 1.2, then 120% of the enclosed water volume vibrates as added mass horizontally. More information is found in (Aquastructures, 2024b).
Horizontal radius inner watermass [mH2O]	AquaSim automatically detects the radius of the cylinder. If 0, then the automatically calculated radius is applied. If any other number, this is interpreted as the radius, in meters.
Drag	
Drag coefficient upstream *(Drag coefficient and Extra drag in front)*	Gives the form drag to the object for the upstream part. Note that the drag load formulation is revised in the 2.20 version. For details, see (Aquastructures, 2024c).
Drag coefficient downstream *(Drag coefficient and Extra drag in front)*	Gives the form drag to the object for the downstream part. Note that the drag load formulation is revised in the 2.20 version. For details, see (Aquastructures, 2024c).
Skin friction coefficient	Drag along the membrane elements.
Lift coefficient	Gives the lift coefficient on the membrane panel. Note that the drag load formulation is revised in the 2.20 version. For details, see (Aquastructures, 2024c).

Diffraction	
Diffraction forces, load formulation ***(Type of diffraction load)***	Methods for calculating diffraction part of the pressure caused by waves. These are further explained in (Aquastructures, 2024c). **Flexible tarp**: load formulation adapted to flexible tarps and woven textiles, and the added mass and hydrodynamic damping factors are related to the volume of the tank. **MacCamy-Fuchs**: Diffraction loads are calculated from the MacCamy-Fuchs theory, and the added mass and hydrodynamic damping factors are related to the volume of the tank. **Numerical diffraction**: Diffraction loads are based on numerical calculation(“sink-source”). Added mass and hydrodynamic damping coefficients are in this case scaling factors used on the added mass and hydrodynamic damping found from the numerical diffraction theory. **Hybrid flexible tarp/numerical diffraction**: Combination of the Flexible tarp- and Numerical diffraction-load formulations. Added mass and hydrodynamic damping is calculated using the Numerical diffraction-theory. The user weights the methods through the “Diffraction scaling” option. **Hybrid flexible tarp/MacCamy-Fuchs**: Combination of the Flexible tarp- and MacCamy-Fuchs load formulations. The added mass and hydrodynamic damping factors are related to the volume of the tank. The user weights the methods through the “Diffraction scaling” option.
Diffraction scaling	Weight factor for the Hybrid flexible tarp/ numerical diffraction and Hybrid flexible tarp/ MacCamy-Fuchs formulations. Applying a value of 0.99 means that 99% of the diffraction force is calculated from either Numerical diffraction, or MacCamy-Fuchs. 1% is taken from the Flexible tarp-method.

Added mass and damping

Added mass coefficient horizontal ***(Added mass coefficient)***	**Flexible tarp:** Added mass for horizontal motion is calculated automatically for each element in the component group based on the 2D volume of the component group at the given depth, the element's horizontal distance from the centerline of the 2D volume at the given depth, the fluid density and scaled with the coefficient. **MacCamy-Fuchs**: Same as for Flexible tarp. **Numerical diffraction**: Added mass for horizontal motion is calculated automatically based on the Numerical diffraction-theory ("sink-source") and scaled with the coefficient. **Hybrid flexible tarp/numerical diffraction**: Same as for Numerical diffraction. **Hybrid flexible tarp/MacCamy-Fuchs:** Same as for Flexible tarp and MacCamy-Fuchs.
Added mass coefficient vertical ***(Added mass coefficient)***	**Flexible tarp:** Added mass for vertical motion is calculated automatically for each element in the component group based on the 2D volume of the component group at the given depth, the element's horizontal distance from the centerline of the 2D volume at the given depth, the fluid density and scaled with the coefficient. **MacCamy-Fuchs**: Same as for Flexible tarp. **Numerical diffraction**: Added mass for vertical motion is calculated automatically based on the Numerical diffraction-theory ("sink-source") and scaled with the coefficient. **Hybrid flexible tarp/numerical diffraction**: Same as for Numerical diffraction. **Hybrid flexible tarp/MacCamy-Fuchs:** Same as for Flexible tarp and MacCamy-Fuchs.

Added mass indicator	Indicator of added mass in and out of water. **0**: Added mass both of fluid inside and outside are assumed distributed to the mean free surface and mass is distributed consistent (no mass in rotational DOFs). The mean free surface is the surface at the steady state condition where approximately 2/3 of the current velocity has been added to the system. **1**: Same as 0, but the mass is lumped to the translational DOFs of the nodes. **2**: In this case added mass for both inside and outside fluid is calculated to the actual water line during the simulation. This option can be suitable for a stiff cylinder going in and out of water in a rather wall sided manner. 2 means combining with consistent mass. **3**: Same as 2 but combining with lumped mass.
Hydrodynamic damping coefficient horizontal ***(Hydrodynamic damping coefficient)***	**Flexible tarp:** Hydrodynamic damping for horizontal motion is calculated automatically for each element in the component group based on the 2D volume of the component group at the given depth, the element’s horizontal distance from the centerline of the 2D volume at the given depth, the fluid density and scaled with the coefficient. **MacCamy-Fuchs**: Same as for Flexible tarp. **Numerical diffraction**: Hydrodynamic damping for horizontal motion is calculated automatically based on the Numerical diffraction-theory (“sink-source”) and scaled with the coefficient. **Hybrid flexible tarp/numerical diffraction**: Same as for Numerical diffraction. **Hybrid flexible tarp/MacCamy-Fuchs:** Same as for Flexible tarp and MacCamy-Fuchs.

Hydrodynamic damping coefficient vertical ***(Hydrodynamic damping coefficient)***	**Flexible tarp:** Hydrodynamic damping for vertical motion is calculated automatically for each element in the component group based on the 2D volume of the component group at the given depth, the element's horizontal distance from the centerline of the 2D volume at the given depth, the fluid density and scaled with the coefficient. **MacCamy-Fuchs**: Same as for Flexible tarp. **Numerical diffraction**: Hydrodynamic damping for vertical motion is calculated automatically based on the Numerical diffraction-theory ("sink-source") and scaled with the coefficient. **Hybrid flexible tarp/numerical diffraction**: Same as for Numerical diffraction. **Hybrid flexible tarp/MacCamy-Fuchs:** Same as for Flexible tarp and MacCamy-Fuchs.
Damping coefficient (flexible tarp) ***(Damping coefficient)***	Damping forces normal to membrane panel. Calculated based on the Flexible tarp load formulation and scaled with the coefficient. For details, see (Aquastructures, 2024c).
Damping coefficient (flexible tarp) tangential to panels ***(Wave damping tangential to panels)***	Damping forces tangential to membrane panel. The same damping as calculated for the normal direction based on the Flexible tarp load formulation, is applied in the tangential direction and scaled with the coefficient. For details, see (Aquastructures, 2024c).
Advanced	
Wave amplitude reduction	Reduction of wave amplitude on element, due to e.g., shadow effects. Input is a number between 0.0 and 1.0. 0 corresponds to 0% reduction, 1.0 corresponds to 100% reduction
Current reduction	Reduction of current on element due to e.g., shadow effects. Input is a number between 0.0 and 1.0. 0 corresponds to 0% reduction, 1.0 corresponds to 100% reduction.
Include drift	To include drift forces to the loads, "With slamming" under the Advanced tab in the Export dialog must be used. This element is calculated with forces to the actual water line, meaning that parts of drift forces are included even if this is not checked.

Combined pressure from waves and currents	The way current and wave loads are combined for calculating pressure from current. 0 means that the "raw" velocity at each element is used as basis such that the pressure is found from the pressure coefficient multiplied with relative velocity at the element. 1 means that the relative velocity is averaged over the elements at similar vertical location. In between means that the effects are weighted.
Vacuum surface suction - *Removed*	Vacuum between membrane and water line. For cases where membrane moves above water. On: activates vacuum. Negative pressure between membrane and water line is allowed. Off: does not enable pressure between surface and membrane (default).
Sloshing	Edit/Add a sloshing table to the net.

4 Parameters AquaView

This section provides a description of how the separation of horizontal and vertical component of the added mass, hydrodynamic damping and inner watermass, as a result of the introduction of the three new parameters, is accounted for and presented in AquaView.

The parameters describing the horizontal and vertical component of the added mass, hydrodynamic damping and inner watermass, are in AquaView version 2.20, denoted “Added mass normal hor per m2 [m3]”, “Added mass factor vert”, “Hyd damp normal hor per m2 [Ns/m]”, “Hydrodynamic damp factor vert”, “Mass normal hor per m2” and “Mass normal vert per m2”, highlighted in green in Figure 3.

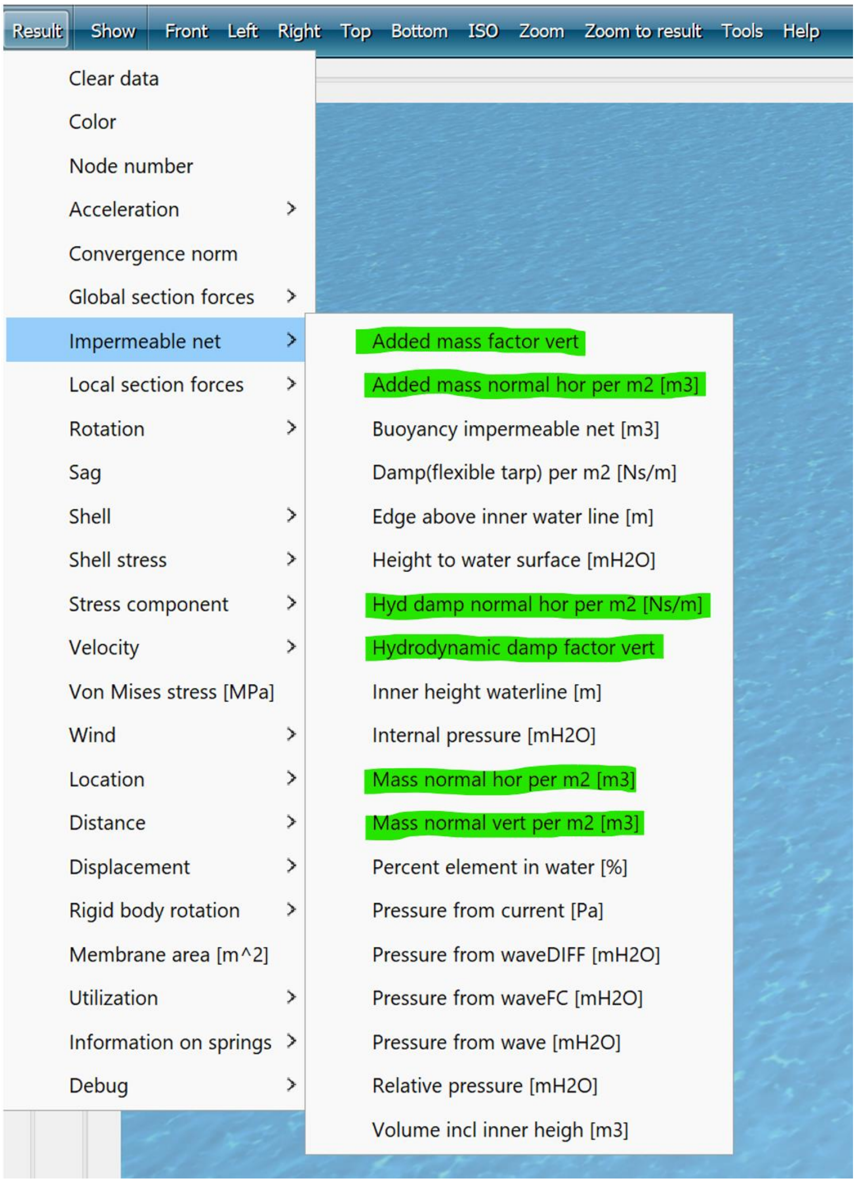


Figure 3 Parameters describing the horizontal and vertical component of the added mass, hydrodynamic damping and inner watermass, highlighted in green, as seen in the result view in AquaView.

Result	Description
Impermeable net	
Added mass normal hor per m2 [m3]	This output shows the added mass in the normal direction of the element, used in the analysis, multiplied with a factor corresponding to AquaEdit input parameter “Added mass coefficient horizontal”. The unit is [m^3/m^2] and corresponds to mH2O that oscillates with the element. The added mass per unit area [kg/m^2] is found by multiplication with the density of seawater.
Added mass factor vert	This output shows the added mass factor in the vertical direction, used in the analysis, corresponding to AquaEdit input parameter “Added mass coefficient vertical”.
Hyd damp normal hor per m2 [Ns/m]	This output shows the hydrodynamic damping in the normal direction of the element, used in the analysis, multiplied with a factor corresponding to AquaEdit input parameter “Hydrodynamic damping coefficient horizontal”. The unit is [$(Ns/m)/m^2$].
Hydrodynamic damp factor vert	This output shows the hydrodynamic damping factor in the vertical direction, used in the analysis, corresponding to AquaEdit input parameter “Hydrodynamic damping coefficient vertical”.
Mass normal hor per m2 [m3]	This output shows the mass of the internal fluid in the normal direction of the element, used in the analysis for horizontal motion, multiplied with a factor corresponding to AquaEdit input parameter “Mass relative to radius following acceleration horizontally”. The unit is [m^3/m^2] and corresponds to mH2O that oscillates with the element. The added mass per unit area [kg/m^2] is found by multiplication with the density of seawater.
Mass normal vert per m2 [m3]	This output shows the mass of the internal fluid in the normal direction of the element, used in the analysis for vertical motion. The unit is [m^3/m^2] and corresponds to mH2O that oscillates with the element. The added mass per unit area [kg/m^2] is found by multiplication with the density of seawater.

5 References

Aquastructures. (2024a). *User manual AquaEdit, AquaSim version: 2.19.* Techn. rep. TR-20000-583-1.

Aquastructures. (2024b). *The AquaSim Package Theory User Manual.* Techn. rep. TR-20000-2049-1.

Aquastructures. (2024c). *Loads on Impermable Nets and Large Volume Objects in AquaSim.* Techn. rep. TR-FOU-2328-6. Rev9.

Aquastructures. (2024d). *User manual AquaEdit, AquaSim version: 2.20.* Techn. rep. TR-20000-583-1.