Client name- Project name - (Structure name) Hydrodynamic Coefficients Calculations- DNV-RP-H103 Simplified method

I. Introduction

In this document the required hydrodynamic properties for conducting a deployment analysis for a 6-D Buoy structure are calculated using the simplified approach based on DNV RP H103 2012. The structure is presented as a rectangular box or a circular cylinder.

II. Reference:

1. DNV RP H 103 Modelling and Analysis of Marine Operations
2. Marine Hydrodynamics. Newman J.N. 1977
3. DWG of the structure

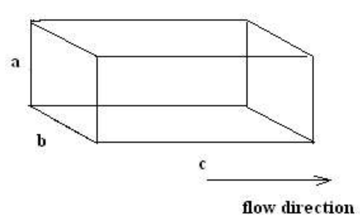
III. Units and Constants

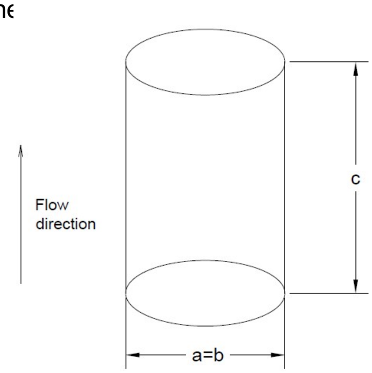
$ORIGIN \equiv 1$

$Te := 1000 \cdot kg$ $\rho := 1.025 \cdot \frac{Te}{m^3}$ input results

IV. Assumptions:

1. Notation:
   a is the shortest dimension in the plane perpendicular to flow direction
   b is the longest dimension in the plane, perpendicular to flow direction4
   c is the height of the structure (dimension along the





In case of a cylinderical structure:
in Z direction: a = b and equal to the diameter of the structure

Notation a, b, and c are re-utilized for each flow direction

2. a, b - are the projected dimensions in case of inclined deployment
3. Drag coefficient for splash zone are taken as 3 times steady flow drag coefficients
4. Drag coefficients for deep zone are taken as equal to steady flow drag coefficients

V. Glossary:

Structure - a manifold, mudmat, suction pile, etc

VI. Input

Mass:

Mass of the structure in air: $M_{box\_air} := 1.6226 \cdot Te$ $\quad M_{box\_air} = 1.623 \cdot Te$

Mass of the structure in water: $M_{box\_sub} := 0.2824Te$ $\quad M_{box\_sub} = 0.282 \cdot Te$

Volume:

Volume of the structure: $Vol_{box} := \dfrac{M_{box\_air} - M_{box\_sub}}{\rho}$ $\quad Vol_{box} = 1307.5 \cdot L$

Shape of the structure:
1 - rectangular
2 - circular

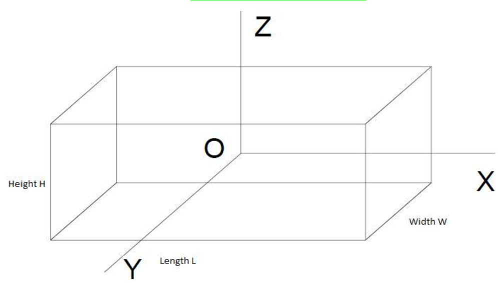
$Shape := 1$

Dimensions:

Length or diameter of the structure: $l_{box} := 3.045m$

Width or Diameter of the structure: $w_{box} := 1.153 \cdot m$

Height of the structure: $h_{box} := 0.902m$



COG location:
Distance from the geometrical center of the structure to COG of the structure:

$x_{box\_cog} := -0.0615m = -0.062\,m$

$y_{box\_cog} := 0.0m = 0$

$z_{box\_cog} := 0.141m = 0.141\,m$

Perforation effect in percent:
(do not put % sign)

$p_x := 0$ %

$p_y := 0$ %

$p_z := 0$ %

VII. Calculation of Hydrodynamic Properties of 6D buoy :

1. Translational properties

X-direction:

a. Dimensions of the structure:

$a := \min(h_{box}, w_{box})$ $b := \max(w_{box}, h_{box})$ $c := l_{box}$

$a = 0.902\,m$ $b = 1.153\,m$ $c = 3.045\,m$

b. Added mass of the structure:

$$C_{a\_b} := \text{linterp}\left(ratio_1, \lambda_1, \frac{b}{a}\right) \qquad C_{a\_b} = 0.648$$

$$\lambda_0 := \frac{\sqrt{a \cdot b}}{c + \sqrt{a \cdot b}} \qquad \lambda_0 = 0.251$$

$$C_{a\_c} := \text{linterp}\left(ratio_{b2a}, \lambda_2, \frac{b}{a}\right) \qquad C_{a\_c} = 0.63$$

$$M_{add.b\_x1} := \begin{cases} C_{a\_b} \cdot \frac{\pi}{4} \cdot \rho \cdot a^2 \cdot b \cdot \left[1 + \sqrt{\frac{1 - \lambda_0^2}{2 \cdot \left(1 + \lambda_0^2\right)}}\right] & \text{if Shape} = 1 \\ C_{a\_c} \cdot \rho\,\pi \cdot h_{box} \cdot \left(\frac{l_{box}}{2}\right)^2 & \text{otherwise} \end{cases}$$

$$M_{add.b\_x1} = 0.8 \cdot Te$$

Reduction due to perforation:

$$M_{add.b\_x} := \begin{cases} M_{add.b\_x1} & \text{if } p_x \le 5 \\ M_{add.b\_x1} \cdot \left[0.7 + 0.3 \cdot \cos\left[\pi \cdot \frac{(p_x - 5)}{34}\right]\right] & \text{if } 5 < p_x < 34 \\ M_{add.b\_x1} \cdot e^{\frac{10 - p_x}{28}} & \text{if } 34 \le p_x \le 50 \end{cases}$$

Added mass with perforation

$$\boxed{M_{add.b\_x} = 0.81 \cdot Te}$$

c. Adjusted Ca coefficient of the structure:

$$c_{add.b\_x} := \frac{M_{add.b\_x}}{\rho \cdot Vol_{box}}$$

$$c_{add.b\_x} = 0.608$$

d. Drag area of the structure:

$$DragArea_{b\_x} := a \cdot b \cdot \left(1 - \frac{p_x}{100}\right)$$

$$DragArea_{b\_x} = 1\,m^2$$

e. Drag coefficient of the structure for steady flow:

$$C_{D.deep.x} := \begin{cases} \text{linterp}\left(ratio_{BH}, C_{ds1}, \frac{b}{a}\right) & \text{if } \begin{vmatrix} Shape = 1 \\ \frac{c}{\sqrt{a \cdot b}} < 1 \end{vmatrix} \\ \text{linterp}\left(ratio_{LD}, C_{ds}, \frac{c}{\sqrt{a \cdot b}}\right) & \text{if } \begin{vmatrix} Shape = 1 \\ \frac{c}{\sqrt{a \cdot b}} \geq 1 \end{vmatrix} \\ \text{linterp}\left(ratio_{cyl\_nor\_LD}, C_{ds\_cyl\_nor}, \frac{b}{a}\right) & \text{if } Shape = 2 \end{cases}$$

$$C_{D.deep.x} = 0.929$$

f. Drag coefficient of the structure for splash zone:

$$C_{D.spl.x} := \begin{cases} 3C_{D.deep.x} & \text{if } 3C_{D.deep.x} > 2.5 \\ 2.5 & \text{otherwise} \end{cases}$$

$$C_{D.spl.x} = 2.787$$

Y-direction:

a. Dimensions of the structure:

$$a := \min(h_{box}, l_{box}) \quad b := \max(l_{box}, h_{box}) \quad c := w_{box}$$

$$a = 0.902\,m \quad b = 3.045\,m \quad c = 1.153\,m$$

b. Added mass of the structure:

$$C_{a\_b} := \text{linterp}\left(ratio_1, \lambda_1, \frac{b}{a}\right) \qquad C_{a\_b} = 0.848$$

Length to width ratio:

$$\lambda_0 := \frac{\sqrt{a \cdot b}}{c + \sqrt{a \cdot b}} \qquad \lambda_0 = 0.59$$

$$C_{a\_c} := \text{linterp}\left(ratio_{b2a}, \lambda_2, \frac{b}{a}\right) \qquad C_{a\_c} = 0.822$$

$$M_{add.b\_y1} := \begin{cases} C_{a\_b}\cdot\frac{\pi}{4}\cdot\rho\cdot a^2\cdot b\cdot\left[1+\sqrt{\frac{1-\lambda_0{}^2}{2\cdot\left(1+\lambda_0{}^2\right)}}\right] & \text{if } Shape = 1 \\ C_{a\_c}\cdot\rho\,\pi\cdot\left(\frac{a}{2}\right)^2\cdot b & \text{otherwise} \end{cases}$$

$$M_{add.b\_y1} = 2.52\cdot Te$$

Effect of perforation:

$$M_{add.b\_y} := \begin{cases} M_{add.b\_y1} & \text{if } p_y \le 5 \\ M_{add.b\_y1}\cdot\left[0.7+0.3\cdot\cos\left[\pi\cdot\frac{(p_y-5)}{34}\right]\right] & \text{if } 5 < p_y < 34 \\ M_{add.b\_y1}\cdot e^{\frac{10-p_y}{28}} & \text{if } 34 \le p_y \le 50 \end{cases}$$

Added mass with perforation

$$M_{add.b\_y} = 2.5\cdot Te$$

c. Adjusted Ca coefficient of the structure:

$$c_{add.b\_y} := \frac{M_{add.b\_y}}{\rho\cdot Vol_{box}}$$

$$c_{add.b\_y} = 1.883$$

d. Drag area of the structure:

$$DragArea_{b\_y} := a\cdot b\cdot\left(1-\frac{p_y}{100}\right)$$

$$DragArea_{b\_y} = 2.7\,m^2$$

e. Drag coefficient of the structure for steady flow:

$$C_{D.deep.y} := \begin{cases} \text{linterp}\left(ratio_{BH}, C_{ds1}, \frac{b}{a}\right) & \text{if } \begin{cases} Shape = 1 \\ \frac{c}{\sqrt{a\cdot b}} < 1 \end{cases} \\ \text{linterp}\left(ratio_{LD}, C_{ds}, \frac{c}{\sqrt{a\cdot b}}\right) & \text{if } \begin{cases} Shape = 1 \\ \frac{c}{\sqrt{a\cdot b}} > 1 \end{cases} \\ \text{linterp}\left(ratio_{cyl\_nor\_LD}, C_{ds\_cyl\_nor}, \frac{b}{a}\right) & \text{if } Shape = 2 \end{cases}$$

$$C_{D.deep.y} = 1.184$$

f. Drag coefficient of the structure for splash zone:

$$C_{D.spl.y} := \begin{cases} 3C_{D.deep.y} & \text{if } 3C_{D.deep.y} > 2.5 \\ 2.5 & \text{otherwise} \end{cases}$$

$$C_{D.spl.y} = 3.551$$

Z-direction

a. Dimensions of the structure:

$a := \min(w_{box}, l_{box})$ $\quad b := \max(l_{box}, w_{box})$ $\quad c := h_{box}$

$a = 1.153\,m$ $\quad b = 3.045\,m$ $\quad c = 0.902\,m$

b. Added mass of the structure:

$$C_{a\_b} := \mathrm{linterp}\left(ratio_1, \lambda_1, \frac{b}{a}\right) \qquad C_{a\_b} = 0.809$$

$$\lambda_0 := \frac{\sqrt{a \cdot b}}{c + \sqrt{a \cdot b}} \qquad \lambda_0 = 0.675$$

$$M_{add.b\_z1} := \begin{cases} C_{a\_b} \cdot \frac{\pi}{4} \cdot \rho \cdot a^2 \cdot b \cdot \left[1 + \sqrt{\frac{1 - \lambda_0^2}{2 \cdot (1 + \lambda_0^2)}}\right] & \text{if } Shape = 1 \\ \rho \cdot \frac{2}{\pi} \cdot \frac{4}{3} \cdot \pi \cdot \left(\frac{a}{2}\right)^3 \cdot \left[1 + \sqrt{\frac{1 - \lambda_0^2}{2 \cdot (1 + \lambda_0^2)}}\right] & \text{otherwise} \end{cases}$$

$$M_{add.b\_z1} = 3.78 \cdot Te$$

Effect of perforation:

$$M_{add.b\_z} := \begin{cases} M_{add.b\_z1} & \text{if } p_z \le 5 \\ M_{add.b\_z1} \cdot \left[0.7 + 0.3 \cdot \cos\left[\pi \cdot \frac{(p_z - 5)}{34}\right]\right] & \text{if } 5 < p_z < 34 \\ M_{add.b\_z1} \cdot e^{\frac{10 - p_z}{28}} & \text{if } 34 \le p_z \le 50 \end{cases}$$

Added mass with perforation

$$M_{add.b\_z} = 3.777 \cdot Te$$

c. Adjusted Ca coefficient of the structure:

$$c_{add.b\_z} := \frac{M_{add.b\_z}}{\rho \cdot Vol_{box}} \qquad c_{add.b\_z} = 2.818$$

d. Drag area of the structure:

$$DragArea_{b\_z} := \begin{cases} \pi \cdot \frac{a^2}{4} \left(1 - \frac{p_z}{100}\right) & \text{if } Shape = 2 \\ a \cdot b \cdot \left(1 - \frac{p_z}{100}\right) & \text{otherwise} \end{cases}$$

$$DragArea_{b\_z} = 3.5\,m^2$$

e. Drag coefficient of the structure for steady flow:

$$C_{D.deep.z} := \begin{cases} \text{linterp}\left(\text{ratio}_{BH}, C_{ds1}, \frac{b}{a}\right) & \text{if } \left| \begin{array}{l} \text{Shape} = 1 \\ \frac{c}{\sqrt{a \cdot b}} < 1 \end{array} \right. \\ \text{linterp}\left(\text{ratio}_{LD}, C_{ds}, \frac{c}{\sqrt{a \cdot b}}\right) & \text{if } \left| \begin{array}{l} \text{Shape} = 1 \\ \frac{c}{\sqrt{a \cdot b}} > 1 \end{array} \right. \\ \text{linterp}\left(\text{ratio}_{cyl\_axial\_LD}, C_{ds\_cyl\_axial}, \frac{c}{a}\right) & \text{if Shape} = 2 \end{cases}$$

$C_{D.deep.z} = 1.176$

f. Drag coefficient of the structure for splash zone:

$$C_{D.spl.z} := \begin{cases} 3C_{D.deep.z} & \text{if } 3C_{D.deep.z} > 2.5 \\ 2.5 & \text{otherwise} \end{cases}$$

$C_{D.spl.z} = 3.529$

2. Mass moment of Inertia

Mass Moment of Inertia

$$Ix := \begin{cases} \frac{M_{box\_air}}{12} \cdot \left(w_{box}^2 + h_{box}^2\right) + M_{box\_air} \cdot \left(y_{box\_cog}^2 + z_{box\_cog}^2\right) & \text{if Shape} = 1 \\ \frac{M_{box\_air}}{12} \left[3\left(\frac{w_{box}}{2}\right)^2 + h_{box}^2\right] + M_{box\_air} \cdot \left(y_{box\_cog}^2 + z_{box\_cog}^2\right) & \text{otherwise} \end{cases}$$

$Ix = 0.322 \cdot m^2 Te$

$$Iy := \begin{cases} \frac{M_{box\_air}}{12} \cdot \left(l_{box}^2 + h_{box}^2\right) + M_{box\_air} \cdot \left(x_{box\_cog}^2 + z_{box\_cog}^2\right) & \text{if Shape} = 1 \\ \frac{M_{box\_air}}{12} \cdot \left[3\left(\frac{l_{box}}{2}\right)^2 + h_{box}^2\right] + M_{box\_air} \cdot \left(x_{box\_cog}^2 + z_{box\_cog}^2\right) & \text{otherwise} \end{cases}$$

$Iy = 1.402 \cdot m^2 Te$

$$Iz := \begin{cases} \frac{M_{box\_air}}{12} \cdot \left(l_{box}^2 + w_{box}^2\right) + M_{box\_air} \cdot \left(y_{box\_cog}^2 + x_{box\_cog}^2\right) & \text{if Shape} = 1 \\ \frac{M_{box\_air}}{2} \cdot \left(\frac{l_{box}}{2}\right)^2 + M_{box\_air} \cdot \left(y_{box\_cog}^2 + x_{box\_cog}^2\right) & \text{otherwise} \end{cases}$$

$Iz = 1.44 \cdot m^2 Te$

3. Rotatitional properties:

a. Drag Moment of Area

For splash zone

$$AM_{spl.x} := \begin{cases} \dfrac{C_{D.spl.y} \cdot l_{box} \cdot h_{box}^{4} + C_{D.spl.z} \cdot l_{box} \cdot w_{box}^{4}}{32} & \text{if } Shape = 1 \\ \dfrac{C_{D.spl.y} \cdot l_{box} \cdot h_{box}^{4}}{32} + \dfrac{C_{D.spl.z} \cdot l_{box}^{5}}{60} & \text{if } Shape = 2 \end{cases}$$

$$AM_{spl.x} = 0.8\,m^{5}$$

$$AM_{spl.y} := \begin{cases} \dfrac{C_{D.spl.x} \cdot w_{box} \cdot h_{box}^{4} + C_{D.spl.z} \cdot w_{box} \cdot l_{box}^{4}}{32} & \text{if } Shape = 1 \\ \dfrac{C_{D.spl.x} \cdot w_{box} \cdot h_{box}^{4}}{32} + \dfrac{C_{D.spl.z} \cdot l_{box}^{5}}{60} & \text{if } Shape = 2 \end{cases}$$

$$AM_{spl.y} = 11\,m^{5}$$

$$AM_{spl.z} := \frac{C_{D.spl.x} \cdot h_{box} \cdot w_{box}^{4} + C_{D.spl.y} \cdot h_{box} \cdot l_{box}^{4}}{32}$$

$$AM_{spl.z} = 8.7\,m^{5}$$

For deep zone

$$AM_{d.x} := \begin{cases} \dfrac{C_{D.deep.y} \cdot l_{box} \cdot h_{box}^{4} + C_{D.deep.z} \cdot l_{box} \cdot w_{box}^{4}}{32} & \text{if } Shape = 1 \\ \dfrac{C_{D.deep.y} \cdot l_{box} \cdot h_{box}^{4}}{32} + \dfrac{C_{D.deep.z} \cdot l_{box}^{5}}{60} & \text{otherwise} \end{cases}$$

$$AM_{d.x} = 0.3\,m^{5}$$

$$AM_{d.y} := \begin{cases} \dfrac{C_{D.deep.x} \cdot w_{box} \cdot h_{box}^{4} + C_{D.deep.z} \cdot w_{box} \cdot l_{box}^{4}}{32} & \text{if } Shape = 1 \\ \dfrac{C_{D.deep.x} \cdot w_{box} \cdot h_{box}^{4}}{32} + \dfrac{C_{D.deep.z} \cdot l_{box}^{5}}{60} & \text{otherwise} \end{cases}$$

$$AM_{d.y} = 3.7\,m^{5}$$

$$AM_{d.z} := \frac{C_{D.deep.x} \cdot h_{box} \cdot w_{box}^{4} + C_{D.deep.y} \cdot h_{box} \cdot l_{box}^{4}}{32}$$

$$AM_{d.z} = 2.9\,m^{5}$$

b. Drag Moment Coefficient $Cd_x := 1$ $Cd_y := 1$ $Cd_z := 1$

c. Hydrodynamic inertia:

$$\delta Ix := \begin{cases} Vol_{box} \cdot \rho \cdot \dfrac{\left(w_{box}^2 + h_{box}^2\right)}{12} & \text{if } Shape = 1 \\ Vol_{box} \cdot \rho \cdot \dfrac{\left(3w_{box}^2 + h_{box}^2\right)}{12} & \text{otherwise} \end{cases}$$

$$\boxed{\delta Ix = 0.2 \cdot Te \cdot m^2}$$

$$\delta Iy := \begin{cases} Vol_{box} \cdot \rho \cdot \dfrac{\left(l_{box}^2 + h_{box}^2\right)}{12} & \text{if } Shape = 1 \\ Vol_{box} \cdot \rho \cdot \dfrac{\left(3l_{box}^2 + h_{box}^2\right)}{12} & \text{otherwise} \end{cases}$$

$$\boxed{\delta Iy = 1.1 \cdot Te \cdot m^2}$$

$$\delta Iz := \begin{cases} Vol_{box} \cdot \rho \cdot \dfrac{\left(l_{box}^2 + w_{box}^2\right)}{12} & \text{if } Shape = 1 \\ \dfrac{Vol_{box} \cdot \rho}{2} \cdot \left(\dfrac{l_{box}}{2}\right)^2 & \text{otherwise} \end{cases}$$

$$\boxed{\delta Iz = 1.2 \cdot Te \cdot m^2}$$

d. Added inertia coefficients Ca:

X axis

Dimensions in flow direction:

$$a_x := \frac{l_{box}}{2} = 1.522\,m \qquad b_x := \sqrt{\frac{w_{box} \cdot h_{box}}{\pi}} = 0.575\,m$$

Ratio b/a

$$X_1 := \frac{b_x}{a_x} = 0.378 \qquad X_2 := \frac{a_x}{b_x} = 2.646$$

Ca coefficient from Newman 1977

$$Ca_x := \begin{cases} Y_1(X_1) & \text{if } X_1 < 1.6 \\ Y_2(X_2)\cdot\dfrac{\left(2\cdot b_x^{\,3}\right)}{a_x\cdot\left(a_x^{\,2}+b_x^{\,2}\right)} & \text{otherwise} \end{cases}$$

$$\boxed{Ca_x = 0.402}$$

Y axis

Dimensions in flow direction: $a_y := \dfrac{w_{box}}{2} = 0.577\,m$ $\quad b_y := \sqrt{\dfrac{l_{box}\cdot h_{box}}{\pi}} = 0.935\,m$

Ratio b/a $\quad X_1 := \dfrac{b_y}{a_y} = 1.622 \quad X_2 := \dfrac{a_y}{b_y} = 0.617$

Ca coefficient from Newman 1977

$$Ca_y := \begin{cases} Y_1(X_1) & \text{if } X_1 < 1.6 \\ Y_2(X_2)\cdot\dfrac{\left(2\cdot b_y^{\,3}\right)}{a_y\cdot\left(a_y^{\,2}+b_y^{\,2}\right)} & \text{otherwise} \end{cases}$$

$$\boxed{Ca_y = 0.154}$$

Z axis

Dimensions in flow direction: $a_z := \dfrac{h_{box}}{2} = 0.451\,m$ $\quad b_z := \sqrt{\dfrac{l_{box}\cdot w_{box}}{\pi}} = 1.057\,m$

Ratio b/a $\quad X_1 := \dfrac{b_z}{a_z} = 2.344 \quad X_2 := \dfrac{a_z}{b_z} = 0.427$

Ca coefficient from Newman 1977

$$Ca_z := \begin{cases} Y_1(X_1) & \text{if } X_1 < 1.6 \\ Y_2(X_2)\cdot\dfrac{\left(2\cdot b_z^{\,3}\right)}{a_z\cdot\left(a_z^{\,2}+b_z^{\,2}\right)} & \text{otherwise} \end{cases}$$

$$\boxed{Ca_z = 0.479}$$

Y_1 and Y_2 functions that are fitted into the Newman's curves for added inertia. See Appendix II for details.

$Added\_mass := \left(M_{add.b\_x}\ \ M_{add.b\_y}\ \ M_{add.b\_z}\right)$

$Drag\_Area := \left(DragArea_{b\_x}\ \ DragArea_{b\_y}\ \ DragArea_{b\_z}\right)$

$C_A := \left(c_{add.b\_x}\ \ c_{add.b\_y}\ \ c_{add.b\_z}\right)$

$C_{D.spl} := \left(C_{D.spl.x}\ \ C_{D.spl.y}\ \ C_{D.spl.z}\right)$

$C_{D.deep} := \left(C_{D.deep.x}\ \ C_{D.deep.y}\ \ C_{D.deep.z}\right)$

$I := (Ix\ \ Iy\ \ Iz)$

$AM_{spl} := \left(AM_{spl.x}\ \ AM_{spl.y}\ \ AM_{spl.z}\right)$

$AM_d := \left(AM_{d.x}\ \ AM_{d.y}\ \ AM_{d.z}\right)$

$\delta I := (\delta Ix\ \ \delta Iy\ \ \delta Iz)$

$Ca := \left(Ca_x\ \ Ca_y\ \ Ca_z\right)$

$Cd := \left(Cd_x\ \ Cd_y\ \ Cd_z\right)$

VIII. Results Summary for Orcaflex

1. Translational properties:

X Y Z

Drag area

$Drag\_Area =$

	1	2	3
1	1.04	2.75	3.51

m^2

Drag coefficients

in splash zone

$C_{D.spl} =$

	1	2	3
1	2.79	3.55	3.53

in deep zone

$C_{D.deep} =$

	1	2	3
1	0.93	1.18	1.18

Added mass coefficient

$C_A =$

	1	2	3
1	0.61	1.88	2.82

Added mass

$Added\_mass =$

	1	2	3
1	0.815	2.523	3.777

$\cdot Te$

Note: In Orcaflex,
- leave Hydrodynamic Mass as "~"
- leave Cm as "~"(it will automatically calculate Cm=Ca+1)

2. Inertia properties:

Moment of inertia

$I =$

	1	2	3
1	0.32	1.4	1.44

$m^2 \cdot Te$

Mass of structure $M_{box\_air} = 1.623 \cdot Te$

Volume of structure $Vol_{box} = 1.3075 \cdot m^3$

Note: In Orcaflex,
- Center of mass is the distance from the origin of the buoy's drawing to COG of the box.
- Center of Volume is located at the middle of the height of the box with respect to the buoy's origin. See Orcaflex help for details.

3. Rotational properties:

X Y Z

Drag moment of Area

in splash zone

$AM_{spl} =$

	1	2	3
1	0.817	10.999	8.745

m^5

in deep zone

$AM_d =$

	1	2	3
1	0.272	3.666	2.915

m^5

Drag moment coefficient

$Cd =$

	1	2	3
1	1	1	1

Hydrodynamic inertia

$\delta I =$

	1	2	3
1	0.239	1.126	1.184

$\cdot Te \cdot m^2$

Added inertia coefficent

$Ca =$

	1	2	3
1	0.402	0.154	0.479

Note:
Specify a contact area and a friction factor for seabed contact in a "Contact" tab

Appendix I: Referenced coefficients for translational properties

1. Coefficients for Added mass calculation [Ref 1 Appendix A Table A-2]

See tables in the Appendix A of Ref 1 for required added mass approximation formulae

Added mass coefficients for plate

$$ratio_1 := \begin{pmatrix} 1.0 \\ 1.2 \\ 1.25 \\ 1.33 \\ 1.5 \\ 1.59 \\ 2.0 \\ 2.5 \\ 3.0 \\ 3.17 \\ 4.0 \\ 5.0 \\ 6.25 \\ 8.0 \\ 10.0 \\ \infty \end{pmatrix} \qquad \lambda_1 := \begin{pmatrix} 0.579 \\ 0.63 \\ 0.642 \\ 0.66 \\ 0.69 \\ 0.704 \\ 0.757 \\ 0.801 \\ 0.83 \\ 0.84 \\ 0.872 \\ 0.897 \\ 0.917 \\ 0.934 \\ 0.947 \\ 1.00 \end{pmatrix}$$

Added mass coefficients for cylinder

$$ratio_{b2a} \equiv \begin{pmatrix} 1.2 \\ 2.5 \\ 5 \\ 9 \\ \infty \end{pmatrix} \qquad \lambda_2 \equiv \begin{pmatrix} 0.62 \\ 0.78 \\ 0.9 \\ 0.96 \\ 1 \end{pmatrix}$$

2. Steady flow Drag Coefficients [Ref 1 Appendix B Table B-2]

Version 2: Changed Ratio B/H from 11 to 50 at Cd 1.9

Cd >= 1 for prism
Cd , based on c/sqrt(a*b

Drag coefficients for plates [Ref 1]:

$$ratio_{BH} := \begin{pmatrix} 1 \\ 5 \\ 10 \\ 50 \\ 100 \\ 1000 \\ 10000 \end{pmatrix} \quad C_{ds1} := \begin{pmatrix} 1.16 \\ 1.2 \\ 1.5 \\ 1.9 \\ 1.9 \\ 1.9 \\ 1.9 \end{pmatrix}$$

Drag coefficients for prisms [Ref 1]:

$$ratio_{LD} := \begin{pmatrix} 1 \\ 1.5 \\ 2 \\ 2.5 \\ 3 \\ 4 \\ 5 \end{pmatrix} \quad C_{ds} := \begin{pmatrix} 1.15 \\ 0.97 \\ 0.87 \\ 0.9 \\ 0.93 \\ 0.95 \\ 0.95 \end{pmatrix}$$

Axial Drag coefficients for Cylinders [Ref 1]:

$$ratio_{cyl\_axial\_LD} := \begin{pmatrix} 0 \\ 1 \\ 2 \\ 4 \\ 7 \end{pmatrix} \quad C_{ds\_cyl\_axial} := \begin{pmatrix} 1.12 \\ 0.91 \\ 0.85 \\ 0.87 \\ 0.99 \end{pmatrix}$$

Normal Drag coefficients for Cylinders [Ref 1]:

$$ratio_{cyl\_nor\_LD} := \begin{pmatrix} 2 \\ 5 \\ 10 \\ 20 \\ 40 \\ 50 \\ 100 \end{pmatrix} \quad C_{ds\_cyl\_nor} := \begin{pmatrix} 0.8 \\ 0.8 \\ 0.82 \\ 0.9 \\ 0.98 \\ 0.99 \\ 1.0 \end{pmatrix}$$

Appendix II: Referenced coefficients for rotational properties

1. Coefficients for Added Inertia coefficient calculation

(From Newman 1977)

$$ba_{ratio} := \begin{pmatrix} 0 \\ 0.02 \\ 0.1 \\ 0.2 \\ 0.3 \\ 0.4 \\ 0.5 \\ 0.6 \\ 0.7 \\ 0.8 \\ 0.9 \\ 1.0 \\ 1.1 \\ 1.2 \\ 1.3 \\ 1.4 \\ 1.5 \\ 1.6 \end{pmatrix} \qquad m55_{upper} := \begin{pmatrix} 1 \\ 0.99 \\ 0.89 \\ 0.7 \\ 0.525 \\ 0.37 \\ 0.24 \\ 0.15 \\ 0.065 \\ 0.03 \\ 0.01 \\ 0 \\ 0.01 \\ 0.025 \\ 0.045 \\ 0.075 \\ 0.1 \\ 0.125 \end{pmatrix} \qquad m55_{lower} := \begin{pmatrix} 0.21 \\ 0.21 \\ 0.205 \\ 0.19 \\ 0.155 \\ 0.13 \\ 0.1 \\ 0.07 \\ 0.045 \\ 0.02 \\ 0.005 \\ 0 \\ 0.005 \\ 0.03 \\ 0.055 \\ 0.14 \\ 0.225 \\ 0.35 \end{pmatrix}$$

$$X := ba_{ratio}$$

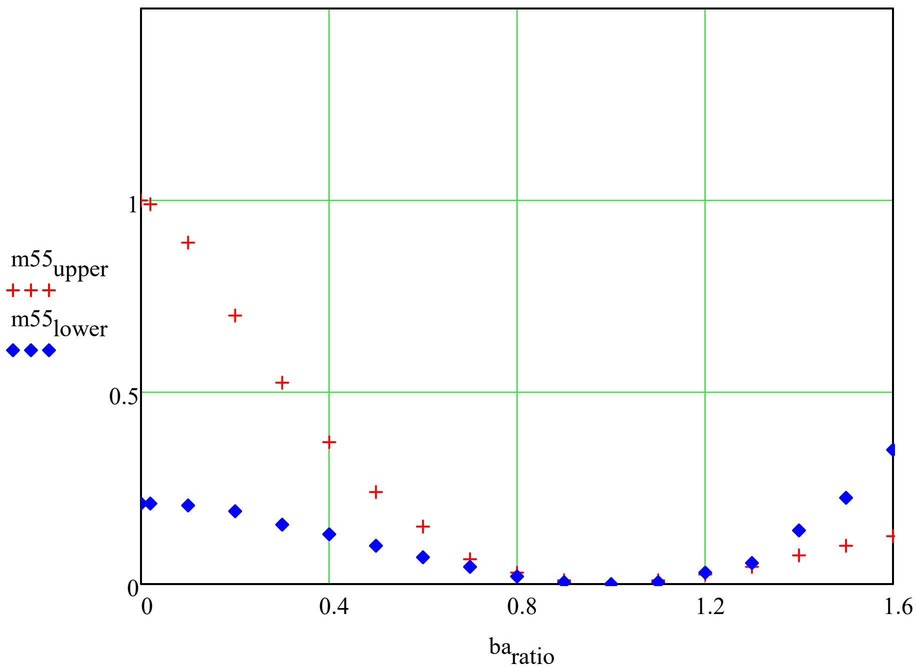
fit curve for m55 Upper

$$Y_1(X) := -0.8958 \cdot X^6 + 5.1304 \cdot X^5 - 11.616 \cdot X^4 + 12.599 \cdot X^3 - 5.3891 \cdot X^2 + (-0.8306) \cdot X + 1.0056$$

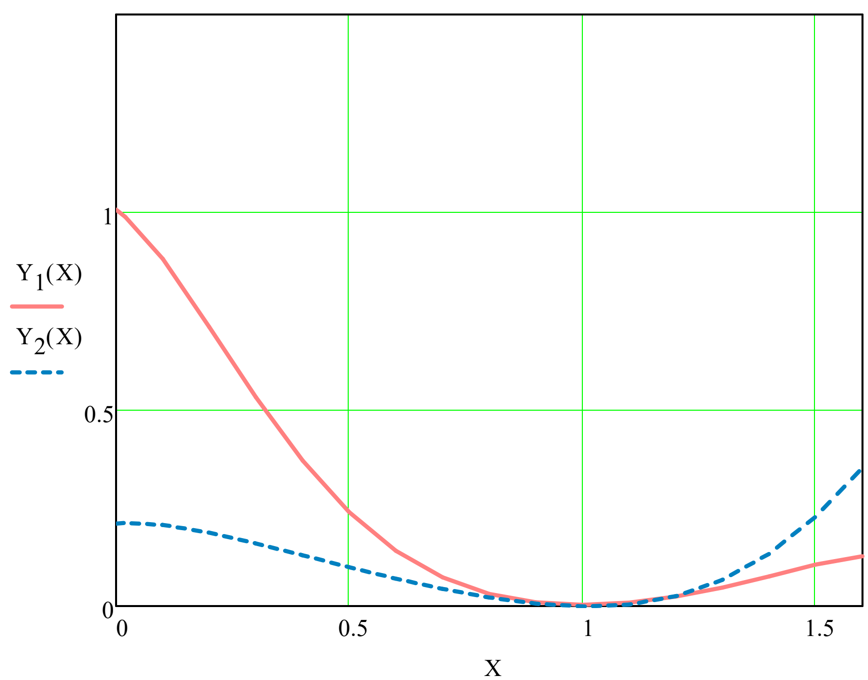
fit curve for m55 Lower

$$Y_2(X) := -0.2602 \cdot X^6 + 1.3492 \cdot X^5 - 2.5645 \cdot X^4 + 2.6105 \cdot X^3 - 1.4314 \cdot X^2 + 0.086 \cdot X + 0.2094$$

Added moment of Inertia for spheroid and sphere



Fitted curves for for Added moment of Inertia



To change the header:
1. Go to View
2. Select Header and footer
3. Left corner change your Client and project name e.i. Shell - Cardamom
4. Center Change structure name, e.i. HDM
5. Change prepared by and checked by rows with corresponding initials. Use a three letter abbreviation e.i. Ayuna Alekseenko, AAL, Erika Bottino da Costa, EBC
6. Do a print Preview to make sure it looks right. Go to File, print preview.
7. Delete this note after completing the Header

!!!SAVE AS the file in your project folder and rename!!!

Note: To adjust the calculation sheet for the project:
1. Change the title
2. Input the drawing #, title, particulars of the structure, e.i. dimensions and weight in input areas (highlighted in green)
3. Insert a drawing of the structure (snapshot)
4. Make sure the orientation the structure for every direction is correct, and the program uses the right dimesions, areas highlighted in teal.
5. Highlighted in Yellow are the results, the summary is presented at the end of the sheet.
6. Delete this note before issuing the document
7. Make sure it is the latest version of the spreadsheet
8. Avoid using spreadsheets from past projects as newer revision might be available

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