Introduction to Hydrodynamic Analysis with Ansys Aqwa

Module 05A: Hydrodynamic Analysis with Forward Speed

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Forward Speed in Aqwa

Aqwa employs a **pulsating source distribution** to estimate the fluid potential around a vessel.

The pulsating source approach assumes that the **vessel is stationary**; strictly, a translating-pulsating method should be used otherwise.

A translating-pulsating source distribution is significantly more computationally expensive, so for typical Aqwa applications it is preferable to use the pulsating source approach with a **forward speed correction**.

Note that pulsating source + forward speed correction **does not predict the Kelvin wake pattern** behind a moving vessel.

Forward Speed in Aqwa

It has been shown that the forward speed correction delivers reasonable accuracy for response calculations provided that:

$$Fn = \frac{U}{\sqrt{gL}} < 0.3$$

Fn is the Froude number; *U* is forward speed; *g* is gravitational acceleration; *L* is a characteristic length (e.g. length at waterline) of the vessel

For a 200-metre (660 ft) vessel, max U ≈ 13 m/s (26 knots)

For a 400-metre (1310 ft) vessel, max U ≈ 19 m/s (37 knots)

Hydrodynamic Coefficients

For a stationary structure in the Hydrodynamic Diffraction analysis we calculate hydrodynamic coefficients at wave frequencies ω and wave directions β:

- RAOs, wave/drift force coefficients are frequency- and direction-dependent
- Radiation Damping and Added Mass are frequency-dependent

When we introduce forward speed, the Radiation Damping and Added Mass matrices now depend on **encounter frequency** ω_e (the rate at which the moving vessel meets the moving waves):

$$\omega_e = \omega - kU\cos\beta$$

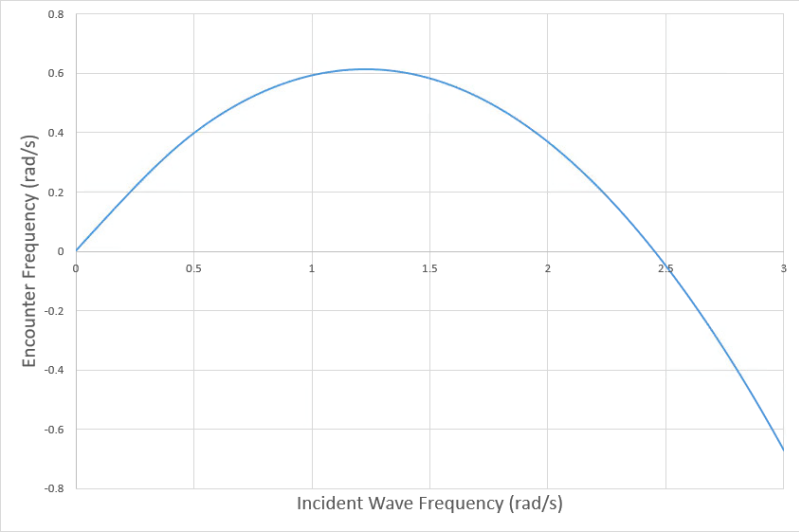
Where *k* is the incident wavenumber (depth-dependent, from dispersion relation).

Hydrodynamic Diffraction with Forward Speed

- Aqwa uses a **modified body boundary condition** for the radiation/diffraction calculation
- Aqwa can analyse **multiple structures** with forward speed, including **hydrodynamic interaction** between them
- However, the forward speed is applied in the **global reference frame**, so you can't have stationary and moving vessels in the same analysis
- Drift coefficients may be inaccurate, as the additional wave resistance due to Kelvin wave effect is not included.

Hydrodynamic Diffraction with Forward Speed

- Aqwa automatically selects encounter frequencies from the defined range:



Water depth = 100 m

Forward speed = 4 m/s

Wave direction = 0°

Wave frequency = [0.001, 3.0] rad/s

- Aqwa will analyse additional encounter frequencies around $\frac{\partial \omega_e}{\partial \omega} \rightarrow 0$ (at the peak)
- For higher wave frequencies, where wave direction -90° < β < 90°, **the encounter frequency may be negative** (i.e. vessel overtakes the waves)
- For negative encounter frequencies, the added mass and damping coefficients can be uniquely determined through the hydrodynamic properties at the corresponding positive encounter frequency – see the **Aqwa Theory Manual** for more info!

Hydrodynamic Response with Forward Speed

- Stability, time domain and frequency statistical analyses can be carried out as usual
- In time domain calculations, we may either:
  - Move the vessel through the water, e.g. by applying a structure force and damping
  - Move the water under the vessel (usually easier)
- For the latter option, an **inverse ocean Current** should be defined (180° heading, speed equal to vessel forward speed)

Details	
Details of Current 1	
Name	Current 1
Visibility	Visible
Activity	Not Suppressed
Water Depth Definition	Use Water Depth in Environment Constants
Water Depth	500 m
Current Definition	
Type	Constant Velocity
Speed	10 m/s
Direction	180°

- Time domain Analysis Settings option ‘Account for Current Phase Shift’ adjusts the incident wave frequencies to account for the effect of the Current

Common Analysis Options	
Convolution	Yes
Call Routine "user_force"	No
Connect to Server for External "user force" Calculation	No
Calculate Motions Using RAOs Only	No
Account for Current Phase Shift	Yes
Apply Drift Force with Multi-Directional Wave Interaction	No

Hydrodynamic Response with Forward Speed

- In time domain calculations where an inverse Current is applied, it may be necessary to apply some constraints to counter viscous drag (due to Morison elements/Current Force Coefficients)
- This can be achieved using:
  - Soft moorings: low-stiffness linear Cables between anchor Fixed Points and vessel Connection Points, to loosely hold the vessel in place
  - Deactivated Freedoms: turn off vessel motions in selected degrees of freedom
  - Constant structure forces: if the mean vessel resultant forces are known, and the instantaneous position is not important
  - Time-varying structure forces: may be defined by a Python script, to model a Dynamic Positioning system to hold the vessel's position