MODELING CURRENT FORCES ON SHIP HULL FOR MOORING STRUCTURES DESIGN

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With constant increase in world transport of goods and raw material, ports and jetties around the world have to face ships bigger and bigger. In order not to oversize the various elements of the mooring design, and thus make substantial savings in their construction and rehabilitation, it is important to assess as accurately as possible forces on ships that are going to be called at these structures.

Mooring structures design can be dealt with specific softwares that compute mooring loads (mooring lines and fenders system). Previously to these studies, it is necessary to estimate external loads on the ship due to hydraulic (current, wave) and meteorological (wind) conditions. Apart from the wave induced forces, the loads generated by winds on the ship's superstructures and by currents effects on the ship's hull may be evaluated by using specific numerical models.

ARTELIA has defined a methodology to compute currents intensity and direction around the ship and deduce forces and moments on the hull. Results are obtained for different water levels which allow identifying the most constraining hydrodynamic condition. An example of application of this methodology is presented for the study of a mooring jetty in an estuary (France).

Firstly, a free surface numerical model (TELEMAC - EDF) at the estuary scale is developed. This model is forced upstream with the daily discharge of the rivers, downstream with the astronomical tide level and the variations of mean sea level due to meteorological conditions. The model is calibrated with water level measurements along the estuary and velocity measurements specifically done for the study nearby the mooring site. Simulations are conducted through several time periods, representative of the variety of hydrodynamic conditions that can be encountered on site.

Analysis of a complete tide on the mooring site allows identifying unfavorable mooring periods (high currents and low water level) for neap and ebb tide.

Then, a local CFD model is constructed (OpenFOAM), including the existing geometric structures (docks, piers) and the maximum size of ship that may call at the jetty. The mesh around the hull of the ship needs to be well refined with a mesh size of about 20 cm for the hull of a boat of 195 m long, 32 m wide and 10.5 m draught.

Boundary conditions of this local model are forced with results of the TELEMAC estuary model. As the entire tide duration cannot be run on the CFD model (due to important computational time), only unfavorable time periods (identified with the large scale model) are simulated, and considered as stationary conditions. Hydrostatic and hydrodynamic pressures induced by currents are calculated for each immersed cell defining the hull and more precisely the draught. The integration of those pressure forces gives resulting forces and moments.

Whereas simulations are conducted for a fixed flow and fixed water level, it is noticed that loads on the hull can be time-varying. Indeed, the ship wake interacts with flow along the river bank and changes current direction at the front of the ship. Strong vortices are then developing. Those effects can be important regarding the design of mooring structures.

Finally, mean and maximum forces and moments are used as input by the dedicated hydrodynamics software DIODORE1 devoted to compute mooring loads and 3D movements of a ship exposed to wind, wave and current. Results allow dimensioning elements of the mooring structure (lines, fenders, dolphins…).