

Review of ship behavior characteristics when operating at sea

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Abstract. During activity 1.1. included in Platmarisc project authors collected information for initial evaluation for ship behavior characteristics when operating at sea. Identification of loads and their influence on the behavior of marine intervention platforms is one of the main contributions of the article. As first step in modelling of the 3D ship we will present the 3D initial Model in ModelMaker and the initial loading case according equipment loading onboard.

Keywords: marine, ship, intervention, ship behaviour, operation at sea

1. Introduction

During the duration of operation, a structure is in continuous interaction with the marine environment, therefore the design of marine structures takes into account the following types of tasks:

□- permanent loads are due to the weight of the structure, the weight of the ballast on board and the masses of the equipment permanently mounted on the platform;

□- live loads are caused by the masses of equipment and materials that are not permanently on board the platform and by the forces generated during the operation of the equipment. Operating tasks include living space, consumables, fluids, life support systems, furniture and heliport. For example: operating the cranes, landing the helicopter. According to British Standards BS6235, the following values are recommended for calculation: Crew and passenger spaces 3.2 KN / m² and workspaces 8.5 KN / m² [British Standards 6235, Code of practice];

-□ tasks due to the environment: wind, currents, wave, temperature, snow and ice, marine organisms, but also earthquakes.

The design of marine structures is dominated by loads due to the marine environment and especially wave loads.

The progress of continuous improvement of management practices is important for assessment of occupational risks and makes it possible to propose measures to improve performance in terms of health and safety and working conditions for the PLATMARISC project based on the experience feedback of the national company SC.COREMAR.SA Constanta, Romania.

2. Loads due to waves and currents

Loads due to waves and currents are the most important in the class of loads from the marine environment when it comes to marine structures. The forces that appear at the level of the structure are caused by the movement of water (movement of waves and currents). To determine these tasks it is necessary to idealize the wave surface and wave kinematics using wave theory. Calculation of forces on individual elements and on the total structure caused by the movement of the fluid. For a known wave height and period, the forces acting on the marine structure are software calculable by integrating the vector field of pressures on the submerged surface of the floating structure. Centennial wave data are normally used and no dynamic reaction of the structure is considered. The static calculation is more than enough for the case where the dominant waves have a much longer period than the studied structure. This is the case for structures in shallow water, subject to extreme storms. Waves are characterized by the following parameters: wave height (H), period (T), water depth (d).

Wave theory describes the kinematics of water waves. They are used to calculate particle velocities, their accelerations and dynamic pressure as a function of the wave height and its period.

1. Wind loads

The loads due to the wind act on the emerged surfaces of the structures, the equipment on board and are distributed on the projected surface on a plane transversal to the wind direction. For the most unfavorable combinations of wave and wind, according to the literature, choose between the two: 1 minute of continuous wind combined with extreme waves or 3 gusts with maximum intensity. For higher structure heights, the standards require that the dynamic effects of wind loads be taken into account as the vortices that occur must be investigated. [American Bureau of Shipping, Mobile marine units 2012].

2. Loads due to temperature

Temperature differences can cause strain on the structure. Therefore, during the design period, the extreme values that will be encountered during the life cycle of the structure must be determined. The temperature of the crude oil and gas produced must also be taken into account.

The use of task combinations in sizing and calculating structures generally depends on how they are designed and how they operate. Thus the combinations of tasks used are differentiated [American Bureau of Shipping, Mobile marine units 2012] as follows:

1. Operation under normal conditions, which requires taking into account the permanent loads (dead loads) plus the maximum operating loads (live loads).
2. Operation in extreme conditions requires dead loads, environmental loads and maximum live loads to be taken into account.

Environmental tasks must be considered according to the probability of their meeting in the area of operation of the platform.

3. Analysis of hydro-aerodynamic loads in fluid mechanics

The marine environment has an important influence when it comes to marine exploitation, the hydro-meteorological characteristics and the particularities of the respective marine area determine the way in which they are designed and built.

The hydromechanics of the waves are of particular importance in the study of marine structures because the strongest demands from the marine environment come from the waves. Hydrostatics analyzes the buoyancy and static stability of offshore structures, which become topics of major importance during the construction, installation and operation of these structures. Hydrodynamic analysis involves determining the distribution of pressures on the free surface of water, by associating the wave and forces.

If the fluid is considered non-viscous and irrotational (potential flow), the theory used is based on that of wave propagation, which makes it possible to determine the velocity and pressure field. In this case, Euler's equation is used in conjunction with the impulse theorem. If viscosity forces are also included, then the Navier-Stokes equations apply.

Navier-Stokes Equation:

$$\bar{F} - \frac{1}{\rho} \cdot \nabla p + \frac{\eta}{\rho} \Delta \bar{v} = \frac{d\bar{v}}{dt} \quad (1.)$$

$$F_x - \frac{1}{\rho} \frac{\partial p}{\partial x} + \nu \left(\frac{\partial^2 v_x}{\partial x^2} + \frac{\partial^2 v_x}{\partial y^2} + \frac{\partial^2 v_x}{\partial z^2} \right) = \frac{\partial v_x}{\partial t} + \frac{\partial v_x}{\partial x} v_x + \frac{\partial v_x}{\partial y} v_y + \frac{\partial v_x}{\partial z} v_z$$

$$F_y - \frac{1}{\rho} \frac{\partial p}{\partial y} + \nu \left(\frac{\partial^2 v_y}{\partial x^2} + \frac{\partial^2 v_y}{\partial y^2} + \frac{\partial^2 v_y}{\partial z^2} \right) = \frac{\partial v_y}{\partial t} + \frac{\partial v_y}{\partial x} v_x + \frac{\partial v_y}{\partial y} v_y + \frac{\partial v_y}{\partial z} v_z \quad (2.)$$

$$F_z - \frac{1}{\rho} \frac{\partial p}{\partial z} + \nu \left(\frac{\partial^2 v_z}{\partial x^2} + \frac{\partial^2 v_z}{\partial y^2} + \frac{\partial^2 v_z}{\partial z^2} \right) = \frac{\partial v_z}{\partial t} + \frac{\partial v_z}{\partial x} v_x + \frac{\partial v_z}{\partial y} v_y + \frac{\partial v_z}{\partial z} v_z$$

Unknown quantities are v (velocity field) and p (pressure field). They are determined by integrating the Navier-Stokes equation by knowing the external force of volume relative to the unit of mass and the boundary conditions of the motion.

4. Elements of analysis in the behavior of intervention platforms

The behavior of floating structures is governed by the combined action of external forces and moments, as well as by the inertia of the body itself. Regarding fluid dynamics, these forces and moments generated by the marine environment on floating structures cannot be considered as acting as a unit on the structure. The complex phenomena that accompany the action of the marine environment can be studied with specialized programs associated with the CFD environment and can assess as accurately as possible the frequency dependencies of additional masses and response functions for the studied structure.

The distribution of forces, moments and kinetic energy presupposes that when studying the dynamics of floating structures, CFD calculation methods consider discrete volume elements that can be analyzed as a continuous phenomenon based on Navier-Stokes equations. Usually, the forces associated with the inertia of the fluid, the own weight of the fluid volume, the stresses generated by the viscosity can be anticipated. The behavior of floating surface structures comprises three main forces generated by inertia, weight, buoyancy and viscosity. It is of major importance in an analysis to estimate each term as close as possible

to the technical reality in order to be able to develop RAO functions and means of analysis as accurate as possible.

The most important elements in defining the behavior of floating structures are:

- determination of displacements and rotations together with their derivatives,
- determination of forces and moments,
- determination of additional masses,
- determination of RAO functions,
- stability study.

It is necessary to apply mathematical mechanisms that represent as accurately as possible the phenomena in the marine environment. It is difficult to include in an analysis all the movements and rotations of the structure relative to its own center of gravity under the action of all forces simultaneously. The forces can be treated separately or in pairs of two dominant forces. To determine the dominant force pair, it is useful to determine the orders of magnitude of the forces and moments of inertia, weight and viscosity separately. In general, the effects of viscosity can be ignored, which greatly simplifies the problem. The proposed models and values will constitute an input data for the "Navi-Trainer Professional 5000" (NTPRO 5000) Simulator manufactured by TRANSAS.

5. Modelmaker 3D intervention platform

So far, the intervention platform for a ship model has been modeled in 3D. Using the Autoship software, the body was modeled and the shape plan was obtained. With the help of the Modelmaker software, the ship was modeled in 3D, including the body, the superstructure and the corresponding tanks. Using Autohydro software we determined the main hydrodynamic characteristics, intact stability and longitudinal strength of the body. With the latest Autopower software, the forward resistance and towing power have been determined. Below we present the initial lines plan, 3D design and ship load case in Autoship software.

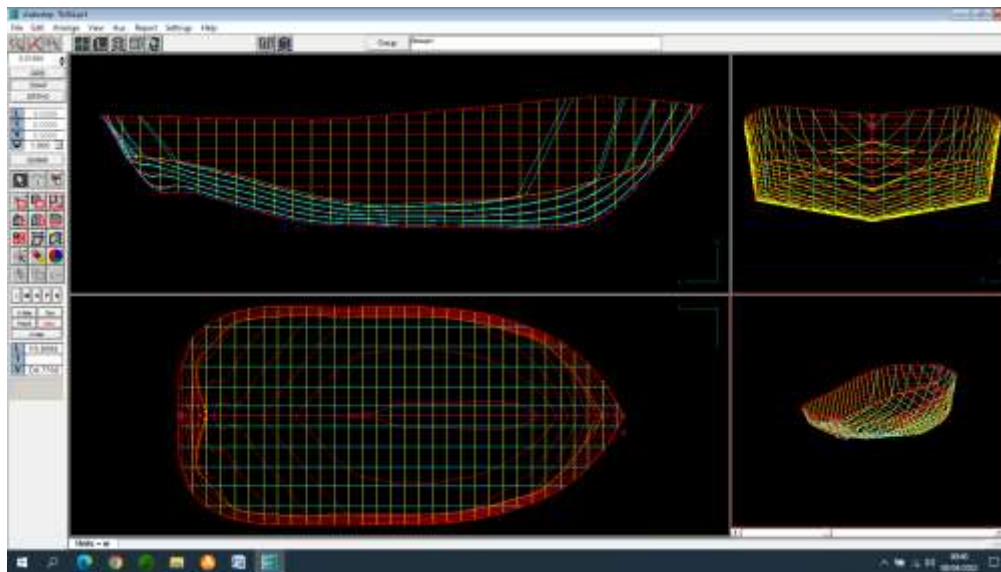


Figure 1. Lines plan presented in Autoship

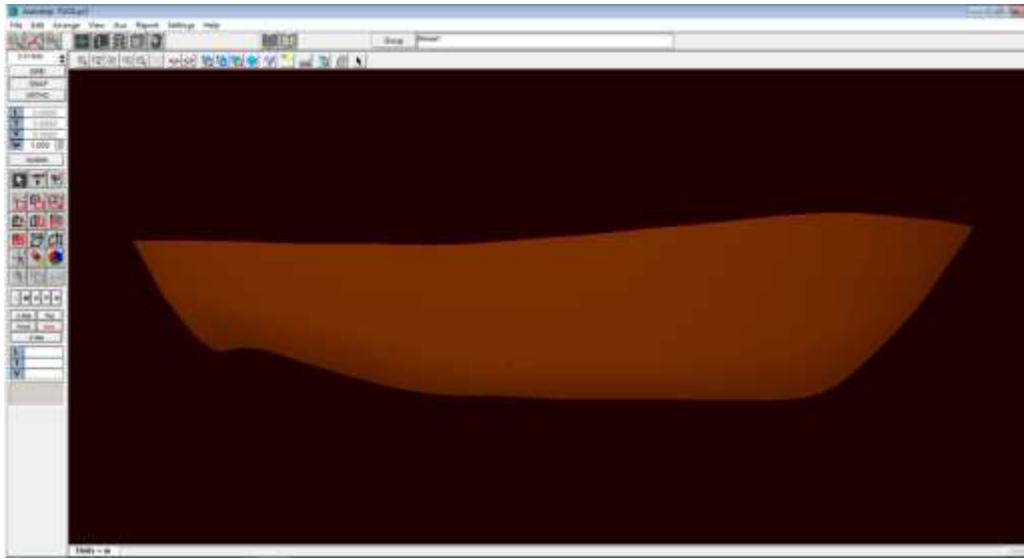


Figure 2. ModelMaker initial design and 3D model preview

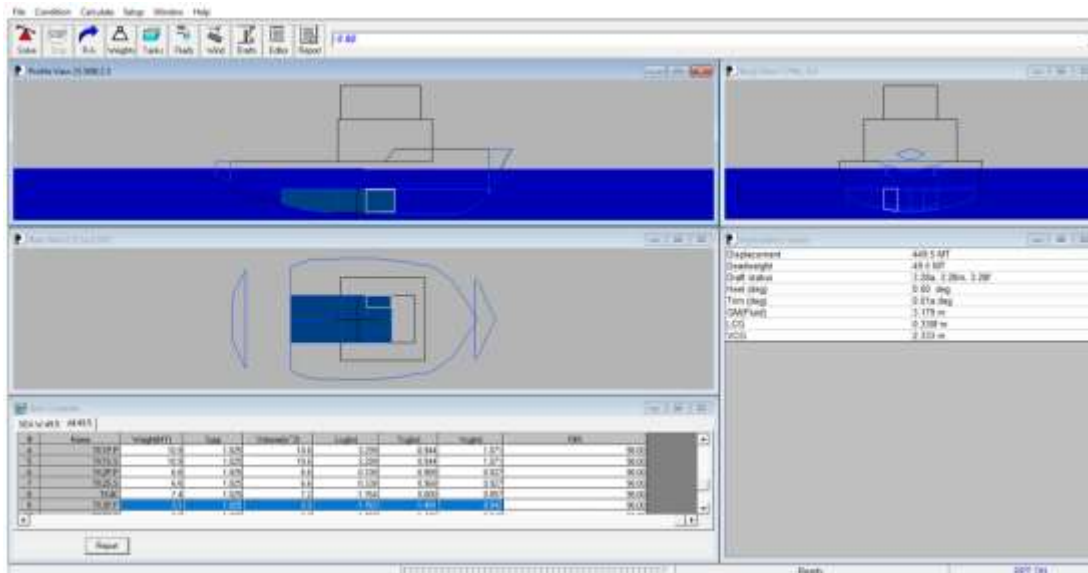


Figure 3. Ship loading case presented in AutoHydro

6. CONCLUSION

Authors participated in PLATMARISC PROJECT in the elaboration of specialized studies related to the dynamics of the different components of the systems from the coastal maritime areas to the Black Sea with a role in disaster risk management:

- we conducted an evaluation study of ship models, which simulates the operation in deep water and shallow water, in different environmental hypotheses.
- we studied the evasive dynamic effects of ships related to undesirable events: collisions, structural damage due to failures, etc.

- we analyzed the main methods for predicting the maneuverability of the ship: self-propelled model test, numerical simulation and semi-theoretical and semi-empirical estimation.

Evaluation of the most reliable simulation models for ship model behavior

For a model of marine platform, made with Modelmaker, the main characteristics of buoyancy, stability, non-submersibility, resistance to advancement, propulsion were determined, using Autohydro and Autopower software. The proposed models and values will constitute an input data for the "Navi-Trainer Professional 5000" (NTPRO 5000) Simulator manufactured by TRANSAS.

We initiated the development of a simplified model of the maritime platform, of fast modular maneuvering, with 4 degrees of freedom and reference technique that can be used for the fast estimation of the maneuvering trajectory and its history of movement.

The model is based on the existing semi-empirical formulations for the hydrodynamics of the hull, rudder and propulsion found in the literature, based on which a satisfactory prediction, in real time, of the maneuvering trajectories for the maritime platform is obtained.

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