WP 3 / Activity 3.3

A Seakeeping Analysis of the Double-ended Hybrid Ferry

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Summary

1. INTRODUCTION

This document presents the seakeeping analysis of the form of the Double-ended ferry. The numerical simulations (CAD import – meshing – computations – visualization) were performed with *Sesam*, a software suite for structural and hydrodynamic analysis of ships and offshore structures, [1]. The numerical simulations were carried out using especially the *HydroD*, a module for hydrodynamic and hydrostatic analysis of fixed and floating structures like offshore platforms and ships.

2. INPUT DATA AND ENVIRONMENT MODELING

The data required to perform the numerical simulation are the sea characteristics, the hull shape, the center of mass for the ferry's loading condition.

The Double-ended ferry is intended for the route in the Adriatic Sea, between Brestova (on land) and Porozina (Island of Cres) through maritime passage Vela vrata, Figure 1. The meteorological and oceanographic data were taken from [2]. Geographical characteristics of the maritime passage dictates the wind directions which usually cause beam seas which can be the most challenging, unpleasant and dangerous of all conditions to navigate.

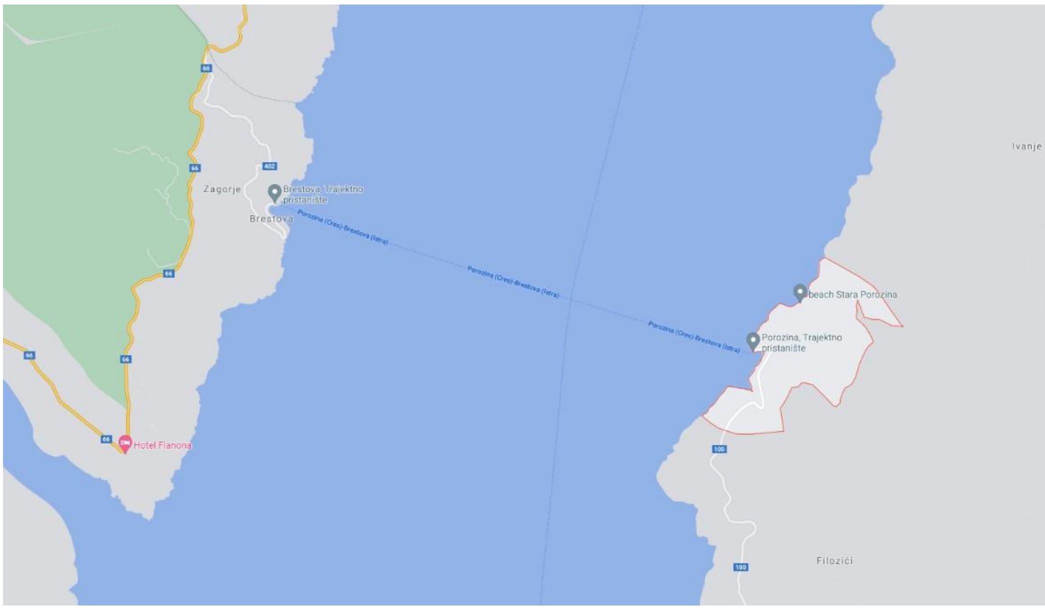

Figure 1. Route Brestova - Porozina

Since the Double-ended ferry is to be suitable for transportation of passengers and road vehicles, it of great importance to have an insight in ferry behaviour at sea. Lashing ropes for vehicles must be properly dimensioned in order to minimize a possible danger of vehicles shifting during high seas. Other point of interest for this analysis is overall comfort onboard during voyage which is crucial for crew to work in an acceptable environment but also for passengers to experience pleasant and safe voyage.

The sea characteristics were modeled through ITTC (Bretschneider) spectrum that is most commonly used in these types of analysis [3, 4]. The significant wave height was taken as 1.5 m with average period of six seconds [5], Figure 2.

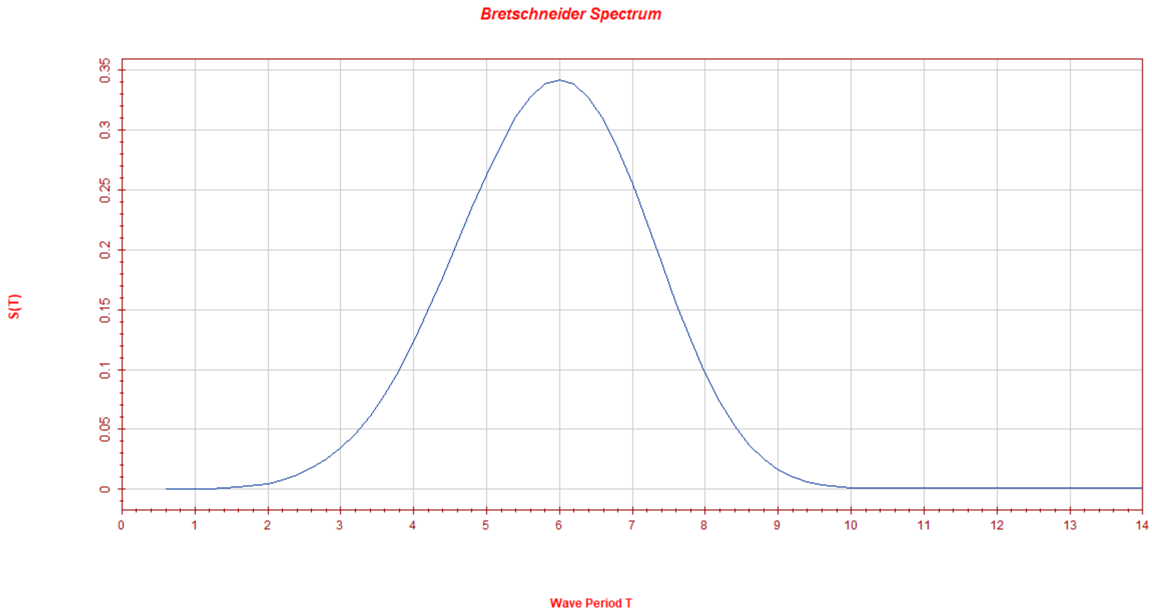

Figure 2. ITTC spectrum

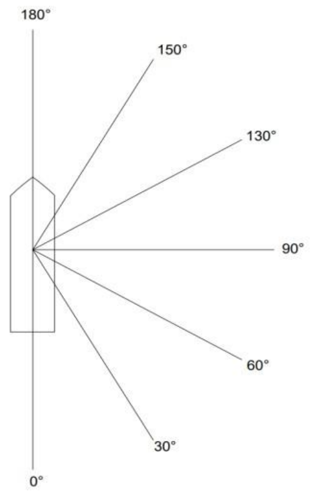

Figure 3. Wave directions applied in calculations

In addition to the significant wave height and the period, it was necessary to determine the directions of waves that ferry would encounter. For this, the direction from bow to stern (0^o - 180^o) was chosen, Figure 3, and the selected step was 30^o. Since the hull of the ferry is symmetric with respect to the plane *xy*, for the numerical simulation only these wave directions were used (0^o - 180^o).

An assessment of seakeeping was made for the most unfavorable loading condition, ie. the "worst" condition that is likely to occur. This condition includes the weights of maximum passenger number and trucks. The parameters of this loading condition are as follows, [6]:

Δ = 2780 t,

T = 2.5 m,

L_{CG} = 46.0 m,

V_{CG} = 5.3 m.

The seakeeping analysis was done for the ferry service speed V_{KN} = 12.0 knots.

The meshed Double-ended ferry hull that is done in module *HydroD* is seen on Figure 4.

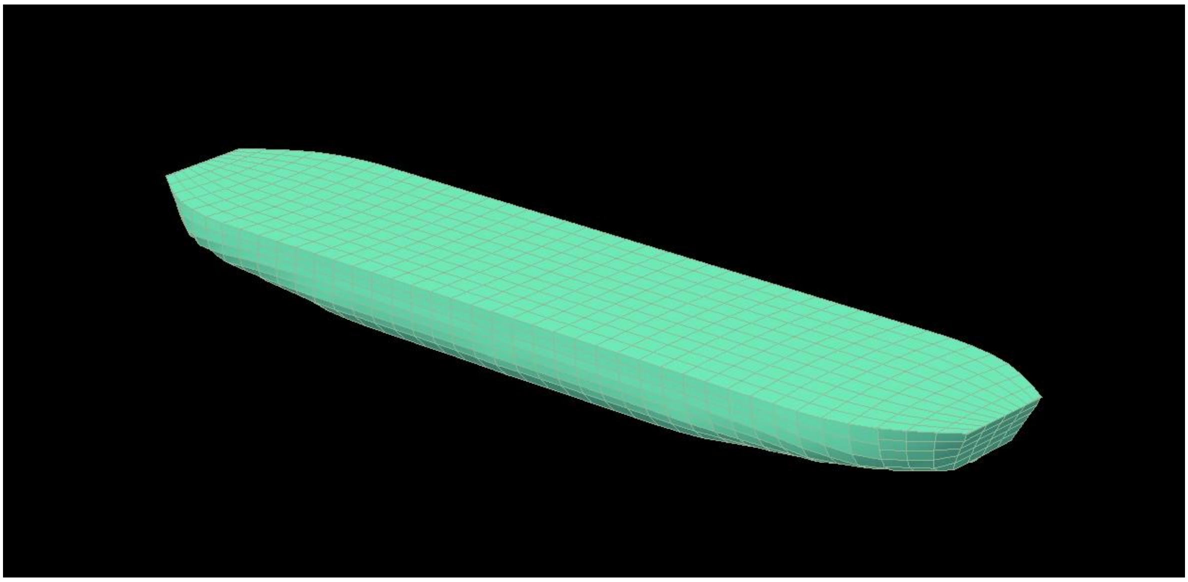

Figure 4. Meshed Double-ended ferry hull done in module *HydroD*

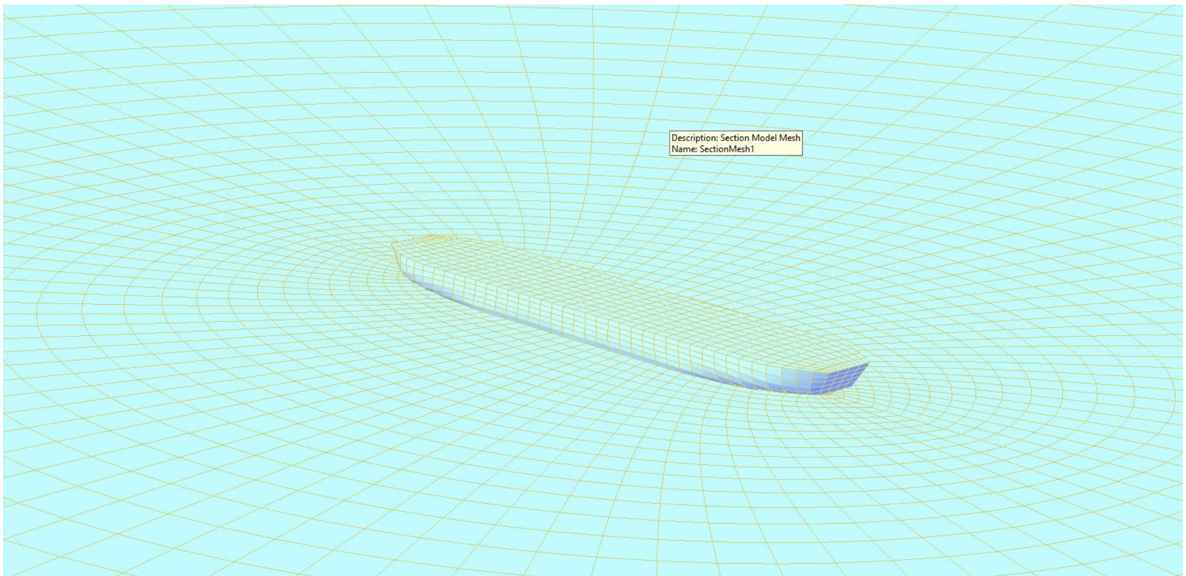

Figure 5. Free surface discretization

The basic CAD model of the Double-ended ferry was prepared by the company Flow Ship Design d.o.o., who was a subcontractor of the project partner Tehnomont Shipyard Pula d.o.o. The model was initially prepared in IGES format. Before the prepared 3D model can be used and imported into the software for CFD simulations, it was necessary to make a comprehensive check of the model, which included, among other things, the check for any irregularities in the model. These actions allow all irregularities to be identified and corrected in advance, in order to subsequently get as smooth as possible mesh required for the numerical simulations.

In addition to the discretized hull, it is also necessary to discretize the free surface, Figure 5.

3. RESULTS

A ship at sea moves in six degrees of motion: heave, sway, surge, roll, pitch and yaw. The first three are linear motions along the *x*, *y* and *z*-axis, while the other three are rotations about these same axes, Figure 6.

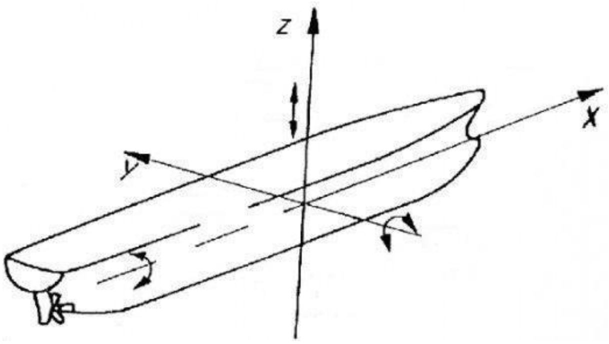

Figure 6. Ship degrees of freedom

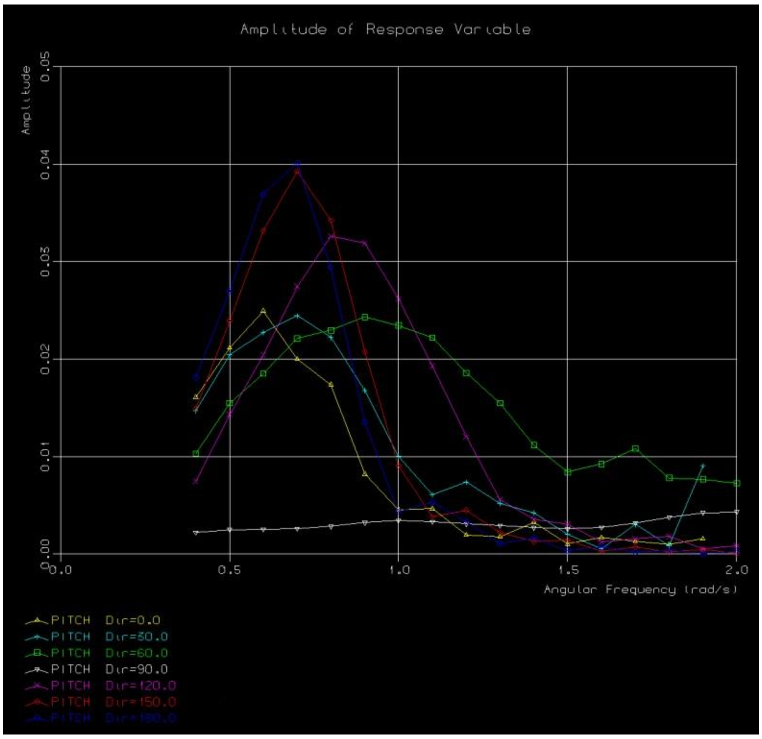

Figure 7. Transfer functions of heave motions

In this seakeeping analysis, only rotational motion of rolling and pitching were observed together with the translational motion in *z*-direction, ie. heaving. These motions are the main cause of seasickness and excessive accelerations.

The seakeeping behaviour of a ship is usually described with transfer functions. The transfer functions of heave are shown in the Figure 7. while the transfer functions of pitching are shown in Figure 8. In Figure 7. there is a visible peak of amplitude but the maximum value of pitching is 1°. In general, a value of 4° is usually considered excessive. In addition, heave and pitch responses in actual amplitudes in time domain are shown in Figure 9. The largest amplitude of heave and pitch appears for head seas (180°).

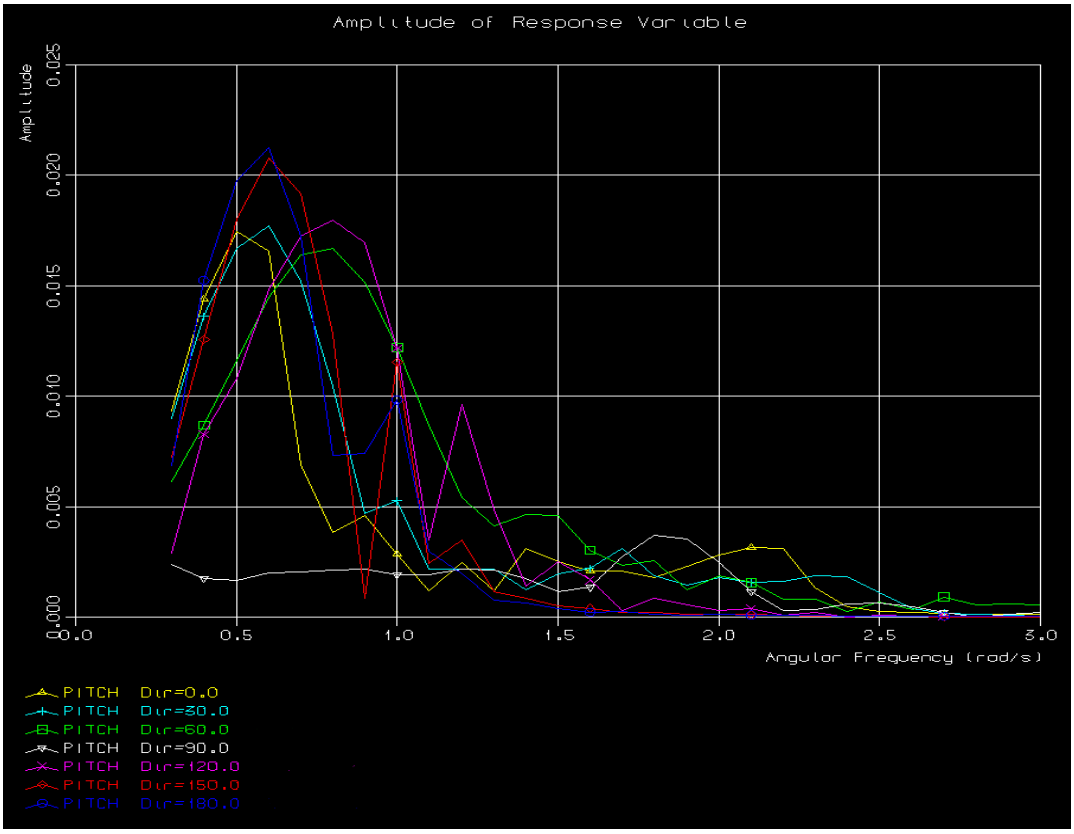

Figure 8. Transfer functions of pitch motions

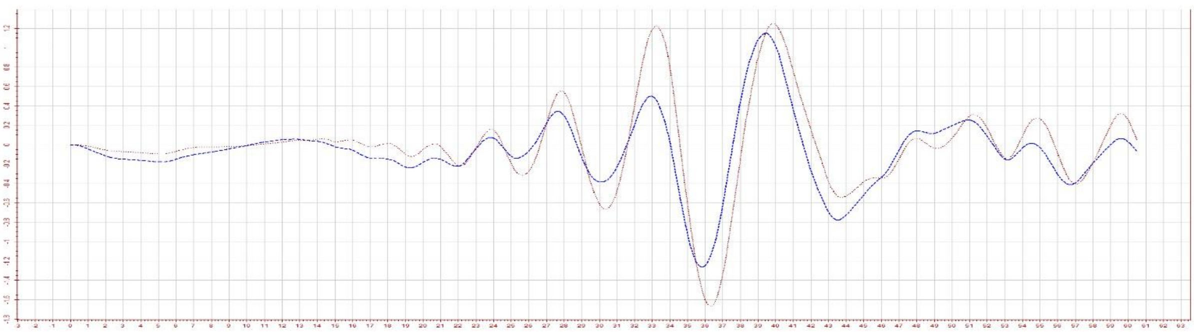

Figure 9. Amplitude of heave and pitch motions for head seas (180°)

The transfer functions for roll motions are shown in Figure 10.

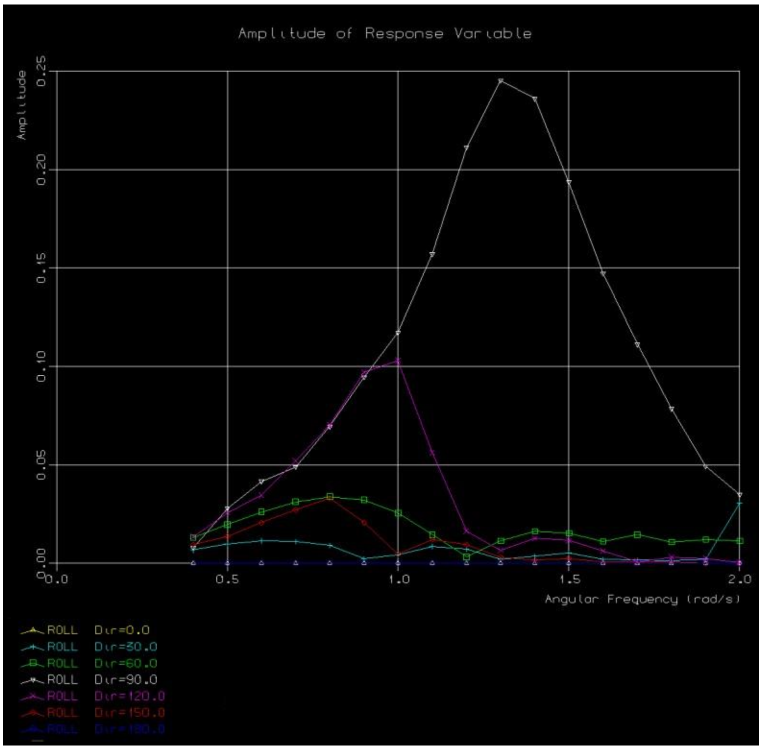

Figure 10. Transfer functions of roll motion

The largest amplitude of rolling appears for beam seas (90°). Increase of amplitude at the end of a time-lapse is due to highly nonlinear effects of rolling which in numerical analysis can be very inaccurate, Figure 11. The amplitude of rolling of the point located on the side of the ferry is presented in Figure 12. It can be seen that the maximum roll amplitudes range up to a maximum of 6°, and the critical values are of about 14°.

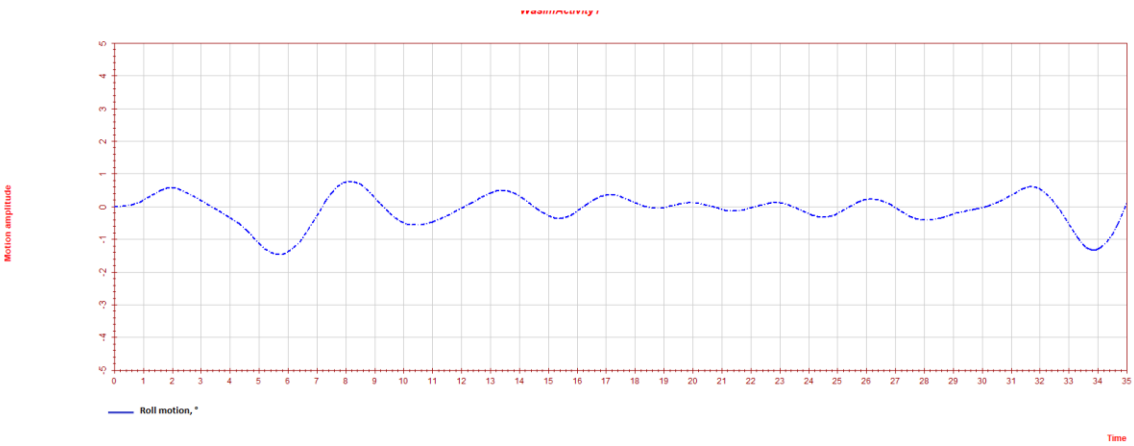

Figure 11. Amplitude of roll motions for beam waves (90°).

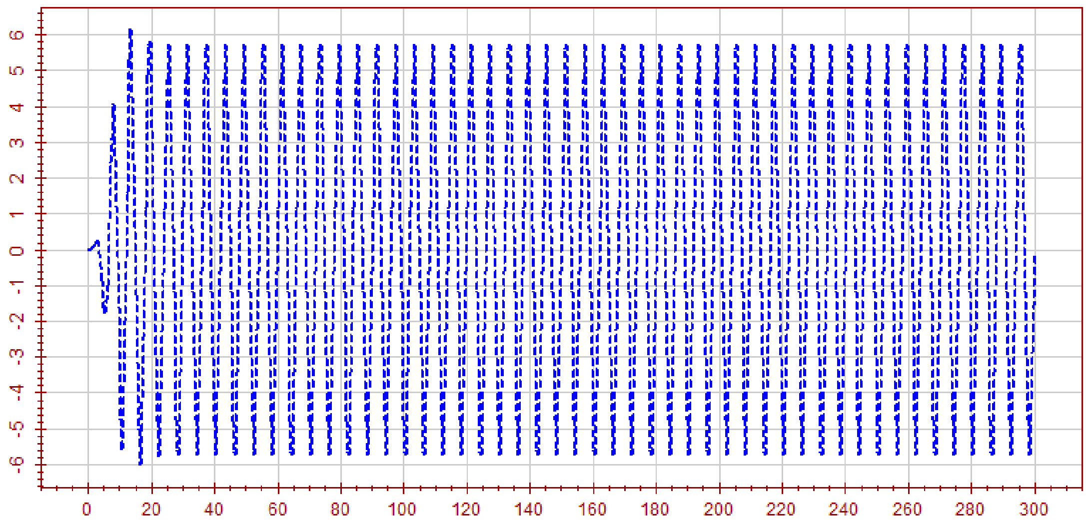

Figure 12. Amplitude of rolling of the point located on the side of the ferry (in °)

Transfer functions for swaying, surging and yawing are not presented since they usually do not cause unwanted dynamic effects.

In Figures 13. and 14. some images obtained from *Sesam* are shown.

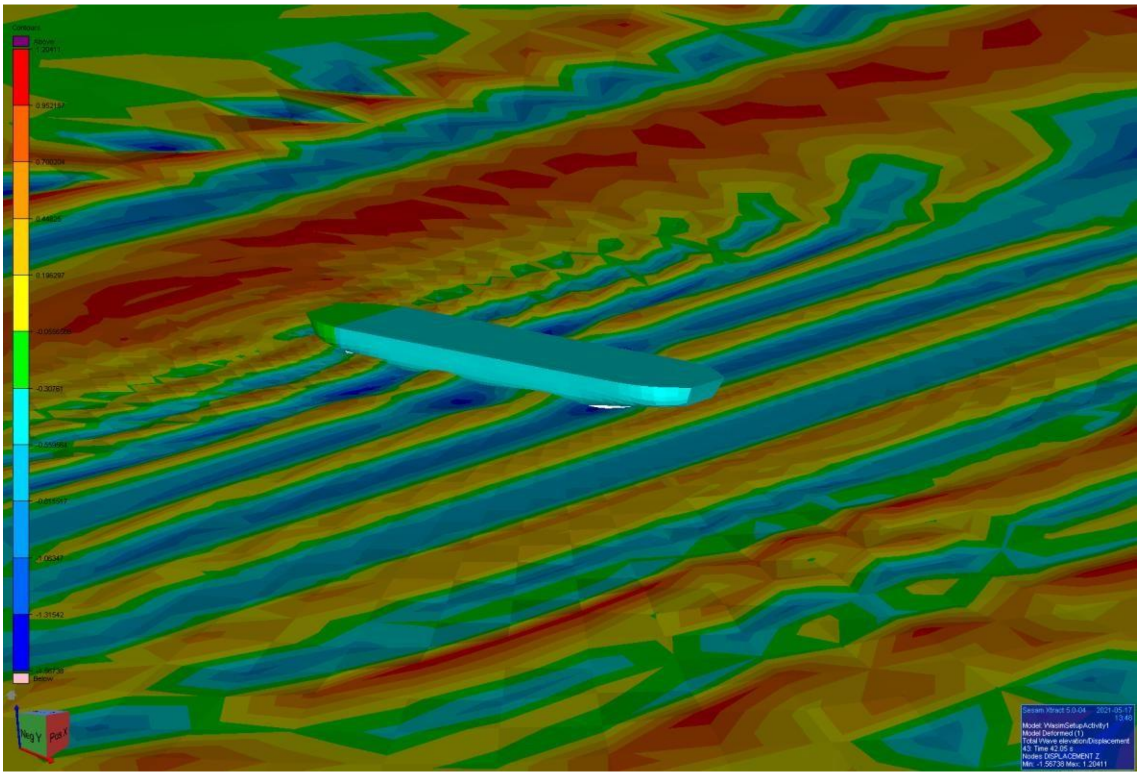

Figure 13. Double-ended ferry in head seas

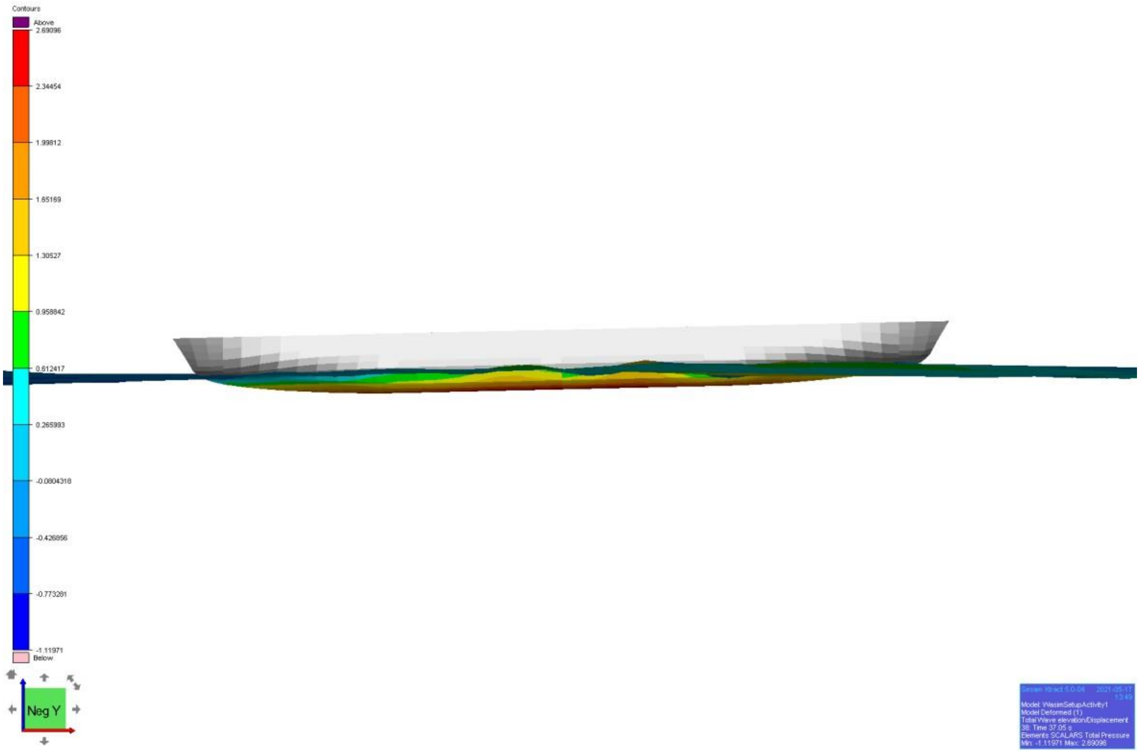

Figure 14. Total pressure on wetted surface

The obtained results of the analysis clearly show a favorable hull shape in terms of response in high seas. The occurrences of slamming and green water are unlikely just as propeller rising from sea which usually cause loss of propulsion efficiency and unwanted noise.

An integral part of this study is also a video titled “Attachment_Seakeeping_DEF_05” which shows the Double ended ferry heave and roll response on regular waves for beam seas. The video was obtained as the result of seakeeping analysis using the *Sesam* suite.

4. CONCLUSION

With this study it was shown that the proposed design for the new Double-ended ferry intended for the route in Adriatic Sea between Brestova (on land) and Porozina (Island of Cres) is suitable for the navigation in Adriatic Sea. Amplitudes of rolling are not significant which contributes to overall comfort onboard. Pitching and heaving is also within acceptable limits which are of great importance regarding slamming, green water and overall dynamic ferry behavior on sea.

NOMENCLATURE

L_{CG} - longitudinal center of gravity, m

V_{CG} - vertical center of gravity, m

T - draught, m

Δ - displacement, t

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