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RAO FUNCTIONS SIMULATION FOR SEMI-SUBMERSIBILES

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Abstract: *Actual semi-submersible uses various technology and systems to improve response in waves. Heave plates are used if required in offshore renewable energy projects to improve lifecycle of the onboard equipments. Using computational fluid dynamics CFD software we will present the difference resulted in Response Amplitude operator for both cases studied. The CFX solver will be programmed to perform a number of trials according various angles and frequencies. Results presented are unique because of the development of the three column semi-submersible.*
Keywords: *Semi-submersible, CFX, wave action, RAO*

INTRODUCTION

Semi-submersible structures of various shapes and sizes waves respond differently and therefore a solution to simplify the way they work is needed to understand the response in waves for these structures [1].
Under the proposed plan testing will be conducted experimental research on semi-submersible model of directions 0, 60 and 90 degrees (Fig.1. Directions test proposed in the tank test). To estimate the forces [2] that occur on the 3D we will use ANSYS CFX to simulate wave action on the semi-submersible with three columns [3] using VoF method. CFX software has the ability to simulate wave action on it from any angle, for that we use a parametric simulation where wave action is the angle parameter analysis.

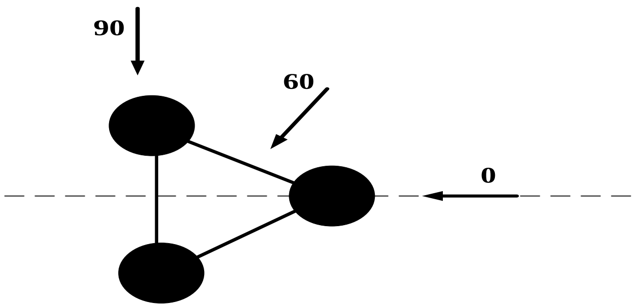


Fig.1. Directions proposed in the tank test

CFD METHODS AND PROCEDURES WORK

CFX analysis is to determine the express forces, moments and movements model waves undergoing regular and CFX module can model the various parameters of analysis. With Design Modeler component semi-submersible structure we have achieved for study and field work using Boolean function / subtraction. The steps were registered Design Modeler and presented in the fig.2 and 3.

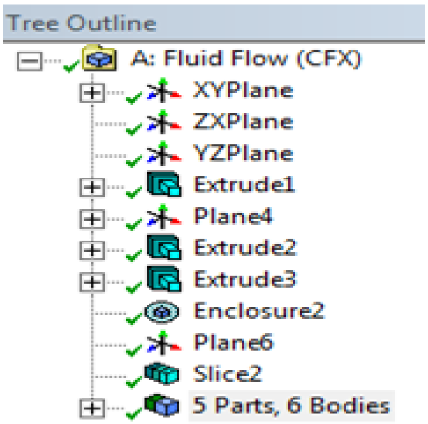


Fig.2.The steps in Design Modeler for geometry

The result of operations shown in the figure above is presented for real values of the semi-submersible structure in 3D figure below. By updating modeling ANSYS WORKBENCH result will be transmitted to the next module Mesh. This module aims to achieve a meshing of the field work addressing needs study and computing power available on the University's computer systems. Limiting the available computing power due to computer systems allow a maximum number of items made from mesh for maximum 4 million and this will affect areas unrefined and not relevant for semi-submersible structure behavior.

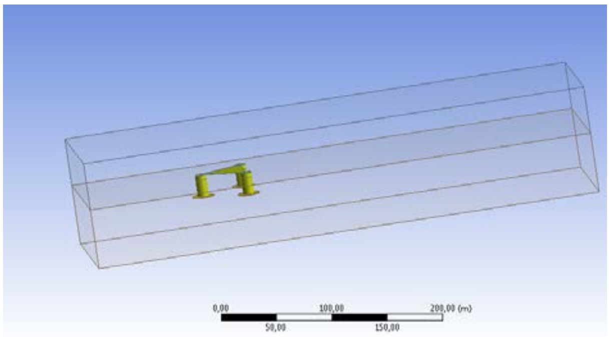


Fig.3. 3D model semi-submersible structure simplified

This program included Ansys Workbench, CFX CFD is a software that can analyze and monitor the simulation parameters on each computing unit (time step) and so the user can carefully observe phenomena that take place in the simulations. Elements of simulations can be monitored and reports window of CFX-solver where every account is print, verify and analyze each step of the simulation.

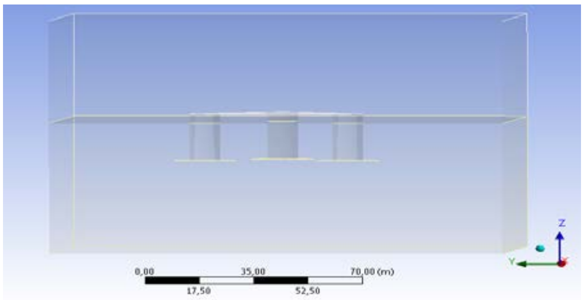
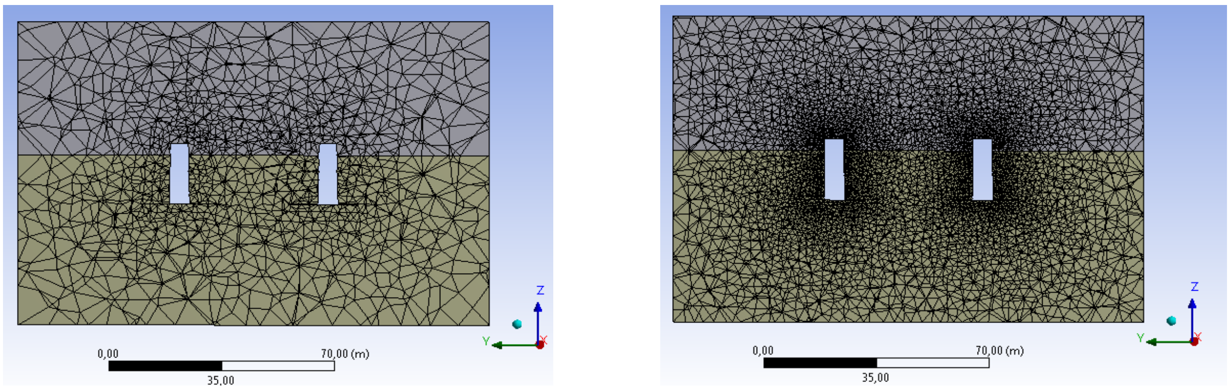


Fig.4. Importing Mesh geometry into view along the axis OX

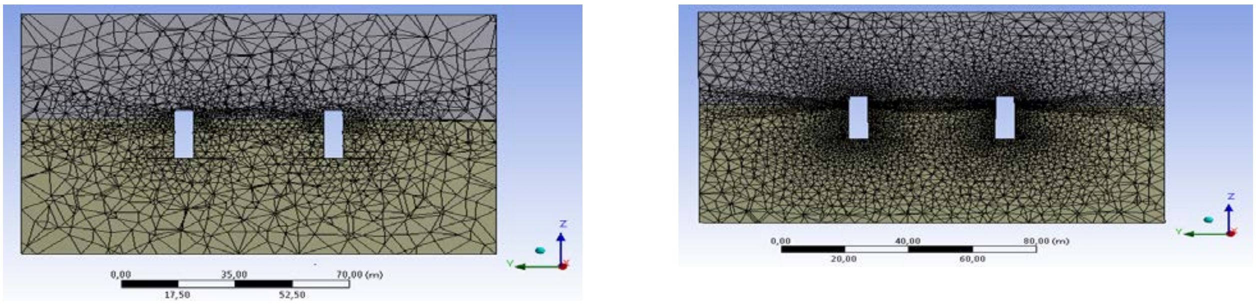
To achieve CFD simulation (fig.4) we use the following assumptions:

- the structure is composed of three vertical columns joined at the top in order to decrease the number of elements of simulations and computational effort to reduce the present capacity of systems within the Naval Academy Constanta (ANMB) fig.4.
- field that is doing the study has an infinite width and delimited domain software friction walls are void [6].
- meshing domain will be done carefully around semi-submersible structure and neglect remote areas of the structure under study [11].



a) Relevance 0 b) Relevance 100

Fig.5. Automatic mesh by view section YOZ (a, b)



a) Relevance 0 b) Relevance 100

Fig.6. Mesh refinement controlled free surface view section YOZ (a, b)

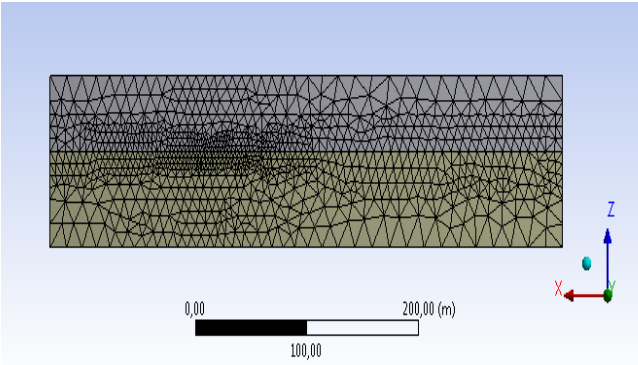


Fig.7. Meshing chosen CFX solver in side

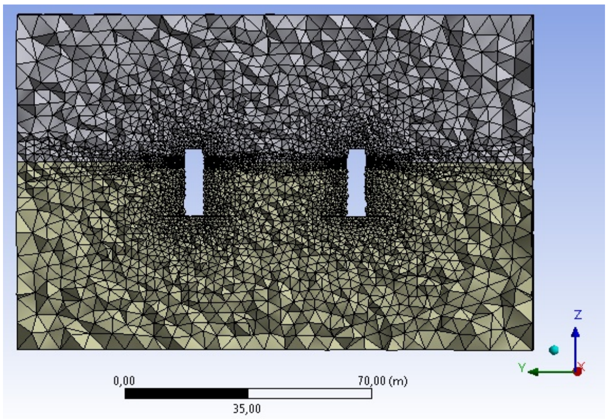


Fig.8. Meshing chosen solver CFX YOZ sectional view "triangle mesher"

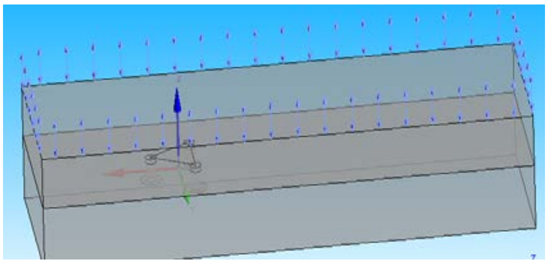


Fig.9. CFX-Pre settings to simulate wave action semi-submersible structure regular model

Making multiphase flows can be done by choosing a general multiphase model but it would not allow the wave and therefore it is necessary to use a model VOF (Volume of Fluid) determined by a set of equations introduced in CFX-Pre with a file. CCL (CFX Command Language). The VOF can use two or more immiscible fluids to solve one set of equations for tracking the volume fractions of the elements of the whole analyzed. The most popular applications are fluid flow VOF method that snags or large bubbles moving through a fluid. This method is suitable for all applications involving gas-liquid interface, but it is needed as well discretized volume to the reference surface. If semi-submersible floating structure we used a fine mesh free surface of water by making a careful meshing close to semi-submersible structure.

Such simulations performed have very high requirements of computer systems [8, 12] and therefore limit the number of elements results in meshing step is a solution for areas not of particular interest for the study. Each component added in a multiphase flow will introduce a new equation that will increase the computing time by about 25%. The number of stages has a significant influence on the requirements of the computing unit (CPU) and this can be seen in Table 1.conducted in accordance with Ansys CFX information in the documentation.

Table1. Increasing CPU memory used by VOF method

Number of phases	**Increasing memory used by CPU**	
	(Hex Mesh)	**(Tet Mesh)**
1	1	1.80
2	2.15	3.40
3	3.50	5.70
4	4.12	7.25
5	6.25	9.15

Based on the results of CFX-Post module can view, measure the results you want for static mechanical analysis model that will build scale. It will have to withstand whatever the direction of the wave pool. Graphical results are presented in figures (Fig. CFX-Post results (izosurface) in regular wave action simulation semi-submersible structure model Fig.4.10. CFX-Post results (VOF Water) to simulate wave action semi-submersible structure regular model).

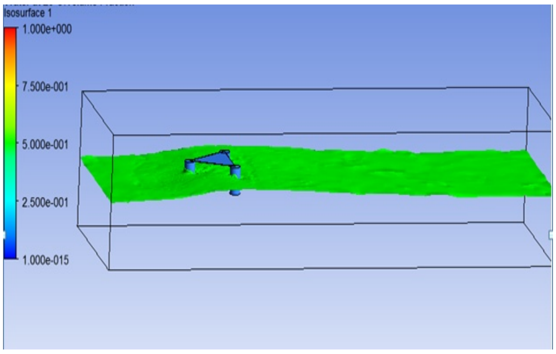


Fig.10. CFX-Post results (izosurface) in simulating the regular wave action semi-submersible structure model

RESULTS FROM SOFTWARE SIMULATION

Presented results are done using VoF method included in CFX solver. VOF method for solving multiphase flows requires that all control elements to be filled with one type of fluid and not allow the existence of empty elements. Therefore less important areas may be less careful refining to avoid unnecessary calculation of areas that are of interest in the behavior of semi-submersible structures. The present method may use one compressible fluid and incompressible fluids unlimited if we studied air and water that is a compressible fluid and incompressible one.

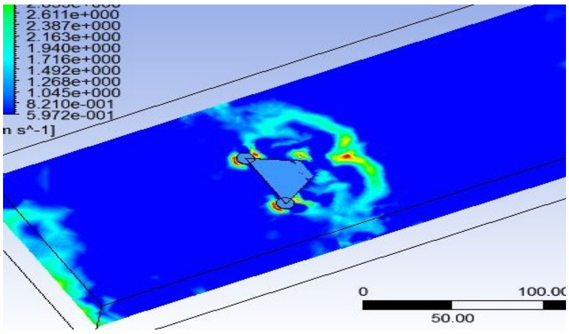


Fig.11. CFX-Post results (VOF Water) in simulating the regular wave action t = 25 seconds

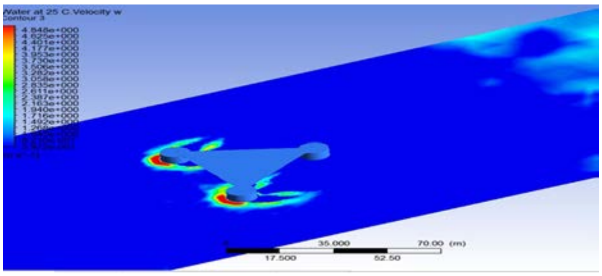


Fig.12. CFX-Post results (VOF Water) in simulating the regular wave action The semi-submersible structure in the z direction speeds at t = 30 seconds

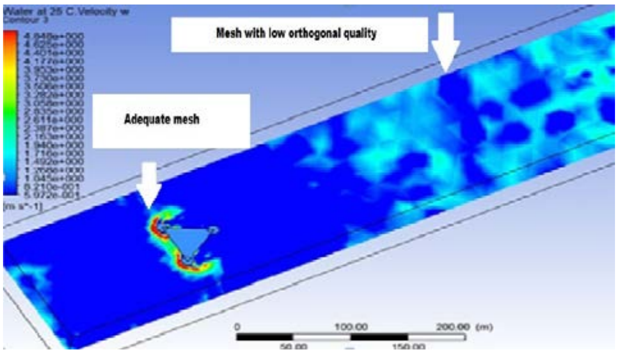


Fig.13. CFX-Post results (VOF Water) in simulating the regular wave action semi - submersible structure model Speeds z direction at t = 35 seconds

During solver CFX calculations using an algorithm for solving linear translation model and a separate algorithm considered rigid body rotations throughout the analysis. There are two options for solving algorithm moments related to body rotation "Backward Euler First Order" and "Simo Wong". For the example I used version that used less demanding computing is solving the reverse-order Euler ("First Order Backward Euler").

Analytical solving Navier-Stokes equations for the flow can only do simple subject to ideal conditions. To obtain solutions for real flows should appeal to a numerical solution of the equations and values can be replaced with approximations and thus can be solved by a numerical method. For this CFX solver uses finite volume method involves meshing domain analysis. Meshing already presented CFX solver is used to build what will be finite volume properties such as mass, time and energy. This is what three lines of work and thus 3D mesh is a process that I will expose in this paper by using sections (2D).

All results are plotted in figures 14 and 15 as frequency functions and the peak presented in both cases have a different frequency and different amplitude. The use of heave plates is affecting the semi-submersible response in vertical translations an also in y-axis rotation.

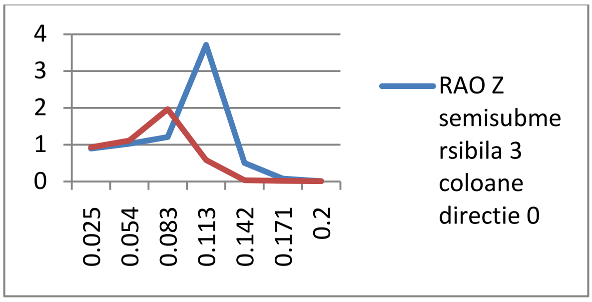


Fig.14. RAO_Z compared for semi-submersible with 3 columns

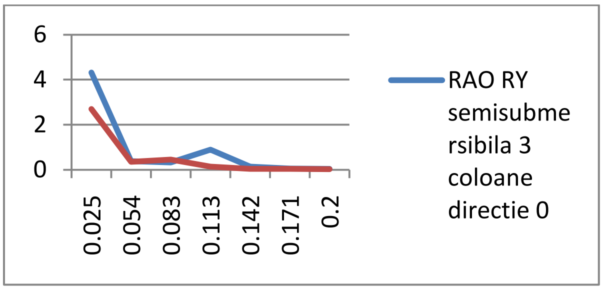


Fig.15. RAO_{RY} compared for semi-submersible with 3 columns

CONCLUSIONS

Whichever direction we have a decrease of the wave function for when RAO use heave plates. This corresponds to the initial assumptions and confirms the need to use end plates where it is desired that the structure to be more stable and less influenced by waves. These values presented will be possible to study experimental on semi-submersible structure model. We will use two configurations to highlight the contribution already visible of heave plates according to numerical results presented in this chapter. Whichever direction we have a decrease of the wave function for when RAO use end plates. This corresponds to the initial assumptions and confirms the need to use heave plates where if it is required to modify parameters for different sea states in operating area.

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