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CONTROLLED DRAFT MODEL FOR OFFSHORE APPLICATIONS

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Abstract: *This paper presents a new way to control depth and manage stability for offshore applications. According to theoretical presumption a simple box shaped model with a open bottom tank is modeled using Autoship. The results plotted are initial stability, static stability curve and expected behavior on transverse waves according to draft. Offshore field is continuously developing and this controlled draft model could be a new way in offshore construction because of its technical simplicity.*
Keywords: *offshore, controlled depth, stability curve, Autoship analysis, offshore*

INTRODUCTION

Worldwide the offshore field is developing fast and requires new technology and new sources of innovation.

The controlled depth model is a new way to improve initial stability for floating structures like semi-submersible boats, semi-submersible rigs(figure 1 left), FPSO (floating production, storage and offloading) and one of the most important recent deelopement seawalk. The modified depth will contribute to a better behavior in waves.

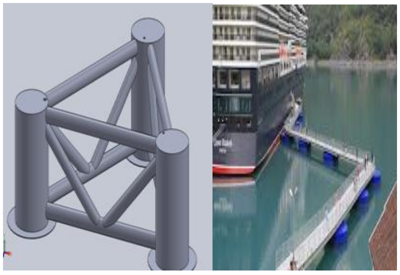

Figure 1 Where to use controlled draft model
(left- semi-submersible rig, right-seawalk)

Submersible boats can also be studied according to controlled depth model. The main difficulty will be the modified centre of gravity when loading or offloading the weight of another ship or a drilling rig.

The depth control will use water, vacuum and pressurized air to manage the depth. Water from low free surface effect tanks will be pushed outside the hull using pressurized atmospheric air. For a drilling rig or a submersible boat we can easily generate on board electrical power needed for the compressors.

DESCRIPTION OF THE MODEL

The controlled depth model for offshore applications will use for analysis a box-shaped structure fitted with a low free surface effect tank. This model of a 3 column semisubmersible platform is shown in figure 1 (left). Instead of using ballast tank to modify the centre of gravity position we will use the same tank wide opened at the bottom. This will allow us to control water level using vacuum or pressure from an air compressor. For a better understanding below are described three distinct situations: The initial box shaped model with no opening, the box shaped model with a 5 m high tank with open bottom and the box shaped model with a 10 m high tank with open bottom.

Initial model

Isometric model view in ModelMaker(component of Autoship) and the waterline for light ship displacement are shown in figure 2. The main dimensions used to draw the model are: lenght:50m, beam:50m, construction height:25m. In this situation the tank is not open to the bottom or is filled with air with higher pressure than outside bottom pressure.

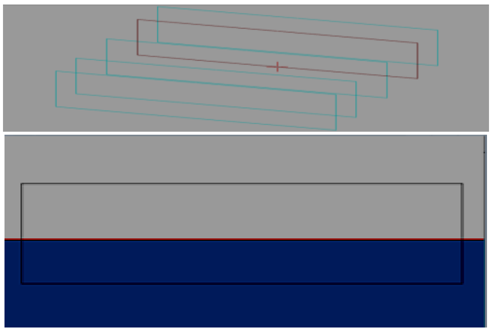

Figure 2 Initial box shaped model with no opening

The box shaped model with a 5 m high tank with open bottom

The open bottom 5m high tank is shown in figure 3. Similar to the first built model and using the same dimensions this second graphic file drawn in ModelMaker is taking into consideration a 30x30x5 open bottom tank. This will make our model establish a new draft and a new metacentric height.

The volume of the open bottom tank is 4500 m^3 divided by 3 longitudinal-vertical walls and 3 transversal-vertical walls. The new draft is 8,55 m in freshwater.

The new metacentric height value is 4,4 m, so the initial stability of the box shaped model with a 5 m high tank with open bottom is higher. Not always a higher initial stability is better because a higher frequency and a lower amplitude will cause higher stress in equipment mooring systems.

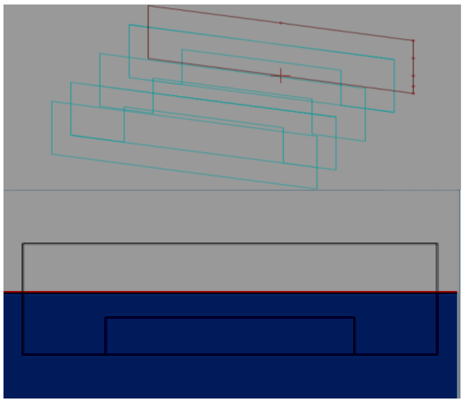

Figure 3 The box shaped model with a 5 m high tank with open bottom

The box shaped model with a 10 m high tank with open bottom

The 30x30x10 open bottom tank is shown in figure 4. This will make our model establish another draft and another metacentric height. Also righting arm as function of heel diagram will change.

The volume of the open bottom tank is 9000 m^3 divided by 3 longitudinal-vertical walls and 3 transversal-vertical walls. The new draft is 10,35 m in freshwater.

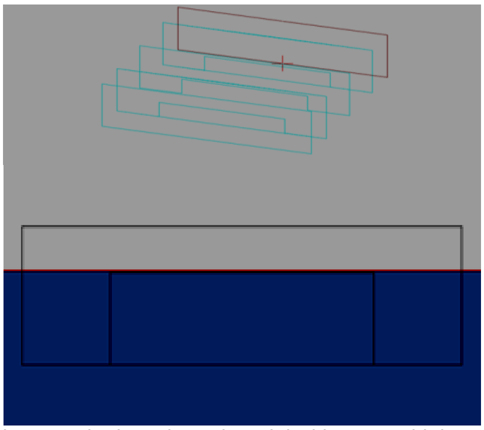

Figure 4 The box shaped model with a 10 m high tank with open bottom

Operating procedure and technical simplicity

This controlled draft with air pressure will not require ballast pumps and will simplify the amount of installed pipelines. Opening the bottom and controlling the air pressure in the tank will increase or decrease the water level in the tank (Fig. 5 and 6). The bottom opening will remain open during operating at any draft. If the opening is closed at any intermediary draft, the centre of gravity will be modified. For the bottom opened tank, the flooded part of the hip will be considered with no buoyancy.

In figure 5 is shown the simplified application of the Controlled draft model with low free surface effect tank while the tank is filling with water and the draft is increasing. The air pressure must be varied slowly or the valves must be carefully open in this case in order to reduce water impact on tank's walls.

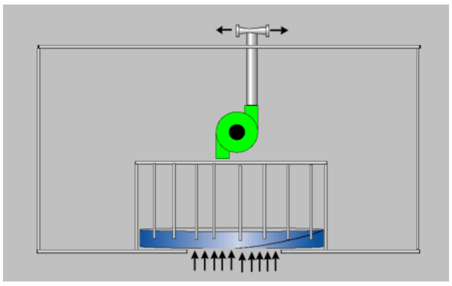

Figure 5 Controlled draft. Increase of water level

For draft decrease, the air compressor must pump air in the upper part of the designed tank. The higher air pressure will push water out. This process will decrease the water level in the tank and also will decrease the draft. In fig. 6 is shown the process and the black arrows tells the direction of the pumped air and the water flow through the bottom opening.

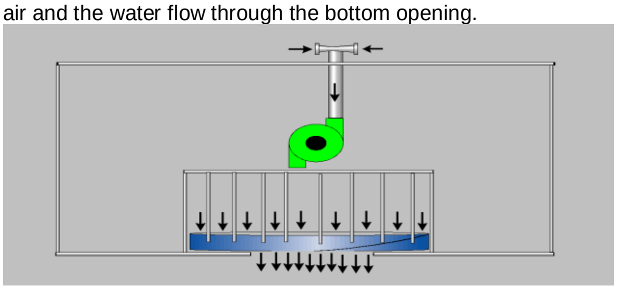

Figure 6 Controlled draft. Decrease of water level

Lower free surface effect due to liquid loading

The free surface effect due to liquid will be minimized with a number of vertical walls according to tank dimensions. Momentum of inertia of water free surface in tank in this case is $I_{initial}$=202500 m^4 and will have a huge effect on initial stability. The solution is to split the tank with minimum 3 verticals walls in both directions of the model: longitudinal and transversal. In this way the metacentric height will be modified with maximum 0,13 m.

STABILITY ANALYSIS RESULTS

Autohydro software(from Autohip package) will automatically solve the selected condition for the graphic files, will calculate the initial metacentric height and the draft and will plot static stability curve.

Initial data for Autohydro software: vertical centre of gravity is set to 32 m according to Argyll FPU. The fresh water density is considered 1,007 t/m^3 and the altwater density is 1,025 t/m^3. The light ship displacement is 17000 tones for all three cases.

Calculated results are shown in table 1 and in figure 7. The graphic also include the initial metacentric variation starting with 6,75 m draft to 10,35 m draft. The angle between controlled draft function and initial draft function depends on the ratio between tank horizontal surface and model horizontal surface.

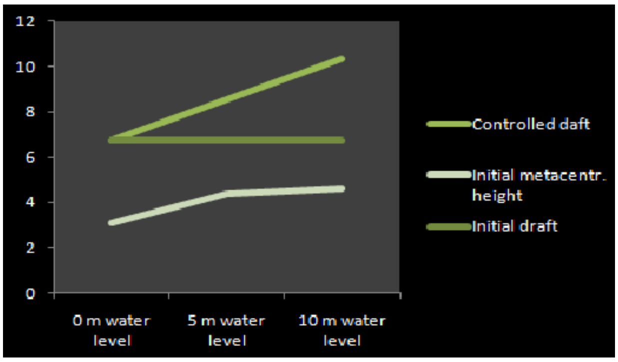

Figure 7 Draft and initial metacentric variation according to water level in tank

Table 1. Resulted values for freshwater(1,007 t/m^3) and saltwater(1,025 t/m^3)

Dimension	Initial model	Open bottom 5 m high tank	Open bottom 10m high tank
Light ship displacement	17000t	17000t	17000t
Fw draft	6.75m	8,55m	10,35m
Sw draft	6,63m	8,43m	10,23m
Initial metacentr. height	3,1m	4,4m	4,6m

The different metacentric height will modify ship response to a 12000 kNm exterior moment due to waves action. The graphs are result of plotting the undamped sinusoidal response according to deck movement at the extremes.

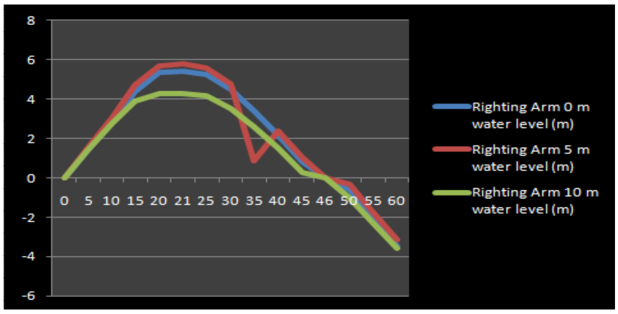

Figure 8 Compared Static stability curve.

The softwate is plotting the righting arm as function of heel for all three cases. The righting arm for 0 m water level (blue) is set as reference when the other two graphs are plotted(red- righting arm for 5 water level, green - righting arm for 10 water level). We observe that function graph are almost similar.

The graphics plotted in figure 9 are blue is for the initial model, red is for the open bottom 5 m high tank, green- open bottom 10 m high tank. The initial model has the biggest amplitude,22 mm, and the lowest frequency due to the lowest initial metacentric value. The other two cases are almost similar the amplitude: 14 mm for the open bottom 5 m high tank and 13 mm for the open bottom 5 m high tank.

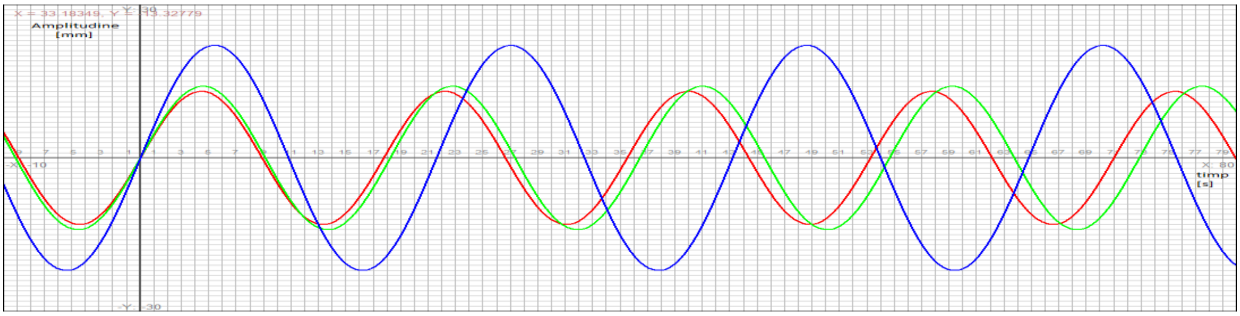

Figure 9 Expected amplitude and period on transverse waves according to draft
Legend: blue - initial model, red- open bottom 5 m high tank, green- open bottom 10 m high tank

CONCLUSIONS

The controlled draft model with low free surface effect tank is suitable for seawalk and could be useful in offshore applications. For the presented model, the vertical centre of gravity remains in the same place and the vertical centre of buoyancy is modifying according to the flooded volume of the tank. All three presented models were analyzed in terms of stability using the draft and initial metacentric height variation according to water level in tank.

The tank is fitted with internal walls as described, the free surface effect due to liquid in case of tank intermediate drafts is lower. The influence, in this case, is much smaller than the initial metacentric height. The free surface effect in the case of no internal walls is so large that the metacentric height could become negative.

This concept could be applied to seawalks because is easier to send compress air and to control pressure from the quay.

Controlled draft for a seawalk is an improvement that will allow to any type of ship to disembark passengers and could be used in further studies.

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