MINIMUM DECK HEIGHT OF A SEMI-SUBMERSIBLE PLATFORM ACCORDING TO BLACK SEA ENVIRONMENT

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Abstract-*The fast evolution of oil/gas offshore industry will need in a near future new oil deposits. The Rumanian shelf is unexplored for water depths higher that 100m. According to this study a semi-submersible platform will be placed in Black Sea for prospection and extraction. The minimum deck height is determined using averaged data about wind and waves from INCDM, and will consider the formation Mechanism of Extreme Storm Waves in the Black Sea.*

The minimum deck height of a semi-submersible platform will be plotted according to heave and pitch simulation in Ansys Fluent CFD environment. Results will be plotted and analised. The numerical results indicate that the Extreme Storm Waves are the most important sources for slamming effects and the extreme edges of the platform will experience the minimal air gap due to the platform heave and pitch motion.

Keywords*: semisubmersible platform, minimum deck height, Black Sea.*

INTRODUCTON

These platforms have hulls (columns and pontoons) of sufficient buoyancy to cause the structure to float, but of weight sufficient to keep the structure upright. A study has to be done in order to establish the minimum deck height in order to avoid wave slamming effects. All Ansys results will be establish in Open Chanel BC with waves accordind with Airy theory.

The practical semi-submersible platform

Semi-submersible platforms can be moved from place to place; can be ballasted up or down by altering the amount of flooding in buoyancy tanks; they are generally anchored by combinations of chain, wire rope or polyester rope, or both, during drilling or production operations, or both, though they can also be kept in place by the use of dynamic positioning. Semi-submersibles can be used in water depths from 200 to 10,000 feet .

So the semi-submersible platform(fig.1) can be used in water oil-gas exploration for water depths more than 100m. The Rumanian Black Sea continental platform in water depths between 100 and 200 m is still unexplored and could represent a huge economical potential. The investment in a semi-submersible platform is huge, the costs of prospection jobs is huge but the reward is higher. Till now, the semi-submersible platform has developed into the 6th generation that can work in water depths from 100 m to 3000m.

In order to prevent the lower deck surface from wave slamming, the minimum deck height should ensure an air gap sufficient to prevent slamming in any sea environment conditions. The air gap is the distance from the lower deck surface to the wave surface. There are many studies on the platforms air gap response for FPSO and different types of offshore structures, this study according to Black Sea Environment is related to the mondial trend of oil/gas rising needs.

The studies above all used Ansys Fluent to simulate a two degrees of freedom in the floating body of the semi-submersible platform subjected to a wave profile characteristic to the Black Sea. The main analyzed variations needed for the deck minimum height are pitch and heave motion.

Fig.1. Semi-submersible platform[wikipedia.org]

The test is showing us the results for the heave motion and the pitch angle history for a period of 15 second, the calculus resolution is 0.005 sec and so we plotted 3000 values.

A. Main semi-submersible platform particulars

The semi-submersible platform used in the paper is the 6th generation deepwater drilling platform under construction in China. The platform has the function of intelligent drilling technology, and ranks advanced level in the world. The main structure of the platform consists of pontoons, columns, deck and derrick, and the main particulars of the semi-submersible platform under survival condition are listed in Table 1.

B. TABLE I. *Main semi-submersible platform particulars*

The main structure of the platform	Unit	Parameters
Pontoon	m	114.07×20.12×8.54
Column	m	17.385×17.385×21.46
Deck	m	74.42×74.42×8.60
Height of derrick	m	64
Waterline from the pontoon base	m	16

C. Environment Condition

Environment for the numerical simulation is based on INCDM data and the wave prediction methods developed on the data collected from INCDM. Details are shown in fig. 3. All values presented below in figures 3-9 are included in the calculation of the average wave and to establish the highest wave height in Black Sea. The ansys simulated environment will replicate these conditions.

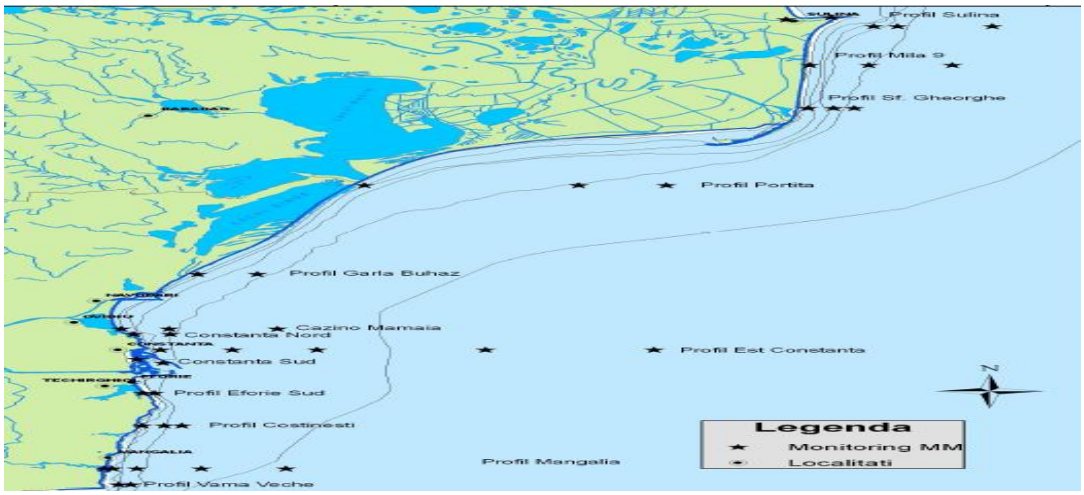

Fig.2 Monitoring points of INCDM [Description of the Black Sea water monitoring, INCDM "Grigore Antipa"Constanţa]

Table 1 Wind frequencies (percentage) corresponding to the principal directions computed for each month, according to INCDM [1]

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Yearly
N	20.7	22.2	18.4	11.0	9.5	9.1	13.2	13.3	14.5	21.6	17.9	17.7	15.8
NE	10.5	16.8	20.9	13.1	11.9	8.8	10.4	13.7	12.5	13.9	9.7	8.0	12.5
E	3.0	4.3	7.4	9.0	10.8	7.7	8.1	9.7	10.7	6.7	5.6	2.4	7.1
SE	3.3	6.4	11.9	16.9	19.4	16.9	13.3	11.5	13.0	11.3	6.4	3.7	11.1
S	9.6	10.3	13.8	20.5	19.4	19.3	15.6	13.0	14.7	13.1	11.3	9.3	14.1
SW	11.3	7.8	7.6	7.1	7.4	8.9	7.6	7.0	7.7	9.2	10.3	11.4	8.6
W	28.0	18.8	11.7	13.3	13.2	18.0	17.4	15.9	18.1	14.2	24.4	31.0	18.7
NW	13.6	13.4	8.4	9.3	8.3	11.3	14.4	14.9	9.7	9.9	14.4	16.4	12.0

Table 2 Wind velocities (m/s) corresponding to the principal directions computed for each month, according to INCDM [1]

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Yearly
N	8.5	8.4	7.5	6.4	5.7	5.6	5.7	6.2	6.7	7.9	7.8	8.5	7.4
NE	8.7	7.7	6.7	5.8	5.6	5.1	5.1	5.5	6.2	7.3	7.9	8.7	6.7
E	6.3	4.7	4.3	3.9	3.9	3.6	3.7	3.7	3.9	5.1	6.5	6.7	4.3
SE	4.7	4.0	3.9	4.2	3.9	4.2	3.7	3.6	4.1	4.1	4.3	4.5	4.0
S	4.6	4.4	4.4	4.4	4.0	4.1	3.8	3.8	3.8	4.1	4.4	4.7	4.2
SW	4.0	4.1	3.8	4.2	3.8	3.2	2.7	2.8	3.1	3.2	3.6	4.0	3.6
W	4.4	4.3	4.6	4.5	4.0	4.0	3.5	3.2	3.7	3.7	4.0	4.3	4.0
NW	4.7	4.9	4.8	4.8	4.3	4.5	4.5	4.4	4.8	4.9	4.8	4.8	4.7
V_{med}	5.78	5.85	5.40	4.77	4.33	4.25	4.13	4.24	4.59	5.37	5.34	5.54	4.97

V_{med} average wind velocity

Fig.3 Data from INCDM

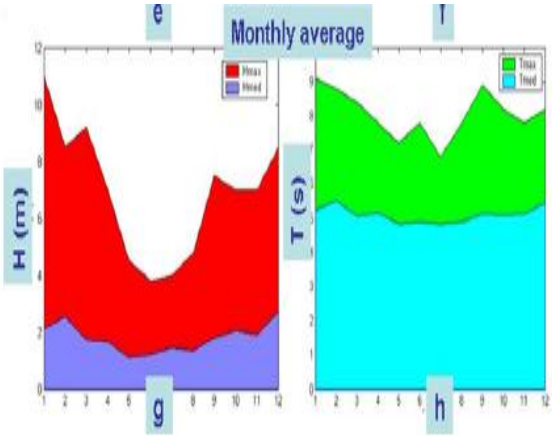

Fig.4 Data analisys. Monhly average for wind velocities and frequency
[Rusu, 2009]

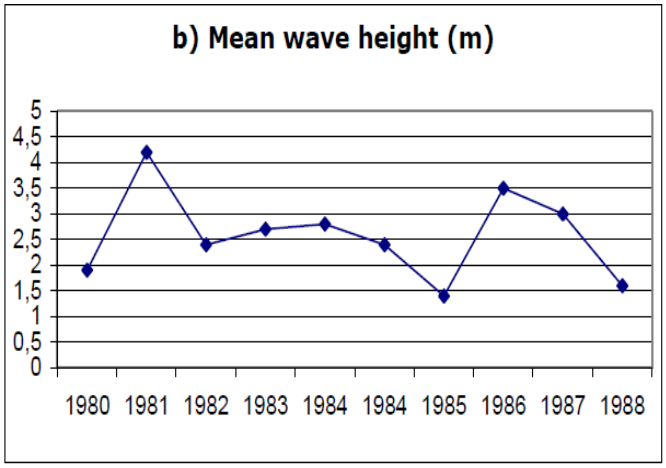

Fig. 5 Mean height during the most violent storms (1980-1988)

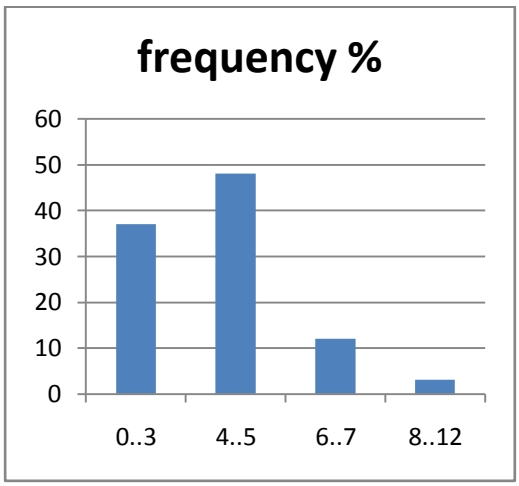

Fig.6. Beaufort scale distribution according to Black Sea state

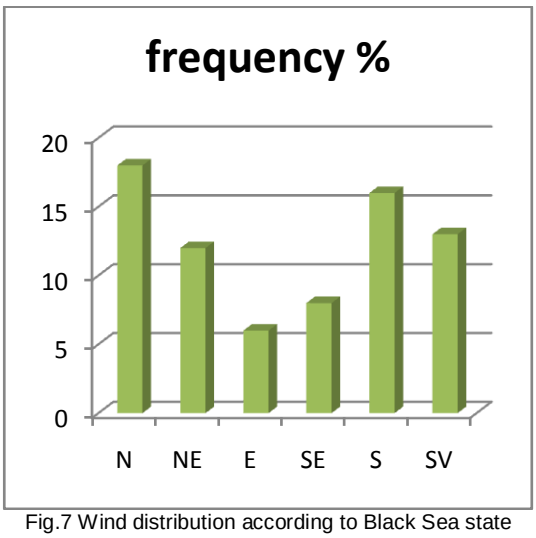

Fig.7 Wind distribution according to Black Sea state

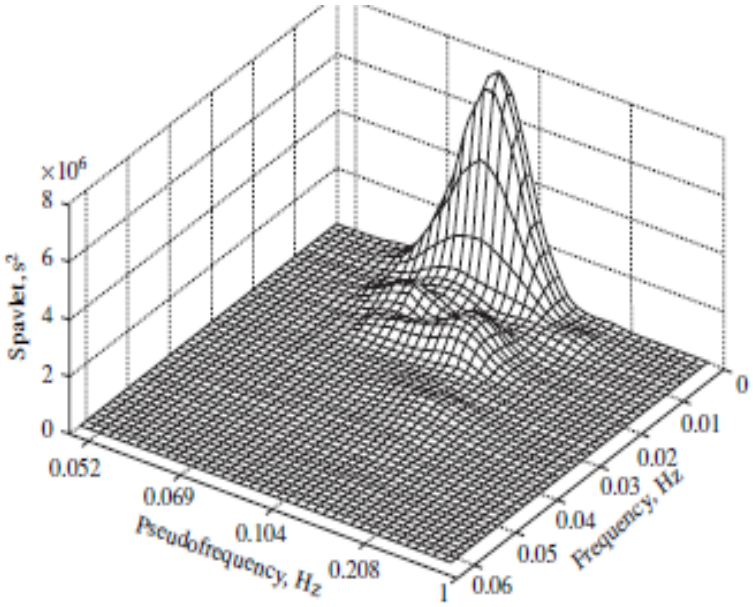

Fig.8 Formation Mechanism of Extreme Storm Waves in the Black Sea [Kuznetsov, 2005]

TABLE III. ENVIRONMENT CONDITIONS

Environment Condition	Storm condition
Maximum registred wave height (H_s)	12.3m [Kuznetsov, 2005]
Wave length for ANSYS simulation 1	6.88m
Wave amplitude for ANSYS simulation 1	4.20m

ANSYS FLUENT SIMULATION

The model of the platform will be analyzed using Ansys Fluent simulation, where the semi-submersible platform is treated as a rigid body and the wave will interact with the platform. The interaction will determine movements and rotations around axes, as shown in fig.9. The most important movement when we analyze the minimum deck height of a Semi-submersible platform in the heave movement and the most important rotation is the pitch. The pitch is closely depending of the semi-submersible longitudinal stability, so that depends on the load status of the platform. All data used are according to table 1 and data from a Solidworks model of a 3 column semisubmersible platform presented in fig. 10.

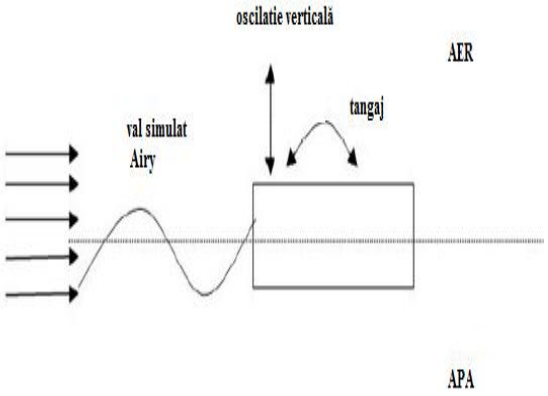

Fig. 9: Schematic of the Problem

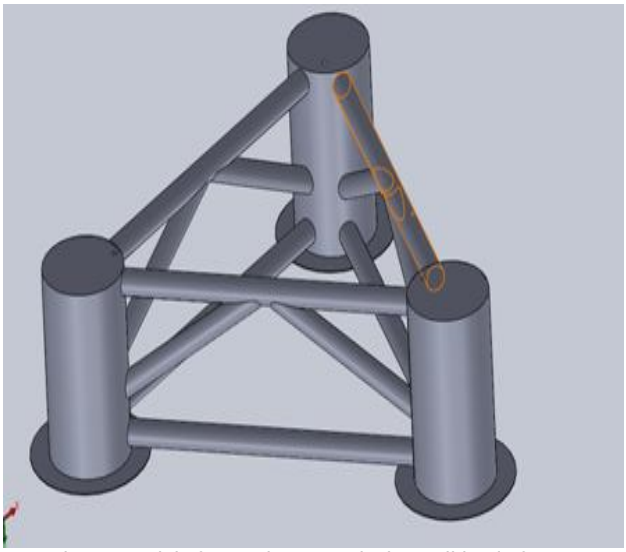

Fig.10. Model of a 3 column semisubmersible platform

After Fluent simulation of a wave according to environmental conditions we plotted the heave movement (fig.10), the pitch (fig.11) and the minimum deck height(MDH) in fig.12.

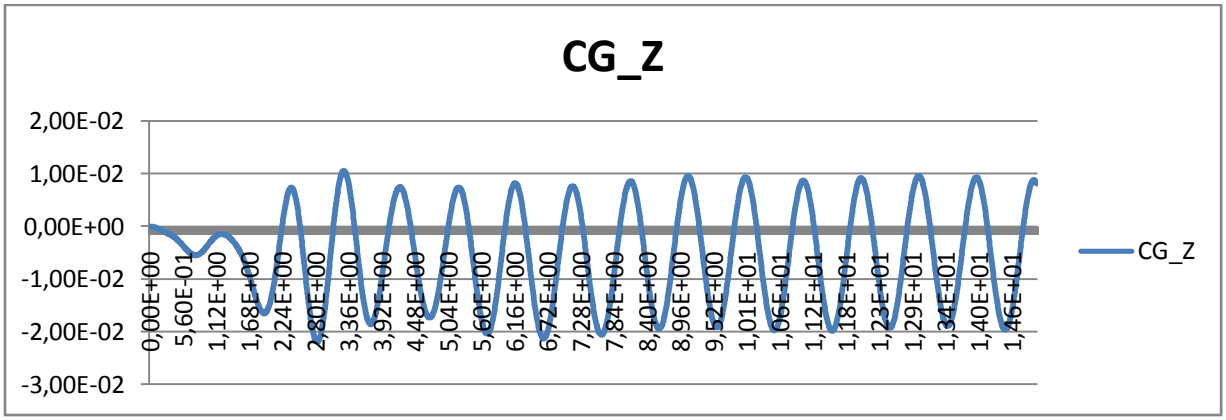

Fig.11. Heave motion simulated in Ansys Fluent

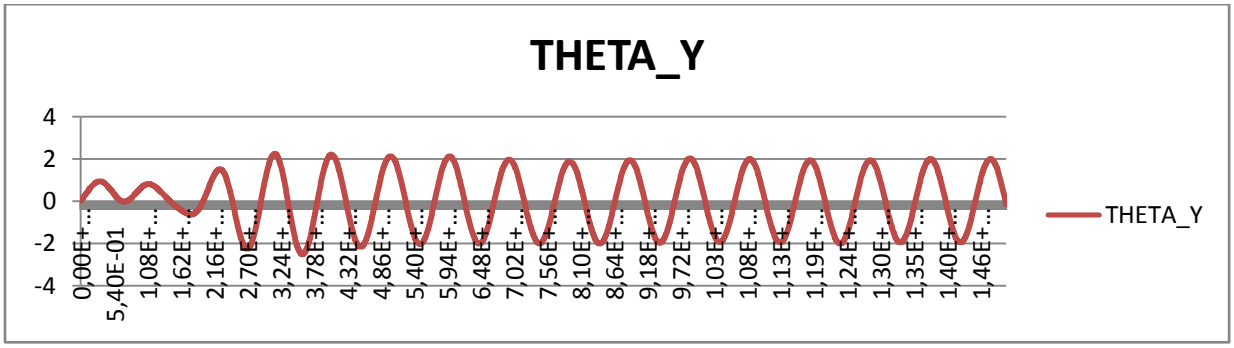

Fig.12. Numerical simulation of model pitch of the semi-submersible platform

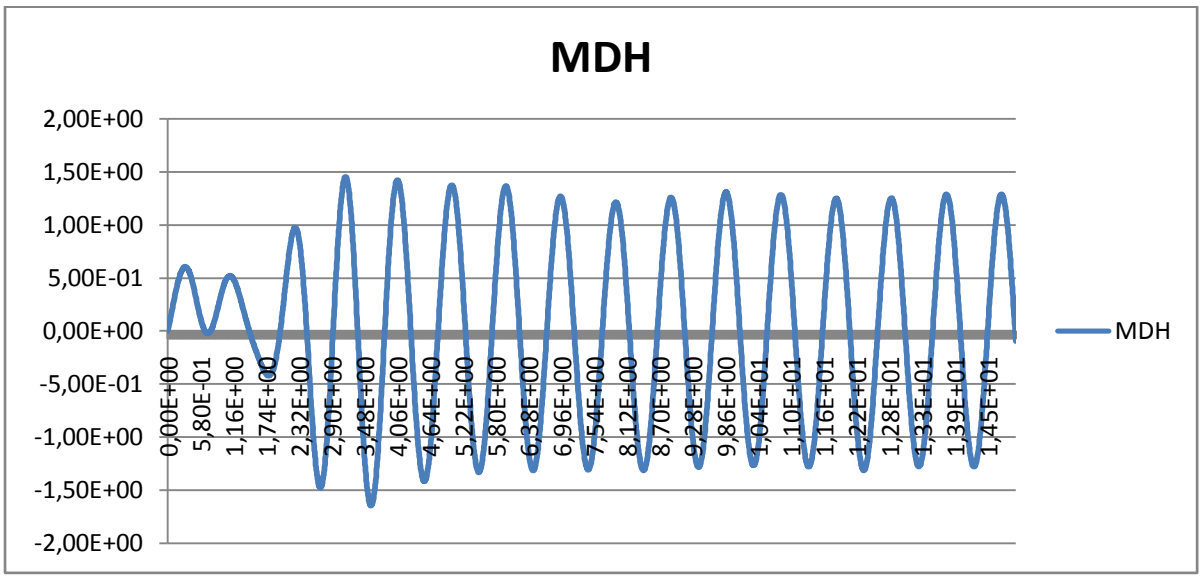

Fig.13. Numerical simulation results of MDH model of the semi-submersible platform

The smallest MDH value of 1.45 m reported to scale 1:100 we will get 13.75 m. For future projects developed for Black Sea is recommended to use a deck height higher than 14 m to avoid slamming during extreme storms that can occur in the Black Sea.

CONCLUSIONS

The maximum measured wave height is 12.3 m, if we add the smallest MDH value of 1.45 m we will get 13.75 m. For future projects developed for Black Sea is recommended to use a deck height higher than 14 m to avoid slamming during extreme storms that can occur in the Black Sea.

The maximum heave during wave action was 1,05 m and the maximum pitch was 2.23°. The paper has determined the way of calculus of minimum deck height. The scattering waves have almost no influence on the platform minimum deck height. The platform minimum deck height is increased by the platform heave motions under the Black Sea condition. The current interaction was not considered and also the wave current interaction.

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