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Studying the Effects of Force and Waves Hydrostatic Pressure on the Underwater Foundation Walls (Caisson Breakwaters)

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ABSTRACT

The aim of this study is to investigate the effect of wave's hydrostatic pressure on the walls of the underwater foundation (caisson of breakwaters). So that we can provide enter of ships to the ports, reduce the energy of waves and protect the coast against waves. To simulate caisson breakwaters, cfxansys software was chosen, and after examining the model, we found that, the body of the caisson breakwater compared with the rocky core break water, because of greater height and a body made of reinforced concrete has less damaging effects on the overall structure of this type of breakwater which this negative effect in breakwaters with stone core is seen as the destruction of the middle layer and therefore it has more stability and quietness for stationary cargo ships and oil reservoirs are provided.

1. INTRODUCTION

Breakwaters are structures that create a calm in the harbor, for the entry of the ship into waterways and ports, reducing the energy of waves and protect the coast against waves are established. Now in a new era of special technologies in creating sustainable coastal area and productivity in the export and import of various products ranging from (industrial and non-industrial) it is essential to conduct further research in this field. In the meantime, to stabilize the banks through extraction, the construction of breakwaters with the core (rock and soil and reinforced concrete constructions are used. Build breakwaters to encompassing an area of beach that merchant vessels berthing in without wave in order to change in their direction are made. Mound breakwater are the most common types, among which we can note the breakwaters with concrete structure (caisson), need to breakwaters that could have their strength and formability against sea surges, and brought exploitation in the long term, more highlights the use of concrete structure breakwaters (caisson). Given the progress that has occurred in the concrete, the use of this type of breakwaters, in general, in terms of manufacturing cost may be more than breakwater with rock mass, but in the long term is more sustainable and more economically feasible, wave impact on structures, due to being armed is also important, which can be increased by changing the type of concrete, from advantage of this structure we can note integrated structure during construction, resistance levels to deal with the wave compared to breakwater with stone core. And most importantly lack of water penetration into the core of this breakwater causes not scour of it. Existence of scour in inner lining of the breakwater will damage it in short term and even during construction. But caisson structure breakwater consists of two main parts bin and base, it is already made in an environment called stilling basin and use the flotation carry to its coordinate location and after immersion is set in its placed and be operated. Innovation in structural design techniques increased the need for breakwaters, what should have always been considered in a caisson breakwater is design, sustainability, cost and performance of needed tools. The reaction of hydraulic structures and the effect of soil type and Earth's crust to structure dimensions should be considered. Wave height is most functional tool in the construction of caisson breakwaters. Wave height affect not only the efficiency of breakwater structure but also plays an important role in sustainability and the structural damage. Hydrodynamic forces resulting from the interaction of the waves with breakwaters are major factor in determining the overall stability and breakwater damage and durability of the project.

METHODS AND MATERIALS

2. RANS-VOF numerical models and turbulence models

The model used in this research, is Lagrangian method based on water particles or components such as semi-clear flowing particulate and particle's hydrodynamic methods (SPH3). These models solve vertical two-dimensional model RANS (2VD equations), turbulent kinetic energy (k) and also the turbulent dispersion (E).

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K-Ɛ turbulence model equations is one of the most famous models that provide an appropriate response for a wide range of phenomena. In this turbulent viscosity model by equation (1) is related to viscosity kinetic energy terms and energy degradation rate of movement:

$$\mu_{t=c_\mu \rho \frac{k^2}{\varepsilon}} \tag{1}$$

In which C_μ is called constant number and K represents turbulent flow energy and Ɛ dissolution rate viscous turbulent kinetic energy.

$$\frac{\partial(\rho k)}{\partial t} + \frac{\partial}{\partial xj}(\rho ujk) = \frac{\partial}{\partial xj}\left[\left(\mu + \frac{\mu t}{\sigma_k}\right)\frac{\partial_k}{\partial xj}\right] + p_k - \rho_\varepsilon \tag{2}$$

$$\frac{\partial(\rho k)}{\partial t} + \frac{\partial}{\partial x_j}(\rho u_j \varepsilon) = \frac{\partial}{\partial x_j}\left[\left(\mu + \frac{\mu_t}{\sigma_t}\right)\frac{\partial \epsilon}{\partial x_j}\right] + \frac{\varepsilon}{k}(cz_1 p_k - cz_2 \rho_\varepsilon) \tag{3}$$

In which σ_K ، C_{ε_1}،C_{ε_2} are constant numbers and P_K term is called turbulence caused by viscous forces. Another important issue is the free surface modeling to simulate complex deformation at the interface of two fluids free surface volumetric modeling method is used. In this case, a transport equation for calculating the volume of the liquid phase (eg, weather) at each time step is solved as follows:

$$\frac{\partial \alpha}{\partial t} + \nabla.(\alpha \bar{u}) = 0 \tag{4}$$

After solving the transport equation of volume, density and viscosity of the fluid is calculated and included in other calculations:

$$\rho_{eff} = \alpha\rho_1 + (1-\alpha)\rho_2 \tag{5}$$

$$\rho_{eff} = \alpha v_1 + (1-\alpha)v_2 \tag{6}$$

In the above equations, the subscript 1 and 2 represent two-phase fluid (water and air).α volume fraction, in other words the presence of two fluid in each computational element percentage that the distribution of it in computational domain if is 1 = α is first fluid, and if 0 = α is second fluid and if 1> α> 0 is the transition area between the two fluids.

3. The governing equations of flow

Governing equations for conservation of mass and momentum are as follows:

$$\frac{\partial \rho}{\partial t} + \frac{\partial(\rho u_j)}{\partial x_j} = 0 \tag{7}$$

$$\frac{\partial \rho u_j}{\partial t} + \frac{\partial(\rho u_i u_j)}{\partial x_j} = -\frac{\partial p}{\partial x_j} + \frac{\partial}{\partial x_j}(\tau_{ij-}\rho \acute{U}_i \acute{U}_j) + g_i \tag{8}$$

Where u, p and g, respectively are speed, pressure and acceleration of gravity, and represents the Reynolds stresses. Based on the eddy viscosity which link Reynolds stresses and velocity gradients together, top-averaged equations are as follows:

$$\frac{\partial \rho u_j}{\partial t} + \frac{\partial(\rho u_i u_j)}{\partial x_j} = -\frac{\partial p}{\partial x_j} + \frac{\partial}{\partial x_j}[\mu_{eff}[\frac{\partial(u_i)}{\partial x_j} + \frac{\partial(u_j)}{\partial x_j}]] + g_i \tag{9}$$

Where μ_eff called the effective viscosity and is defined as follows:

$$\mu_{eff=\mu+\mu_t} \tag{10}$$

4. Wave break:

To determine the location of structure range of wave conditions, and what force exerted on it, have to determine the depth and height of wave breaking weggel rule is used which considers the effects of seabed slope.

$$\frac{H_b}{h_b} = (b - a\frac{H_b}{gT^2}) \quad (11)$$

$$a=43.8(1-e^{-19m}) \quad (12)$$

$$b=1.56(1+e^{-19.5m})^{-1} \quad (13)$$

In the above equation g is the acceleration of gravity, T wave period, and m is the slope of the bed. Equation number (13) can be solved only by trial and error. Ideally, if the depth of the structures operations be more than hb, will affect unbroken waves of structures and if it is less than hb, broken waves hit the structure. In a state of draws, breaking waves will shine on the breakwater. In fact in state of draw, wave enter to structure in braking mode.

5. Discussion:

This research was done by simulation Kayson structure breakwaters using cfxansys software and mainly the response of hydraulic structures and its optimum performance from stability point of view as well as from the practical point of view, were studied and the effects of changing power and torque on the Kayson breakwater was determined.

6. The force on caisson:

Compound breakwaters have created a barrier to wave motion and reflect it. So field stationary wave is formed in front of the structure. Since the sea waves have non-linear nature, whatever these waves get closer to the coastal waters, due to the reduction of depth, show their nonlinear properties more. Therefore, the use of nonlinear wave theory within coastal waters will invariably lead to more accurate results. For access to better answer, there are 4 types of waves to analyze caisson, forms 1 to 4 show force changes in time unit for 4 kinds of waves. Graphs related to distribution of power in time function analyzed separately and shown as follows. The shown graphs indicate that due to the waves crashing caisson body and dealing with residual effects of wave, energy on the caisson walls is reduced. So that this process can be seen in long waves.

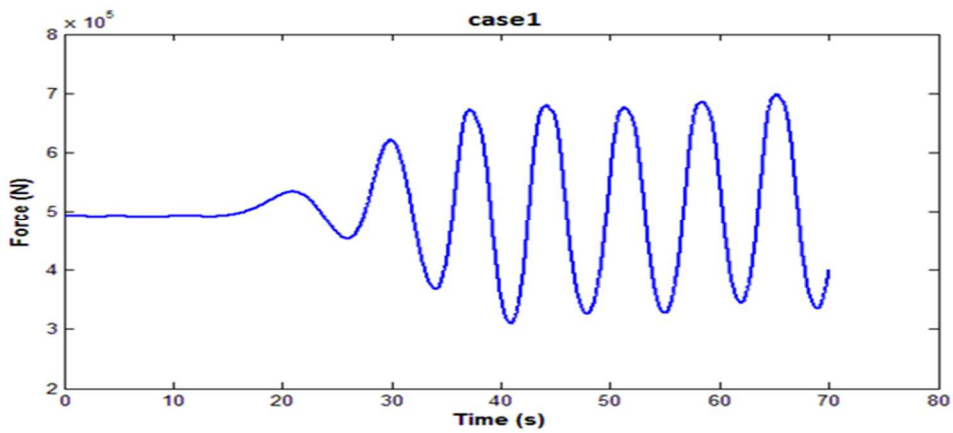

Fig 1: force changes per time unit for the wave 1

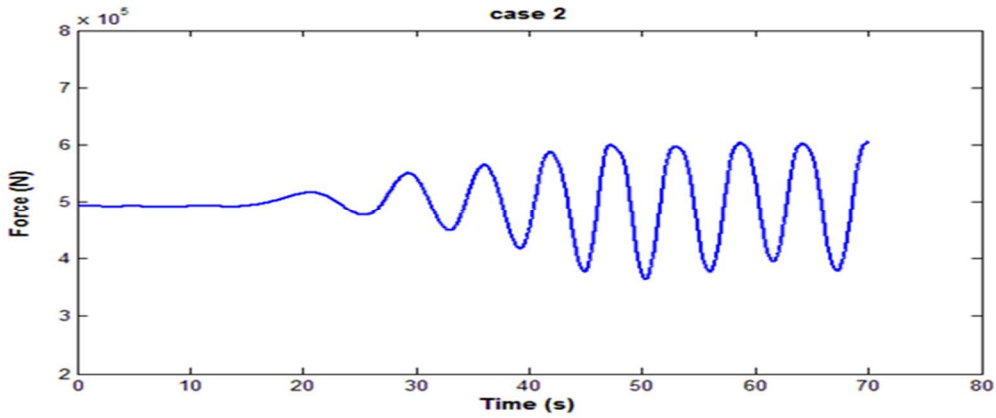

Figure 2. Force changes per time unit for the wave 2

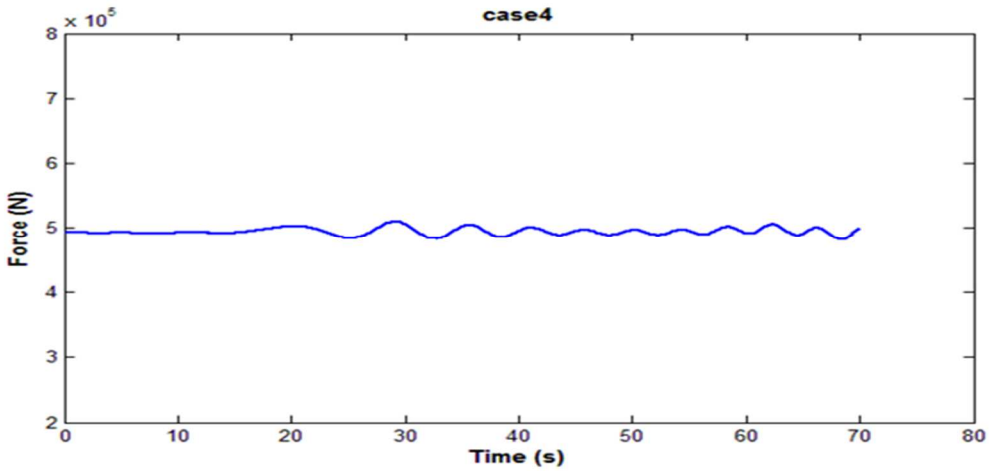

Figure 3.Force changes per time unit for a wave 3

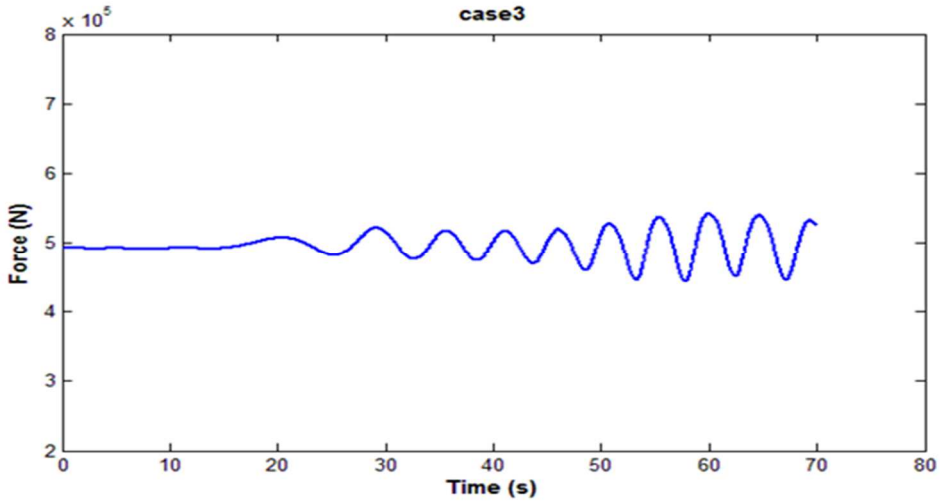

Figure 4.Force changes per time unit for a wave 4

According to figures 1 to 4, as is remarkable in a period of 80 seconds of power fluctuations start about 20 seconds. At the first wave of t= s44 reach to maximum value about n / m 106 × 6.8, in the second wave in t= s42reach the maximum value 106 × 5.7, in the third wave in t= s55 reach the maximum value about 106 × 5.5 and in the fourth wave at t= s29 reach to the maximum value about 106 × 4.9. In initial seconds applied torque will be almost constant.

7. The effect of hydrostatic pressure:

Given that 4 kind of waves are used for caisson analysis, relevant charts to create hydrostatic pressure at the caisson base in time function separately analyzed and have been shown in Figures 5 to 9. The graph shown indicate that due to the waves crashing to caisson body and dealing with residual wave energy effects on caisson walls is reduced. And therefore the resulting torque will be lower so that this process can be seen in the long waves.

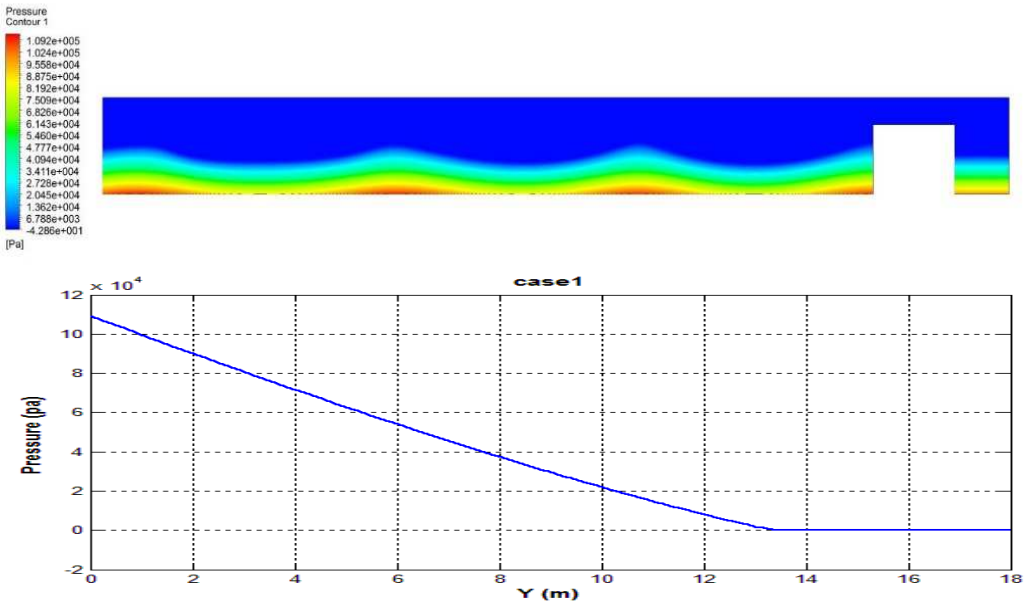

Figure 5. The variation of the hydrostatic pressure on the body caisson per meter of wave 1

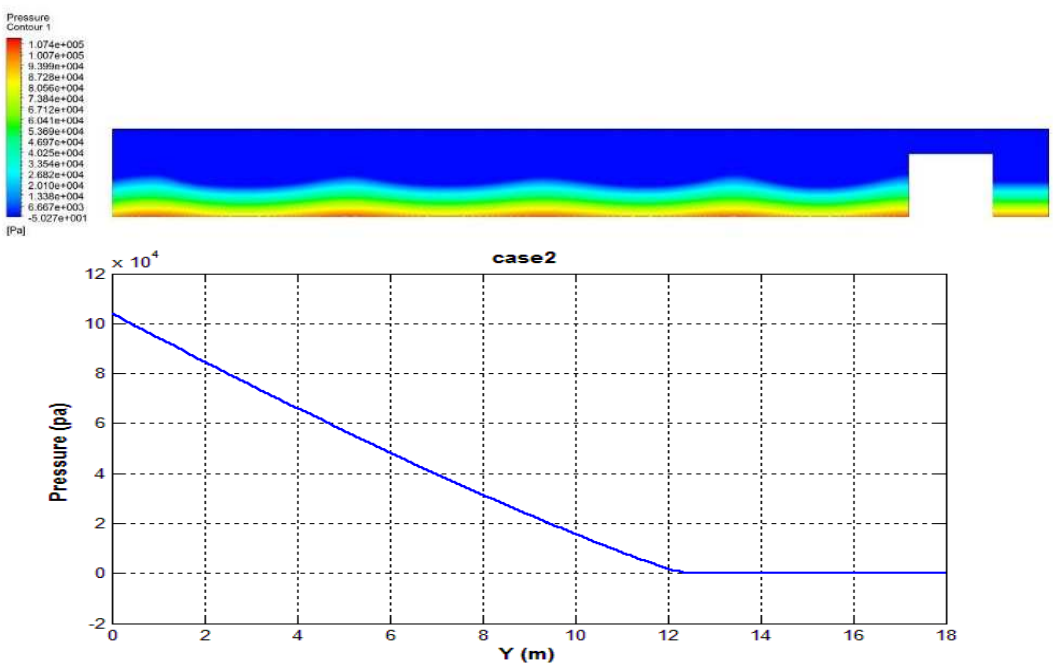

Figure 6: changes the hydrostatic pressure of the caisson body per meter of wave 2

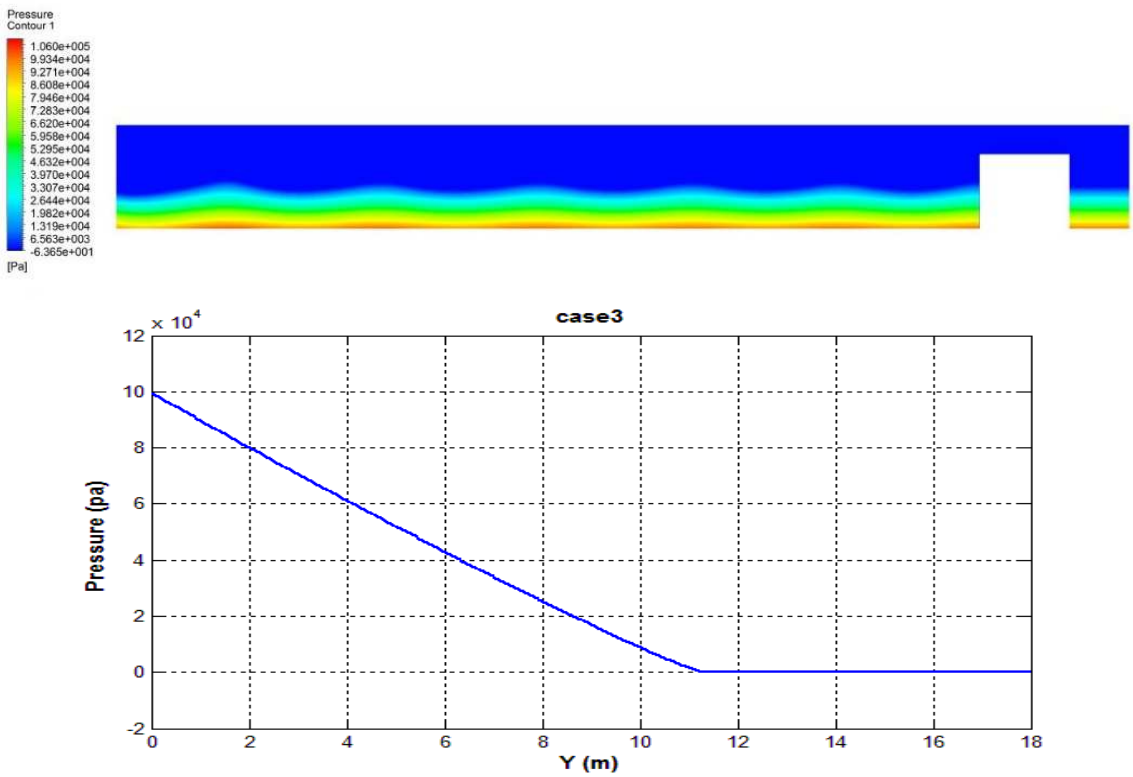

Figure 7: changes the hydrostatic pressure of the caisson body per meter of wave 3

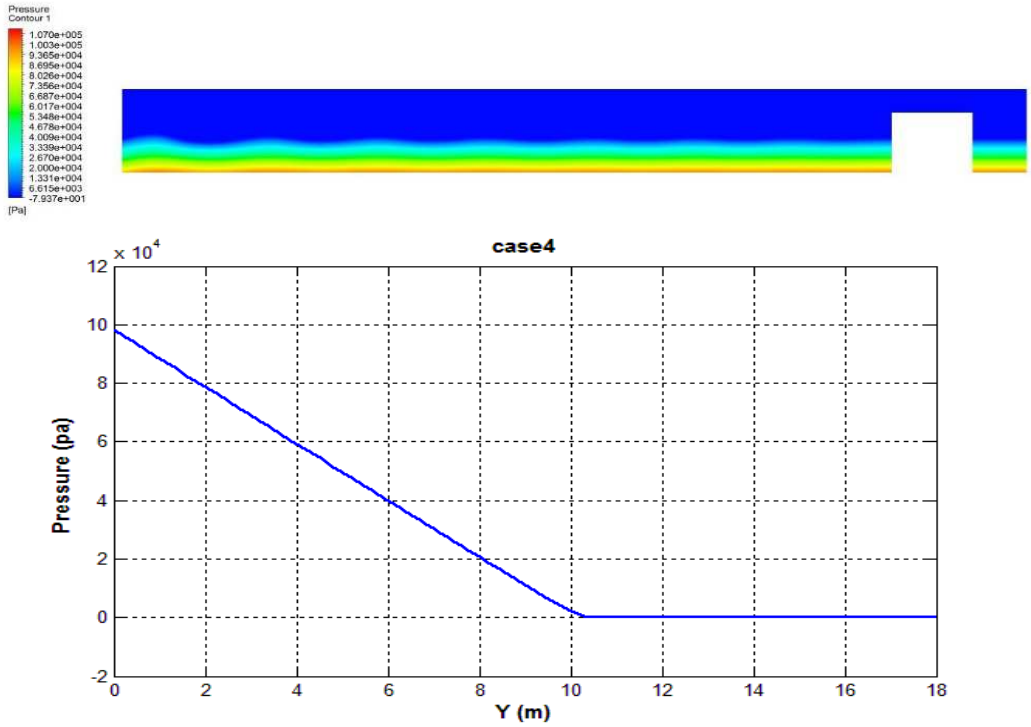

Figure 8: changes the hydrostatic pressure of the caisson body per meter of wave 4

According to the shapes shown in Figures 5 to 8, hydrostatic pressure created on the caisson body at the highest altitude above sea level will be 12.60 cm. In addition, this action due to the quadripartite waves hit reduced periodically so that as a result pressure in wave 4 will be fixed. This means that according to the height of 18 meters intended for the construction of caisson that 8 meter immersion and 10 meters in the water level, the most efficient possible way in terms of height for its construction, is intended. This issue can prevent unstable flow into the stilling basin. Thus big merchant ships benefit greater security to dock in the pond.

8. Conclusion:

- In specified time in initial seconds entered force will be almost constant
- The greatest amount of the force will be related to the first wave.
- The least amount of the force will be related to the fourth wave.
- The maximum height of hydrostatic pressure happens in the first wave
- Lowest height of hydrostatic pressure happens in the first wave.
- The force is directly related to the torque.

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