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ABSTRACT

Breakwater walls are buildings that are built to prevent the collapse of the soil or other granular materials and the safety of the sea. One of the destructive phenomena in these structures is the impact of sea wave forces on the overturning phenomenon and instability of the coastal wall, which has damaged the structures existing on these sites. The pattern of interaction between water and seas is complex in coastal structures. In this research, the influence of the different wall heights and soil type changes on wall stability and water pressure distribution in the coastal wall have been investigated. Also, studies will be done on the investigation and optimization of the wall and Finally, by comparing the results obtained with classical methods, the strengths and weaknesses of the classical methods have been analyzed and the effectiveness of these methods (classical) has been evaluated. These walls are made in two types of weighted and flexible (mainly metal) types, in which flexible performance is considered in this research. The behavior of metal shields in front of the water will be examined using the ANSYS software. Several methods for calculating wave forces on perforated coastal walls are also reviewed. In this study, the behavior of the elastic wall is assumed. Coastal walls have been investigated in different hardships and the distribution of pressure and anchor due to hydrodynamic pressure of water on the wall have been investigated. The walls are different in terms of material and amount of rigidity.

1. Introduction

The coast is a natural and dynamic environment where water and land are interspersed with each other and have a huge population. Today, more than half of the world's population lives in these areas, and many others regularly visit beaches. There are about 3,000 km of coastline in Iran (my country), and about 20% of the country's population resides in coastal provinces. People in these areas are busy working, recreation and living, and the number and variety of coastal users are constantly added. Therefore, it is expected that within a short period of time, the interference of the activities of different groups would create environmental, social and economic issues in these areas. To prepare for these issues, there is a pressing need for statistics, information and tools to increase human understanding and knowledge of existing phenomena and changes that are taking place.

Coastal erosion is one of the most critical threats to coastal areas. Torabi et al. in 2015 experimentally investigated on the stability and erosion of the foundation of the vertical breakwater. He proposed new method to estimate the erosion rate [1]. Erosion and undesirable forms of change are a danger that has always threatened the industries of these areas, including industrial facilities, transportation industries, coastal tourist industries, natural beauty and inland roads. In these areas, the land has a very high economic value, and every year, huge costs are incurred for the development and increase of land and the prevention of the advance of the sea to the drought on the officials and residents of these areas. Therefore, coastal management and protection against erosion and undesirable forms of change are very urgent.

Flexible structures are among the cheapest and most commonly used coastal structures. The materials needed are often easily deployed and cost less than other types of coastal protection structures. On the other hand, due to the use of natural materials, it is more compatible with the environment, hence the use and construction of these types of structures is common [2-7].

The coastal wall is one of the common types of shore protection structures that are used to protect the shore from shocks and erosion. Flexible coastal wall is a new type of structure that has been developed in the last two decades. The weight of the parts used in this type of structure is two to ten times less lightweight than the traditional type, so the cost of construction is less and the method is easier to run. In addition, repair and maintenance of this type of structure is cheaper, therefore, it is usually more economical than the traditional one [8-13].

2. Research Objective

In this research, after reviewing the history and recounting the old design methods, we use the numerical methods to the dynamic study of breakwater walls is investigated. With the development of new design perspectives, reverse triangular dynamic pressure is applied to the seismic pressure of the earth and the seismic pressure of the waves, in line with the dynamic analysis of the flexible coastal walls. Unlike traditional methods, the hydrodynamic forces in this method are considered when the dynamic forces are specified and balanced with the unit weight of the static structure and dynamic structure.

We shall review a class of perforated/slotted coastal structures from a hydrodynamic point of view, with a focus on the reflection and transmission characteristics. The wave forces on some of these structures are also reviewed.

2.1. Background Research

Many methods for designing coastal structures are presented in many codes and Regulations. These studies can be divided into two parts: theoretical studies and laboratory studies. Theoretical studies include studies based on numerical methods and analytical methods.

Perhaps Jarlan 1961, [14] was the first one to discuss the perforated-wall caisson breakwaters (now this type of breakwaters bears his name). In its simplest form, a Jarlan-type breakwater consists of a perforated front wall and a vertical impermeable back-wall. (A vertical plate member is called a wall when it is sitting on the bottom). Since Jarlan first introduced his design of the Jarlan-type breakwater, different designs have been proposed over the years to improve the hydrodynamic efficiency and to better control the scouring at the toe of the structure. The first scientific account of the slotted breakwaters (sometimes called slotted wave screens or pile breakwaters) was given by Wiegel at 1960, [15], even though this type of breakwaters has been in use since ancient times. Slotted structures and perforated structures are sometimes used interchangeably in the literatures since both of them share a similar energy-dissipation mechanism [10]. The main advantages of the slotted/perforated coastal structures are the saving in construction cost in relatively deep water and less disturbance to coastal water environments.

3. Methodology

Flexible coastal walls are designed using the traditional method, and from this, we can see that this method also has problems and errors. An old design method usually requires estimating the pressure on the back of the wall, and ultimately selecting the wall geometry to satisfy the equilibrium conditions with a reliable coefficient. By determining the overhead effect on the surface of the earth and behind the wall and the effect of the hydraulic pressure (due to the difference in water level across the wall).

The researchers have shown that the inertial force of the coastal wall, the dynamics of the earth and the water pressure produced at the bottom of the ditch, and the reduction of shear strength along the boundary between the coastal wall and the foundation of the soil, is the reason for the wall movement [5].

In connection with the development of a new method for designing breakwater walls, forces must be properly identified and design parameters for static and dynamic applications in the traditional model. The result of this study is important to improve the process of analyzing the retaining wall stability process.

4. Modeling by ANSYS software

To solve the problem you can answer two paths. The nature of the problem is time-dependent and requires a transient analysis. Therefore, a solder must be used to satisfy this condition. ANSYS software has two solvers for solving time-dependent mechanisms. From the two perspectives, the above problems can be solved. The first path or first solver that provides more accurate results is Transient Structural. Another solver that has a lower accuracy is the Response Spectrum solver.

4.1. Transient Solution

For modeling the above problem using ANSYS software, because our problem has a transient solution, then a Transient Structural solver can be used. So after opening the Workbench page in the Analysis Systems section, select the Transient Structural option and enter the Project scheme.

4.2. Material Specifications

In the first part, the materials used will be imported. To use this section, after selecting Engineering Data, a special window opens for specification of materials.

In the open window named Outline of schematic A2, the default material is entered. In this section, the steel construction is preset. To create a new item, you can click on the * option under the third part and enter the name of the substance. In the Physical Properties section, we can define properties such as density and damping coefficient and other properties. In the Linear Elasticity section, you can also enter the elastic properties of the soil, such as the modulus of elasticity, the Poisson ratio, and so on. After specifying the characteristics of the materials used in the analysis, for example, soil, steel, or reinforced concrete for the retaining wall, returns to the main page by pressing Return to Project.

4.3. Boundary Conditions

In finite element analysis, reducing the number of elements will increase the speed of computing. In most of the soil-structural interaction issues, rigid or almost rigid boundaries, such as the bedrock, are within a considerable distance from the target area. As a result, the waves released from the joint soil and structure will be sufficiently damp. In the finite element method, proper modeling of boundaries is of particular importance. The types of boundaries in this way can be classified into three groups:

4.3.1. Primary Boundaries

That the boundary conditions with a zero displacement value are modeled by them. The full reflection of these boundaries causes the energy to be captured inside the system. This phenomenon is called the boxing effect, and it will create an error in the system response. In order to reduce or eliminate these errors, the distance between the initial boundaries should be sufficiently distant from the common ground of the structure to the waves emitted, being damped and not get it, Zahabi et al in 2018 modeled a shallow water reservoir to investigate the scouring with primary boundaries which is used in this paper [6].

4.3.2. Local or Viscous Boundaries

the use of viscous dampers represents a typical local border. Wolf, 1985, proved that the amount of damping coefficient necessary to completely absorb energy depends on the collision wave angle [16]. Waves at different angles reach the boundary and a local boundary with constant damping coefficient will always reflect part of the impact wave energy. By increasing the distance between the boundaries and the desired range, the effects of reflection on the local boundaries can be reduced.

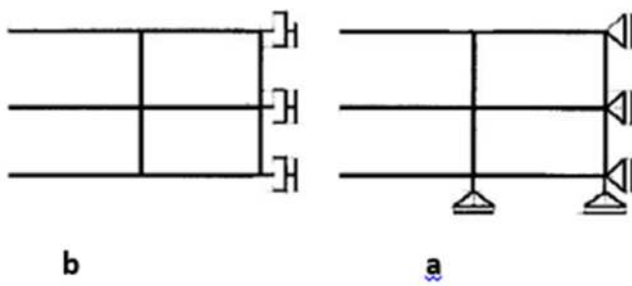

Fig. 1. a) Primary Boundary Model, b) Local Boundary Model.

4.3.3. Compatible or Transitional Boundaries

The most appropriate analytical boundaries are energy absorption and are able to influence long distances to be compatible with the finite element model, model the system and apply it. Such boundaries can absorb all bulky and superficial waves under any angle and in all frequencies. This method was developed by Wass & Lysmer in 1972 [17], and later expanded by Kause in 1974 [18]. In addition to various corrections, he reduced the number of degrees of freedom by modifying the lateral boundaries. Nonlinear soil behavior can also be considered using nonlinear finite element method.

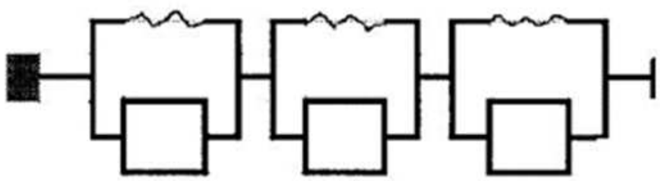

Fig. 2. Compatible or Transitional Boundary Model.

To reduce the effect of reflection, we increased the distance to the border. Here also we used absorbent borders.

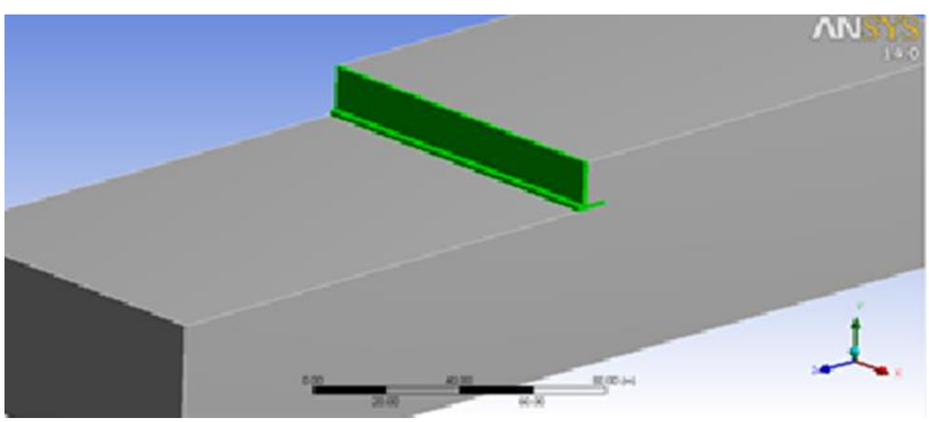

Fig. 3. General system of soil-wall-water system boundary conditions, movement of zero.

4.4. Mesh sizes

The meshing and dimensions of the elements have a significant impact on the system response. The use of large finite elemental grids makes the filtering of high-frequency components because nodes can not model their short wavelengths at high distances. Numerical studies have shown that it is best to be the largest dimension of each element to 1/8 to 1/5 the shortest wavelength considered in the analysis should be limited. The type, shape, position, as well as the number of elements used in the production of finite element mesh, affects the results. The smaller the mesh, the more accurate the results will be. However, necessarily making the mesh smaller does not result in a more accurate answer and may also lead to a divergence of responses.

5. Results

5.1. Results for soil type 1

Graphical results of retaining wall analysis for soil type 1 (Normal tension and shear tension for retaining wall) have been shown in Figure 4.

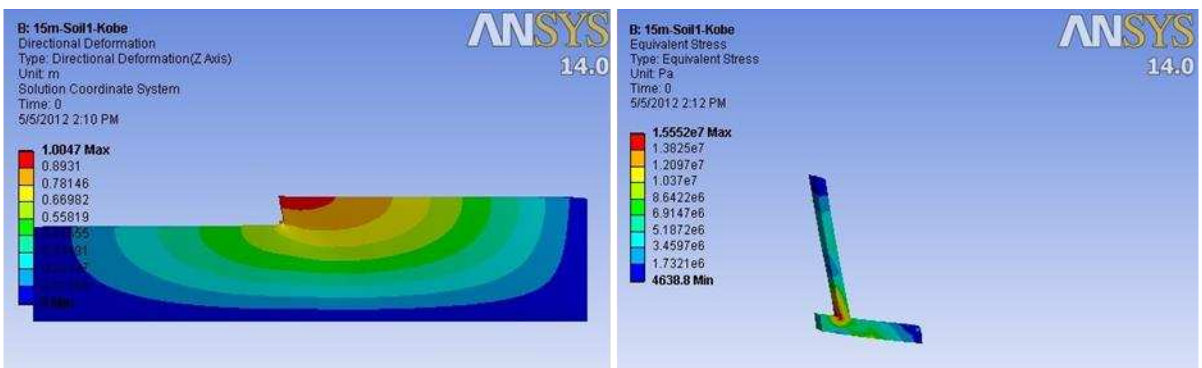

Fig. 4. Soil type 1 analysis.

5.2. Results for soil type 2

In this section graphical results of retaining wall analysis for soil type 2 (soil deformation and tensile strength and retaining wall) has been shown

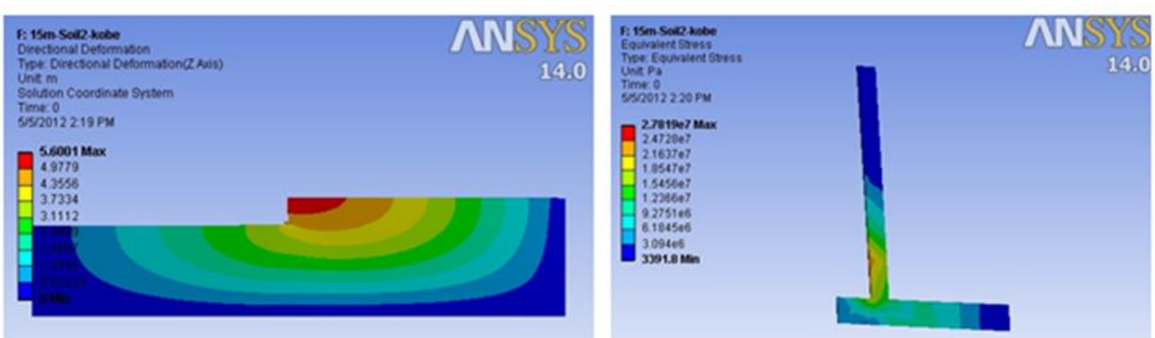

Fig. 4. Soil type 2 analysis.

6. Conclusion

1- After analysis, it was observed that changing the type of soil behind the wall (type 1 and 2 soil) has a significant effect on the pressure behind the wall.

2- According to the shear stresses on the wall, the shear stresses on type II soil show a higher amount than type 1 soil.

3- When the wall height is higher, the shear stress on the soil type 2 shows a higher rate than that of type 1 soil.

4- The analysis of the numerical analysis of the software suggests that Flexible wall movement modes and the progressive movement that has a significant effect on the distribution of lateral pressure on the soil and can lead to a nonlinear distribution of lateral pressure relative to the depth.

5- Due to the lateral forces entering the back wall and as well as vertical and shear stresses on the wall floor, rotation around the base of the wall causes a lot of movement at the top of the wall.

6- Aspects other than hydrodynamic coefficients and structural stability also need to be considered. For the protection of coastal environments, the flushing time of harbors and the water exchange across the slotted/perforated breakwaters are worth consideration in further studies. Scouring around the pile breakwaters also deserve more research. Possible oscillations and contaminant transport in harbors protected by slotted/perforated breakwaters are also chal- lenging topics.

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