ISSN 2250-3153

General Guidance for Planning and Design of Harbors

Kabir Sadeghi[1], Özbil Akbil[2], Mehmet Angın[3]

[1]Professor, Civil Engineering Department, Near East University, Nicosia, CYPRUS
[2]Researcher, Civil Engineering Department, Near East University, Nicosia, CYPRUS
[3]Researcher, Civil Engineering Department, Near East University, Nicosia, CYPRUS

Abstract- The planning and design of harbor is an important engineering phenomenon with both major commercial and social implications. The literature suggests that various approaches for harbors design of harbors such as fishing, commercial and refugee harbors. The aim of this paper is to present a general guidance for the planning and design of harbors. There are a number of general requirements which has to be fulfilled while designing the harbors but also there are some specific requirements for each of them. Furthermore, the different types of foundations such as shallow water foundations, deep water foundations and pile foundations, as well as breakwaters such as permanent breakwaters and temporary breakwaters, and finally caissons are submitted for the design of harbors. The equations, formulae and specifications for the design of the essential components of harbors are also given.

Index Terms- Harbor, Design, Breakwater, Caisson, Pile

I. Introduction

Due to the incremental growth in the world population and the current trend of globalization, there is a significant interest for harbor development whether this includes constructing new harbors or existing ports that need to improve or grow their ability.

A harbor is a position of security and solace, a little bay or other shielded piece of a zone of water, generally very much ensured against high waves and solid streams, and sufficiently profound to give dock to ships and other specialty. It is likewise a place where port facilities are given such as convenience for ships and cargo dealing facilities.

Harbor construction activities include installing anchor piles, constructing jetty, mooring and berthing dolphins which are designed to safely moor vessels alongside offshore structures and quay wall renovation which might be required to reinforce existing quay walls to enable heavier materials and equipment to be handled.

Harbors can be classified into three categories which are natural, semi-natural and artificial harbors (Yuvaraja, 2013):

- Normal formations bearing safe release facilities for ships on ocean coasts, in the type of brooks and bowls, are called Natural harbors. With the quick advancement of naval forces drew in either in trade or war, made great strides on settlement and on facilities for repairs, stockpiling of freight and associated conveniences are given in natural harbors. The dimensions and draft of current ships have caused the works improvement for natural harbors. The variables, for example, local geographical conditions, increment in population and also improvement of the area have made them enormous and alluring.
- Semi-natural harbors are preserved on sides by headlands protection and it needs artificial protection only at the entrance.
- In Artificial harbors native facilities are not accessible. Countries having a coastline had to form or construct such refuges making use of engineering knowledge and methods.

II. Context and Scope

The scope of the research is the design analysis of the harbors. Harbor types, construction sequences and design parameters and techniques are investigated. Harbor types (refugee, commercial and fishing) are reviewed. The requirements for each type of harbors are examined and key areas highlighted. Different types of foundations are identified and examined such as piling and caisson. Formulae and figures are provided for the calculations along with the design of foundations, caissons and breakwaters.

III. Research Methodology and Findings

Research answers three main questions which are given below:

- How many types of harbors are existing? (see Section 3.1)
- What are the design requirements of these harbors? (see Section 3.2)
- What are the formulae needed for the calculations? (see Section 3.3)

Search period of the literature databases is between 1979 and 2016. Some of the literature databases used for the research are listed below:

- "www.sciencedirect.com"
- "https://scholar.google.com"
- The Near East University library

3.1. Major Types of Harbors

Considering their benefit and situation, harbors are separated into three types as refugee harbors including naval bases, commercial harbors connected with ports and fishery harbors (Pritchard, 2013).

3.1.1. Harbors of Refugee Including Naval Base

A harbor of refugee is a secured water region utilized exclusively as a sanctuary for ships in a tempest or a part of a commercial harbor with satisfactory space for a different dock

ISSN 2250-3153

zone that does not meddle with the commercial traffic. The basic characteristics of a decent harbor of refugee are protected access from the ocean or sea during bad weather and a decent holding base for the ship's anchors. An outstanding harbor of refugee is the mouth of Delaware Bay near Cape May, N. J. Dover, England, has a combined harbor of refugee and commercial harbor. A military harbor is a naval base for servicing naval vessels. Pearl Harbor, Hawaii, is a well-known naval base (Quinn, 2007).

3.1.2. Commercial Harbors Connected With Ports

A commercial harbor is one that has docking facilities comprising of piers, wharves, or dolphins at which ships berth while loading or unloading cargo. Huge numbers of extensive commercial harbors in urban communities are municipal, or government-controlled, harbors operated by port authorities. New York, Los Angeles, and London harbors can be given as cases. Some commercial harbors are owned and operated by private industry; for example, Taconite Harbor, in Minnesota.

3.1.3. Fishing Harbors

A fishing harbor contains multifunctional facilities that provide sufficient requirements for the capture of fish and its consumption. Large fishing vessels and huge number of fish creates a demand for well-bred maintenance and repair facilities not only for the vessels but also for the equipment as well. An all-inclusive fishing harbor should include fish processing facilities, refrigerators, ice plants and bureaucratic offices and some other utilities inclusive of roads, parking areas for private and commercial vehicles, sufficient space for loading and unloading and also areas for future expansion. As the activities in the fishing harbor cause contamination, wastes must be properly examined and managed.

3.2. Design Requirements for Harbors

Before designing a harbor, there are two major activities which have to be done. These activities are ‘Collecting the necessary information’ and ‘Identifying the area required’.

3.2.1. Collection of the Necessary Information

To carry out the planning of a harbor, the first step is that the collection of necessary information of the existing properties of the suggested site. The following important facts should be investigated first:

- To perform a complete investigation of the neighborhood including the foreshore and depths of water in the vicinity
- To study the nature of the harbor (if it is refuge or not)
- To study the existence of sea insects which could give damage the foundation
- To study the problem of silting or erosion of coastline
- To ascertain the character of the ground borings and to take the soundings
- To identify the probable surface conditions on land and borings on land
- To study the natural metrological phenomenon at site with respect to frequency of storms, rainfall, range of tides, maximum and minimum temperatures, direction and intensity of winds, humidity and also direction and velocity of currents

3.2.2. Identify the Area Required

The area of the harbor depends upon the following factors:

- Size and number of ships to be accommodated in the harbor at a time
- Length and width needed for movement of ships to and from berths
- Type of cargo carried

3.2.3. General Requirements of a Harbor

To build a more valuable and useful harbor for working and dispatching, the water depth in the entrance of the harbor, approach channel and harbor basin is needed to be kept sufficient even at the low water spring tide. Other than the water depth, to provide an easier maneuverability, the location and alignment of the entrance, approach channel, turning basin, breakwater, wharves, jetties and docks should be carefully positioned. The main aim of a harbor is to provide a safe and appropriate accommodation to the supplies, vessels, repairs, refugee, refueling or transfer of cargo and passengers.

Following are the requirements of a good harbor:

- The ship channels should have sufficient depth for the draft of the visiting vessels to the harbor
- The bottom of the harbor should provide secured anchorage to hold the ships against the force of strong winds
- The land masses or breakwater must be provided to protect against the destructive wave action
- The entrance of the harbor should be wide enough to provide the ready passage for shipping and at the same time it should be narrow enough to restrict the transmission of excessive amount of wave energy in time of storms.

3.2.3.1 Requirements of a Harbor of Refugee Including Naval Base

Following are the requirements of a harbor of refugee:

- Facilities which obtain repairs and supplies
- Safe and convenient anchorage against the sea
- Ready accessibility from the high seas
- Spacious accommodation as damaged ships will need immediate shelter and quick repairs
- Accommodation for naval vessels

3.2.3.2 Requirements of a Commercial Harbor

Following are the requirements of a commercial harbor (Yuvaraja, 2013):

- Storage sheds for cargo,
- Good and quick repair facilities to avoid any delay,
- Long and large quays to make loading and unloading of cargo and facilities for transporting easier and quicker,
- Sufficient accommodation for the commercial marine,
- Large accommodation for the commercial marine,
- Well and enough sheltered conditions for loading and unloading.

3.2.3.2 Requirements of a Fishing Harbor

Following are the requirements of a fishing harbor:

- The harbor should be continuously available for arrival and departure of fishing ships
- Loading and unloading facilities along with quick dispatch facilities for the perishable fish catch such as railway sidings and roads should be there,
- Freezing compartment stores with sufficient storing space for keeping the fish safe.

3.3. Analysis of Harbors

To analyze harbors it is preferable to use dynamic numerical models during analyzing process. Furthermore, as it is crucial to consider structure and properties of the waves such as frequency and amplitude, wave deviation, wave shear and wave rotation should be investigated and then modeled according to the site it is being planned to build a harbor. The spectral changes while the waves approaching the shore must be analyzed and modeled as well. Next step is choosing, designing and modeling the breakwaters. Turbulences inside the harbor should be tested under irregular wave series. Beside waves, water level changes should be observed under the effect of different conditions such as atmospheric changes, wind or waves. Finally, solid matter transport and morphological modeling are needed to be done.

3.3.1. Shallow Water Foundations

There are five well-known types of foundation used when the water depth is shallow. These are:

- Spud cans
- Piles
- Gravity base structures (GBS)
- Concrete caissons
- Steel Buckets

The correct foundation type is selected by considering the seabed soil conditions. Some foundations cause high settlements than the others.

3.3.2. Deep Water Foundations

In deep water depth, it is crucial to create solutions with a balance not only considering reliability but also the economy. As it is not realistic to build jackets or gravity based structures when the depths are deep, different foundation types are used such as anchors. There are eight types of anchors as listed below under two main types (Randolph and House, 2002).

Gravity anchor types include:

- Boxes
- Grillage and Berm

Embedded anchor types include:

- Anchor piles
- Suction caissons
- Drag anchors (fixed fluke)
- Vertically loaded drag anchors (VLA)
- Suction embedded plate anchors (SEPLA)
- Dynamically penetrated anchors (DPA)

3.3.3. Pile Foundations

Piles are strong materials with long cylindrical shapes which are placed into the ground to support structures constructed on it. They are generally made of concrete. Piles are used if there is a weak soil layer on the surface or when the structure is too heavy. They are mostly needed when the structure is subjected to horizontal forces from waves or the impact of berthing ships. There are two types of pile foundations which are grouted piles and driven piles (Simoes De Abreu, 2014).

3.3.4. Pile Resistance

The determination of the soil resistance can be made applying current offshore guidelines, e.g. API RP2A and ISO 19902 or CPT- based methods. The latter's advantage is that it takes account of the detailed stress history of the soil around the pile (Randolph et al., 2005; Dean, 2009).

Unit Parameters

Table 1 summarizes the unit parameters recommended by API RP2A and ISO 19902.

The equation used for shaft friction is expressed as,

$$q_{bu} = Nq\sigma'_{v0} \leq q_{bu-max} \quad (1)$$

Where N_q ranges from 12 to 50 according to the grain size and relative density of the material. All parameters needed to determine pile resistance in sand are given in Table below.

Table 1. Design parameters for steel piles in siliceous sands in ISO 19902: 2004

Soil description	*Soil density*	D_r (%)	δ' (°)	T_{s-max} (kPa)	N_q	q_{bu} (MPa)
Sand	Loose	15-35 %	20	65	12	3
	Medium	35-65 %	25	80	20	5
	Dense	65-85 %	30	95	40	10
	Very dense	85-100 %	35	115	50	12
Silty sand	Loose, Med	15-65 %	20	65	12	3
Clayey sand	Dense	65-85 %	25	80	20	5
	Very dense	85-100 %	30	95	40	10
Sandy silt	Loose	15-35 %	15	45	8	2

Med dense	35-85 %	20	65	12	3
Very dense	85-100 %	25	80	20	5

3.3.5. Analysis of Breakwater

Breakwater is a part of the harbor that is constructed for protecting the harbor against to waves. Therefore, they keep ships and cargos in safe. Natural rock and concrete are mainly used materials for construction of breakwaters. There are two types of breakwaters which are permanent breakwaters and temporary breakwaters (Abdelhamid, 2013).

3.3.5.1Permanent Breakwaters

- Rubble Mound Breakwater
- Vertical Wall Breakwater
- Vertical Composite Type

3.3.5.2 Temporary Breakwaters

- Pneumatic and Hydraulic breakwater
- Floating Breakwater

The economic life of harbors should be taken into account while designing breakwater according to their importance and usage purpose (Abdelhamid, 2013).

- Very important Marine Structures 100 years
- Important Marine Structures 50 years
- Normal Marine Structures 25 years
- Temporary Marine Structure 1-2 years
-

3.3.5.3. Wave Height Design

3.3.5.3.1 Non-Breaking Wave Condition, H_d

- Normal Marine Structures $H_{1/3}$
- Temporary Marine Structures H_m

3.3.5.3.2 Breaking Wave Condition, H_b

$$Hb = 0.78d \tag{2}$$

Where:
d represents the water depth.

3.3.5.4 *Design of Armor of Breakwater*

3.3.5.4.1 *Weight of Indıvıdual Armor "Hudson Formula"*

Hudson formula is used for calculation of the minimum size of riprap required to obtain enough stability characteristics for rubble structures as breakwaters under wave attack. The Hudson formula is same as shown below (Abdelhamid, 2013):

$$W_{50} = \gamma_a H^3/\{K_D (S_a - 1)^3 \, Cot\, \theta\} \tag{3}$$

Where:

W_{50}: Weight of individual armor unit

H: Design wave height

γ_a: Unit weight of armor unit material

γ_w: Unit weight of water

S_a: Specific gravity of armor material, γ_a / γ_w

θ: Angle between seaward structure slope and horizontal, $cot\ \theta = t$

K_D: Armor unit stability coefficient

3.3.5.4.2 *Thickness of Armor Layer*

Armor layer is a kind of layer that is made to protect the breakwaters and seawalls. Thickness of armor layer formula is shown below:

$$D_{50} = \{W_{50} / \gamma_{rock}\}^{1/3} \tag{4}$$

$$ta = 2K_0\, D_{50} \tag{5}$$

$$D_{max} = 4.000\, D_{50} \tag{6}$$

$$D_{85} = 1.960\, D_{50} \tag{7}$$

$$D_{15} = 0.400\, D_{50} \tag{8}$$

$$D_{min} = 0.125\, D_{50} \tag{9}$$

D is the nominal size (equivalent cube of the stone).

Table 2. K_D No-Damage Criteria and Minor Overtopping

Armor unit	*n*	*Placement*	*Structure trunk (Break wave) K_D*	*Structure trunk (Non-break wave) K_D*	*Structure head (Break wave) K_D*	*Structure head (Non-break wave) K_D*	*Slope (cot)*
Quarry stone (rough)	2	random	3.5	4	2.9	3.2	1.5
Rough angular	2	random	3.5	4	2.5	2.8	2.0
Quadripod	2	random	7.2	8.3	5.9	6.5	1.5
Tetrapod	2	random	7.2	8.3	5.5	5.1	2.0
Dolos	2	random	22.0	25	15.0	16.5	2.5
Modified Cube	2	random	6.8	7.3	-	5.0	-

Table 3. Layer coefficient and porosity

Armor unit	*n*	*Placement*	*Layer coefficient*	*Porosity*
Quarry stone (rough)	2	random	1.15	31%
Cube (modified)	2	random	1.10	47%
Tetrapod	2	random	1.04	50%
Quadripod	2	random	0.95	49%
Dolos	2	random	1.00	63%

3.3.5.4.3 ***Placement Density***

Placement density formula is shown below;

$$N_r = A.n.K_\Delta\, [1 - P\%/100].[\gamma_u/W]^{2/3} \quad (10)$$

Where:

N_r: Number of units for a given surface area

A: Surface area

$P\%$: Percentage of average porosity of layer

3.3.5.5 ***Design Secondary (underlayer) of Breakwater***

3.3.5.5.1 ***Weight of Under Layer W_s***

Weight of underlayer formula is shown below;

$$W_{50} = W_{armor}/10 - W_{armor}/15 \quad (11)$$

$$D_{50} = \{W_{50}/\gamma_{rock}\}^{1/3} \quad (12)$$

$$D_{max} = 4.000\, D_{50} \quad (13)$$

$$D_{85} = 1.960\, D_{50} \quad (14)$$

$$D_{15} = 0.400\, D_{50} \quad (15)$$

$$D_{min} = 0.125\, D_{50} \quad (16)$$

Filter Criteria:

$$(D_{15})\ armor/\ (D_{85})\ secondary \leq 5 \quad (17)$$

3.3.5.5.2 ***Thickness of Under Layer (t_s)***

Thickness of underlayer formula is shown below:

$$(t_s = n\, K_\Delta [W_{rock}/\gamma_{rock}]^{1/3} \quad (18)$$

Where:

t_s: Total thickness of layer

n: number of layers of protection units

K_Δ: Layer coefficient

γ_{rock}: Unit weight of material

W_{rock}: Weight of individual protection unit in layer

3.3.5.6 ***Core Design***

Core design formula is shown below:

$$W_{50} = W_{armor}/200\ to\ W_{armor}/6000 \quad (19)$$

With:

$$D_{50} = \{W_{50}/\gamma_{rock}\}^{1/3} \quad (20)$$

$$D_{max} = 4.000\, D_{50} \quad (21)$$

$$D_{85} = 1.960\, D_{50} \quad (22)$$

$$D_{15} = 0.400\, D_{50} \quad (23)$$

$$D_{min} = 0.125\, D_{50} \quad (24)$$

Filter Criteria:

$$(D_{15})\ secondary/\ (D_{85})core \leq 5 \quad (25)$$

3.3.5.7 ***Design of Crest Width and Level***

3.3.5.7.1 ***Crest Width***

$$B \geq 3\, K_\Delta\, [W/\gamma_u]^{1/3} \quad (26)$$

Where:

B: crest width

3.3.5.7.2 ***Crest Level***

$$CL = DWL + R \quad (27)$$

Where:

CL: Crest Level of Breakwater

DWL: Design Water Level

R: Wave Run-Up

3.3.6. Analysis of Caisson

When caisson foundations system is used, the resistance is supplied by a combination of concrete self-weight and the contact between seabed and caisson (Randolph et al., 2005).
The weight of concrete foundation is used to calculate the average static tension. Forces and loads caused by cyclic waves and wind are transferred to the soil by skirt friction and suction under the top cap (Stove et al., 1992).

The concrete caisson installation procedure is explained below:

• Releasing the concrete caisson on the seabed.
• Evacuating the water from the inside of the caisson with the help of pumps. Caisson settles to the soil due to suction.
• Then, the ballast covers the top of the foundation to increase the weight.
• Connecting and tensioning is made.

When calculating the resistance for the skirts of the caisson;

- Depending on the material chosen, adhesion coefficient α is taken between the values 0.15 and 0.30 (Randolph et al., 2005).
- Allowable resistance due to suction is analyzed on site as soil characteristics and play a big role.
- As the cyclic tension loads increases, bigger suctions will develop.

Generally, suction anchors are closed at the top and open at the bottom. They are usually big in diameter which means more than 5 meters in diameter. Their length varies between 20 to 30 meters. The ratio of length to diameter (L/d) is between 3 and 6. On the other hand, diameter to wall thickness ratios of the cylinders (d/t) is much larger and varies from 100 to 250. This ratio combined with the horizontal loads exerted by moorings creates structural buckling problem while installation which could be solved by using internal stiffeners. An anchor line, which optimizes the holding capacity, is attached to the side of the caisson to apply mooring loads. The line of action of the load passes at depth of about 65 % of the deep-seated depth.

3.3.7. Wave analysis and further information

For additional information on the environmental data together with necessary formulas and the data needed for design and analysis of such structures, the instructions, data and recommendations given by (Kaiser et al., 2013), (DNV Technical Report, 1996), (Jerman, 2015), (API, 2010), (Sadeghi, 1989, 2001, 2004, 2007a, 2007b, 2008 and 2013), (US Army Coastal Engineering Research Center, 1980), (US Army Corps of Engineers, 2002), Muyiwa and Sadeghi, 2007), (Sadeghi and Aleali, 2008) (Nouban and Sadeghi, 2013 and 2014), (US Army Corps of Engineers, 2011), (Nouban, 2016), (Nouban et al., 2016) and (Nouban et al., 2017) can be used.

IV. CONCLUSIONS

The aim of the report is discussing the information required for the planning and design a harbor. To plan and design a harbor it is required to collect necessary information of the existing properties of the suggested site. This information includes a complete survey of depth, nature of the harbor, the existing of any sea insects, the probability of silting or erosion, the character of ground borings, surface conditions, the frequency of natural events such as storms, the direction of waves, rainfalls or changing temperature. The size of the harbor is identified by considering the number and size of the ships.

Three major types of harbors; harbor of refugee, commercial harbor and fishing harbor, they all require some common properties such as providing sufficient depth, secured anchorage, breakwaters and a wide entrance. However, there are some requirements which create the difference between each of these harbor types.

A harbor of refugee must provide the facilities which obtain repairs and supplies, ready accessibility from the high sea, large accommodation as damaged ships will need immediate shelter and quick repairs and also accommodation for naval vessels. On the other hand, a commercial harbor must provide, storage sheds for cargo, good and quick repair facilities to avoid any delay, long and large quays to make loading and unloading of cargo and facilities for transporting easier and quicker, sufficient accommodation for the commercial marine and also enough sheltered conditions for loading and unloading.

Finally, a fishing harbor must be continuously available for arrival and departure of ships. A fishing harbor also must provide loading and unloading facilities along with quick dispatch facilities for the perishable fish catch such as railway sidings and roads. Finally one of the most important requirements that a fishing harbor must provide is freezing compartment stores with sufficient storing space for keeping the fish fresh and safe.

Analysis and design of the harbors are done in three major steps. One of them is the designing of foundations which are classified as shallow water foundations, deep water foundations and pile foundations. The other is designing the breakwater which is classified as permanent breakwaters and temporary breakwaters. The last step is the designing the caisson. The specifications, equations and formulae are discussed in detail.

Also, it is found that the breakwaters play a major role when building a harbor.

On the other hand, there are several limitations to this paper.

REFERENCES

[1] Randolph M. F. and House A.R. (2002) “Analysis of suction caisson capacity in clay”. Proc. Annual Offshore Technology Conf., Houston, Paper OTC 14246.

[2] Randolph M. F., Carter J.P., and Wroth, C. P. (1979). “Driven Piles in Clay – The Effects of Installation and Subsequent Consolidation.” Geotechnique, 29(4), 361-393

[3] Sciortino J. A., (1999) “BOBP for Fishers Management” Bay of Bengal Programme

[4] Bindhra S. P., (2012) “Docks and Harbour Engineering”

[5] Sciortino J. A., (2010) “Fishing Harbour Planning, Construction and Management”

[6] Stove O.J., Bysveen, S. and Christophersen, H.P. (1992). “New Foundation Systems for the Shore Development.” Proc. Annual Offshore Technology Conf., Houston, Paper OTC 6882

[7] Randolph, M.F., Gaudin, C., Gourvenec, S.M., White, D.J., Boylan, N., & Cassidy, M. J. (2011)

[8] Randolph, M., Cassidy, M., Gourvenec S., & Erbrih, C. (2005) “Challenges of Offshore Geotechnical Engineering”

[9] Dean, E.T. (2009). “Offshore Geotechnical Engineering”

[10] Nepote, E., Bianchi C.N., Morri C., Ferrari M., Montefalcone M. (2016) “Impact of a harbour construction on the benthic community of two shallow marine caves”

[11] Roca G., Romero J., Colombu S., Farina S., Pages J.F., Gera A., Inglis G., Alcoverro T. ”Detecting the impacts of harbour construction on a seagrass habitat and its subsequent recovery”

[12] http://www2.nkfust.edu.tw/~ypke/CE/data/Unit26.htm

[13] https://www.deme-group.com/expertises/harbour-construction

[14] http://www.pfri.uniri.hr/~bopri/documents/14-ME-tal_001.pdf

[15] http://www.dphu.org/uploads/attachements/books/books_2509_0.pdf

[16] http://www.fao.org/docrep/013/i1883e/i1883e00.htm

[17] https://www.slideshare.net/LATIFHYDERWadho/design-principles-and-requirements-of-harbours

[18] Nagi M. Abdelhamid “Design of Breakwaters”

[19] Nagi M. Abdelhamid “Design of Breakwaters-Rubble Mound Breakwater”

[20] Sadeghi, K. (1989). Design and Analysis of Marine Structures. Tehran: KNT University of Technology.

[21] Sadeghi, K. (2001). Coasts, Ports and Offshore Structures Engineering. Tehran: Power and Water University of Technology.

[22] Sadeghi, K. (2004). An Analytical method for Precasting the Downtime in Caspian Sea for Installation Purposes. Sixth International Conference on Coasts, Ports & Marine Structures (ICOPMAS2004), 1(1), 83-95.

[23] Sadeghi, K. (2007a). A numerical simulation for predicting sea waves characteristics and downtime for marine and offshore structures Installation operations. GAU Journal of Soc. & Applied Sciences, 3(5), 1-12.

[24] Sadeghi, K. (2007b). An overview of design, analysis, construction and installation of offshore petroleum platforms suitable for Cyprus oil/gas fields. GAU Journal of Soc. & Applied Sciences, 2(4), 1-16.

[25] Muyiwa, O. A. & Sadeghi, K. (2007). Construction planning of an offshore petroleum platform. GAU Journal of Soc. & Applied Sciences, 2(4), 82-85.

[26] Sadeghi, K. (2008). Significant guidance for design and construction of marine and offshore structure. GAU Journal of Soc. & Applied Sciences, 4(7), 67-92.

[27] Sadeghi, K. (2013). An Overview on Design, Construction and Installation of Offshore Template Platforms Suitable for Persian Gulf Oil/Gas Fields. Kyrenia: First International Symposium on Engineering, Artificial Intelligence and Applications.

[28] US Army Coastal Engineering Research Center. (1980). Shore Protection Manual. Washington: U.S. Government Printing Office.

[29] Sadeghi, K. & Nouban, F. (2013). Numerical simulation of sea waves characteristics and its applications on Mediterranean Sea waters. International Journal of Academic Research, 5(1), 126-133.

[30] US Army Corps of Engineers. (2002). Coastal Engineering Manual. Washington: U.S. Government Printing Office.

[31] US Army Corps of Engineers. (2011). Coastal Engineering Manual (CEM). Washington: U.S. Government Printing Office.

[32] Nouban, F. & Sadeghi, K. (2014). Analytical Model to Find the Best Location for Construction of New Commercial Harbors. Academic Research International, 5(6), 20-34.

[33] Nouban, F., French, R. & Sadeghi, K. (2016). General guidance for planning, design and construction of offshore platforms. Academic Research International, 7(5), 37-44.

[34] Nouban, F. (2016). An overview guidance and proposition of a WBS template for construction planning of harbors. Academic Research International, 7(3), 9-24.

[35] Sadeghi, K. & Aleali, S. A. (2008). Applied Technical Proposal for Planning, Design and Installation of Offshore Wind Farms Suitable for Persian Gulf, Oman Sea and Caspian Sea. Proceedings of the 8th International Conference on Coasts, Ports & Marine Structures (ICOPMAS “2008”), 40-44.

[36] Nouban, F., Sadeghi, K., Abazid, M. (2017). An overall guidance and proposition of a WBS template for construction planning of the template (jacket) platforms. Academic Research International, 8(4).

[37] Pedro Gomes Simoes De Abreu (2014).Offshore Foundations Technologies, Design and Application.

AUTHORS

First Author – Kabir Sadeghi, Professor, Civil Engineering Department, Near East University, Nicosia, CYPRUS, kabir.sadeghi@neu.edu.tr

Second Author – Özbil Akbil, Researcher, Civil Engineering Department, Near East University, Nicosia, CYPRUS, ozbilakbil@hotmail.com

Third Author – Mehmet Angın, Researcher, Civil Engineering Department, Near East University, Nicosia, CYPRUS, mehmtangin@hotmail.com