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ANALYSIS OF FLOATING STRUCTURES AND ARTIFICIAL ISLANDS WITH ITS CONSTRUCTION CHALLENGES

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ABSTRACT

Due to rise in the sea level and rapid growth in population, it is expected that there will be an area shortage in the coastal areas in the upcoming years. Many countries had solved their land shortage issues by either reclaiming lands or creating new islands or design of offshore structures and floating structures. Changing scenarios and needs have shaped the today's requirements of the creating of artificial islands or design of offshore structures and floating structures. If we look at the practices in historic times, early artificial islands included factors of security and cultures as main factors. Floating structures have attracted the attention of architects, city planners, and engineer because they provide an exciting and environmentally friendly solution for land creation from the sea as opposed to the traditional land reclamation method. The offshore structure, including offshore oil platforms and offshore wind turbines. This paper will be about how the objectives of the making of new islands or land reclamation, design of offshore structures and floating structures. Floating structures are an attractive option to support oil and gas production in deep water. They promise relatively economic designs, with little sensitivity to increases in water depth. Corresponding challenges arise from complex fluid structure interactions, which lead to basic hydro-dynamic questions of estimating applied forces and restoring properties such as damping. The novelty of these structures suggests the need to study their reliability and to consider practical load and resistance factor design (LRFD) procedures for such structures. These would parallel recent LRFD guidelines for fixed structures. The writers consider here one specific floating structure: a deep-draft cylinder known as a spar buoy. This concept has gained considerable industry interest. This paper focuses on a particular spar buoy, which serves as the "theme structure" of the NST Centre for Offshore Technology Research (OTRC) in Texas. The oceans cover 71% of Earth's surface. Those countries starting the early colonization of the earth may be obtain advantages through additional territory or creating their own independent state. The best solution to this problem, however, is the provision of floating cities, islands, states.

I.INTRODUCTION

As population and urban development expand in land-scare island countries (or countries with long coastlines), city planners and engineers' resort to land reclamation to ease the pressure on existing heavily-used land and underground spaces. Using fill materials from seabed, hills, deep underground excavations, and even construction debris, engineers are able to create relatively vast and valuable land from the sea. Countries such as the Netherlands, Singapore and Japan, have expanded their land areas significantly through aggressive land reclamation program. However, land reclamation has its limitation. It is suitable when the water depth is shallow (less than 20 m). When the water depth is large and the seabed is extremely soft, land reclamation is no longer cost effective or even feasible. Moreover, land reclamation destroys the marine habitat and may even lead to the disturbance of toxic sediments. When faced with these natural conditions and environmental consequences, very large floating structures may offer an attractive alternative solution for birthing land from the sea. There are basically two types of Very Large Floating Structures (VLFSs), namely

1: The Semisubmersible-type and

2: The Fixed platforms/Pontoon-type.

: SEMI-SUBMERSIBLE TYPE FLOATING STRUCTURES

They are raised above the sea level using column tubes or ballast structural elements to minimize the effects of waves while maintaining a constant buoyancy force. Thus, they can reduce the wave induced motions and are therefore suitably deployed in high seas with large waves. Floating oil drilling platforms used for drilling for and production of oil and gas are typical examples of semi-submersible-type VLFSs. When these semi-submersibles are attached to the seabed using vertical tethers with high pretension as provided by additional buoyancy of the structure, they are referred to as tension-leg platforms.

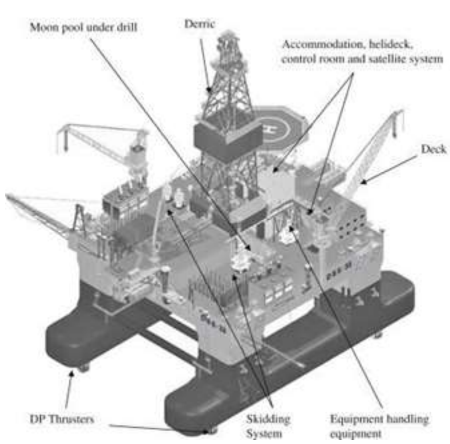

Fig 1.1: Semi-Submersible Type Floating Structure

Semisubmersible platforms, also known as SS platforms, are floating rigs with a hull designed specifically to withstand the topside loads of an offshore rig. The hull can be built based on different concepts, but most hulls consist of vertical columns and pontoons that act as submerged floats. The positioning of the unit in the exact location for exploration and production is done using an anchoring system composed of moorings and anchors. Another higher cost option is the dynamic positioning system used in some types of floating platforms and based on GPS (Global Positioning System) satellite guidance. A sophisticated controlling system collects the reference position indicators obtained from the satellites and compares them with the actual rig location, making the permanent correction of its position through thrusters. As shown in fig.1 Semisubmersibles are stable and cost-effective platforms. As the offshore oil and gas development moved into deeper water, the use of semisubmersible platforms became increasingly popular because of their spacious deck area to accommodate large topside equipment and the ease of topside–hull integration at quayside. Besides the conventional design with a shallow draft, there is an improved version called deep-draft semi. The latter was developed to further reduce the vertical motion of the platform. The reduced motion helps to improve the performance of steel catenary risers, and thus can be more cost-effective, and may even allow for a dry tree solution. Semisubmersible is one of the floating offshore platforms, preferred over other alternatives due to a few advantages: It has better stability in the harsh environment, a larger deck area, superior constructional and installation features, and higher mobility. The natural frequencies of semisubmersible vary inversely with the draft and length of the platform

: FIXED PLATFORMS/PONTOON-TYPE FLOATING STRUCTURES

They lie on the sea level like a giant plate floating on water. Pontoon-type floating structures are suitable for use in only calm waters, often inside a cove or a lagoon and near the shoreline. Large pontoon-type floating structures have been termed Mega-Floats by Japanese engineers. As a general rule of thumb, Mega-Floats are floating structures with at least one of its length dimensions greater than 60 m. Referring to fig. 2, a Mega-Float system consists of a

(a) very large pontoon floating structure,

(b) mooring facility to keep the floating structure in place,

(c) an access bridge or floating road to get to the floating structure from shore, and

(d) a breakwater (usually needed if the significant wave height is greater than 4 m) for reducing wave forces impacting the floating structure.

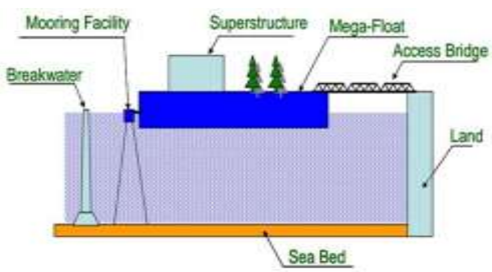

Fig 1.2: Components of A Mega-Float System.

Fig 1.4: Pontoon-Type Very Large Floating Structures

: OFFSHORE

The term offshore refers to a location outside of one's home country. The term is commonly used in the banking and financial sectors to describe areas where regulations are different from the home country. Offshore locations are generally island nations, where entities set up corporations, investments, and deposits. Companies and individuals (typically those with a high net worth) may move offshore for more favourable conditions, including tax avoidance, relaxed regulations, or asset protection. Although offshore institutions can also be used for illicit purposes, they aren't considered illegal.

: GREEN FLOAT

An Environmental Island Floating on the Equatorial Pacific. The population explosion and urban overcrowding generates environmental problems. Oceans account for 70% of the earth’s surface. Cities on the sea! Taking to the sea and tapping the sea’s potential.

: THE BOTANICAL CITY CONCEPT

We live remarkably convenient lives in cities that have developed along economic lines. But happiness should be measured separately from material wealth. Contact with Nature. Time passed leisurely in cultural pursuits. Healthy and comfortable living. We can make a city, like a single plant, that embodies these principles. Our model of a new environmental city was born from these aspirations.

: OFFSHORE WIND FARMS

Offshore wind farms or offshore wind energy is the generation electricity through wind farms in bodies of water, usually at sea. There are higher wind speeds offshore than on land, so offshore farms generate more electricity per amount of capacity installed. Offshore wind farms are also less controversial than those on land, as they have less impact on people and the landscape. Unlike the typical use of the term "offshore" in the marine industry, offshore wind power includes inshore water areas such as lakes, fjords and sheltered coastal areas as well as deeper-water areas. Most offshore wind farms employ fixed-foundation wind turbines in

Fig 1.6: Offshore Wind Farms

II.LITERATURE REVIEW

Lin, Ming / Wang, Rukai (October 2020) : Artificial Island Construction Using Large Steel Cylinders: To meet the construction schedule, the authors proposed and implemented a novel method of constructing the artificial islands, using deep-insert steel cylinder piling with auxiliary cells. Using this method, two artificial islands, each with a land area of around 100,000 m2, were formed in 6 months, whereas the originally proposed construction methods would have required 3 years.

Wu, Silin / Zhu, Wei / Lv, Yiyan (November 2018): Quality control indexes and curing agent values for submerged poured solidifying-silt island; case study of the artificial island of Dalian Bay, China. The artificial island of the Dalian Bay Cross-sea Traffic Engineering Project is the first project in China to use solidified waste dredged soil. The selections of quality control indexes and the suitable silt-cement mixing method for solidified silt island are unclear. We present tests for the curing agent values of different mixing methods, and the compression and permeability characteristics of solidified silt.

Fang, Xinyue / Li, Qie / Yang, Tao (March 2017): Preparation and characterization of glass foams for artificial floating island from waste glass and Li2CO3 A type of glass foam for artificial floating island applications was produced from solid waste glass by using powder sintering technology at a low temperature using Li2CO3 as the foaming agent. The effects of Li2CO3 content and foaming temperature on the microstructure, crystalline phase composition and macroscopic properties of glass foams were investigated.

Li, Gang / Zhang, Jin-li / Yang, Qing (March 2016): Centrifugal test and numerical assessment for settlement of a large-scale artificial island constructed on deep marine clays. This paper presents a testing and numerical study on the deformation behaviours of marine clays from Jinzhou Bay, China, where a large-scale artificial island is under construction for the Dalian offshore airport. The mechanical behaviours of marine clays were investigated by laboratory tests, triaxial creep tests and centrifugal test. An elasto-viscoplastic constitutive model (Adachi-Oka model) and a finite element programme (CFEM 2D) were used to calculate the deformation of the marine clays.

Radhi, Hassan / Sharples, Stephen / Assem, Essam (December 2015): Impact of urban heat islands on the thermal comfort and cooling energy demand of artificial islands—A case study of AMWAJ Islands in Bahrain Man-made islands, created by reclaiming land from the sea, have become more prevalent in the Gulf Corporation Council countries (GCCC) in recent years as demand for additional land to develop grows. The creation of such islands will affect the landscape, climate and environment through the replacement of sand and water with hard artificial surfaces and buildings. Exposing urban man-made surfaces, such as roads and buildings, to the sun increases the temperatures of their surfaces and the atmosphere

CASE STUDIES

CASE STUDY 1: THE PALM ISLANDS IN DUBAI

The Palm Islands in Dubai are the three largest artificial islands in the world. They are being constructed by Nakheel Properties, a property developer in the United Arab Emirates, who hired the Dutch dredging and marine contractor Van Oord, one of the world's specialists in land reclamation. The islands are The Palm Jumeirah, The Palm Jebel Ali and the Palm Deira.

The islands were commissioned by Sheikh Mohammed bin Rashid Al Maktoum in order to increase Dubai's tourism. Each settlement will be in the shape of a palm tree, topped with a crescent, and will have a large number of residential, leisure and entertainment centres. The Palm Islands are located off the coast of The United Arab Emirates in the Persian Gulf and will add 520 km of beaches to the city of Dubai.

The creation of The Palm Jumeirah began in June 2001. Shortly after, The Palm Jebel Ali was announced and reclamation work began. In 2004, The Palm Deira, which will be almost as large in size as Paris, was announced. Palm Jumeirah is currently open for development. Construction will be completed over the next 5-10 years.

Fig 3.1: Map of Dubai Showing the Location of The Palm Jumeirah in The Bottom Left

Design Concept:

The Palm Jumeirah was first envisioned in the 1990’s as a luxury residential and commercial area,

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a tourist destination, and a means of providing Dubai with more development space. The island consists of two main regions: the breakwater and the palm. The breakwater forms a circular arc that acts as a barrier to the sea, protecting the inner palm from potentially harmful wave action and water flow. The palm consists of a main trunk and 17 fronds, providing a large portion of residential and commercial space. The fronds contain a variety of beachfront villas, while the trunk contains hotels, apartments, condos, shopping malls and other commercial properties. The breakwater contains a mix of luxury hotels, resorts, condos and villas

Fig 3.2: Rendering of The Palm Jumeirah

III.MATERIALS

Materials

: Floating Concrete:

Floating concrete is a fluid mixture of density less than water, which is suitable to build floating structures, reducing the consumption of land for buildings. The procedure of preparation of mix proportion of floating concrete, materials used & various test results of compressive strength at the age of 7 days & flow, for acceptance of this concrete. Also, it presents an application of this concrete for canoe construction along with a light weight but, strong reinforcement. Despite the self-weight of the canoe, it can bear a certain amount of external load.

Fig 4.1: Floating Concrete

: Stainless Steel:

Stainless steels are inherently corrosion resistant. In the presence of oxygen, a tightly adherent protective layer of chromium oxide spontaneously forms on their surface, which means they can perform satisfactorily in a wide range of environments without protective coatings. This intrinsic characteristic of stainless steel is particularly important for offshore structures situated in harsh environments exposed to chlorides from sea water.

Fig 4.2: Stainless Steel

: Plastics and ceramics

The word ceramic is derived from the Greek word (keramos). The term covers inorganic non-metallic materials which are formed by the action of heat. Up until the 1950s or so, the most important of these were the traditional clays, made into pottery, bricks, tiles and the like, along with cements and glass. Clay based ceramics are described in the article on pottery. A composite material of ceramic and metal is known as cermets. The word ceramic can be an adjective, and can also be used as a noun to refer to a ceramic material, or a product of ceramic manufacture. Ceramics may also be used as a singular noun referring to the art of making things out of ceramic materials. The technology of manufacturing and usage of ceramic materials is part of the field of ceramic engineering. Many ceramic materials are hard, porous, and brittle. The study and development of ceramics includes methods to mitigate problems associated with these characteristics, and to accentuate the strengths of the materials as well as to investigate novel applications.

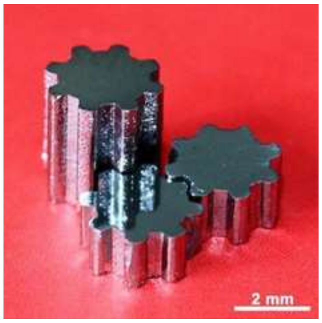

Fig 4.3: Ceramics

IV.METHODOLOGY

Methodology

: Methodology of Floating Structures

: Wave Environment

Because floating structures can show significant dynamic effects, the wave elevation h(t) at the platform centre should be modelled as an irregular, random process with appropriate frequency content. This is most commonly parameterized by the significant wave height, Hs = 4sh, and the peak spectral period Tp.

Following common approaches for both North Sea and Gulf of Mexico sites, the writer’s model only large wave ‘‘events’’ in which Hs exceeds a specified threshold hmin. In particular, three- hour sea states with Hs > hmin are assumed to follow a truncated Weibull distribution.

$$G_{H_S}(h) = P[H_s > h] = \exp\left[-\left(\frac{h}{h_0}\right)^{\gamma} + \left(\frac{h_{\min}}{h_0}\right)^{\gamma}\right]$$

EQ.1

Assuming events with Hs > hmin occur independently with an annual rate n, the distribution of annual maximum Hs values

Is

$$F_{\text{ann}}(h) = P[\max \text{ annual } H_s \leq h] = \exp[-\nu G_{H_S}(h)]$$

EQ.2

Fann(h) = P [max annual Hs # h] = exp[2nGHS(h)] (3) compares the distribution, Fann, of the annual maximum in (3) from four site-specific models of G (h): HS

• GOM1: A generic Gulf of Mexico site, subjected to the full hurricane population (Banon et al. 1994). This formed the basis of an industry study on code calibration of tension-leg platforms.

• GOM 2: The combined population of sudden hurricanes and winter storms in the Gulf of Mexico. This has defined nonacceptable events on which American Petroleum Institute requalification standards have been based (Petrauskaset al. 1994).

• NNS: The Stat fjord site in the Northern North Sea (Haver and Gudmestad 1992).

• SNS: The Ekofisk site in the Southern North Sea (Haver and Gudmestad 1992).

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Fig 5.1: Floating Structure

Parameter (1)	GOM1 (2)	NNS (3)	SNS (4)
Storm threshold h_{min} (m)	8.00	7.50	6.50
Expected annual number of storms, ν	0.10	7.60	5.80
(a) Significant wave height H_s			
Scale parameter h_0 (m)	6.42	4.58	2.03
Shape parameter γ	2.29	2.00	1.25
H_{100} (m)	11.7	14.0	13.5
H_{1000} (m)	14.3	15.6	15.8
H_{1000}/H_{100}	1.22	1.11	1.17
(b) Spectral peak period T_p			
Distribution type	Normal	Lognormal	Lognormal
$E(T_p \| H_s = h)$ (s)	$5.39h^{[illegible]}$	$-14.5 + 16.88h^{0.137}$	$-2.6 + 6.59h^{[illegible]}$
$COV(T_p \| H_s)$	0.06	0.09	0.09
Median $(T_p \| H_s = H_{100})$ (s)	13.8	16.0	15.1
Median $(T_p \| H_s = H_{1000})$ (s)	14.9	16.8	16.2

TAB.1: THE PARAMETER

: Wave Load and Response Model

The method used to predict the hydrodynamic loading on a structural member generally depends on both wave and structural parameters. For members whose dimensions in the longwave direction is small compared with the wave length, it is common to assume that the fluid flow is unaffected by the presence of the structure. In this case, wave radiation and diffraction are commonly ignored, and the loading is estimated by the Morison equation. For floating structures, however, the dimensions of their hulls suggest that wave radiation and

$$\eta(t) = \sum_{k=1}^{N} A_k \cos(\omega_k t + \theta_k) = \text{Re} \sum_{k=1}^{N} C_k \exp[i(\omega_k t)]$$

EQ.3

diffraction must be included. Thus, the diffraction theory is used here to model the wave loads on the spar buoy. [Note that the diffraction load model used here has been systematically studied and compared with wave tank experiments for the spar buoy under consideration here; cf. Jha et al. (1997). Good agreement has been found for both North Sea and Gulf of Mexico sea states. Viscous effects are found to be relatively less important, and their primary effect is to induce additional damping. This is modeled here through an assumed linear viscous damping coefficient, taken here to be 5% of critical damping, in view of the experimental results.] The use of linear diffraction theory to predict wave loads is well established, and various numerical radiation-diffraction codes for these linear (first-order) loads are available. Specifically, assume that the irregular, random wave elevation h(t) is given by the following Fourier representation: in terms of the wave frequency vk, phase uk, and associated(complex) Fourier amplitude Ck = Ak exp(iuk). In this case, the resulting first-order surge force f1(t) can be similarly expressed as in terms of the wave frequency vk, phase uk, and associated (complex) Fourier amplitude Ck = Ak exp(iuk). In this case, the resulting first-order surge force f1(t) can be similarly expressed as

$$f_1(t) = \text{Re} \sum_{k=1}^{N} C_k H_f(\omega_k) \exp[i(\omega_k t)]$$

EQ.4

V.CONCLUSION

- The nation of Kiribati is currently in a dire situation, and its problems are highly likely to worsen. Increasing levels of international aid will be required to maintain the population at its current standard of living.
- This paper has demonstrated that an artificial island can bea feasible solution to accommodate the residents of South Tarawa in their home island. Its construction and population would require a large leap of faith by both the financiers and the inhabitants, but it has the potential to

provide a range of economic, social and environmental benefits both for the population and for the country.

- Alternative options could be to construct major sea defences, dredge the seabed to reclaim earth or ship earth to Tarawa Atoll, construct a platform over the island or raise all buildings on stilts, or abandon the atoll and relocate the population.
- All of these options would require significant financial input, but none could provide the same level of benefit provided by this sustainable island design.
- This project has highlighted a number of interesting topics which could benefit from future research, in particular the analysis of loading and behaviour of mega-float offshore structures and air-cushion supported structures.
- Building an artificial island would seem like an overly ambitious dream to most, but for one of the wealthiest countries in the world, it was one of several ambitious projects that have come to make the country one of the top luxury and tourist destinations in the world.

REFERENCES

1. Government of Kiribati. 2014. Kiribati Adaptation Programme. Available at www.climate.gov.ki/kiribati-adaptation-program. Accessed 04/14.

2. New Zealand Aid Programme. 2014. Kiribati. Available at www.aid.govt.nz/where-we-work/pacific/kiribati. Accessed 04/14.

3. Vijayaraghavan A. 2012. Kiribati's Entire Population is Being Moved to Fiji. Available at www.triplepundit.com/2012/03/kiribatis-entire-population-being-moved-fiji. Accessed 04/14. 4. The Pacific Region Infrastructure Facility. 2009. Kiribati: Infrastructure Sector Review.

Available at www.theprif.org/sites/theprif.org/files/Final%20Kiribati%20Infrastructure%20Sector%20Re view.pdf.Accessed 04/14.

5. EtukiK. 2007. Hands on Sub-Regional Workshop on Gender Mainstreaming in Rural Energy Development. Available at ict.sopac.org/VirLib/MR0668.pdf. Accessed 04/14. 6. Chakrabarti SK. Hydrodynamics of Offshore Structures. WIT Press, UK; 1988

7. Fu S, Moan T, Chen X and Cui W. Hydroelastic analysis of flexible floating

interconnected structures. Ocean Engrg.; 2007, 34(11–12), pp. 1516–1531.

8. Hong DC, Hong SY and Hong SW. Reduction of Hydroelastic responses of a very-long floating structure by a floating

oscillating-water-column breakwater system. Ocean Engrg.; 2006, 33(5–6), pp. 610–634. 9. Ikoma T, Maeda H, Masuda K, Rheem C-K and Arita M. Effects of submerged vertical

plates and air chamber units in Hydroelastic response reductions. ISOPE2002; 2002, pp. 547–552.

10. Ikoma T, Masuda K, Rheem C-K, Maeda H and Moan T. Hydroelastic motion of aircushion type large floating structures

with several aircushions using a three-dimensional theory. OMAE2009-79292; 2009

11. Inoue K, Nagata S and Niizato H. Stress analysis of detailed structures of Mega-Float in irregular waves using entire and

local structural models. Proc 4th Int Wksp VLFS; 2003, Tokyo, Jpn. pp. 219–228.

12. John F. On the motion of floating bodies. Comm Pure and Appl Math; 1949, Part I. 2, pp. 13-57.