Proceedings of the *1st Annual International Geotechnical Innovation Conference (IGIC 2024),* Jeddah Hilton, Kingdom of Saudi Arabia, May 06–07, 2024. Published and Indexed by Gulf Scholar.

Floating Artificial Islands versus Classic Reclamation Islands: Comparison of Geotechnical Features and Challenges against Climate Change Effect

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ARTICLE INFO

Published on 23rd of October 2024.
Doi:10.54878/8xw65266

KEYWORDS:

Artificial Islands, Floating Islands, Geo-hazards, Geotechnical Features, Climate Change

HOW TO CITE:

Floating Artificial Islands versus Classic Reclamation Islands: Comparison of Geotechnical Features and Challenges against Climate Change Effect. (2024). *1st International Geotechnical Innovation Conference*, *1*(1).

ABSTRACT

The innovative technology of Floating Artificial Islands is being used recently in different fields as a solution to the climate change effect on the coastal environment. This varies from floating renewable energy farms -such as floating (wind turbines, wave energy converters, solar energy systems) - to floating cities, and floating airports, etc. However, though they are proposed as solutions, similarly to the classic reclaimed artificial islands, floating ones are facing sustainability measures against the effect of climate change. This study focuses on the geotechnical features of climate sustainability challenges and suggests a preliminary comparison between the floating artificial islands, and the classic reclamation islands.

1. Introduction

NOAA (National Oceanic and Atmospheric Administration) reported that of the sea level rate raised drastically from 1.7 mm/year to 3.2 mm/year in the last 50 years, and the records of the increase of Carbon dioxide emission by 25 % since 1958 (Ref. 5). The main climate change features that interfere significantly with the coastal/marine infrastructure are the sea level rise, and the increase of carbon dioxide emissions, and their direct impacts on the both the physical and geo-chemical behaviours of the coastal installations:

1. The physical part focuses mainly on the design water level in the geotechnical analysis and its impact on the failure modes, such as the slope stability verification, the liquefaction analysis, the foundation bearing capacity, etc.

2. The geo-chemical part of the natural materials that accommodate the artificial islands foundations, such as the seabed materials, the rock strata for the pile foundations, the calcareous sand characterizing the reclamation islands bodies, etc.

It should be noted that the artificial islands technology (reclamation and floating) is being used for a number of main purposes, such as the land recovery/land insufficiency, oil and gas production (offshore), touristic/investment purpose, renewable energy production purpose. The analysis results provided in below consider the ES score proposed by RIAM matrix developed by the Danish hydraulics Institute (Ref.8).

2. Geotechnical Challenges to Climate Change for the Classic Reclamation Islands

The reclamation islands in the Middle East are built mainly using calcareous sand dredged materials. The bodies/ core of the islands is often composed of calcareous sand compacted layers (dynamically compacted), and the islands boundaries comprise rock protection rubble mounds, quay wall/ marinas port facilities. The physical and geo-chemical challenges can be summarized as follows:

1. The physical Geohazards concerns the liquefaction potential –and liquefaction induced settlement- due to the rise of groundwater level for the sand bodies, and as well the long-term static deformation (creep) that affects both the island body and the rock layers of the coastal protective structures, as well the quay walls.

2. The geo-chemical part for the reclamation islands concerns the soil degradation due to the ocean acidification as result of increase of carbon dioxide dissolution in the sea water, and this phenomenon happens because of ccarbonic acid reaction with carbonate ions in the water to form bicarbonate, which weakens the shelly calcareous sand consisting of main body material of the reclamation islands.

3. Geotechnical Challenges to Climate Change for the Floating Artificial Islands

The floating artificial islands can be installed by either anchoring systems by installation of deep anchor blocks into the seafloor, or by a combined system of fixed deep foundations (such as Fixity dolphins) similarly to the Japan Megafloat airport prototype and moored to anchorage system from the other side (semi-floating islands). In both scenarios, these floating islands depend on the rock layers of the seafloor soil profile, where the foundations are designed based on the friction with rock strata. The physical and geo-chemical challenges can be summarized as follows:

1. The physical Geohazards concern the dynamic stability of the foundations faced to the increase of intensity and severity of the storm surges and typhoons. The increase of the micro seismicity effect (the increase of earthquakue magnitude due to global warming is still a subject of research works), however, the hydrodynamic variance affects the scouring systems protecting the floating islands foundations (anchoring systems).

2. The geo-chemical part for the floating islands concerns the rock strata materials whose friction is required for the stability of floating islands foundations. These rock layers are subject to the weather because of the carbon dioxide gas reaction with water molecules. The release of hydrogen due to this reaction weather the rock strata for the production of bicarbonate ions (Ref.1).

4. Comparison of the Results

The comparison has been performed by averaging the ES score for each type of artificial island, where the Physical/Chemical Component represent the physical geohazard and the geochemical feature explained above. Summary of the results are provided in Figure 1:

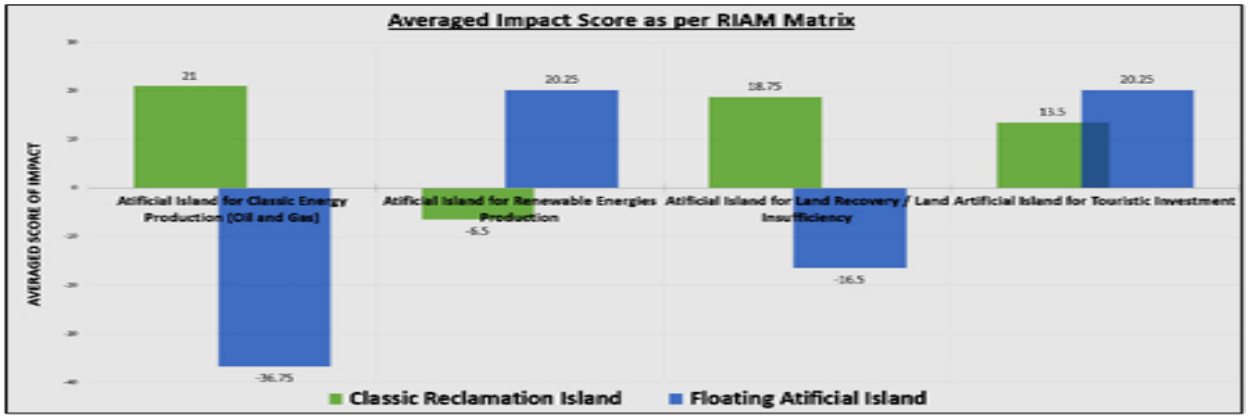

Figure 1: Averaged Impact Score Results for the Different Artificial Islands

5. Findings and Conclusions

The current study results prove the selection of the new artificial island development shall take into consideration the purpose of the investment, and the climate change features, the floating island could provide better results than classic reclamation islands, if constructed for renewable energies production or touristic purposes. However, for the land recovery islands and the oil and gas classic energy production, the classic reclamation islands provide better permanence behaviour and investment results, rather than the floating islands option.

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