DEVELOPMENT OF ALEXANDRIA COAST BY MEANS OF ARTIFICIAL ISLANDS

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ABSTRACT

Many researchers have been drawn to the problem of erosion along the Alexandria coast in the last ten years. Alexandria erosion, combined with the recent widening of the existing Cornish Road, resulted in the narrowing of some sandy beaches and the disappearance of others. Overtopping waves carry beach sand onto the adjacent roadway during a strong winter storm, causing traffic jams. Three strong storms occurred in the last ten years in December 2003, 2006, and 2010. The study's goal is to solve these problems by building a new bridge based on a multipurpose island. The bridge was built to alleviate traffic jams, and the island was built to withstand offshore storms and can be used for a variety of touristic purposes. The project has a different type of coastal measures as a causeway by using the artificial island as coastal protection by constructing the detached islands with dimensions of 2.5 km length and 0.5 km width for each to protect about 10.5 km of the total coast. Furthermore, Detailed information about the recorded waves, bathymetry, and tide. Mike21's waves and currents are also distributed (Flow model). The suggested layout was checked using a variety of mathematical models such **as MIKE 21 FLOW MODEL FM**. The new project was tested and verified by the numerical model. The project has been created by **REVIT** software to be more vision for the readers. Finally, after investigating the impact of the islands' proposed new bridge. It was discovered that the coast has been improved and stable enough to be used for swimming and other activities. Tourists and various restaurants can use artificial islands. This research is being conducted to create a new coastal city in Alexandria.

Keywords: Alexandria, Waves, Artificial islands, Coastal

1.1 INTRODUCTION

Alexandria, Egypt's second capital and most visited tourist destination, is located on the Mediterranean Sea. Strong waves reach heights of 7.60 m every fifty years, with a maximum height of 8.10 m occurring at least once every hundred years. There were a lot of waves running up on the sandy mid-beaches. Storms like these flooded parts of the main coastal road and washed away all the beach's light structures Furthermore, many existing protection projects have a negative impact on the coastal zone. Corniche, which is relatively high in elevation, has significant alongshore variability ranging from 2.41 to 12.27 m relative to mean sea level. (Frihy et al., 2004). Recently, the road was widened to alleviate traffic problems, which have been a daily waste of time.

The research's main goal is to develop a new proposal for necessary protection structures to protect the city's coastal zone area from erosion and storms, as well as to solve traffic problems. The construction of the new bridge appears to have been forced on the multipurpose island.

The beaches facing Alexandria city are narrow and suffered from annual erosion. Some submerged breakwaters were built to solve the problems of the surf zone. This paper introduces a new and relevant multi-use artificial island. Urban development, recreation, and the construction of recreational structures such as hotels or water parks are all justifications for artificial islands. Along the Alexandria coastline, from Abu Qir Bay to Alexandria Western Port, these man-made islands will be used as a coastal protection structure.

The Alexandria Island proposal calls for the construction of three large islands with a length of 2.5 km and a width of 0.5 km, located 0.50 km from the Cornish Road. The suggested site's seabed is 5.0 meters below the mean sea level. The suggested solution's hydrodynamic analysis shows that these three islands will provide calm seas at the original shore and safe currents in the surf zone

1.2 Background Research of Artificial Islands:

In response to changing conditions and needs, the demand for artificial islands has evolved. A man-made island is an important tool for developing and utilizing marine areas, islands, and mudflat resources. Furthermore, and as a side note, it has been proposed to create new islands for a completely different reason as follows:

1- Gaining new land and artificial cities
2- Tourism and entertainment land
3- To generate electricity using renewable energy sources.
4- Transportation facilities

The key challenges of artificial island development were investigated and analyzed considering the current state of artificial island development in other parts of the world.

Firstly, Egypt's recent emphasis on urban development and tourism promotion, and coastal manmade islands have received insufficient attention. Despite popular perception, artificial islands have a long history in many parts of the world, dating back to Ancient Egyptian civilization's reclaimed islands.
Moreover, China designed and built the first modern artificial island, which was completed in August 1995 after 16 months of construction. Following that, artificial islands gained popularity and began to spread throughout the world. Dubai, for example, is a neighboring country that identified the brilliance of the concept about twenty years ago and built the notable Palm Islands, which have remained a key pillar in the city's attraction to tourists and investors ever since a list of examples will be discussed as follows.

1- The most famous artificial islands recently are Dubai islands shown in (Figure 1) is an extreme example of this, with plans to increase the 45 km coastline to more than 1500 km (>3300%) through the construction of The Palms, The World, The Universe, and Waterfront City developments, among others. Many of the plans were never realized, but The Palms alone (Figure 1) has increased the shoreline's linear extent by 130%. Doha and Bahrain have also built elaborate artificial islands (Firth et al., 2016).

2- The Pearl-Qatar in Doha spans nearly 4 km2 as shown in (Figure 2), and the Durrat Al Bahrain is made up of a slew of crescent-shaped islands that spans nearly 5 km^2. (Firth et al., 2016).
3- Ocean Flower Island, at one and a half times the size of The Palm Jumeirah, is said to be the world's largest artificial island, but it is three separate islands connected by causeways as shown in figure 3. Ocean Flower Island is in Hainan, an island province off China's southern coast about 2,000 Km from Beijing, with tropical weather all year. The island complex, shaped like a peony flower, spans about eight square Km, with much of it set aside for accommodation for up to 200,000 visitors. The central area, dubbed Ocean Flower Island No 1, is intended to be a self-contained vacation destination. "Fairyland," a fantasy-themed amusement park, and "Snow Mountain," a water park, are among the attractions (Langton, 2022).
4- Sheikh Jaber Al-Ahmad Al-Sabah case way bridge consists of the 200-meter-long main bridge, an elevated road, and five Km of access roads that are all part of the new Kuwait City. Along with the 37 km causeways that cross the bay as shown in figure 4. As part of the project, two artificial islands with a combined size of about 30 hectares will also be created. These islands will have two small harbors for pleasure craft, rest and refilling areas, and maintenance buildings. The project's main objectives are to build new highways to improve the development planned for Kuwait City's northern regions, promote greater integration between those regions, and cut travel time across the bay to under 30 minutes (it currently takes about 90 minutes to cross the bay using the coast road) (Al, Sheikh,2005).

Figure 1: Dubai's Palm Islands and The World (Images courtesy of Google Earth.)

Figure 2: Doha's Pearl-Qatar. (Images courtesy of Google Earth.)

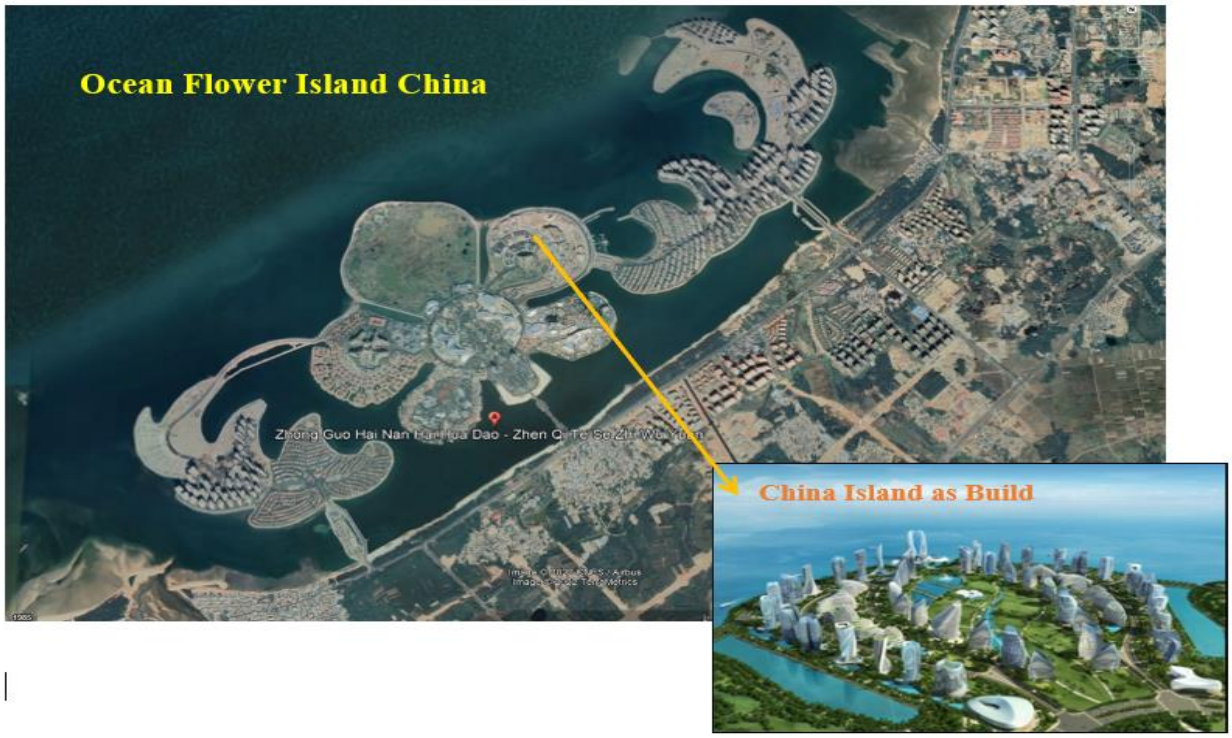

Figure 3: Ocean Flower Island-Bot'l.Gard., Danzhou, China (Images courtesy of Google Earth.)

Figure 4: Sheikh Jaber Al-Ahmad Al-Sabah case way bridge (Al, Sheikh,2005).

The fundamental data, site selection, shape, reclamation plan, coastal structure design, full consideration of extreme events, and abundant funds are the key issues in the development of artificial islands. The core of the key problems of artificial island development, which is primarily constrained by natural conditions, is site selection. The natural environment of the island's sea area will have a significant impact on the artificial island's site selection. In general, the artificial island is placed as far away from the middle and weak tide bays as possible, with weak wave dynamics or semi-closed seas.

1.3 Study area description

Alexandria is Egypt's biggest beach resort on the Mediterranean Sea. Alexandria is located on the Mediterranean Sea. The city's beaches and coastline front have been plagued by a multitude of issues. Alexandria's beaches were small and prone to erosion. The coastal highway, one of the two main roadways, was prone to erosion and overtopping concerns seaward of the wall. A plan for the development of the city's coastal front was devised, which covered both the beaches and the coastal roadway and its protection. Submerged breakwaters were created in Alexandria in reaction to environmental difficulties encountered with detached emergent breakwaters, which were frequently utilized to safeguard the northern Nile Delta shoreline. A variety of factors were considered in the design of the new coastal highway protection. The Alexandria Coastal Highway stretches for about **16 Km from Montaza to Ras El Tin**. The highway is one of Alexandria's two main thoroughfares and is notoriously crowded, especially during the summer. A vertical concrete barrier that was prone to corrosion and overtopping protected the route from the water (Frihy,1996). Driving along the roads was difficult in several spots during the winter, especially during storms due to wave overtopping. The barrier's seaward degradation has long been seen. To address the issues of highway protection where there are no beaches, concrete cubes with a capacity of 2.45 m3 have been put seaward of the wall on two levels. The recent protection and restoration of beaches, as well as the repair of the coastal roadway, have substantially boosted Alexandria's desirability as a beach destination. Submerged breakwaters, for example, have made this possible while simultaneously providing an efficient answer to long-term erosion

concerns. Due to the presence of low-lying residual depressions. These depressions are connected to Alexandria's high-elevation shore-parallel carbonate ridges (Figure 5). where these ridges came from. The elevation of these ridges, which number 8 to 10 and are located farther west of Alexandria, gradually rises from 10 meters along the shore (ridges 1,2, and 3) to 100 meters as shown in figure 6, around 40 Km inland from the western coast. Alexandria Cornish Road is where you may see the remnants of these ridges (Frihy et al., 2021). This was the main concept of the project that Alexandria has diffracted the storm wavers by a parallel ridge. The design and construction of breakwaters require detailed knowledge of wave activity and persistence under all conditions. Data on extreme wave heights are required for the design of structures.

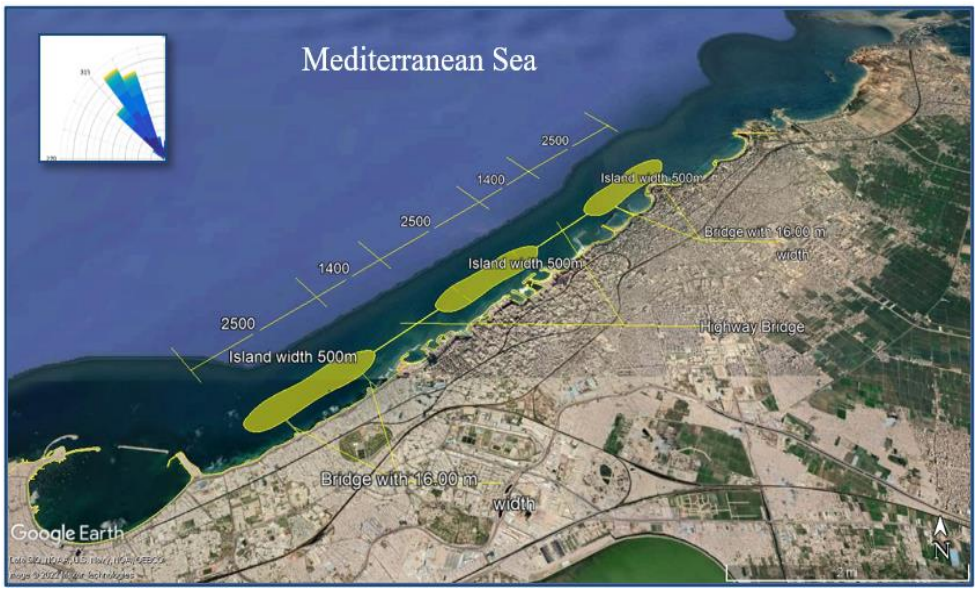

Figure 5**:** Master plan of the new proposed project (By Author)

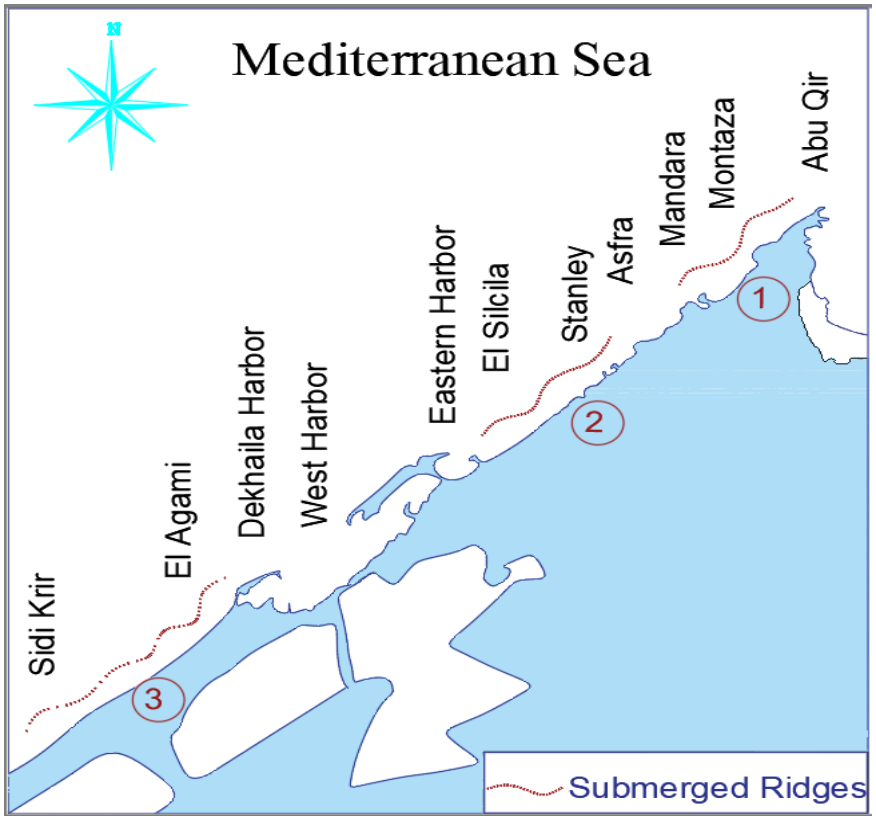

Figure 6: Submerged ridges located along the Alexandria coast distributed in three locations parallel (By Author)

1.4 The Proposed case way of Alexandria coast by means of Artificial islands.

How long does it take you to go between Mandara to Qaitbay? The major goal of this study is to reduce the trip time on the Cornish Road by one-third. To offer a new and pertinent multi-use artificial island, the new causeway will be built on three artificial islands that we will utilize as coastal protection and a tourism destination. Firstly, selecting the shape of the island as curved shape to activate the water flow. Secondly, the Artificial islands have several explanations, including urban development, recreation, and the construction of recreational buildings like hotels or water parks. These artificial islands will serve as a coastal measures system along the Alexandria shoreline, from Abu Qir Bay to Alexandria Western Port. Finally, the construction of three sizable islands with a combined length of 2.50 km and a width of 0.5 km, situated 0.50 km from the Cornish Road, is proposed for Alexandria Island. The seafloor at the proposed location is 5.0 meters below the mean sea level. All projects' details are shown in figures (7-A), (7-B),(7-C), and (7-D) Showing the elevation, side view, and plans of the project and the passage connection between the land and the island.

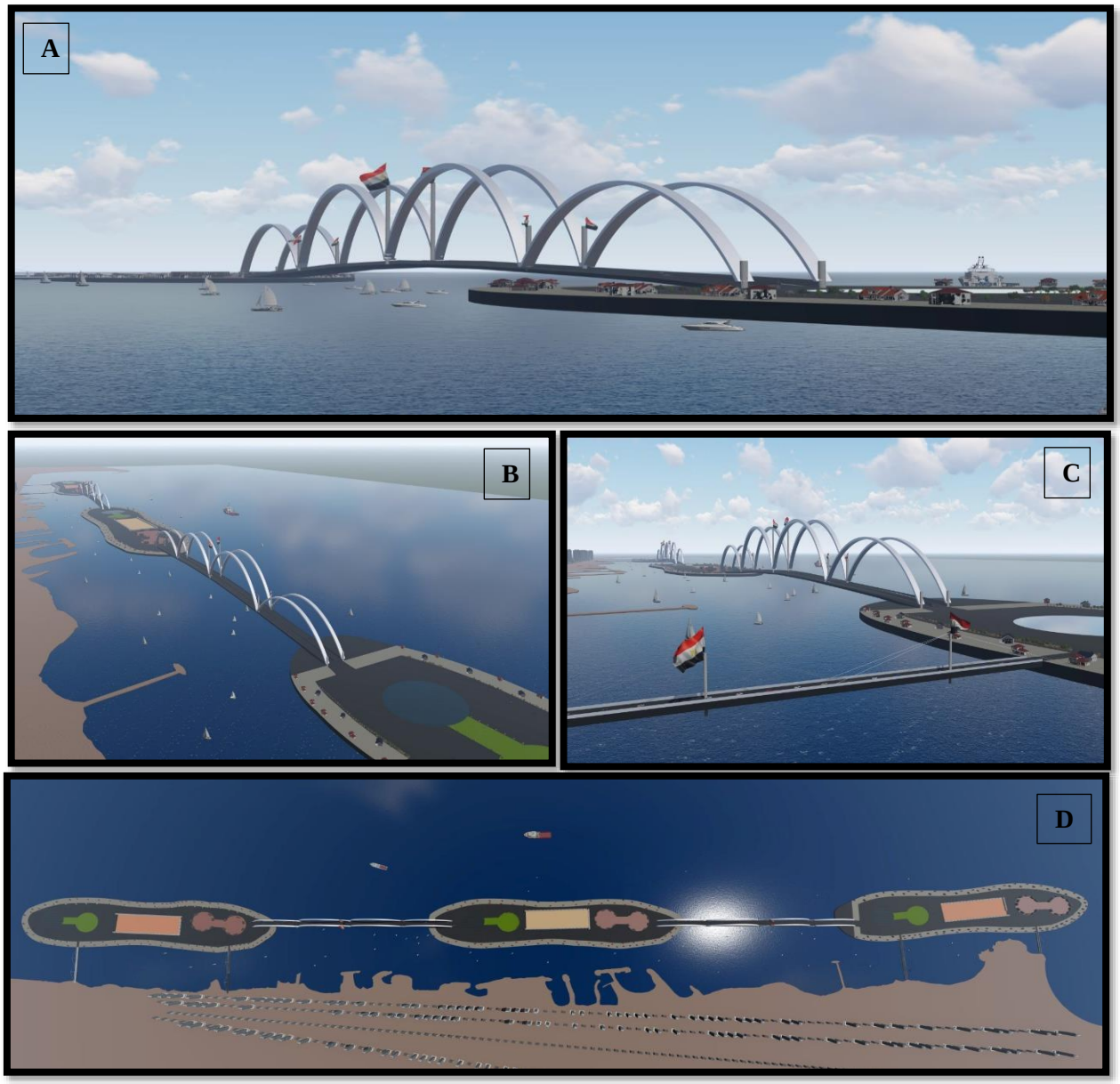

Figure 7: The proposed project includes the causeway and the multi-purpose Artificial islands,(7-A) the elevation island's heights with the bridge,(7-B) the plan of the artificial islands,(7-C) the connection of the land with the island,(7-D) plan of the three artificial islands with the shoreline by the current coastal measures.

1.5 Data and Methods:

Developing a new design for our research requires several criteria such as shape, location, and morphology, as well as the project impact. The suggested project's methodology.
1- Choosing a form based on practical concerns. Curved-shaped islands to avoid erosion and smoothing with water flow.

2-At locations where erosion from a certain direction is a concern, the shape and alignment of the islands may have to be established by the prevailing current and wave to employ the islands as coastal global measures to safeguard Alexandria.
3- Examining the surface morphology by concentrating on parallel natural ridges
4- Coastal impact assessment to determine the project's influence on the coastal zone area by means of numerical modeling to know the impact of the project on the waves and current velocities and create calm areas for swimming, and safely tourist islands. Using (MIKE 21 FLOW MODEL FM and (MIKE 21 SW-SPECTRAL WAVES)

1.5.1 Input data:

Table 1. Data input for numerical model

Parameter	Description	Data Source
Bathymetry	Bed level depths defined in the model	Measured in the year 2020 SOURCE (CoRI).
Tide	Measurement data level data	Using data on changes in sea level recorded in the study area during 2015.
Wave	Wave characteristic in study area	Using the wave data of the monitoring station in Abuquir, which was recorded in 2010
Sediment	D50 of the bed material 0.35 mm	Site survey (CoRI field data)

1.5.1.1 Mesh and boundary condition

Bathymetry and mesh Setting up the mesh entail selecting an acceptable region to be represented, resolving the bathymetry, wave, wind, and flow fields under consideration, and defining codes for essential and land borders. One of the most significant responsibilities in the modelling process is describing the water depth in the given model domain. In our paper bathymeter was created from field data perpendicular profiles distributed location with bed depths (Cori,2020). The constraint conditions an absorbing (land) barrier is the most used remedy for a border where no wave information is available. Additional boundary scenarios with varying wave heights are shown in Figure 8, and Figure 9.

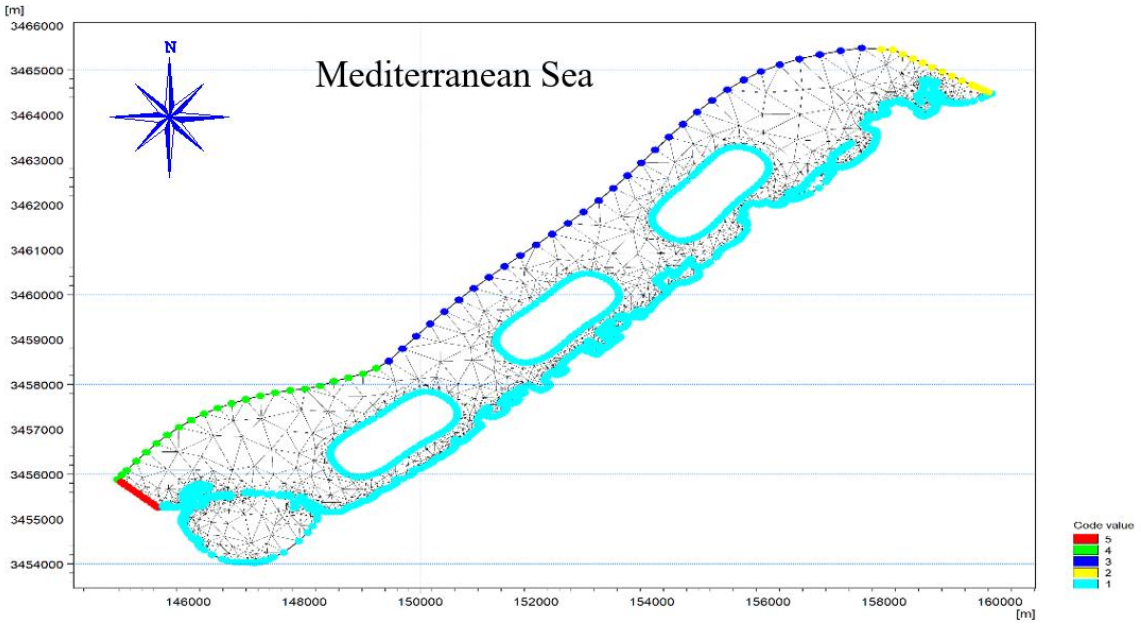

Figure 8: Mesh generation with external boundary condition and the new artificial islands (MIKE 21 Sw)

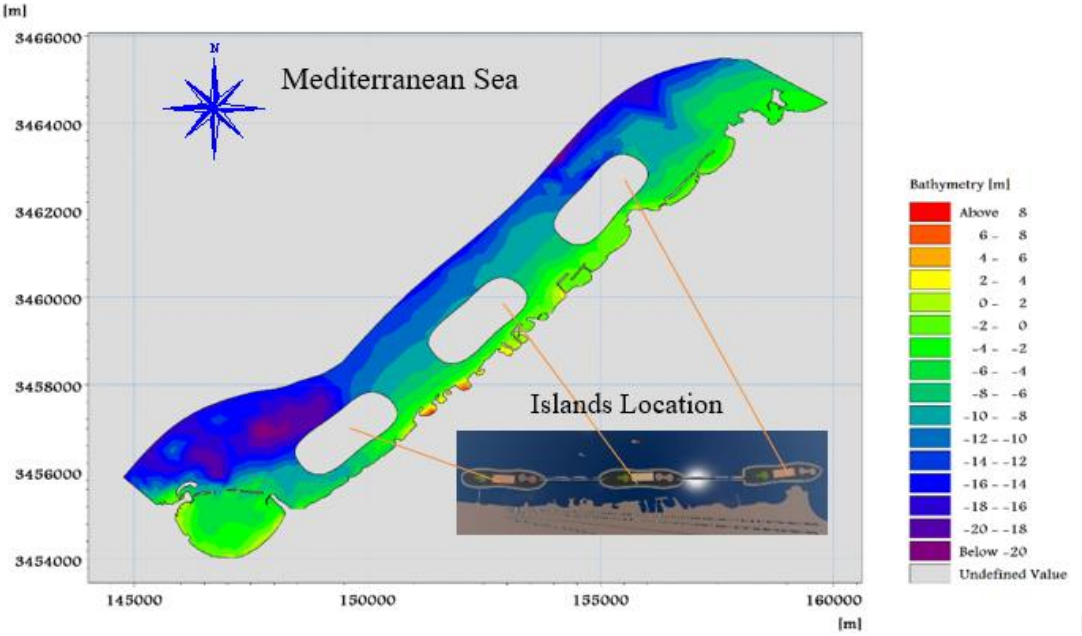

Figure 9: Generated bathymetry by using Mike21 showed the different depths at the artificial island location. The end of the Artificial Island reaches a depth of 10 m.

1.5.1.2 Wave height analysis and history

Using the wave data of the monitoring station in Abu Quir, which was recorded in 2010 at 18.5 meters in-depth, the measurements included the height of the wave, its time, and direction with an iterative period every 4 hours. The new design craze the design approaches given in this section is based on the concept that some waves that occur throughout the project lifetime may be greater than the design wave, which is decided primarily by the project's function. A service life of 50 to 100 years is commonly assumed, although, for the reasons listed below, the design wave should typically have a significantly longer return duration. Estimates of extreme wave heights are summarized in Table 2 (Iskander,2013). The

available wave rose and tide obtained by CoRI distributed by mike 21 is shown in Figure 10 and Figure 11

Table 2 Estimated extreme wave heights based on wave measurements made in Abu Quir Bay between 1985 and 1990 at a depth of 18.5 m. (Iskander,2013).

Return periods(year)	1	2	5	10	20	30	40	50	100
Wave Height (m)	4.70	5.20	5.90	6.40	6.90	7.20	7.40	7.60	8.10

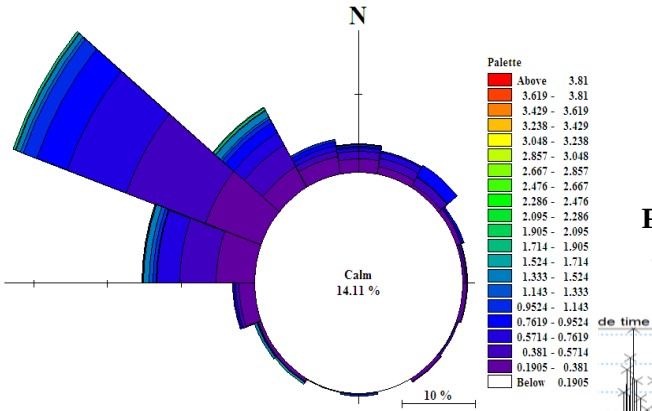

Figure 10: Wave rose distribution by Mike 21, trend of the waves is of the Northwest (43%)

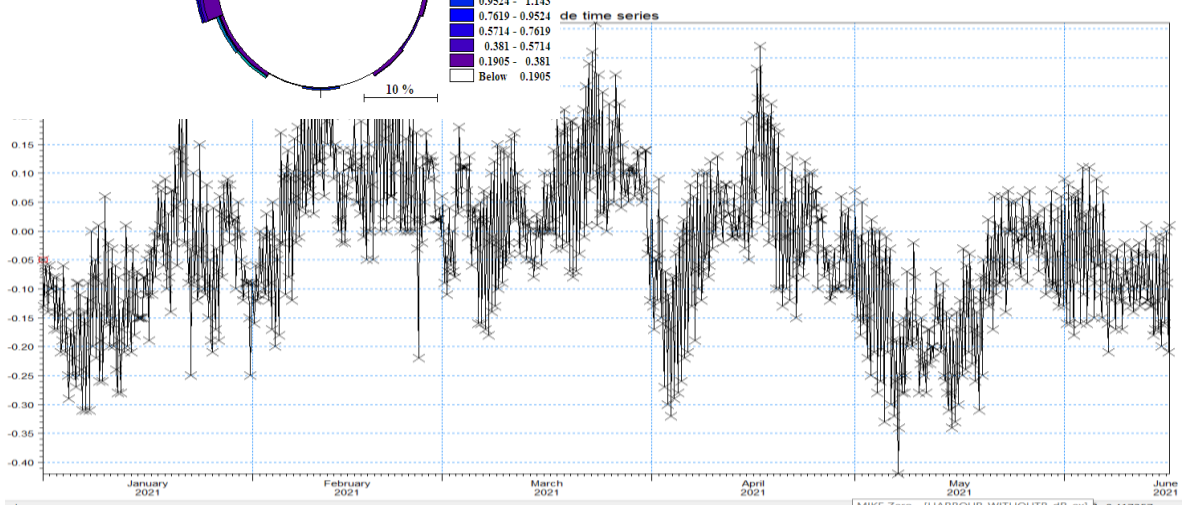

Figure 11: Tide serious of the study period for one year

1.5.2 Calibration:

The calibration was created by using real current velocity measured at the Alexandria coast in 2019 near the proposed Artificial Island measured by the Shore protection authority. The data were compared by simulation of the current velocity (m/sec) obtained by MIKE 21 FLOW MODEL FM. Shown in Figure 12. The difference between the measured and simulated data.

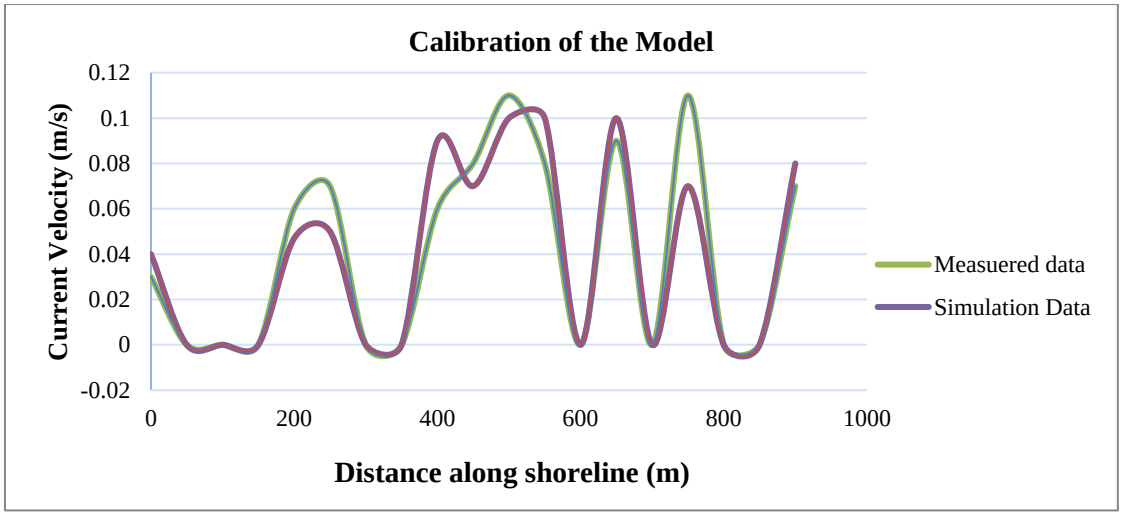

Figure 12: Calibration of Current Speed velocity (m/sec) Alexandria coast

1.5.3 Results and Analysis:

The suggested Island is planned to become a multi-purpose Island, investment demands the North coast of Egypt. Mike21 was used to simulate the distribution of waves and ocean currents. The program includes several separate computational units (models), each unit concerned with calculating or simulating a marine phenomenon. According to the requirements of the study, two mathematical models of MIKE 21 FLOW MODEL FM and (MIKE 21 SW-SPECTRAL WAVES) were used to simulate the pattern of waves and sea currents distributions off the coast of the study area. The depth map (Bathymetric map) was derived using the data of the short sectors measured by the marine areal lift. The tidal data were entered as mentioned in the data analysis report. A wave spectral model called MIKE21 SW can be used to process a wide range of conditions, including wind waves, nonlinear interactions between waves, energy losses caused by whitecaps, bottom friction, wave breaking, reflections, diffractions, and shallow water deformations, interactions between waves and water flows, and depth changes.

1.5.4 Distribution of different cases of waves

The data were back-refracted to deep water and then forward-refracted to maintain the distribution of wave characteristics along the Abuquir area. Data show that the trend of the waves is of the Northwest (43%) with the maximum height of the waves 4.40 meters from the north-west direction and distinctive height equal to 1.16 meters and periodic time for waves is less than or equal to 8 seconds as shown in figure 13, figure 14 and figure 15.

Case (1): Natural wave

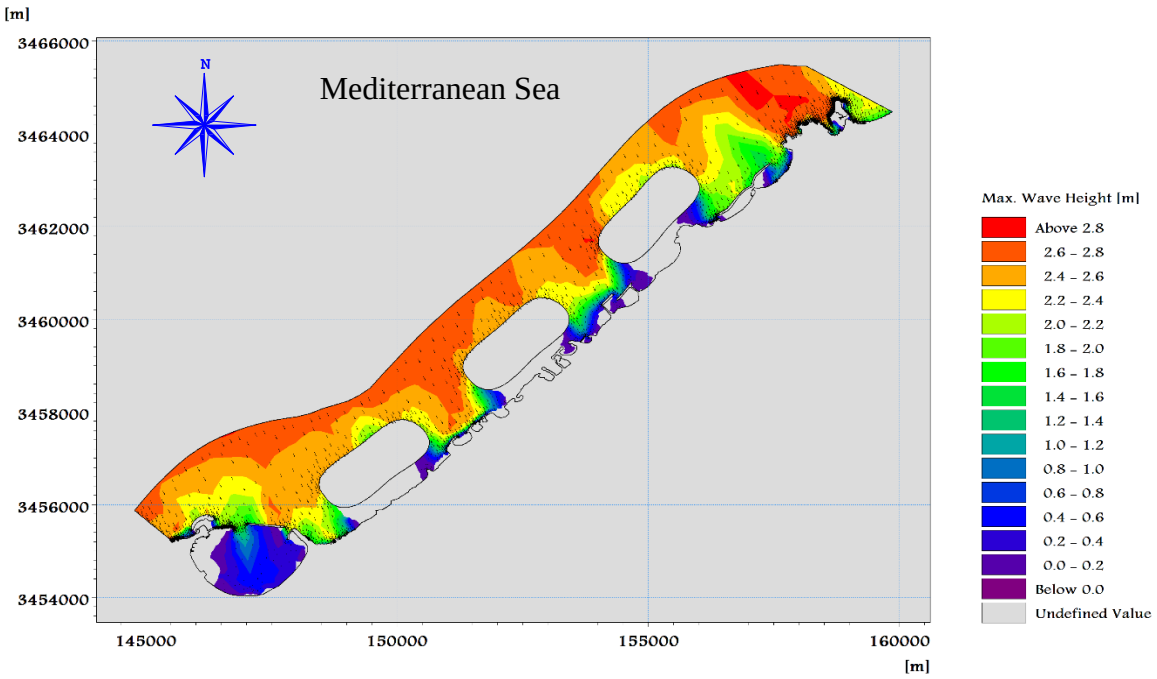

Figure 13: Wave distribution by the annual normal wave by max =2.85 m

Case (2): Distribution of extreme waves by return period 100 years.

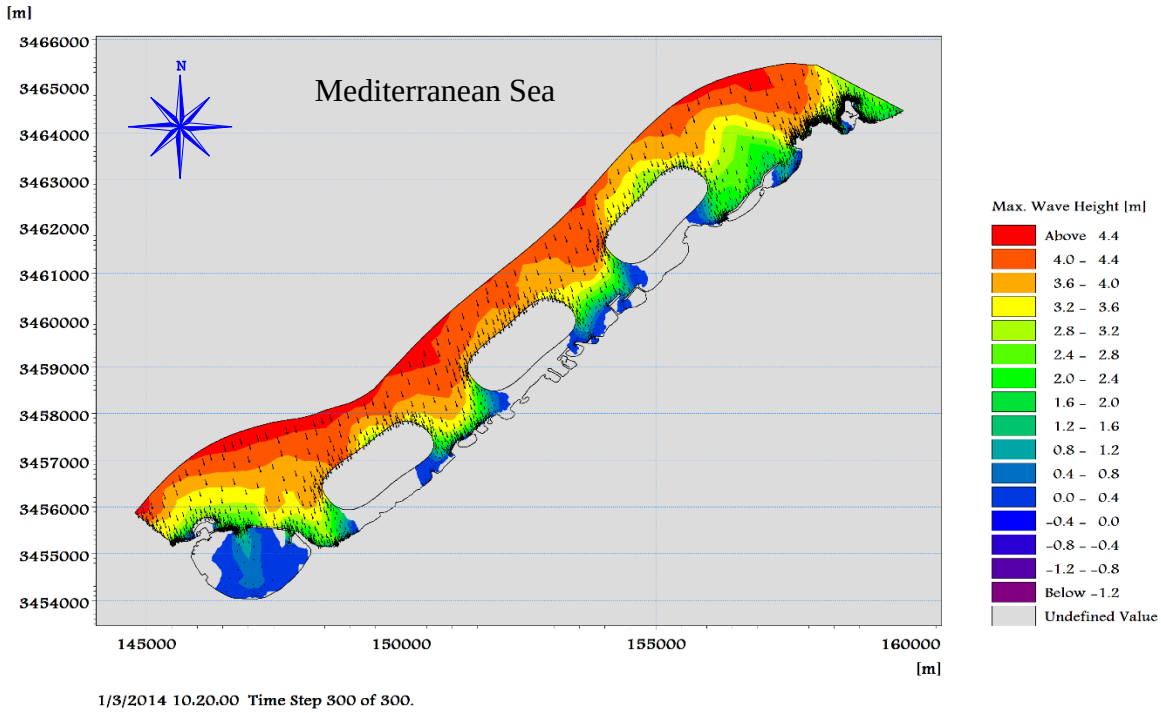

Figure 14: Wave distribution by the annuals normal wave by max = 4.40 m

Current Distribution in surf Zone location after project construction by means of Artifial islands:

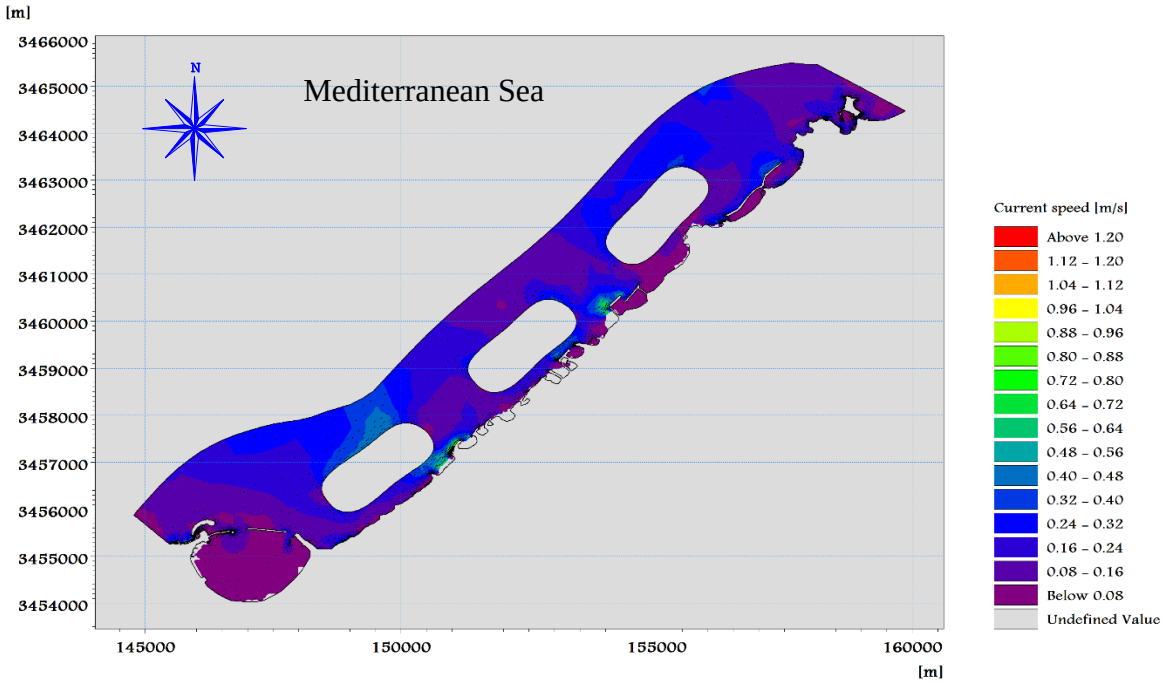

Figure 15: current velocity distribution after constructing the islands which have a good swimming surf zone area

Including the development of tourism, nearshore and detached islands constructions have several detrimental consequences. Firstly, The natural state of the Alexandria area had many dangerous characteristics, the most important of which was the height of the waves and the speed and direction of the currents, both of which led to a continuous erosion of the coastline of the entire Alexandria coast, which led to the implementation of many marine installations to protect the beach from erosion Before the construction of the islands the wave height is recorded to 2 m and the current speed is 0.50 m/s near the shoreline.
Moreover, the maximum wave height in the facing wave direction of the proposed island is 4.50 meters, and the current speed in the surf zone area is recorded between 0.08 to 0.36 m/s in several locations at Alexandria beach after the construction of the proposed island.
In many places, the height of the waves has become almost zero (in the surf zone) due to the construction of the proposed islands

1.6 CONCLUSION

The authors of this article used computer-based evaluation MIKE 21 FLOW MODEL FM and (MIKE 21 SW-SPECTRAL WAVES) to determine the effects of manmade structures on coastal erosion. The results demonstrate that the structure of islands is shown.

1- Creation of a suitable sea area for swimming
2- Creation of a developed tourism area
3- Solving the traffic problem of the coastal road
4- A good protection against erosion of the original coast
5- A new financial touristic source for Alexandria

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