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Coastal protection and development of Alexandria

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Abstract

Alexandria City is the main beach resort on the Mediterranean Sea of Egypt. The beaches and coastal front of the city have been suffering from a number of problems. Alexandria beaches were narrow and suffered from erosion. The coastal highway, forming one of the two main roads, was susceptible to erosion seaward of the wall and experienced overtopping problems. A plan for the development of the coastal front of the city was prepared, which addressed the beaches as well as the coastal highway and its protection. This plan, as well as the technical solutions chosen to protect a number of beaches and to reconstruct the coastal highway, are the topics of this paper. Beach protection and development of three beaches; Cleopatra, Sporting and San Stefano are presented. In response to environmental problems experienced with detached emerged breakwaters which were often used to protect the northern Nile Delta coast, submerged breakwaters have been introduced in Alexandria. In the design of the new coastal highway protection, a number of constraints related to environmental and functional requirements had to be fulfilled. These requirements and the solutions are presented.

1 Introduction

Alexandria is situated on the southwestern part of the Mediterranean Sea in Egypt and is considered one of the oldest cities in the area, Figure 1. This major city is also the main beach resort on the Egyptian Mediterranean. Alexandria beaches

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extend for about 15 km from Montaza to the east till Chatby to the west, Figure 2.The beaches are narrow, their width not exceeding 50m.

Alexandria beaches are suffering from erosion problems. The Egyptian Shore Protection Authority has carried out a number of studies from 1984-2001 to investigate the coastal problems in the area and propose/ implement the necessary protection measures.

The coast of Alexandria is bordered by a highway, known as the Corniche, which follows the coastline for a distance of about 16 km from Montaza on the east to the eastern harbour on the west. The Coastal highway forms one of the two principal east-west thoroughfares of Alexandria. The highway has been protected by a vertical concrete seawall built around the beginning of the twentieth century. The coastal highway has been suffering from a number of problems such as wave overtopping and erosion. In addition, traffic problems became a usual characteristic of the Corniche over the last two decades especially during summer.

Coastal protection structures have been proposed for a number of Alexandria beaches since 1984 ,Tetra Tech [1], Sogreah [2], [3] in an attempt to limit beach erosion. The proposed protection schemes included the use of detached breakwaters with sand nourishment. Detached breakwaters have been widely used in protecting a number of beaches on the northern Nile Delta Coast of Egypt in the eighties and early nineties. However, due to budget limitations, the only measure taken was periodic nourishment of the beaches suffering from erosion. Since 1995, the government of Egypt started to undertake a new plan for the development of Alexandria City including the development of beaches, coastal front and highway. Due to the increased awareness to environmental problems associated with emerged breakwaters, new protection schemes using submerged breakwaters were introduced to a number of beaches replacing the previously proposed detached breakwaters. A number of submerged breakwaters are currently under construction. This is done besides the periodic nourishment which is undertaken on a yearly basis for most of Alexandria's beaches.

To overcome the coastal and traffic problems of the highway, the coastal protection of the highway has been redesigned to limit the problems associated with wave overtopping and erosion which threatened the old highway. To overcome the traffic problems, the highway has been widened from Montaza on the east till Al Silsila on the west for a length of about 16 km. The construction of the coastal highway started in 1998 and is now completed.

The objective of the present paper is to present the coastal problems of a number of Alexandria's beaches and present the plan for the development of those beaches and of the coastal highway.

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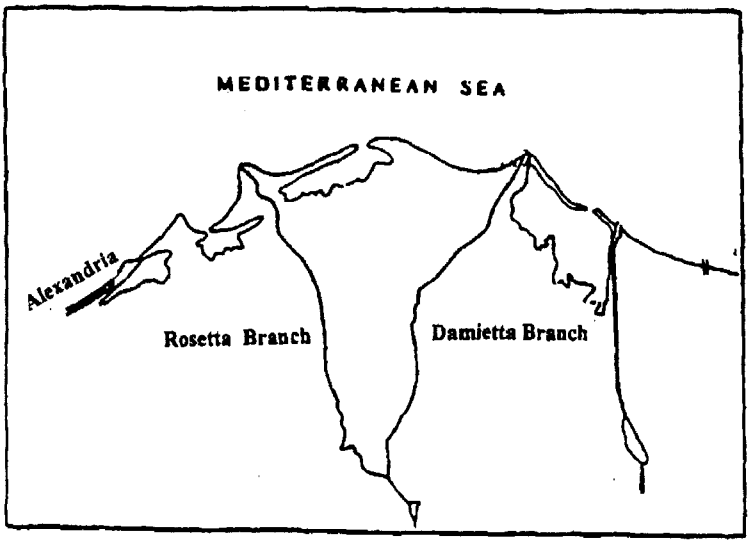

Figure 1: Location of Alexandria, Egypt

2 Oceanographic conditions

Wave conditions along the Nile Delta Coast are closely related to the local wind. In winter (October to March), waves are predominantly approaching from the NW and NNW. During spring and summer, waves are predominantly from NNW and WNW with small component from NNE.

The wave climate in the deep water off Alexandria has been described by Teisson [4]. Hindcasting of the wind-induced wave regime and statistical analysis of wave observations by ships indicated that 75% of the waves reaching the coast are from the WNW–NNW sector. Significant offshore wave heights for return periods of 1 year and 100 years are about 4.0 m and 8.0 m, respectively and 60% of the time, wave periods are in the range 6–9 seconds for NW waves and 5–8 seconds for NE waves.

The annual wave conditions offshore Alexandria have been estimated by Aelbrecht [5] . For the NW and WNW, the significant offshore wave heights and peak periods were found to be 4m and 8 sec, respectively. For the NE direction, the corresponding values were found to be 3 m and 7 sec, respectively.

The tides along the Nile Delta Coast are semidiurnal with an average tidal range of about 0.3-0.5 m.

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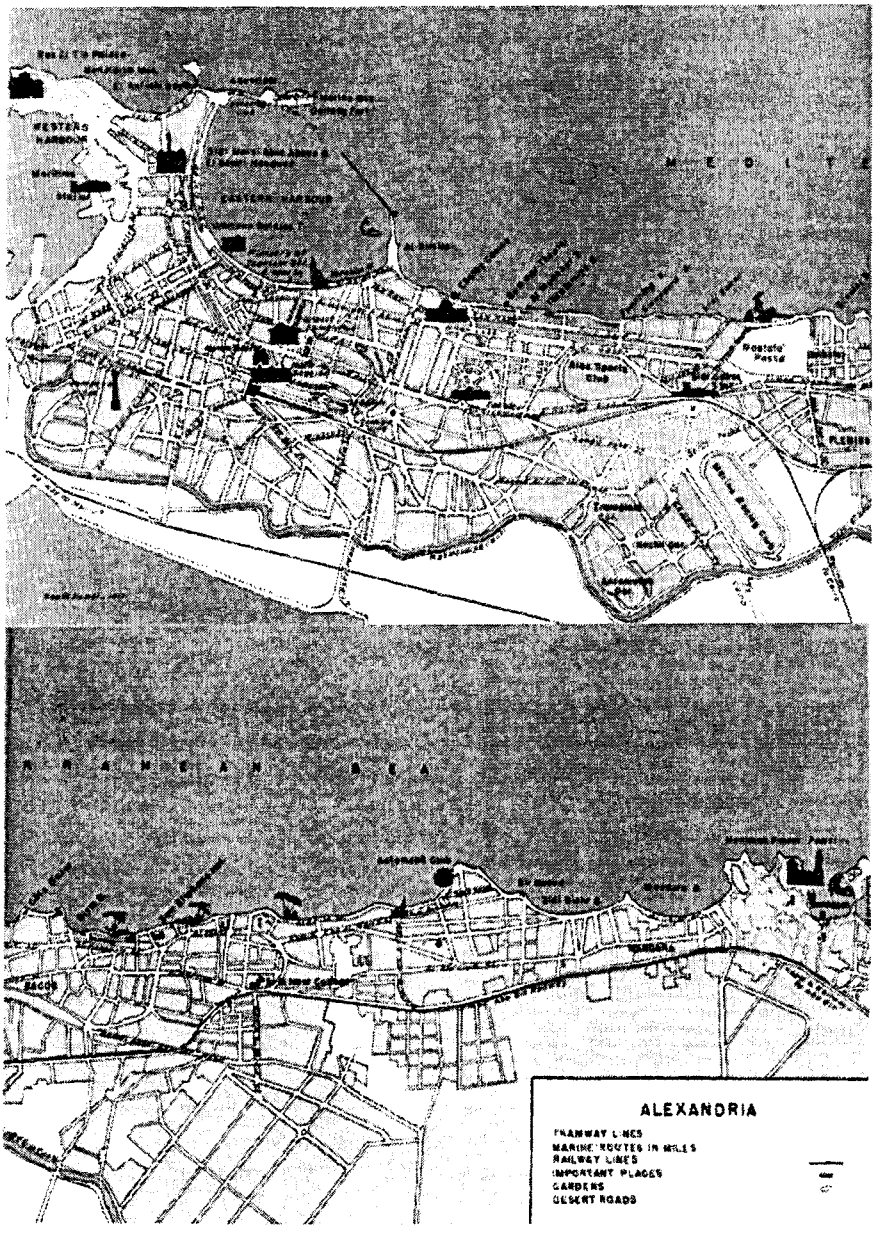

Figure 2: Alexandria beaches on the eastern(top) and western (bottom) sides

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3 Coastal problems of Alexandria beaches

Alexandria's beaches are narrow, their width not exceeding 50m.Alexandria's beaches are considered undernourished. They are perched upon rocky shelves or contained as pocket beaches between headlands, Tetra Tech [1]. The breakwaters of the eastern harbour on the west and the rocky headlands at Montaza on the east constrain the longshore transport to several distinct cells where littoral drift can be transported back and forth within the cell, Tetra Tech [1]. This is besides the long term losses directed offshore, Tetra tech [1].

Data regarding the sedimentary movements and coastal regime in Alexandria is rather limited. Sogreah [2] calculated the longshore transport at different points along the Alexandria coast using GENSIS computation code and concluded that the transport is reasonably in balance. Sogreah [2] indicated that between contour –5m and the shore, onshore-offshore transport participates in the erosion of the beaches which do not benefit from a natural sand supply. Sogreah [2] concluded that the beaches of Alexandria are generally eroded through the onshore-offshore sand transport to such depths that their reconstitution during fine weather periods can only be limited.

4 Beach protection and restoration projects

Tetra Tech [1] recommended in a study prepared for the Shore Protection Authority that beach restoration projects are necessary for a number of Alexandria beaches such as those located on the east side of the eastern harbour. Tetra Tech [1] suggested the use of detached breakwaters for straight beaches and sand nourishment for pocket beaches.

A number of studies for protection and restoration of Alexandria beaches followed Tetra Tech study. This paper highlights the protection of three of Alexandria's beaches, namely, Cleopatra, Sporting and San Stefano beaches. This is motivated by the fact that the first two beaches have been neglected and were hardly used due to their very limited beach width. For this reason, the Shore Protection Authority made those beaches a priority. For San Stefano, a huge private investment is currently under development and beach facilities are needed to ensure its success.

4.1 Cleoptra beach

The Sogreah study [5] in 1997 addressed Cleopatra beach as well (Figure 2). The stretch of the coast at Cleopatra is about 900 m. On the western border of this area, a

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groin of about 50 m extends seawards.The beach at Cleopatra is not wider than 10-15 m and at some places, there is hardly any beach at all. The sea bed material at Cleopatra is sand with an average grain size of 0.3 mm.

The layout proposed by Sogreah [5] for the development and protection of Cleopatra beach consists of four offshore submerged breakwaters constructed at approximately 3.5 m water depth and a downdrift groin approximately perpendicular to the shoreline extending 60m offshore. The length of each breakwater is 120 m and the gap width is 110 m each as shown in Figure 3. The breakwater crest level is at 0.00 Chart Datum (CD), where CD is 0.34 m below MSL, and crest width of 18 m. The armour protection consists of Accropode® of 1.5 m^3. Sogreah [5] estimated a volume of about 200,000 m^3 of beachfill needed for the development of Cleopatra beach. The breakwaters at Cleopatra are currently under construction. Submerged breakwaters were chosen because their impacts on water circulation and water quality are limited and they do not obstruct the view.

4.2 Sporting beach

A study [6] has been carried out for the Shore Protection Authority for the protection and development of Sporting beach for a length of about 900 m. The project area is located about 600 m west of Cleopatra. The beaches at Sporting are very narrow especially on the east side, where they do not exceed 10 m. On the west side of Sporting,, a jetty extends about 50 m offshore.

The protection of Sporting beach consists of continuous submerged breakwater located at 3.5 m water depth, combined with sand nourishment. A downdrift groin will be constructed on the east side of the project to extend about 50 m, in order to prevent sand being transported eastward.

The breakwater crest level has been selected at –0.5 m MSL and the crest width of 18 m. The armour protection consists of 3 tonnes of Antifer units. The layout for the protection of Sporting beach and cross section of the breakwater is shown in Figure 4.

4.3 San Stefano beach

There is hardly any beach at San Stefano area and there is a rocky outcrop on the eastern edge of the area. Tetra Tech [1] identified San Stefano as one of the beaches in Alexandria that needs development. In 1996, Sogreah was commissioned to conduct a study for the development of a number of Alexandria beaches which included San Stefano. Sogreah proposed the use of detached emerged segmented breakwaters and beach nourishment for San Stefano beach. The proposed protection scheme consisted of 5 segmented breakwaters to be constructed in an average water depth of 3.5 m. Four of these are 110 m and the fifth most eastward breakwater is 75

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m. The gap width is 100m long. The armour protection proposed is Accropode® of 2 m^3 . This proposed protection scheme was not executed.

In 1999, a huge project was proposed by a number of investors for the development of San Stefano area. The project consists of a luxurious hotel, residential building and recreational facilities. The project included the development of a new beach with its associated protection besides other beach facilities.

The proposed layout for the development of the beach at San Stefano consists of sand nourishment and a single offshore submerged breakwater of 120 m length. The breakwater crest width is about 20 m and the crest level is -0.5 m MSL . The armor protection is Antifer armour units of 1.85 m^3. A huge rock outcrop forms the eastern boundary of the project acting as a natural groyne. On the western boundary of the project, recreational activities have been proposed including restaurants, casino..etc on a reclaimed area extending into the sea. The project is currently under review for approval by the relevant authorities.

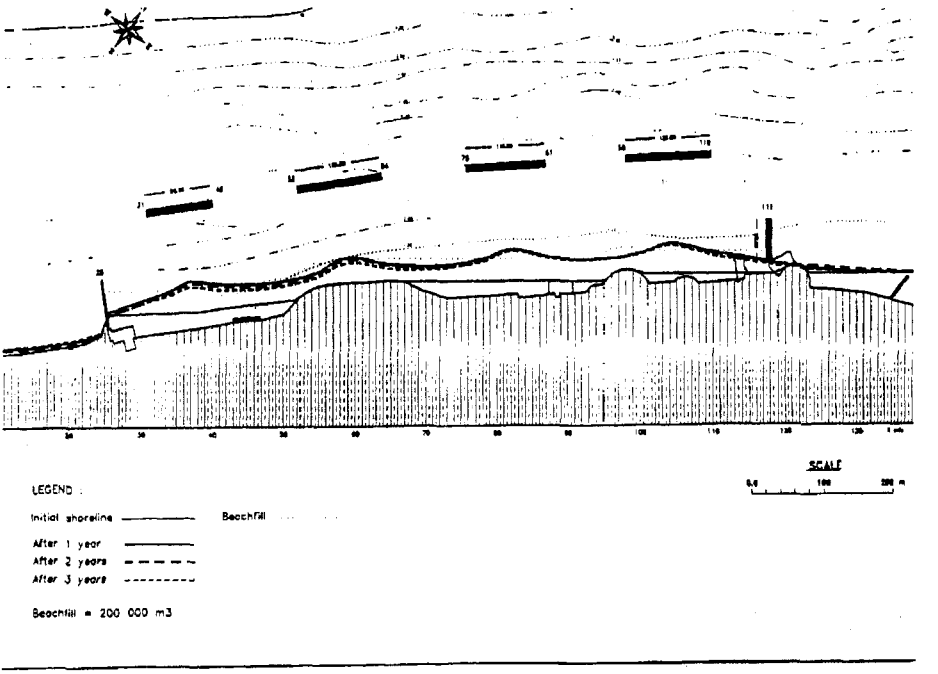

Figure 3: Layout for the protection of Cleoptra beach [5]

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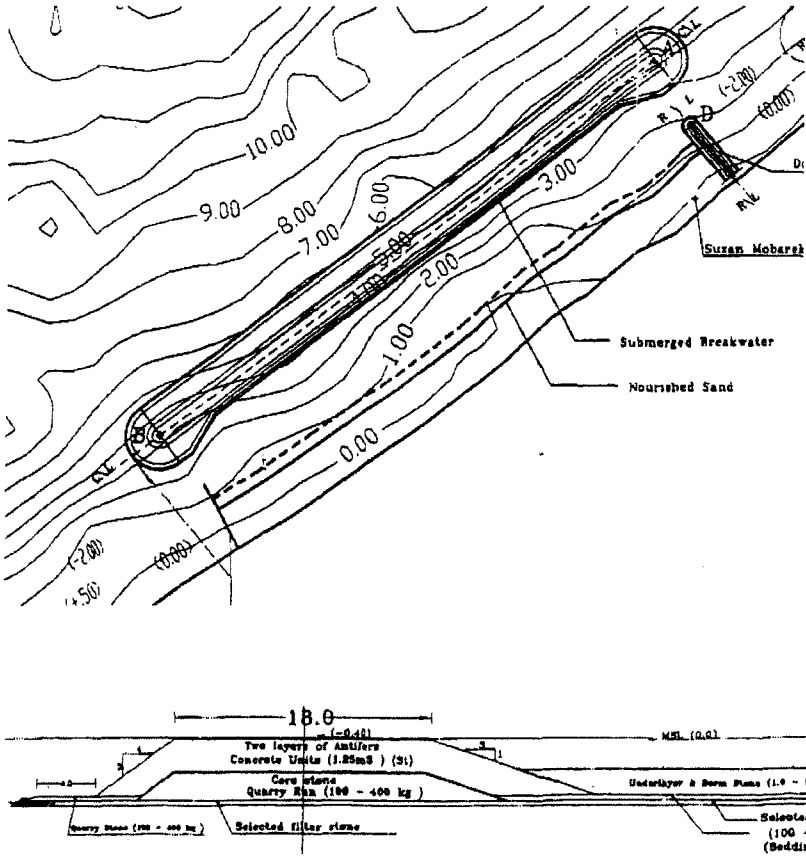

Figure 4: Layout and cross section for protection of Sporting beach [6]

5 Development of new Alexandria coastal highway

The Alexandria Coastal highway extends over about 16 km from Montaza on the east to Ras El Tin on the west. The highway is considered one of the two main roads extending through Alexandria and is usually full of heavy traffic especially during summer. The highway has been protected from the sea by a vertical concrete seawall which has been suffering from erosion and overtopping problems. There were some locations where driving along the highway was difficult in winter especially during storms due to wave overtopping. Erosion seaward of the seawall has always been noticed. In an attempt to limit the problems of the highway

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protection where no beaches exist, concrete cubes of volume 2.45 m^3 have been added seaward of the wall in two layers to reach 4-5 rows by year the 1997.

Accordingly, in the development plan for Alexandria City, priority has been given for the study of the problems of the coastal highway. A study was carried out for The Egyptian Ministry of Housing in 1998 for the redesign of the Alexandria Coastal Highway. The traffic study indicated the need for widening of the Corniche road . In addition, a new design for the seawall protection was made, in order to overcome the overtopping and erosion problems.

The widening of the Coastal highway extended between Montaza wall on the east to El Silsla on the west for a length of approximately 16 km. The highway became generally six lanes (two way traffic).

The highway protection has been completely redesigned to limit the erosion and overtopping problems. In addition, a number of factors has to been taken into consideration . The parapet wall should not exceed 60 cm for esthetic reasons. There was a requirement from the public to increase the width of the coastal promenade. Besides, those practicing fishing as a hobby required some access to the sea (no fishing boats to be allowed).

To satisfy the above mentioned requirements, the new coastal highway protection has been selected as a slope protection. Concrete cubes, volume 2.45 m^3 and 4.9 m^3, depending on the water depths, have been used as armor protection placed on slope 3:2. A typical cross section of the highway protection is shown in Figure 5. Overtopping discharges have been calculated using guidelines indicated in CIRIA publication number 83 [7] .The parapet wall , 60 cm high, has been placed on the inner edge of the quarry run bund. Seaward of the wall, cyclopine concrete was placed on top of the quarry run bund and the underlayer. This was used as a promenade. The berm in front of the slope protection was used for those practicing fishing as a hobby.

The widening of the highway and construction of coastal protection works started in 1998 and was executed in phases, each phase extending over 5 km. The construction works were only carried out from October to May. In the year 2001, the project was completed. It has been reported that in the year 2000, a very severe storm occurred, and a very small amount of overtopping discharges was noticed on the landward side of the new parapet wall proving the effectiveness of the design.

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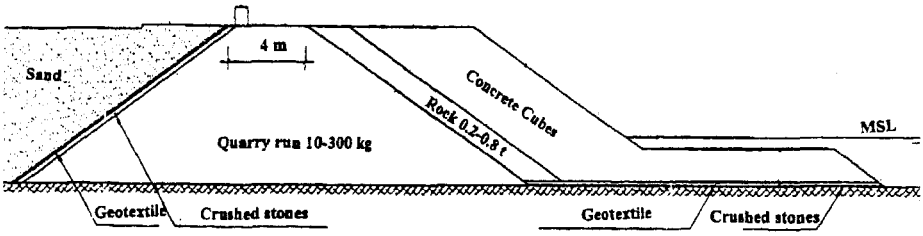

Figure 5: Typical cross section for the new protection of the coastal highway

Conclusions

The attractiveness of Alexandria as a beach resort has increased significantly due to the recent protection and restoration of beaches and of the reconstruction of the coastal highway. Modern design schemes such as submerged breakwaters have made this possible, while also proving an effective solution to the long term problems of erosion.

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