CHAPTER 307

Shore Protection Studies for Ras-Elbar, Egypt

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Introduction and Background of the Coastal Changes Along the Northern Coast of the Nile Delta

The northern coastline of the Egyptian Nile Delta extends some 280 km from a point 30 km west of the City of Alexandria to 30 km east of the City of Portsaid. The coastline is considered to be in a state of continuous change under the action of sea waves and currents.

Over the years the River Nile and its two main branches, Damietta and Rosetta, supplied large volumes of sediment from the mouth of these branches to the sea. This large volume of sediment exceeded the loss of sediment caused by wave and current action; thereby providing natural beach protection and excess sediment to the Nile Delta.

Construction of the Aswan Nile Dam significantly reduced the volume of sediment deposited along the Nile Delta shoreline causing severe erosion. The erosion started after construction of the first Aswan dam, the development of other dams, and the increasing diversion of the river water for irrigation purposes. After closing the Aswan High Dam in 1966, erosion along the Delta coastline accelerated considerably, resulting in loss of several beaches and blockage of estuaries and navigation channels because of accreting sediment and flooding of coastal villages. The erosion had a severe effect on the nearby agricultural areas because of salt water intrusion affecting these areas.

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A successful shore protection management plan must be developed for the next twenty years.

Available Data and Description of the Ras-Elbar Area

Ras-Elbar is located at the Damietta branch mouth of the Nile. This popular resort beach has declined severely over the past twenty years due to extensive erosion. Many hectares of beachfront property have been lost since 1965 and erosion is continuing.

The Ras-Elbar area is only five kilometers away from the new Port at Damietta. The development of the port facilities, related industries and new town development will have a significant economic impact upon the coastal erosion at the Ras-Elbar area, and will affect tourism and industrial development in the area.

The Damietta branch of the River Nile was developed during the tenth century. The Nile sediments, directed toward the west and east sides of this branch, developed this area by wave action. The old maps show that the Ras-Elbar-Damietta promontory advanced about three kilometers in the period between 1800 and 1900. At present, the coast is retreating due to sediment supply cut off since 1966 and the permanent closures of the Faraskour Dam some 20 km south of the mouth. Since 1966 erosion has been quite active in this area. The average retreat of the Ras-Elbar Peninsula had been about 30 m/yr before the construction of the western jetty in 1941. This jetty has stabilized the northern part of the Ras-Elbar shoreline, although the rest of the coast continued to erode with a diminishing rate for a distance of 3 km west of the jetty.

In 1970 a series of three short groins were constructed to protect the eastern part of the resort. In 1982 two Dolosse embankments between groins 1 and 2, and 2 and 3 were constructed. The Ras-Elbar nearshore region showed continuous deepening of the water depth and steepening of its underwater shore slope.

Mathematical Studies and Procedure

Computer hardware. The computer used in this study was an IBM 486 DX2 with a 66 MHz clock speed, a 16 MB RAM memory, a 240 MB hard drive memory and a math co-processor. A Hewlett Packard Laser Jet IV P printer and 1 7475A plotter were used. A Numonics 1.0 x 1.20 m digitizer was used to digitize the Ras-Elbar area drawings. The above equipment was proven to be reliable within the range of this study. The average CPU time was 2 hours.

Phases of this study. This study was conducted for the purpose of establishing and examining protection plans for the Ras-Elbar area coastline and to determine their long-term impact on the shoreline and the volume of sediment transported.

The study was conducted in four main phases. The first phase established the behavior of the initial shoreline subject to the design wave and served as a base reference.

The second phase studied the effect of a system of detached breakwaters on the behavior of the shoreline under the same wave elimate conditions. The system proposed by Delft Hydraulics in 1987 was examined for comparative purposes.

The third phase studied the effect of a system of groins on the behavior of the shoreline having the same wave climate conditions.

Finally, the fourth phase evaluated the effect of a combined system of detached breakwaters and groins on the behavior of the shoreline under the same wave climate conditions. All computer runs were conducted for three wave directions.

Simulation Procedure and System Setup. The procedure was as follows:

1. The shoreline data were digitized using the Autocad release 11.0 with a digitized accuracy of 4.16 m. The digitized data were analyzed and extracted using the Quick surf-Cad based program, and the shoreline digitized data were prepared as DXF file. Ras-Elbar shoreline was digitized using Drawing No. 2 prepared by Tetra Tech Inc.
2. The wave data were prepared using the Coastal Research Institute (CRI) and the Suez Canal Authority (SCA) data recorded over various periods of time.
3. A computational program (GENESIS) (Gravens and Kraus 1992) was used to conduct the required simulation. This program was developed by Hanson and Kraus (1982).

Two major tests were conducted:

1. Conducting sensitivity and error analysis runs:
   The changes in the output resulting from the intentional change in the input were examined to determine the limitations of different variables. To produce quality results, a knowledge of the sources of errors is important.
2. Conducting sensitivity analysis runs:
   Compromise between the efficiency and accuracy of the numerical code while maintaining its stability. To achieve the stability analysis test, several pre-runs were conducted with various conditions and various shore-protection structure alternatives. As a result of these

runs, two parameters were fixed to maintain the stability (without loosing either the efficiency or the accuracy of the numerical scheme). The time step was chosen to be 6 hours; 18,992 time steps were calculated. The number of grid cells within the simulation area reach was 60 with a grid spacing of 50 meters.

The start and setup files were selected for each run of the proposed shore plan. If the proposed plan was not successful due to the formation of tombolos, diffracting structures interaction or ineffective structure position, the file had to be redesigned until a successful run was reached. A simulation time of thirteen years was selected for each run to establish a case of relatively-stable state, undergoing minor or moderate changes. The simulation starting date was November 30, 1986, and the ending date was November 30, 1999. The results were calculated and plotted once a year. Figure 1 shows a general layout of the study area.

The following numerical model arrangement was used for all cases:

a. the total length of simulated coast was 3 km. This length was divided into sixty equal cells, each 50 m in width.
b. simulation starting date, November 30, 1986 and ending November 30, 1999,
c. time step used was 6 hours with a total of 18,992 time steps per run,
d. shoreline position was calculated and presented once a year,
e. longshore sediment transport coefficients K_1 and K_2 selected were 0.5 and 0.25 respectively (these values are typically 0.5 $K_1<K_2<1.5$ K_1 for sandy beaches from experiments and experience),
f. the depth of the offshore wave input was 10.0 m,
g. the number of incoming calculated wave cells was four,
h. only one wave direction was assumed,
i. the average effective sand diameter was 0.25 mm,
j. the average height of land above mean water level was 1.5 m, and the limiting depth of profile movement seaward was -6.0 m,
k. average beach slope was one on twenty,
l. it was assumed that the breakwaters and groins were impermeable structures, and
m. it was assumed that there was no wave reflection from the structures.

Analysis

The series of runs conducted were very illustrative in showing the long-term effect of different structures on the shoreline position. The results of the simulation performed can be divided into four different groups:

1. no protection measures,

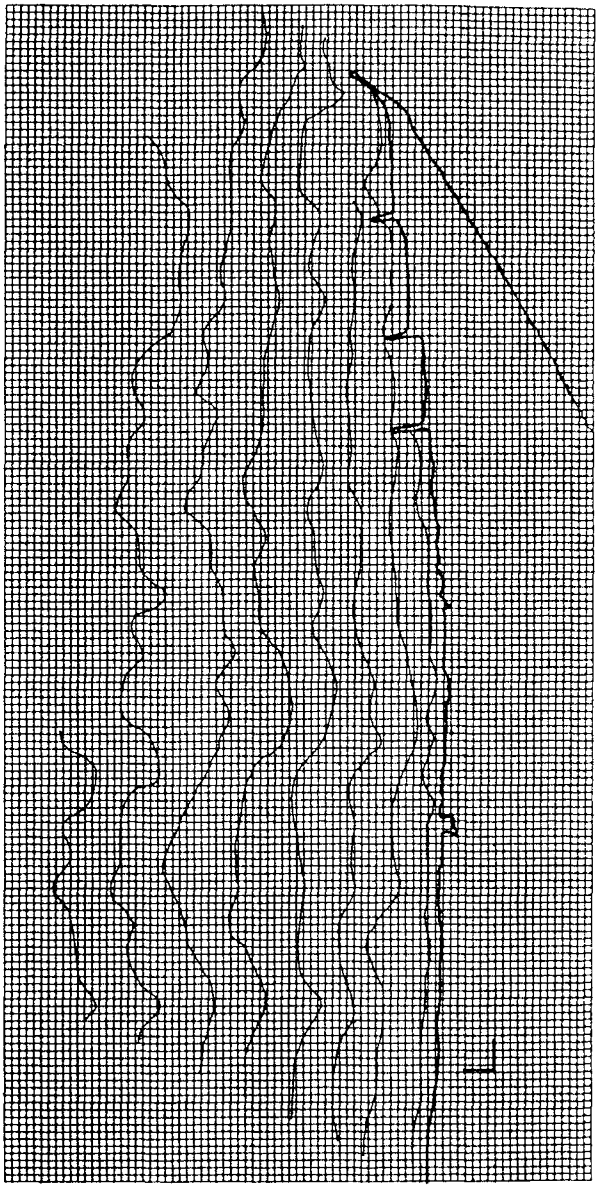


Figure 1. Ras-Elbar Study Area

2. effect of a system of detached breakwaters on the shoreline including the systems proposed by Tetra Tech, Inc. and Delft Hydraulics,
3. effect of a system of groins on the shoreline, and
4. effect of a combined system of detached breakwaters and groins on the shoreline.

For all groups, the final shoreline positions were plotted for each year until reaching a semi-equilibrium state. Relations representing the shoreline change and the average net sediment transport rate for all runs were also provided.

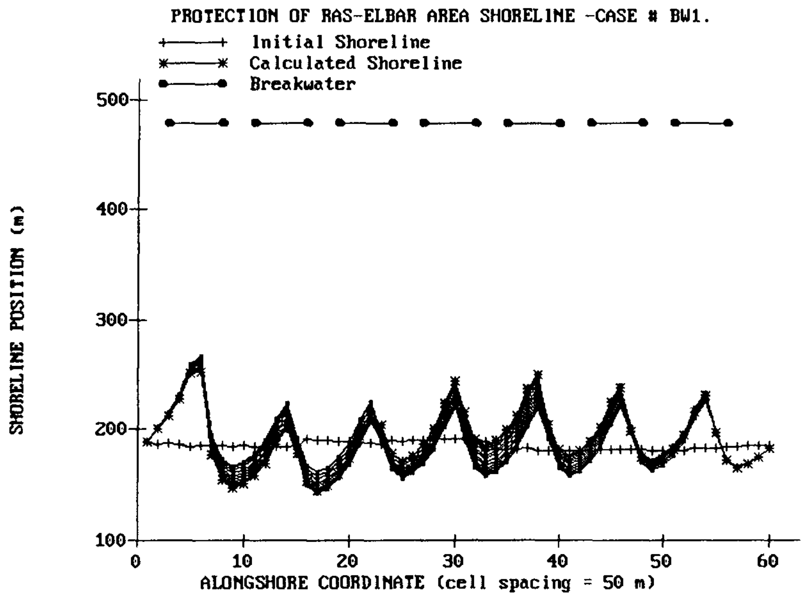
The breaking wave heights and angles were computed for each cell point on the grid. A figure representing the net volumetric change of sediment was prepared to indicate whether a region was gaining or losing sediment.

The different shoreline positions, longshore transport rates, and the shoreline changes from measured values were prepared for each run to illustrate the effect of different parameters and protection plans on the shoreline.

Conclusions

The results of this study were found to be reliable and applicable to a wide range of coastal engineering problems. For the Ras-Elbar area the following conclusions can be made:

1. Large fluctuations in littoral drift were noted.
2. The advantage of being able to vary wave conditions and structural protection plans was clearly apparent throughout this study.
3. A system of offshore detached breakwaters has proven to be the most efficient and reliable plan as a long-term shore protection for long reaches of the coastline.
4. Shore protection planning for a whole region was proven to be useful in providing a continuous interaction plan for the whole coastline.
5. This study has shown that increasing the number of breakwaters (from 4 to 7) for the whole region provided better results than employing a two- or four-breakwater system (Figure 2).
6. The ratio of G = 1.5 B proved to provide a good estimate of the length and the gap of a system of detached breakwaters (where G = distance between two breakwaters, B = length of the breakwater). Four locations of detached breakwaters were studied (165, 294, 445 and 545 m) from the shoreline. At a distance of 294 m from shore, the breakwaters provided minimum shoreline changes. For every case there is an optimum design for the detached breakwater system that will provide minimal or moderate shoreline changes, or cause the formation of tombolos.



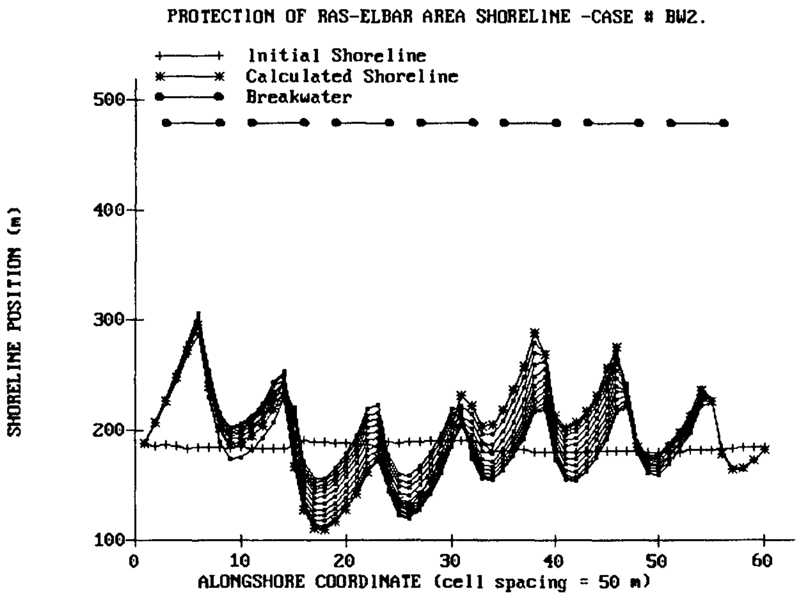


Figure 2. Protection of Ras-Elbar Area Shoreline - Case Numbers BW1 and BW2

7. A system of inclined and staggered breakwaters behaved in a similar manner to the parallel and continuous systems. The higher cost of constructing staggered or inclined offshore structures would make such a system uneconomical.
8. A combined system of offshore detached breakwaters and non-diffracting groins had a fairly similar result to that of using groins only. However, the higher cost involved in construction of two protection systems make it economically unfavorable. Using diffracting groins (which is more realistic) created more problems due to an overlap of the diffracted wave patterns from the groins and the breakwaters.
9. It is concluded that a complete system of detached breakwaters permits the continuation of shore sediment transport and will not affect the coast downstream of the system after equilibrium is reached. At the same time, this system breaks the energy of the incoming waves causing minimum shoreline change in the shadow zones. Sand nourishment should be considered in conjunction with a system of detached breakwaters to accelerate reaching equilibrium and assuring supply of sediment downstream of the system. Moreover the detached breakwater system tends to change the shoreline in a time-dependent manner. A fairly long time will take place to affect and cause changes in the shoreline.

Recommendations

Recommendations for future work are summarized as follows:

1. A uniform numerical grid of 50 m spacing was used, a finer grid spacing less than 50 m should be considered for refinement of the numerical plan.
2. A one-dimensional program employing constant grid spacing and time-step representations was used in this study and proved to be a flexible, reliable and economical method for shoreline change simulation. Higher order two- and three-dimensional schemes with variable grid spacing and time steps should be considered employing a mainframe computer. It should be noted in representing the physics of the flow and the sediment transport process that a compromise between the overall accuracy and the computation costs must be made.
3. As the shore protection structures employed in this study were assumed to be impermeable, consideration of the use of different coefficients of transmissions and permeability are strongly recommended.
4. Use different wave periods and wave heights to study their effect on the shoreline (only one wave height and one wave period were used in this study).

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