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IMPACT OF THE CONSTRUCTION PHASE ON THE COASTAL STRUCTURE BEHAVIOR

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ABSTRACT

The behavior of the partially completed coastal structure within the construction phase is not deeply studied within the design phase. However, this leads to a significant impact on the environment and unexpected coastal problems within the project lifetime. Construction methodology, structure schedules and construction season are part of the construction phase parameters that affect the final behavior of the coastal structures.

This study highlight the effect of the construction phase, factor affecting it, and its effect on the structure final behavior.

The method used depends on detail field monitoring for the effect and behavior of some Egyptian coastal structures within the construction phase during the period from 1990 to 2016. The effect of the construction methods, the construction schedule and delay, as well as the effect of construction phase on the structure final behaviors are checked within the monitoring program. Miami- El Mandra coastal area protection work at Alexandria, Six of October village detached breakwaters at the northwest coast of Egypt and Baltim detached breakwaters at the Nile Delta are part of the Egyptian coastal protection work which monitoring to identify the effect of the construction phase.

Analyzing the monitoring program data from the three areas show that, construction methodology and schedule can change the structure behavior as in the case of Baltim breakwaters. On the other hand, the delay within the construction schedule can cause serious environmental problems as for the case of Miami-El Mandra protection work and Six of October village.

To improve the environmental condition, it is recommended to include the construction phase as well as the risk assessment study for the delay within the construction phase as a main part in the environmental impact assessment study. In addition, Contractures should execute during-construction monitoring to improve coastal construction techniques for the future works.

Keywords: *Coastal protection, Construction phase, Environmental impact, Temporary harbor, Detached breakwater.*

INTRODUCTION:

Coastal zone worldwide suffers from many coastal and environmental problems. That is leads to more than 50% of Mediterranean coastlines only are dominated by concrete structures, (EEA, 1999). Some of these projects have bad environmental side effect, (Masria et al., 2015). Coastal protection works are very complicated engineering task from design to execution. The choices made during the design and construction process can have a significant impact on the environment. In practical, the construction methodology selected depends mostly on the economics of construction, (Airoldi et al., 2005). The behavior of the partially completed coastal structure within the construction phase is not deeply studied within the design phase. However, this leads to a significant impact on the environment and unexpected coastal problems within the project lifetime. On the other hand, even if the construction phase is taking into consideration, the behavior of protection measure is complex and prediction of their behavior is based on physical and numerical models, which provide only a partial description, (Dugan et al., 2011). That is leads to considerable uncertainty about how a particular structure will respond particularly if the structure is partially completed.

Construction methodology, delay in structure schedule and construction season are part of the construction phase parameters that affect the final behavior of the coastal structures. This study highlight the effect of the construction phase, factor affecting it, its effect on the structure final behavior, and how to include it in the project study.

METHODOLOGY:

The method used depends on detailed field monitoring for the effect and behavior of some Egyptian coastal structures within the construction phase during the period from 1990 to 2016. The monitoring plan emphases on identifying the construction method, construction schedule, any change or delay in schedule and the development in execution. In addition, It includes shoreline survey, structure deterioration survey, and coastal zone infrastructure deterioration survey. The effect of the construction methods, the construction schedule and delay, as well as the effect of construction phase on the structure behaviors are checked within the monitoring program. Miami- El Mandra coastal area protection works at Alexandria, Six of October village detached breakwaters at the northwest coast and Baltim detached breakwaters at the Nile Delta are part of the Egyptian coastal protection works which monitoring to identify the effect of the construction phase, figure (1).

MIAMI- EL MANDARA BREAKWATERS:

Miami- El Mandara beach locates east of Alexandria city, Egypt at Latitude 31° 16' 38.84" N and Longitude 30° 0' 8.54" E, figure (1). It characterized by embayment with narrow sandy beaches not exceed 50 m in width. It is the lowest coastal area along the Alexandria coastal zone, the level of the Corniche road at some points is less than 2.4 m above the mean water level. It has some coastal problems such as: undermining of the corniche road, loss of the beach sand, overtopping problem, which causes difficulties in the traffic flow in the storm period and rip currents that cause hazards to swimmers.

Many projects were executed to solve these problems and to avoid the undermining of the corniche road. It began with placing four tons concrete blocks at the toe of the corniche sea wall, followed by executing artificial beach nourishment projects during the period from 1987 to 1988. The beach nourishment projects succeeded in eliminate the beach retreat, (frihy et al., 2004). In 1999, the Corniche road of this area was widening out of the beach width and most of the beaches within the project sector are disappeared. This condition amplified the coastal

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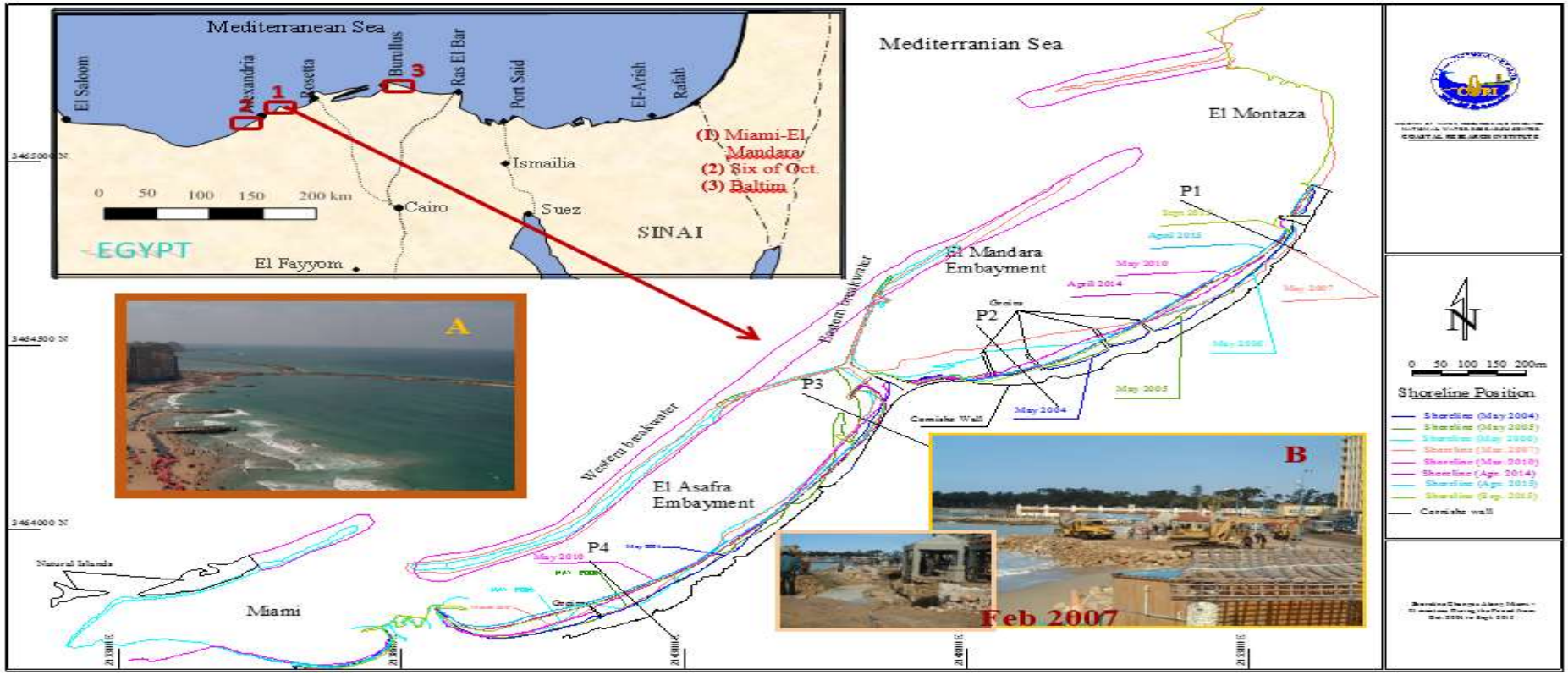

Figure 1 Shows the location of the three-selected site for monitoring program (upper left) as well as the shoreline changes for the first site Miami-El Mandara. It illustrates the effect of the construction phase (from 2004 to 2008) as well as the complete project effect (from 2010 to 2015) of the coastal protection measure. A) Initial shape of protection work before modification in 2008 to be submerged breakwater., B) Maintain the Cornish road at El Mandara during Feb2007 after collapse as a side effect of the construction phase

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problems. In order to that, group of breakwaters are executed within the study area during the period from 2004 to 2008 to eliminate the coastal problems. This group consists of two breakwaters started from El Mandara headland and oriented to the east and west parallel to the shoreline, figure (1). The eastern one extended about 700 m and the western breakwaters extended about 950 m. These two breakwaters are constructed between depths 4.0 and 5.0 m. There are also two addition breakwaters, the first one started from Miami headland and go eastward to El Asafra with total length of about 400 m. The second one started from El Montaza headland and extended westward with length of about 450 m, Figure (1). A monitoring program is executed during the period from May 2004 to September 2015 to measure the side effect of the coastal structures and the actual behavior within the coastal zone. Within the construction phase (from 2004 to 2008), the development of the breakwaters to the east and west from El Mandara headland caused accumulation of sediment within the sheltered area of the breakwaters and erosion of the shoreline in front of the end part of the breakwaters. The maximum advanced of the shoreline reach 45 m/year east and west of El Mandara headland (P2&P3). The corresponding erosion rate in front of the breakwaters head did not exceed 20 m/year (P1 & P4) but causing infrastructure collapse of the Cornish road because the beaches is very narrow in this area, figure (1-B). El Mandara bay faced more bad effect than El Asafra bay because the eastern part of the breakwater take longer time in construction than the western part. These side effects cost a lot of money and effort to repair within the construction phase. While, these side effects are not expected in the environmental impact assessment study (EIA) of the project, (El-Sharnouby et al 2007). Where the EIA study take the effect of the complete structures only. The final side effect of this project is worse than the ordinary case. It causes severe erosion and sedimentation problems, Cornish road collapse in some points, pollution problem and bad side seeing. It cost more than 38 million dollars to construct and repair the bad side effect of the project.

In year 2008, this project was modified by changing the breakwaters from merged to submerged, (El-Sharnouby et al 2007). The monitoring program during the period from 2010 to 2015 showed that new structure condition modified the effectiveness and efficiency of the structures and solve most of the side effect of the structure. The distribution of sediment along the two main embayment are partially homogenies and the shoreline movements are very limited.

Six of October village Detached Breakwaters:

Six of October Village is located west of Alexandria in El Agami Mediterranean coast of Egypt at latitude 31° 5' 31.12" N and longitude 29° 43' 24.88" E, Figure (1 &2) . It is considered as a principal public resort beach in this region. The main problem facing the beaches of this stretch is their unsuitability for swimming and are associated with hazardous rip currents. These

circumstances have encouraged developers to build seven dolos emerged detached breakwaters to provide a safe and secure area for swimming activities. Each breakwater is 100 m in length, 200 m away from the shoreline (in depth between 4 and 5 m), and the gap between each two breakwater is 50 m. A small temporary harbor was built west of these breakwaters to facilitate construction activities of the breakwaters, figure (2). The construction phase covered the period from 1998 to 2003 (5 years). The Environmental study for the project indicated that the dimensions used in designing the breakwaters are comparable with cases producing minimum morphologic changes with insignificant shoreline movement, (Iskander et al., 2007). The monitoring program was executed during the period from April 2001 to May 2005 to evaluate

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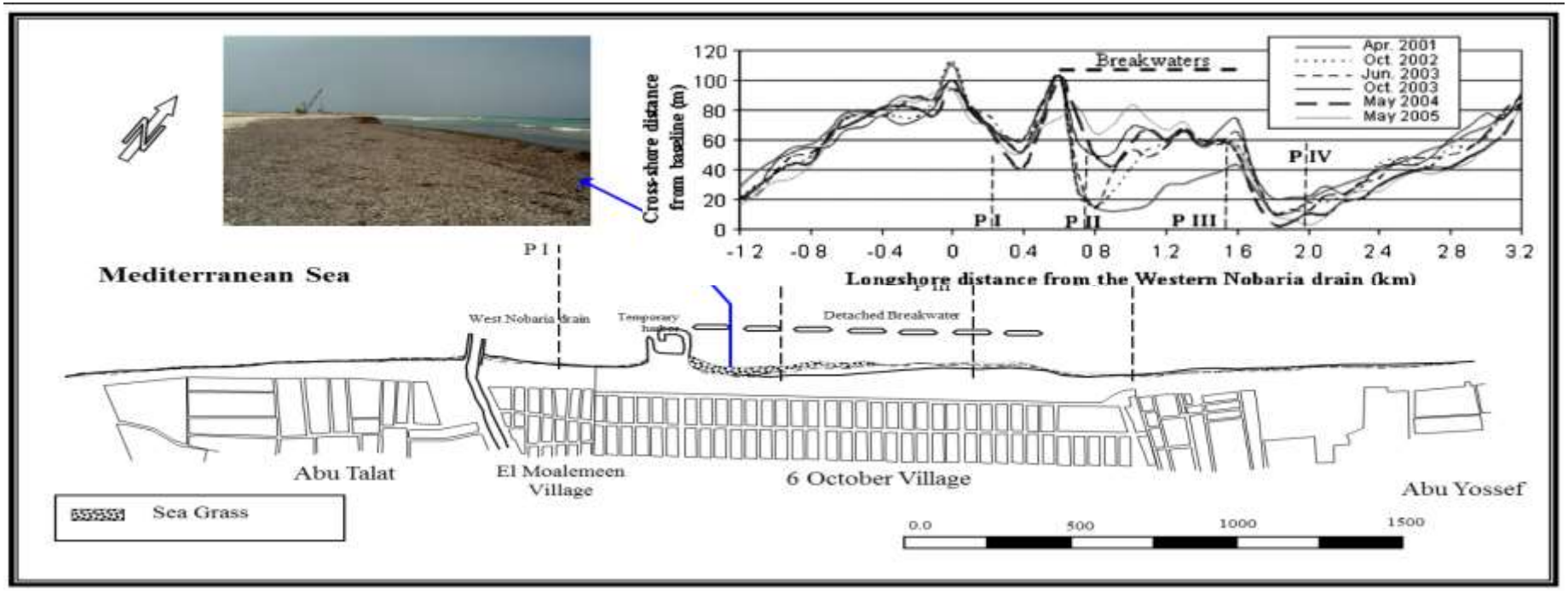

Figure (3): General location of Six of October resort village shows the shoreline changes during the period from April 2001 to May 2005 and the accumulation of sea grass within the sheltered area between the temporary harbor and the detached breakwaters, Modified from Iskander et al., 2007.

the effect of the construction phase (1998-2003) and the effect of removing of the temporary harbor (2005), (Iskander et al., 2007). During the period from April 2001 to May 2005, the average retreat of the shoreline up-coast of the breakwaters reached 8.0 m while it reached 10 m in the down-coast. The results reveal significant morphologic changes behind the detached breakwaters with salient accretion (20–70 m) in the low-energy leeside of such structures. Concurrent with this sand accretion is the accumulation of a large amount of benthic algae in the coastal water of the shadow area of these structures, which in turn have adverse effects on swimmers. Considerable efforts were made to mechanically remove this algae but accumulation has reoccurred. This problem was totally solved following dismantling of the temporary harbor in 2005. Comparison between the survey conducted immediately before May 2004 and after removal of the temporal harbor in May 2005 indicates that the beach width diminished eastward and the shoreline tends to be parallel to the breakwaters. The results show that the temporary harbor which used in the construction phase and did not take into consideration in the initial environmental study as well as the delay of the construction (5 years) have dramatically side effect on the study area. This side effect partially removed with dismantling the harbor. The harbor dismantling increases water flow between the shoreline and breakwaters and thus eliminates accumulation of dead algae as well as sediment in the swimming water, (Iskander et al., 2007).

BALTIM DETACHED BREAKWATERS:

Baltim resort is located in the Nile Delta coast at latitude 31° 35' 57.37" N and longitude 31° 6' 56.66" E. Before 1991, Baltim resort beach suffered from erosion with shoreline retreated rate ranges from 6.6 to 12.0 m/year, Badr 1996. According to that, Egyptian Shore Protection Authority (SPA) constructed 14 detached breakwaters to protect the resort shoreline in four phases. The first phase, which started in July 1991 and finished in June 1993 consists of four detached breakwaters, figure (3). The breakwaters lengths are 250 m except the third one of 350 m length. The gaps between breakwaters are 320 m except between 3rd and 4th breakwaters it increases to 400 m. The distance from the shoreline is 220 m to reach depth of 2.75 m. The first breakwater was constructed during the period from June 1992 to October 1992. The second breakwater was constructed during the period from August 1992 to December 1992. The third one was constructed during the period from January 1993 to March 1993. The last one was constructed during the period from March 1993 to July 1993.

The detached breakwaters were executed from the land by constructed four temporary groins. As soon as the first and second breakwaters were constructed in Dec. 1992, their tombolo's were rapidly developed not only due to the dimension of the breakwaters which, allows the formation of tombolo (the ratio between breakwaters length to the distance from the shoreline is greater

than one) but also manly due to sedimentation around the temporary groins, figure (3). Due to the effect of the temporarily groins, the littoral drift from the west side was blocked and accumulated in the western side of the project. By May 1994, the tombolo of the second, third and fourth breakwaters were formed, El Kolfat, 1998. Year after year, the sand filled all the tip of the first three breakwaters and these breakwaters are totally landward. For the rest

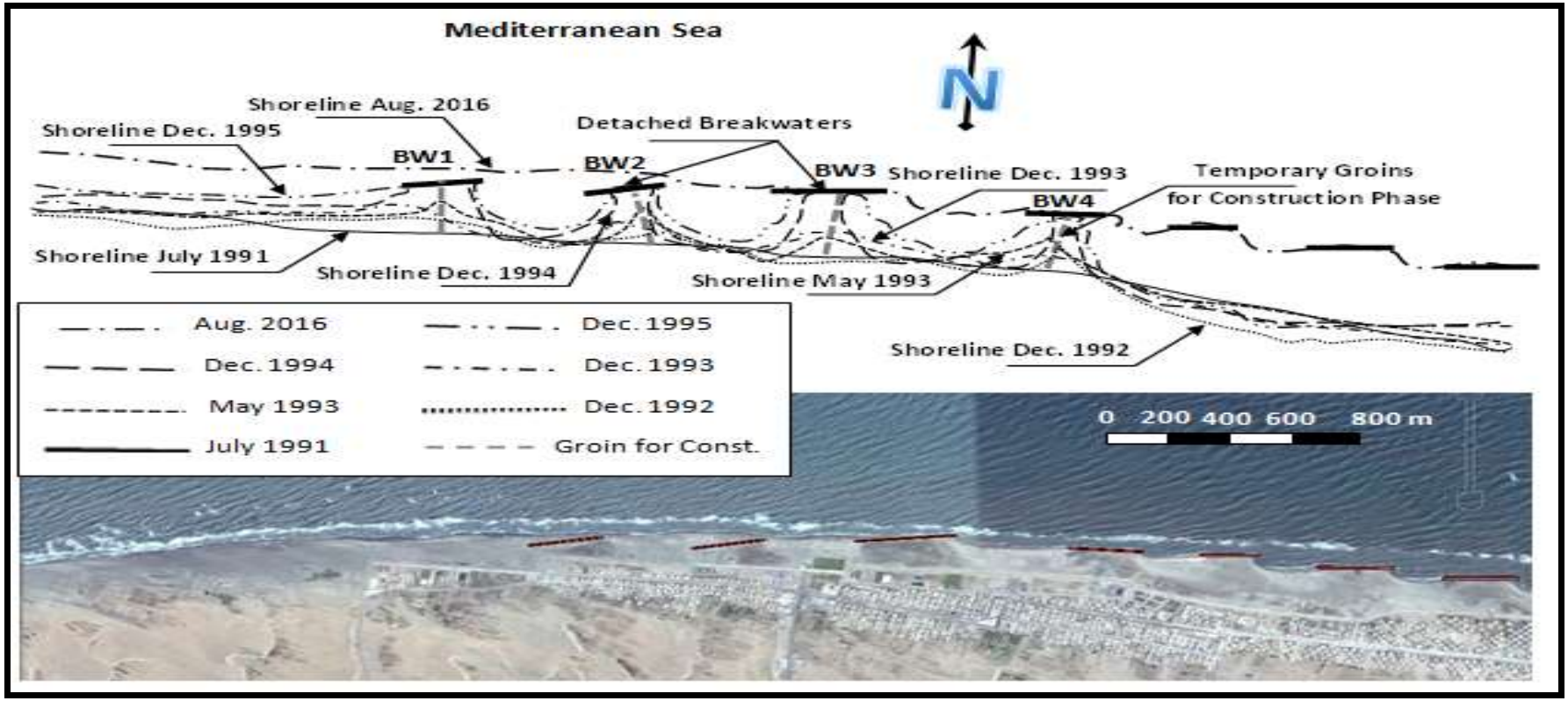

Figure (3): Shoreline changes around Baltim detached breakwaters during the construction phase and the recent condition, Baltim resort, Kafr El Shiakh governorate, Egypt.

phases, SPA increased the distance between the shoreline and the structures from 220 m in phase one to 300 m in phase two and 375 m in phase three. In spite of that, the tombolo is still formed due to using temporary groins in construction phase and the behavior of the coastal area was changed according to that. The sediment were blocked and accumulated by the temporary groins and the shadow zone of the breakwaters became shallower and blocked by sediment, figure (3).

CONCLUSIONS AND RECOMMENDATIONS

The effect of the construction phase on the coastal structure behavior was checked in three sites along the Mediterranean coast of Egypt during the period from 1990 to 2016. A detail-monitoring program has been executed at Miami- El Mandra coastal area at Alexandria, Six of October village at the northwest coast and Baltim at the Nile Delta during and after construction, the coastal measures to identify the effect of partially completed structure on the environment. The monitoring program included shoreline changes, structure development, infrastructure deterioration checks, construction methodology, execution schedule and delay. Analyzing the monitoring program data from the three spot areas showed that, construction methodology and schedule could change the structure behavior as in the case of Baltim breakwaters. In this case, land base groins were constructed to execute the detached breakwater from it. That is lead to sedimentation around the groins, which affected the function of the detached breakwaters. On the other hand, the delay within the construction schedule can cause serious environmental problems as discussed in the case of Miami-El Mandra protection work and Six of October village. In these two cases, stopped the construction or delay for a while, caused unexpected erosion or sediment and sea grass accumulation as well as destruction of the beach facilities. Also, the construction method as in Six of October village caused project dramatically bad environmental impact within the project coastal zone. The temporary harbor breakwater, which used as a facility for execution caused dramatically accretion and accumulation of sea grass in the sheltered zone of the structure.

It is clear that the construction phase has effective roles in the coastal project succession. Therefore, it is recommended that the construction phase should be taken as a main part in the environmental impact assessment study to protect the environment. In addition, the risk assessment study for the delay within the construction phase is essential to save the coastal resources from any unexpected side effect. Also, during-construction evaluation is useful to improve the construction technologies for the future coastal works.

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