DEVELOPMENT OF LOW CRESTED BREAKWATERS FOR SAFE SWIMMING AND SHORE PROTECTION ALONG THE NORTH-WEST COAST OF EGYPT

تطوير حواجز الأمواج المغمورة لتوفير مناطق أمنة للسباحة وحماية شواطئ الساحل الشمالى الغربى بمصر

Ayman M. Mostafa[1] and M. A. Hasan[2]
[1]Dept. of Irrig. & Hydr., Faculty of Engineering- Cairo University, Orman, Giza, Egypt
[2] Dept. of Civil Eng., Faculty of Engineering, Banha University, Cairo, Egypt

تم إعداد دراسة لتطوير تصميم حواجز الأمواج المغمورة بمنطقة الساحل الشمالى الغربى للأسكندرية بمصر بغرض توفير مناطق آمنة للسباحة وحماية خط الشاطئ من الغمر والنحر مع السماح بمعدلات جيدة لتجدد المياه والحفاظ على جودتها وقد تم استخدام بيانات الرياح والأمواج والمساحة البحرية بمنطقة الدراسة وإدخالها إلى البرامج الرقمية (BEM–EFM, SMS) لتمثيل التداخل الديناميكى بين الأمواج وحاجز الأمواج المغمور المقترح تحت تأثير العواصف والأمواج المحتمل حدوثها كما تم معايرة البرامج ودراسة حالة استخدام حاجز الأمواج المغمور على بعد عدة مئات الأمتار من خط الشاطئ عند عمق للمياه حوالى ٨ متر ودراسة تأثير الأبعاد المختلفة والخصائص الداخلية لحاجز الأمواج على قيمة معامل إنتقال الموجة سواء المحسوب بالبرامج الرقمية أو المعادلات التجريبية ووجد أن النتائج متقاربة إلى حد كبير وخاصة معادلات [١و٢و٣] كما تبين أن برنامج الـ BEM-FEM يعطى قيم لمعامل إنتقال الموجة أكبر قليلاً من القيم المحسوبة بالمعادلات التجريبية وأن حاجز الأمواج بأرتفاع حوالى ٦٣% من عمق المياه وعرض قمته فى حدود نصف طول الموجة الساقطة (أو أرتفاعه ٧٥% من عمق المياه وعرض قمته ٢٥% من طول الموجة الساقطة) يسمح بمعامل انتقال للأمواج فى حدود ٦٠% فى حالة الموجة القصوى بأرتفاع ٢,٥م وفى حالة الموجة الأكثر حدوثاً (حوالى ٢٥% من أوقات العام) بأرتفاع ١,٠ متر يكون معامل إنتقال الموجة من ٧٥% إلى ٩٠% طبقا للطريقة المستخدمة وبناء عليه فإن التصميم المقترح لحواجز الأمواج يؤمن أرتفاع موجة فى منطقة الشاطئ أقل من ١,٥م فى ٩٧% من السنة وأكبر من ٠,٥ م فى ٦١% من السنة مما يجعل حواجز الأمواج المقترحة أداه مؤثرة فى السيطرة على أرتفاع الأمواج بمنطقة الشواطئ بحيث تضمن تقليل إحتمالات غمر الشاطئ أوالنحر مع الحفاظ على معدلات مناسبة لتجدد المياه وتوفير مناطق أمنة للسباحة.

ABSTRACT:

A study has been conducted to develop a new design of Low Crested Structures (LCS) along the North-West coast of Egypt to protect swimmers from high waves and the shoreline from erosion while maintaining good circulation conditions. The wind/wave conditions and bathymetric survey along the study area have been used and the coefficient of wave transmission has been computed using various equations in literature as well as some numerical models, e.g., BEM-FEM, SMS. The latter models have been adopted to simulate the dynamic interactions among waves and a submerged breakwater for various wave conditions. The BEM-FEM and SMS models have compared with experimental results. The breakwater is suggested at a water depth of 8.0m and a few hundred meters offshore. Various dimensions and internal properties of the breakwater have been considered and the transmitted wave conditions have been estimated. Comparisons have also been made among the transmitted wave coefficients computed by various empirical formulae and the numerical models. It has been noticed that the wave transmission coefficient computed by the numerical models are very similar to those computed by [1, 2, 3]. However, the BEM-FEM model predicts slightly higher values for the coefficient of transmission than most empirical formulae. It has also been found that a submerged breakwater with its crest height equals 63% of the water depth and its crown width is about half the incident wave length, or alternatively the crest height is 75% of the still water depth and its crown width is 25% of the incident wave length, would produce a trasnmission coefficient of approximately 60% for an incident wave height of 2.5m along the North-West coast of Egypt. On the other hand, the coefficient of transmission for the prevailing wave conditions (H=1.0m for about 25% of the year) has been found to range from 75% to 90% as computed by various empirical formulae in literature. The proposed design would allow wave heights (H_t) < 1.5m for 97% of the year and H_t >0.5m for 61% of the year. Thus, wide-crown LCS can be an effective tool in limiting the wave heights in the area between the submerged breakwater and the shoreline while maintaining good circulation and limited shoreline changes.

KEYWORDS: *Wave-structure interaction; Numerical models; Non-linear waves; coefficient of wave transmission and submerged breakwater.*

INTRODUCTION:

The North-West coast of Egypt has been suffering from severe waves and strong rip currents along various sections. The sand beaches are generally as low as less than two meters above the Mean Sea Level (MSL) in some locations. During severe storms in winter seasons, high waves overtop the sand beaches causing serious hazards to the beach and existing structures. During the summer season, high waves break and induce strong rip currents that would cause drowning of swimmers or at least prohibit visitors from using the sea. Moreover, the expected Sea Level Rise (SLR) due to climate change along the North coast of Egypt would make the situation worse unless suitable and economic intervention has been adopted with emphasis on its environmental impacts. The latter effect was estimated to range from 0.5 to 1.0m during the next a few decades. The levels of the beach should be kept unchanged from aesthetic and economic points of view while protection from overtopping remains a must.

One of the effective tools for controlling waves in the shore area is the use of submerged breakwaters. The submerged breakwater damps high waves allowing only smaller waves to approach the shoreline with minor adverse impact on the environment. Although some high short-crested or surface piercing breakwaters have been recently constructed at different locations in Egypt and around the world, several adverse impacts have been noticed. These include the development of poor water quality and excessive shoreline changes. Thus, there is a growing need for the appropriate design of submerged breakwater system with emphasis on its crest freeboard, crest width, internal properties and water depth.

Earlier use of sub-aerial parallel rubble mound breakwater (4.0 meter above water level) was an effective tool to control erosion in Mandara beach, in Miamy - Montaza area, of Alexandria in Egypt, but it had a severe adverse impact on water quality and aesthetics. [4] suggested a submerged breakwater system constructed from natural stones and armored with concrete blocks in place of the sub-aerial rubble mound breakwater constructed in Mandara beach (see Figure 1). The submerged breakwater has a crest freeboard of 0.5m below MSL and its crest width is almost as the incident wave length, i.e., crest width=36~46m. [5] reported the results of using submerged breakwaters instead of the sub-aerial one as follows:

- Flushing time of water mass in the breakwater lee ranged from 4 to 6 days in calm weather conditions .
- The current velocities behind the submerged breakwater were about 5 times of those in case of emergent breakwater and from 50% to 100% of currents in open sea .
- The submerged breakwater provided a transmission coefficient ranging from 0.28 to 0.36 in storm conditions.
- The shore line was found to be well protected from wave attack providing a width of beach sand not less than 30 meter.
- Wave height is about 0.50 meter or less in the leeside of the submerged breakwater for at least 90% of the year.
- Continuous submerged breakwater provided better shore line stability with a 60% decrease of the total eroded volume.
- Accretion took place within 12 months after installation of the submerged breakwater.

Some resorts used surface piercing detached breakwaters for protecting the swimmers, e.g., Marabella and Al-Nakhil resort at the West coast of Alexandria Governorate of Egypt constructed during 1990's. In the latter cases, accretion was developed shortly after the construction of the breakwaters and the down drift zones suffered from shoreline erosion. The erosion has been dramatically increasing causing demolishment of large parts of the down drift beaches. Moreover, floats and debris are usually trapped behind surface piercing breakwaters while eddies are evident at the end sections. It is noteworthy that the latter cases violate the environmental laws of Egypt, but they could somewhat protect the swimmers from the risk of drowning. Thus, the use of the submerged breakwaters is quite new along Alexandria coast. Most of the results were based on empirical formulae and field observations after construction of the proposed structures. Moreover, the size of the submerged breakwater used in Alexandria is seen to be considerably large and a room exists for the improvement of design from both economic and environmental points of view. To expand the use of submerged structures and mitigate possible adverse environmental impacts, the geometric dimensions (crest width, crest freeboard, side slope), internal