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Numerical Model for a Case Study in Egypt at Marsaalam Beach using (Breakwaters and Groins) As a Shore Protection against Wave Impact

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ABSTRACT

Due to the highly importance of coastal zones, some previous researches tried to reduce wave energy attacking the shoreline, so this research presents a numerical model of a case study in Egypt at MarsaAlam beach using two different kinds of protection (Breakwater & Groins). Because of the great importance for the conservation and protection of beaches that caused changes in the shoreline, so the simulation process using also the wave height and the wave period, and most of the GENESIS model of calibration was preformed for the period from 2013 to 2021. Also, from the results of the numerical models we can deduce the relation between the distance offshore and distance along shore for different years and angles for using the two different kinds of protection (Breakwater & Groins).

INTRODUCTION

In fact, the areas located on the coast of the seas or oceans are very dynamic ecosystems, where only interactions between terrestrial processes, the atmosphere, and the oceans are produced over different time periods. Therefore, activities that are related to humans often play an important role with the presence of impacts. Also additional, over the past nearly fifty years, the remarkable and advanced increase in all tourism, residential, industrial, commercial and recreational activities have led to nearly about 1.2 billion people that living on the coasts in all countries in general.

Nearly, over 23 % of the earth population lives in small part of the earth, leading a population ratio that is approximately about treble more than this long term for an average, by accounting mostly for the values reported until 1990 (Small & Nichols, 2003). In addition, a higher growth rate than the global average for coastal populations has been tabulated over the last years.

The coastal zone defined as the area directly affected by coastal hydrodynamic processes. It is divided into three areas the Coast, Shore and the Continental Shelf.

SHORELINE PROTECTION

Shorelines named as the line between Seaor Ocean and land, (WIOMSA, 2010) and the initial location of the water-land line at one juncture (Boak and Turner, 2005).Leading to the active existence for coastal property and water bodies, the shore is constantly changing (Paterson et al, 2010).

Shoreline shift represents the location of the shoreline changes over time (WIOMSA, 2010). Also, shoreline protection a set of engineering solutions that focus on protecting land and water based facilities from erosion, flooding or storm.

Induced flooding through armoring, shoreline stabilization systems and designed to slowdown erosion and dissipate wave or current energy; and beach maintenance. Armoring involves bulkheads, cribbing, ripping and revetment. Stabilization includes jetties, breakwaters, sills and plants. Images of these methods are available in Allen et al. (2006) and Rella and Miller (2012a).

TYPES OF SHORE LINE PROTECTION

Breakwaters

The main goal of marine barriers is to work to break down wave energy and reduce it and work on the process of accumulation of sediments. There are various forms of it that can be fixed, floating, or on the sea floor, connected to the beach or not, fragmented or connected. The shape with gaps will allow for increased tidal exchange, as well as for improved access to the waterfront.

Secure the coast and the port by increasing the strength of high energy waves until they hit the shore. They can either be built with one end attached to the coast or they can be built away from the coast.

The purpose is to prevent coastal erosion to reduce wave energy in lee and to reduce long shore transport simultaneously to shoreline Allow some alongshore.

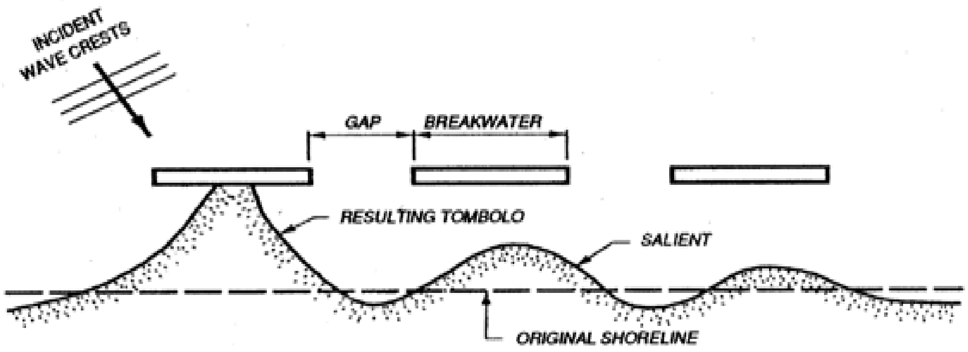

Figure1. *kinds of shoreline changes by using a single and detached breakwater*

Figure2. *artificial types of breakwater*

A salient defined as the best shoreline solution by using a breakwater system that can be designed for the Corps, as explained in Chasten et al. (1993). This is to enable alongshore for the sediment transport to keep moving through the coastal area directly to the drifting beaches. Salient's are maybe too dominant when the breakwaters are nearly faraway from shore line, short relative for also the incident wavelength.

Relatively transmissible, knowing that the large gaps or low crested with nearly low sediment input. However, the wave action and long-shore currents tend to try fixing the salient from being connected towards coastal structures.

Groins

The main concept is to intercept water flow and sand moving parallel to the shoreline in case for trying to prevent the process of coast erosion and break waves and retain sand placed on coastal zone.

The second purpose is to reduce the erosion of the beach or to stop the filling of the beach by trapping or slowing down onshore transport. Generally perpendicular to shoreline Built to both hold back sand and allow transport to reduce downstream impacts.

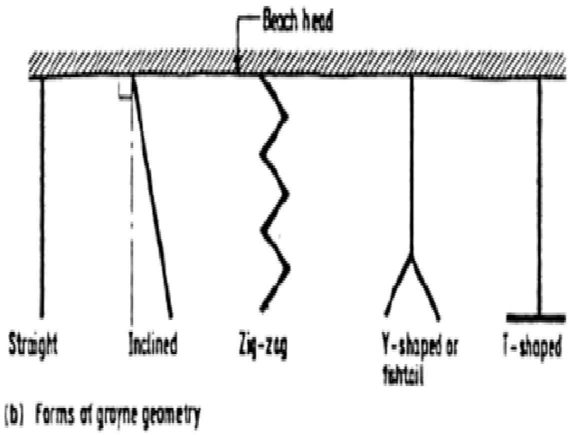

Figure3. *Types of shoreline groin*

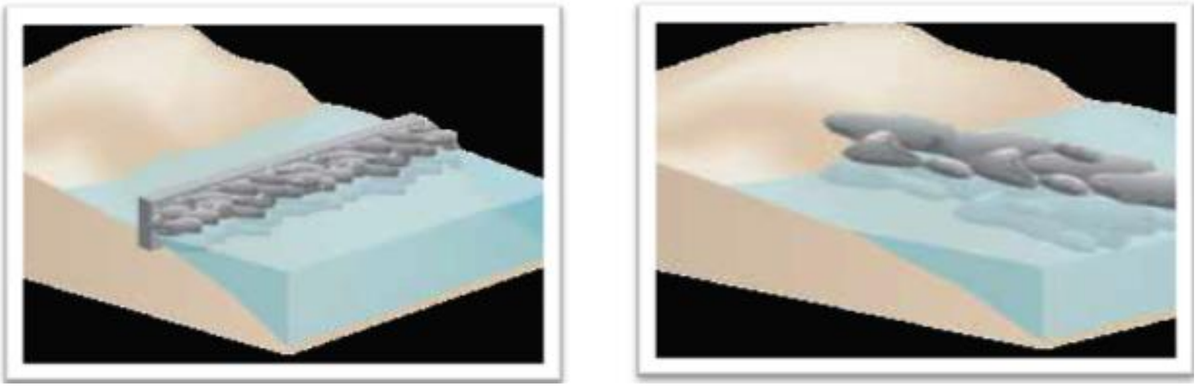

Figure4. *shape of shoreline breakwater and groin*

Numerical Modeling

The used model to make Simulation for the Shoreline changes (GENESIS) was created by Hanson (1987), either by the Coastal Engineering Research Center (CERC) and finally by using US Army for Engineering Waterways Experiment Station. The all of the full technical views for the design is given in some reports published also by Hanson & Kraus (1989), but the user manual was also developed by Gravens, Kraus and Hanson (1991).

The GENESIS model was defined as a "generalized" one-line model, for describing the coastal change simulations generated by spatial and temporal variations in long shore sand transport.

The development has been planned and designed mainly for the coastal engineering projects, coastal movements that caused by for example the beach fillings or river discharges, and shoreline responses to the presence of the near shore coastal structures. Where cross-shore processes are very important, GENESIS will not provide a very good information as these processes are assumed to be averaged out over a sufficiently long simulation interval or, for a design of a new projects, classified as a rapid change in shoreline location from a non-stable to a stable position.

Governing Equations

GENESIS modeling system was consisting of two main sub-models: the first thing is to calculate the long shore sand transport frequency and the shoreline shift and secondly calculation under simpler conditions, the shape of the break-up wave height and the long shore angle as calculated by the wave information provided at the offshore reference level.

For the case of the first sub-model, the main assumption presumed by GENESIS that the shape of the coast line profile is always in equilibrium, heading towards land and either to the ocean, whose perpendicular to itself, while giving the same form. Meanwhile the sand keeps moving over the profile between the specified shoreward limit, for the site of berm level elevation DB, and a certain restricting depth or shuttering depth DC beyond which the shape of the profile exactly does not adjust.

However, for the terminology, for the right-hand Cartesian coordinate system is considered, and defined the "y-axis" points of the offshore location and the "x-axis" is also to be parallel to the direction of the shoreline denoting the long-shore range as shown in figure1.

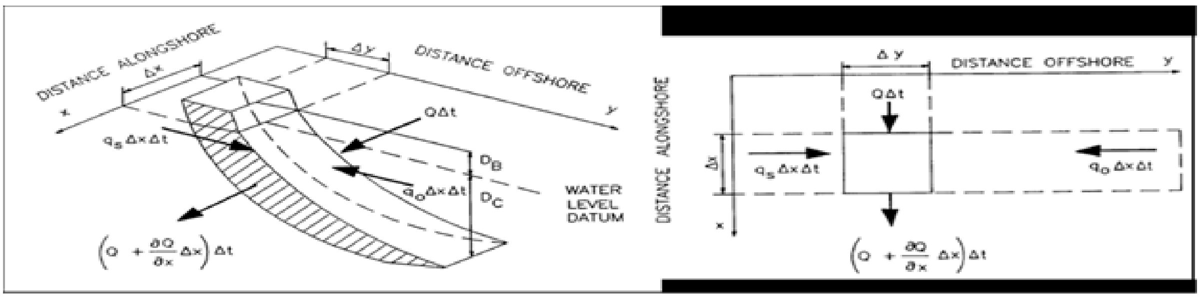

Figure5. *Shape for the Shoreline Calculations.*

(Left side as : Three dimensional view) & (Right side as: Plan view)

For (Kraus & Hanson, 1991)

Also that equation indicating shoreline change is as follows for conservation of sand volume>

$$\Delta V = \Delta x \Delta y (D_B + D_C) \qquad (1)$$

The volume difference is determined by the net amount of sand that or leaves or enters the segment or domain, from all its four sides.

The contribution to the volume shift occurs if the long shore sand transport rateQ that can varies from the lateral sides of the using cells.

$$\Delta Q \Delta t = \left(\frac{\partial Q}{\partial x}\right) \Delta x \Delta t \qquad (2)$$

Also, another contribution may occur from the line source or sink of sand **q= q_s+ q_o,** which removes or adds a volume of sand per unit of beach width from either the shore side at the rate of **q_s**or the offshore side at a rate of **q_o**. This resulted in a shift in the size of **qΔxΔt**. and the following equations will be obtained by adding these contributions to the changing volume equations as follows.

$$\Delta V = \Delta x \Delta y (D_B D_C) = \left(\frac{\partial Q}{\partial x}\right) \Delta x \Delta t + q \Delta x \Delta t \qquad (3)$$

$$\left(\frac{\partial y}{\partial t}\right) + \frac{1}{D_B + D_C}\left(\frac{\partial Q}{\partial x} - q\right) = 0 \qquad (4)$$

Where,

y = defined as shoreline position. D_B=defined as the average berm height over the average or mean water level.

x = as the long shore co-ordinate. D_C = as the depth of closure.

t = time. Q = long shore transport.

q = defined as the line sources and/or sinks along the coast.

Also, by using the Bagnold model for the phenomena of sand transport and the description (Komar 1975) of long shore current, created by a combination of obliquely breaking waves and long shore differences in wave heights, is an expression of long shore sand transport which accounts for the dependence of the long shore gradient in wave height πH/πx, defined for the connection of the breaker angle α is obtained.

By also using GENESIS program, that is will be expressed as:

$$Q = \left(H^2 C_g\right)_b \left(a_1 \sin 2\emptyset_{bs} - a_2 \cos \emptyset_{bs} \frac{\partial H}{\partial x}\right)_b \qquad (5)$$

Where, H = defined as the wave height & Cg = defined as the group speed that given bmy liner wave theory.

b = as the subscript defining breaking wave condition.

a_1 = was the dimensionless parameter 1.

a_2 = was the dimensionless parameter 2.

$\emptyset_{bs}$ = the angle of the breaking waves towards the local or initial shoreline.

The contribution of the second term was introduced into the shoreline change modeling by Ozasa and Brampton (1980) and also (Horikawa, 1988). The non-dimensional parameters al and a2 are also given by,

$$a_1 = \frac{k_1}{16(s-1)(1-\rho)(1.416)^{5/2}} \qquad (6)$$

$$a_2 = \frac{k_2}{8(s-1)(1-\rho)(\tan\beta)(1.416)^{7/2}} \qquad (7)$$

Where,

k_1 and k_2 = are the transport calibrating parameters.

S=ρ_s/ρ= density of sediment material (taken for quartz sand as 2.65 x 10^3 kg/m^3).

ρ = defined as the density of salt water equal to (1.03 x 10^3 kg/m^3).

tan β= was defined as the average bottom slope.

Although the k_1 and k_2 values (Komar and Inman, 1970) have been empirically calculated for their assumptions used in the shoreline method, as well as the limits of statistical equations for estimating long shore sediment transport, it is reasonable to view k_1 and k_2 as site-specific parameters to be established by using the calibration of the shoreline model.

It should be stressed that, in addition to the factor 1/ (D_B + D_C), the transport parameter k_1 controls the time scale of the simulated shoreline change and the magnitude of the long shore sand transport rate and also as shown (see eq. 6).

While the value of k_2 represents the relevance of the term δH/δx term as shown (see eq. 7).

For an example, the sandy beaches, experience has shown that 0.1< k_1<1.0 and 0.5 k_1<k_2<l.5 k_1. Also for that three cases of gradients in the long shore transport are considered by GENESIS.

So that;

If there is no morphological change > Qin = Qout

For Accretion of Shoreline > Qin >>Qout

For Erosion of Shoreline > Qin <<Qout

For the relation to the wave height (H), the width of Q is nearly large whose dependent on Øbs as shown in(eq. 5), which changes according with the shoreline direction, and also the significant morphological variations are required where the bends are also located on the coast.

INPUT DATA

Calibration of Genesis Model Coefficients

The simulation of shoreline variations with genesis must be starting with design parameter Calibration for the zone of importance measurements of samples taken at the site indicate that the quality of sand particles ranges from (0.1 to 0.45) 0.33was used in simulation and calibration of long shore sand transport coefficients K1, K2by comparing the time of coastal changes(2013-2020). The measured values for K1, K2 are also equal to respectively equal to 0.4 and 0.2.

OUTPUT RESULTS

Figure6. *Bathymetric data*

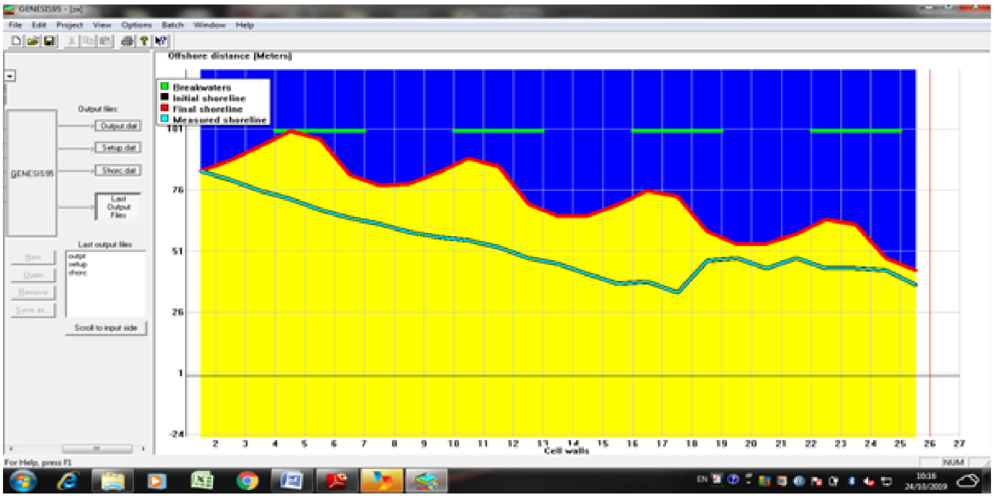

Figure7. *Example of numerical analysis output (detached Breakwater at K_t=0.3)*

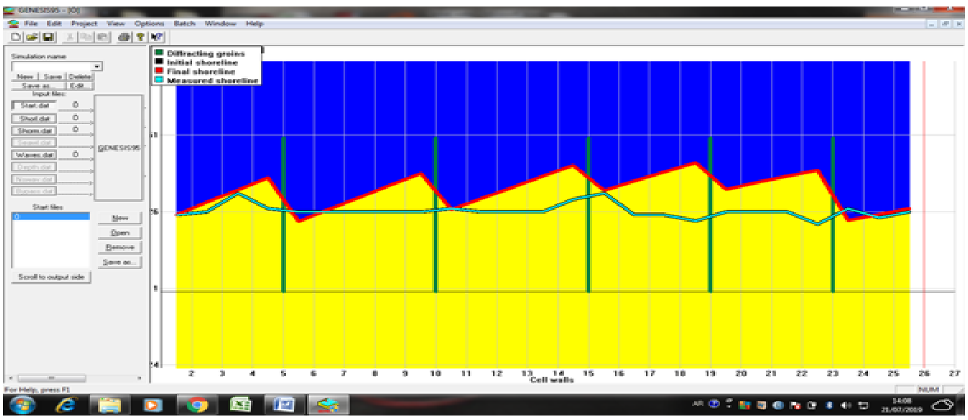

Figure8. *Example of numerical analysis output (groins at K_t=0)*

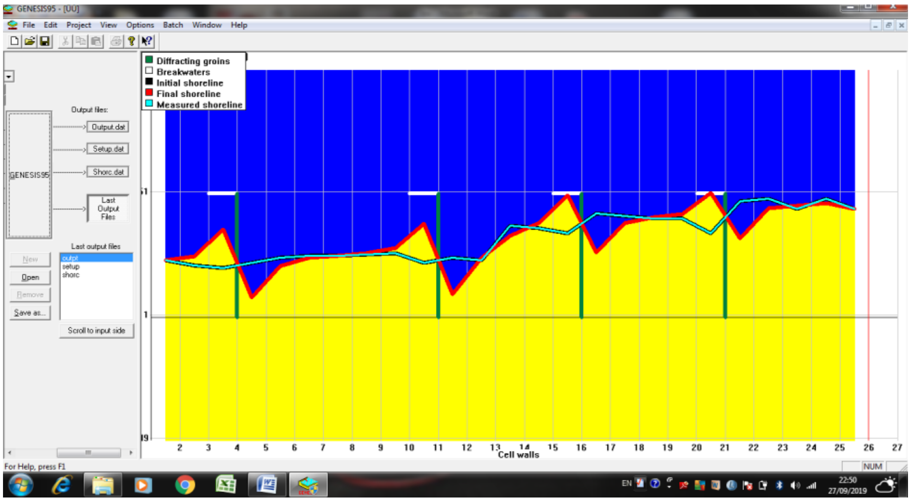

Figure9. *Example of numerical analysis output (breakwater and groins at K_t=0)*

DISCUSSION OF RESULTS

A parametric study was conducted to investigate the effect of change shorelineby using (breakwater and groins) anddate when simulation year (2013-2021). Effective grain size diameter is (0.33mm) , closure depth is (6.0 m), wave height (1to 5.0 m), and wave angle (12.5,15,22.5,and 45).

Effect of Change of Shoreline at Different Protection

Figure 6 shows the relationship between the distance offshore (Δy) and distance along shoreline(x) for different year (Detached Break water) ranging between 2012 to 2020.It can be shown that the distance offshore(Δy) decreases with increase in different years.

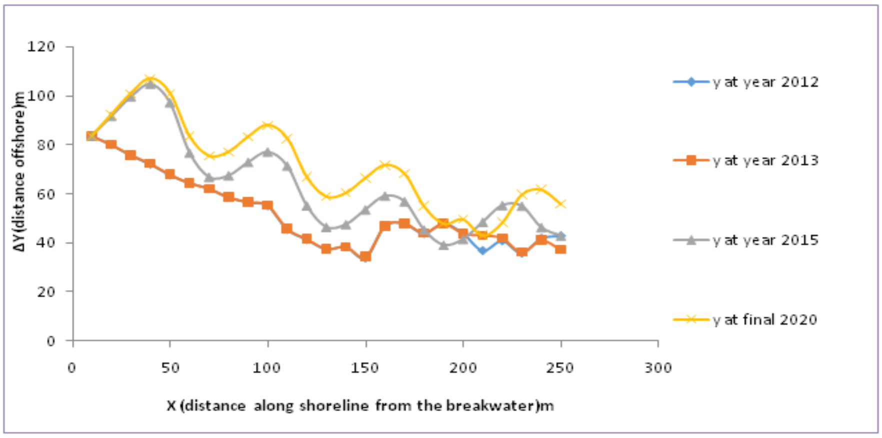

Figure10. *Relationship between the distance offshore(Δy) and distance along shoreline (x)for different years (Using Breakwater at angle 15)*

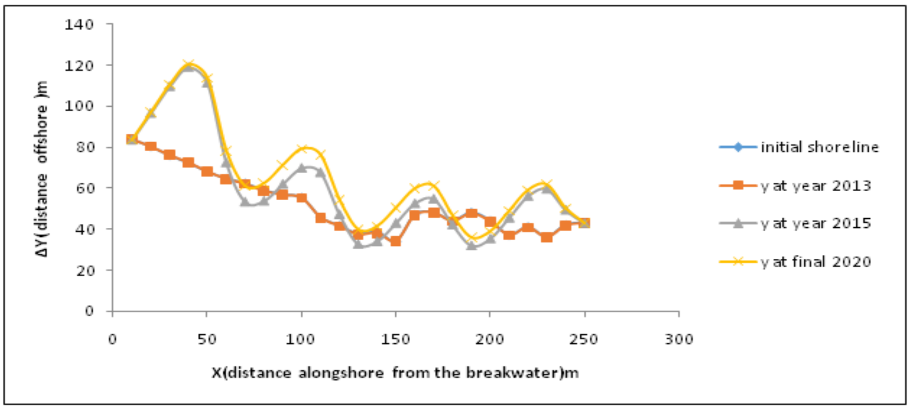

Figure11. *Relationship between the distance offshorey (Δy) and distance along shoreline (x)for different years (Using Breakwater at angle 45)*

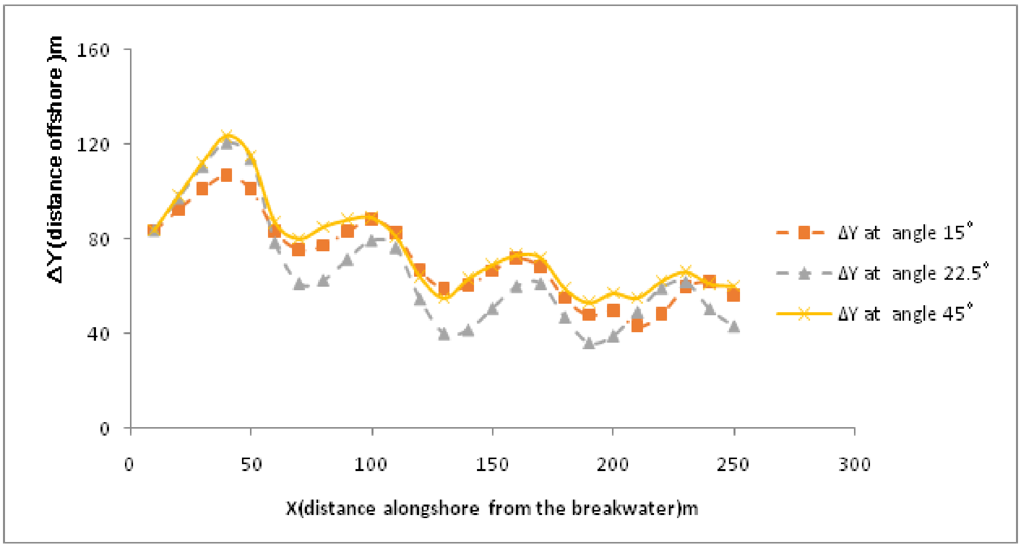

Figure12. *Relationship between the distance offshore(Δy) and distance along shoreline (x)for different angles (Using Breakwaters)*

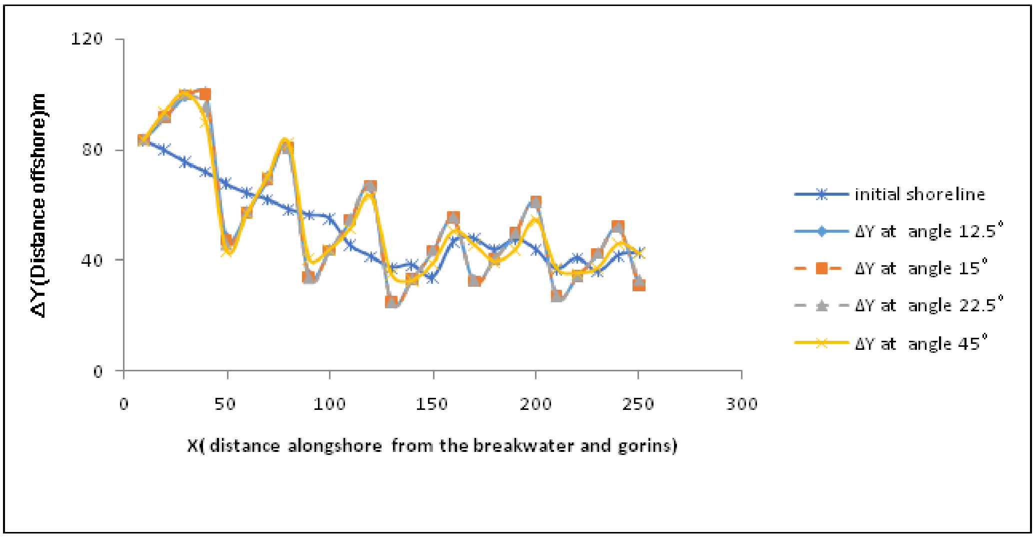

Figure13. *Relationship between the distance offshore(Δy) and distance along shoreline (x)for different angles (Using Breakwaters and gorins)*

CONCLUSIONS

This numerical study from this paper for the impact wave acting for the using break waters and groins system on the Marsa Alam Beach, by using the software ***GENESIS***, to study the changes of the shoreline.

- The results of this study for protection the shore line using breakwater and groins are as follows:

Using Breakwater:

- The shoreline changes were exactly inversely proportional to along shoreline.
- The average change for the shoreline lies between 45 and 95% along shoreline for different experimented angles.

Using Groins:

- Also the shoreline changes either were inversely proportional to along shoreline.
- The average change for the shoreline lies between 25 and 75% along shoreline for different experimented angles.

Using Breakwaters and groins together:

- The average change of the shoreline lies between 30 and 95% along shoreline for different experimented angles.

**Finally using Groins for shore protection are more sufficient than Breakwater.

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