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Modelling of Dynamic Structures to mitigate the Scouring at Littoral Zones

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Abstract

The demand for the protection of natural structures, groynes, resources and landscapes is raising high and it is vital as it is affecting the growth of mankind. The causes of this perturbation come from innumerable aspects of occurrences. The vital factors are dynamics of nature and the developments by mankind. One of the area in which the man is facing difficulty to discern is about littoral zones and its dynamical behavior in course of time. This is a nature dominant phenomenon including human involvement sometimes. One of the difficulties to discern the dynamic behavior of littoral zones is innumerable variables, the system comprising of. The proposed methodology suggesting to keep the variables or constraints which are having less effect as constant and to consider the variables, which has dominant effect on the dynamics of littoral zones [1]. The hypothesis is to build a groyne inshore so that the changes can be predicted prior so that the plan of action can be executed against the change. The dynamic structures are movable in space and are sized, shaped and designed according to our convenience, importantly by considering the changes in littoral zones is hypothesized to minimize the scouring effect. The method of fundamental numerical modeling is opted to support the hypothesized results.

Keywords:

Littoral drift;
Littoral zone;
Groyne;
Incidenceangle;
Numerical modelling.

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1. Introduction

The littoral zone is a part and parcel of sea which is nearer to shore. The littoral zones are the systems comprising of many constraints. These zones are affected by currents, tides and due to groynes that are structured by a men for their own naval or some other own purposes. In coastal environments the littoral zone is the area in between the high water mark and shoreline areas that are permanently submerged. It always includes the intertidal zone in its region. In precisely the littoral zones are not definite and fixed [2]. The littoral zone can be divided into sub regions based on type of context. The adjacency of areas of water adds a number of distinctive characteristics to littoral regions [3]. The erosive and accretion power of water are two pertinent parameters in this study. These two parameters are non-linear functions of other distinct parameters such as littoral drift, depth of the sea and angle of wave incidence with respect of normal to the surface. The study of non-linear is systems are complex.

The characteristics of every system which is dynamic can be represented as a wave which fits best by considering all the constraints of the whole system. This type of study consists of parameters, which varies in terms of not only one but also many. In this regard the hypothesized modelling and analysis has been done based on the dynamic wave equation comprising of partial derivatives [7] [9].

Hydro-dynamic modelling is the fundamental theory for many other modelling studies especially in case of dynamics of coastal line. The studies involve sediment transport, morphology, waves, water quality and/or ecological changes are being investigated and analyzed to understand occurrences that may be positive or negative a head [4][5]. The new trend of research is being carried out to improve the representation of tides, waves, currents, and surge in coastal waters. In this methodology, the technique of wave modelling has considered to study the parameters which affect the coastal dynamics. The general dynamic coastal modelling has constraints and sometimes it comes more in number to have a perfect analysis. In this methodology the number of constraints is limited to reduce complexity by allowing the change in the final output within a tolerated deviation.

2. Research Method

The approach followed in this methodology is more or less morphological. The dynamical coastline equation in course of time is found [1] with the aid of the continuity equation and a simplified dynamical equation with some unknown constants.
The fundamental continuity equation of coastal wave [8]: [9] is

$$\frac{dQ}{dx} + D\,\frac{\partial y}{\partial t} = 0 \qquad \text{------------------------------ (1)}$$

Q = littoral drift analogous to current
y = Seawards distance
x = Distance along a coastal line
D = Depth up to where accretion takes place

From the expression of Taylor's series

$$Q = Q_0 - q\,\frac{\partial y}{\partial x} \qquad \text{---------------------------- (2)}$$

$$q = \frac{dQ}{d\alpha}$$

α = Incidence angle of wave

By substituting (2) in (1), we obtain

$$\frac{\partial y}{\partial t} = \frac{q}{D} \times \frac{\partial^2 y}{\partial x^2} \qquad \text{----------------------------- (3)}$$

In this equation, left hand side derivative refers to accretion over a time and right hand side derivative refers to curvature.

From the above equation it is comprehensible that the change of seawards distance over a time is zero but if Q is constant. But it is very difficult to expect that the constant littoral drift. It paves the path to consider the whole study in the form of wave modelling and analysis. Wave modelling is the technique which overcomes many demerits in the existed so far techniques.
From the wave modelling technique, the coastal dynamic equation to represent the change of coastal line [10]: [11] is

$$y = e^{-\frac{q}{D}k^2 t} \cos K x$$

This is a sinusoidal shaped coastline of which the amplitude decreases in course of time if q is positive (small angle of wave incidence), but increases if q is negative (large angle of wave incidence). This solves the problem of the indefiniteness.

3. Results and Analysis

In making use of the continuity equation and the above-mentioned dynamic equations one can compute many stationary and dynamic cases. Initial situation of the coastline obviously gives the lines of beach and inshore are parallel. The obtained wave equations shows that the construction of the groynes may lead to some build-up on the one-hand side of the curvature and erosion will takes place on another side. It must be stressed, that the influence of diffraction is not taken into account. If more groynes are constructed, the littoral drift along the beach is stopped more and more, because the beach turns in the direction of the wave crest.

The hypothesized wave modelling of whole coastal line by considering all constraints may pave the path for us to construct a dynamical structures or groynes to arrest the reflectance waves, which scours the coast. The proposed dynamic structures are approximately can be shaped into U- piped structure to allow the short and high incident waves to dissipate its energy so that scouring affect can be curbed.

The following graphical images are taken from by running dynamic wave equation model in MATLAB with limited constraints. It gives us a clear view about the consequences of change in q that is change of drift with respect to angle of incidence.

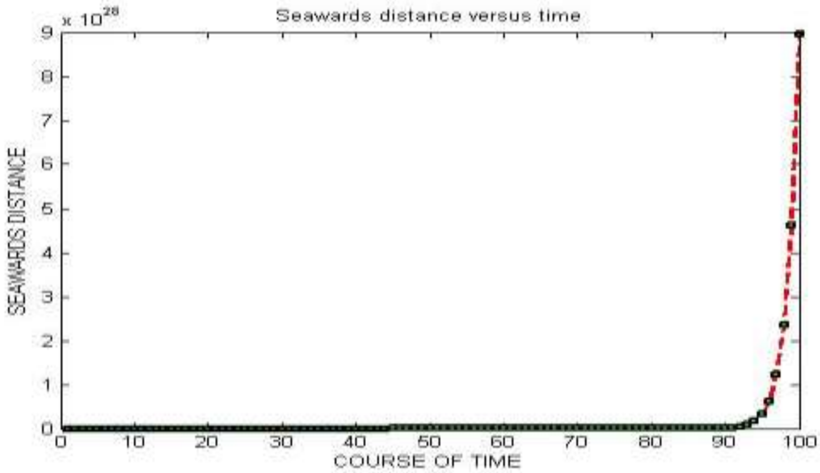

Figure1. *Seawards distance when q is negative*

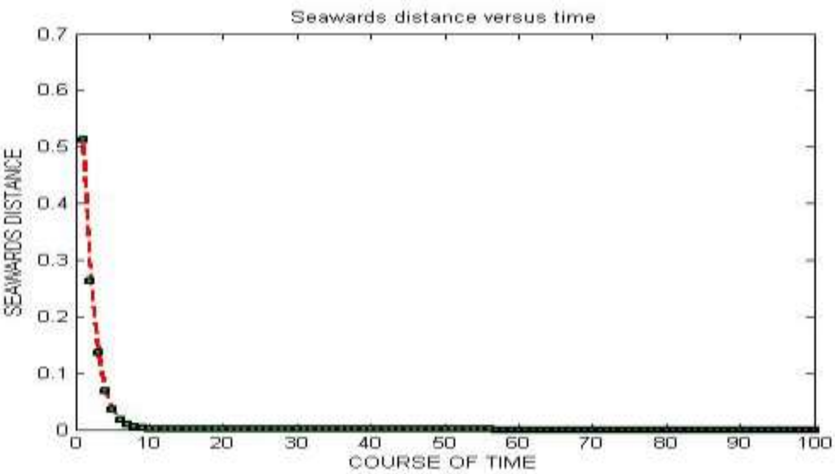

Figure2. *Seawards distance when q is positive*

4. Conclusion

The constraints, which create an impact which is against the people's wish, are negative in general. The present methodology is very clear to show the so called negative constraints will help us if we transforming them by allowing or accepting it's change. The analysis can be called as precise and approximately ideal by taking all the constraints in their effect on the dynamic wave modelling of coastal line. The parameters such as currents, tides and their direction, geo-graphical parameters like surface, its aspect with respect to the equilibrium value may produce an approximation close to the ideal. The mentioned parameters will be included in the next level this work.

Here it is hypothesized that there are two types of solutions to the scouring effect in the coastal line. Firstly by constructing dynamic groynes to act against high tides the scouring can be diminished. Secondly U shaped space dynamic groynes can be fixed so that the high tides kinetic energy is utilized to produce electrical energy by transforming it using low speed alternators. And the same modelling can be applied to the whole coastal line by considering it as a wave, once the estimated or hypothesized results are generated.

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