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Wave Transformation Studies Using Mike-21And Excel- Vba Programming

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Abstract— The world's economy is based on transport across the world of which a huge part is accomplished over sea. Coastal Engineering, as it relates to ports and harbors, starts with the development of maritime traffic, perhaps before 3500 B.C shipping was fundamental to culture and the growth of civilization and the expansion of navigation and communication in turn drove the practice of coastal engineering. For development of any major or minor port, fishery harbor in any coastal area wave climate of that particular area is required for the Coastal Engineers to design any of the various marine structures as needed. Therein wave data plays an important role in designing and execution of any marine structure. Wave data of any coastal area can be fetched by installing wave buoy and collecting data from the equipment but it takes a long time which may not be allowed by the requirement of the client. Therefore, here comes the need of Wave Transformation studies in which the real sea condition is simulated using MIKE-21, Spectral Wave model taking observed ship data offshore and the results obtained are programmed using EXCEL – VBA programming and hence Wave climate Inshore is obtained which solves the purpose of the client and hence time and money both are saved

Index Terms— Wave Transformation studies, MIKE-21, Spectral Wave model, EXCEL-VBA programming.

1 Introduction

Coastal Engineering investigations are an essential pre-requisite in the development of projects which will lead to alteration of existing conditions within the coastal environment. Such projects may include development of a harbor, implementation of a coast protection scheme or construction of an outfall structure for effluent disposal. The coastal engineering investigations required in this connection should essentially concentrate on two main aspects: establishment of existing conditions within the project environment; and prediction of impacts due to proposed changes within the environment. The methodology adopted in a particular coastal engineering investigation may involve exclusively either mathematical modelling or physical modelling or desk calculations or an appropriate combination of all these three approaches. Out of these investigation approaches, mathematical modelling has become increasingly popular over the last decade or so. The main reasons for this can be attributed to the advances made in theoretical description of physical processes, evolution of efficient numerical solution techniques and, most importantly, the development of high speed computers that can handle a large volume of numerical calculations at an unbelievably quick time. Today, more and more well proven mathematical models are becoming available to practicing coastal engineers as computer software packages with user-friendly interfaces.

Prior to the advances made in mathematical modelling, physical modelling was the only available choice in the investigation of complex coastal engineering problems. The main advantages of mathematical models over physical models are the ease and convenience with which structure layouts and bathymetric changes can be incorporated, the possibility of preserving different model set ups used for studying various solution options for future re-use and the absence of scale effects. These advantages make mathematical models highly versatile tools in coastal engineering applications. Any disadvantages in mathematical models arise out of the simplification of physical processes in the theoretical description and numerical discretization and the inability to provide the user with a physical visualization of the processes. However, the rapid advances made in theoretical developments and numerical solution techniques, and the ever increasing capability of software packages in providing real-time animations have gone a long way towards nullifying these disadvantages.The establishment of natural conditions within a particular coastal environment often requires acquisition of various forms of data such as waves, currents, sea bed topographical data (bathymetry), etc. A sound interpretation of these data using good technical judgment will be necessary in establishing existing conditions. The conditions within a coastal environment may vary throughout the year due to varying influence of oceanographic factors such as tides, waves and currents, and meteorological factors such as wind and temperature.

However, it is physically not possible to acquire relevant data covering a wide range of sea states. This is where properly set-up mathematical models become useful in establishing natural conditions under different simulation scenarios. Prior to applying a mathematical model it is necessary to verify the validity of its computations using field recordings. This process is known as the "model calibration". A well calibrated mathematical model can then be applied to predict altered conditions due to any man-made implementations.

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2 Modelling Consideration

The primary consideration in a mathematical model application is the identification of physical phenomena of interest. Among the physical phenomena of interest to the coastal engineer are wave dynamics, tidal circulations, storm surges, sediment transport and advection-dispersion processes. The recognition of important processes will lead to the selection of appropriate modelling tools which can be used to simulate these processes. In this paper, the selection of appropriate mathematical modelling tools is described by making references to computational modules available within MIKE 21, two dimensional mathematical modelling system. MIKE 21, developed at Danish Hydraulic Institute (DHI), Denmark is a highly versatile software package, with a wide range of applications in coastal and estuarine waters. CW&PRS has successfully applied MIKE 21 in numerous projects carried out in India.

2.1 Hydrodynamic Modelling

Hydrodynamic modelling is carried out basically to establish water surface elevations and velocity fields within the area of interest under different simulation scenarios. These simulation scenarios typically consist of different combinations of tidal forcing, wind fields, wave incidences, outfall/intake and river discharges. The hydrodynamics for example, within the continental shelf off the Sri Lankan coast is typically characterized by weak tidal flows with flow velocities in general less than 0.1 m/s. At times strong intermittent wind influences may enhance velocities beyond 0.25 m/s. The tidal range along the coast is also marginal with about 0.7 m during spring tide and 0.15 m during neap tide. In the very shallow seas close to the beach, strong shore parallel currents due to breaking waves with an angular approach may be generated. These currents are responsible for longshore transport of sediments and are commonly known as "littoral currents". The peak littoral currents are, in. general, in the range 1.0 m/s. The existence of nearshore reefs detached from the coastline, at certain localities may give rise to strong currents due to overtopping water masses.

2.2 Wave Propagation Modelling

Wave propagation modelling in the open ocean is carried out to establish nearshore wave fields for design of breakwater structures to withstand wave loads, to establish wave induced radiation stress fields for computing littoral currents and, in turn, sediment transport, and wave agitation within proposed harbour basin layouts. An essential prerequisite for wave propagation modelling is the establishment of directional wave field representative for the study area at a reasonable distance away from the coast. Such wave statistics are available from measurements and wave studies for a more or less continuous coastal stretch along the south western coast. Due to their predominantly different characteristics, it is necessary to obtain wave statistics in terms of sea and swell wave systems. Sea waves are those being developed locally under a wind field. Swell waves originate in the deep southern Indian Ocean.

2.3 Wave Disturbance Modelling

In the planning of a harbor, it is primarily important to ensure that wave conditions within the basin are within acceptable limits for safe loading and unloading of cargo and safe mooring of vessels. In order to determine wave conditions within a harbor basin it is necessary to consider complex influences of transmission, absorption, reflection of wave energy by harbor structures, in addition to other processes considered in wave propagation modelling. MIKE 21's BW (Boussinesq Wave) model is a versatile tool that can be applied to compute wave heights within a harbor basin due to penetration of irregular directional waves. The model uses the numerical solution of Boussinesq Equations accounting for wave reflection properties of structures, in terms of a "porosity" and so called sponge layers, to absorb wave energy at natural beaches and at undesirable locations. A numerical wave generator may be placed outside the harbor entrance to generate waves. The model computation is supplemented with service programs available within MIKE 21 for numerical wave generation, wave disturbance coefficient computation (the ratio of simulated and incoming wave heights) and computation of porosity characteristics to simulate a desired reflective property from a structure.

2.4 Sediment Transport Modelling

Sediment Transport modelling is carried out in coastal engineering investigations in the preliminary phase to assist in the establishment of a sediment budget for an area of interest. For this purpose, LHI has successfully applied LITPACK, a one dimensional Coastal Processes Modelling System, also developed at Danish Hydraulic Institute. LITPACK model is capable of computing longshore current, longshore and cross shore sediment transport for a given bathymetric profile. The model usage may be extended for multiple profiles and multiple wave conditions to compute annual or seasonal sediment transport capacity and determine coastline and beach profile changes due to implementation of coastal and harbor structures. MIKE 21 in itself is possessed of two dimensional sediment transport modules for computing sediment transport fields for pre-established hydrodynamic and wave fields. These computations can be used to obtain an indication of sediment by-pass capacity at a harbor entrance or an outlet stabilization structure, or to identify eroding and accreting areas.

2.5 Advection – Dispersion Modelling

Advection -dispersion of accidentally or intentionally released effluent matter is of particular importance to coastal engineers and environmental planners. These effluent substances could be sewage, heated water, decaying matter such as coliform bacteria, organic matter (BOD), dissolved oxygen and non-toxic and toxic metallic substances. The dispersion in the near-field of effluent matter is governed by its own discharge characteristics such as mass, momentum and buoyancy fluxes, geometry and the ambient velocity of the receiving body. In the far-field, once the effluent substance is well diluted over the receiving water body, further dispersion is governed entirely by the ambient flow conditions. In general, there is however a transition region between these two zones of mixing. Due to different forcing characteristics involved in the disper-

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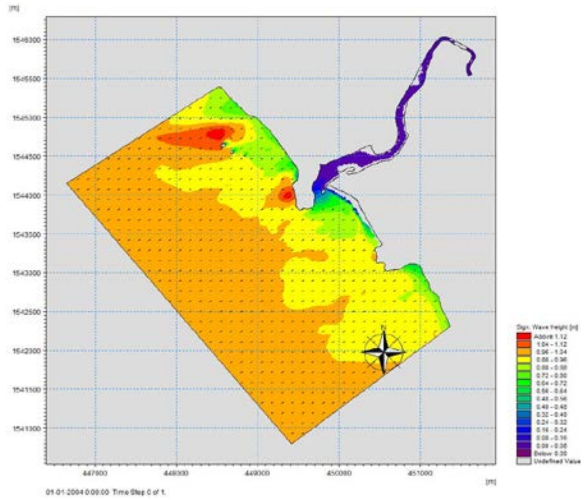

Fig. 2 SW model run for 247.5(degrees) wave direction

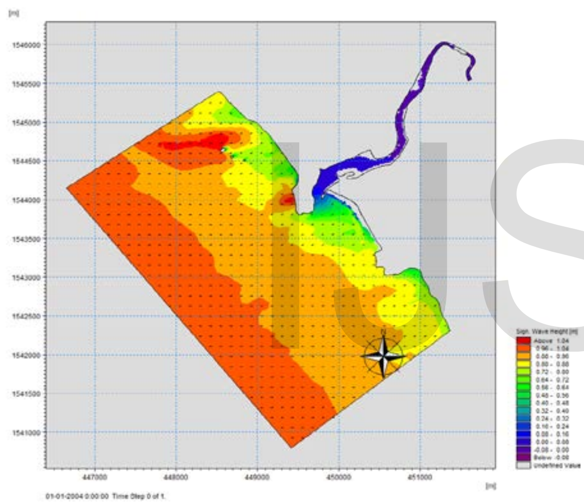

Fig. 3 SW model run for 270(degrees) wave direction

sion processes, the near-field and far-field modelling is typically carried out independent of each other. The near filed computations can be used to develop appropriate effluent discharge boundary conditions for far-field modelling. The near field modelling was carried out using a semi-empirical CORMIX3 model. The far field dispersion was computed using MIKE21's advection-dispersion module, MIKE 21 AD.

2.6 Water Quality Modelling

The large scale environmental pollution mainly resulting from industrial development has affected the coastal environment as well. Therefore, water quality modelling is increasingly becoming an attractive option for studying pollution levels in water bodies. To date, DHI has not engaged in complex water quality modelling except for simplified applications using MIKE 21 AD and CORMIX3 models. The MIKE 21 model itself is equipped with three environmental modules that may be used for water quality studies. These are the Water Quality Module (WQ), the Eutrophication Module (EU) and the Heavy Metal Module (ME). MIKE 21 WQ, which is particularly applicable for coastal waters is used for advanced water quality studies considering dissolved oxygen (DO), organic matter (BOD), ammonia, nitrate and phosphorous.

3 Work Undertaken In Project And Procedure Followed

A project was undertaken "Mathematical model studies near Bhatkal, Karanataka, area in which raw wave data was analyzed by a VBA - Excel program code and a standard format of percentage wave occurrence of offshore data was extracted in tabular format, which was in turn linked MIKE 21 SW model and thus by simulating the real sea conditions the inshore wave data was obtain from the offshore wave data.

4 Results Obtained By Mike-21 Sw Model

5 Conclusion

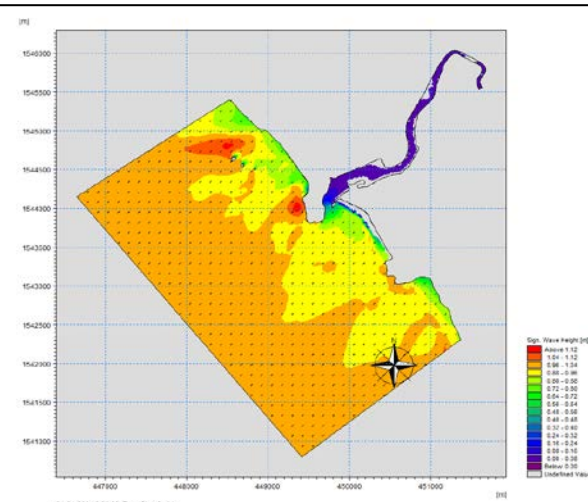

Fig. 1 SW model run for 225(degrees) wave direction

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1. By analyzing the raw wave data it was found that 38.99% of the waves offshore have the wave angle as 247.5 (degrees) and also 40.94% of waves offshore have the wave height of0.75m to 1.25m.
2. Of the given wave data 36 (numbers) of the data is classified into "Calm"(i.e. Wave heights <= 0.25m)
3. After transformation the inshore wave characteristics shows that the 77.19% of waves approaching at 247.5 (degrees) inshore.
4. Also the inshore wave characteristics clearly depicts that 40.46%, 19.3% and 5.65% of the waves inshore have the wave heights in the range 0.75m to 1.25m, 1.25m to 1.75m and 1.75m to 2.25m respectively.

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