APPENDIX 6

Details of Modeling Packages

A.6.1 Details of MIKE 21 PMS module

Description

MIKE 21 PMS is a linear refraction-diffraction model based on a parabolic approximation to the elliptic mild slope equation. The model takes into account the effects of refraction and shoaling due to varying depth, diffraction along the perpendicular to the predominant wave direction and energy dissipation due to bottom friction and wave breaking. The model also takes into account the effect of frequency and directional spreading using linear superposition.

MIKE 21 PMS is based on a parabolic approximation to the elliptic mild slope equation. Several parabolic approximations are implemented in MIKE 21 PMS ranging from the simple approximation valid for small angles to the more sophisticated approximations valid for large angles. The parabolic equation is solved using the Crank-Nicholson finite difference scheme.

The basic output data from the model are integral wave parameters such as the root mean square wave height, the peak wave period and the mean wave direction. Other output data that can be obtained from the model are radiation stresses and instantaneous surface elevations.
Application

MIKE 21 PMS can be applied to the study of wave disturbance in open coastal areas and for computing wave fields in coastal areas with structures when back scatter (reflection into the incoming waves) can be neglected and diffraction is predominantly perpendicular to the main wave direction.

The assessment of wave conditions (i.e. wave heights, wave periods and wave directions) and wave induced currents are essential for the calculation of sediment transport and erosion/deposition patterns in the coastal zone. Wave conditions and the radiation stresses (used in the calculation of the wave induced current) can be calculated using MIKE 21 PMS. For the successful application of MIKE 21 PMS module for wave simulation, it is important that the grid spacing is selected to provide adequate resolution in space.

Features

The main features of the MIKE 21 PMS module are

- Small computer requirements
- Crank-Nicholson finite difference scheme
- Once-through marching procedure
- Regular or irregular waves and
- Long-crested or short-crested waves
A.6.2 Details of LITLINE module in the LITPACK model

Description

LITLINE calculates the long-shore coastline position based on input of the wave climate as a timeseries. The model is, with minor modifications, based on a one-line theory, in which the cross-shore profile is assumed to remain unchanged during erosion/accretion. Thus, the coastal morphology is solely described by the coastline position (cross-shore direction) and the coastal profile at a given long-shore position. The sediment transport can be calculated for varying profiles in the longshore direction and basically four types of coastal structures can be taken into account together with sources and sinks of sediment.

Groynes and jetties are coast-normal (normal to the baseline in the model) structures. Both have a direct blocking effect on the long-shore transport at its position and further a sheltering-effect on the wave action down-wave of the structure. For jetties, the transport capacity in the sheltered area is calculated including diffraction effects. Groynes are considered to be relatively short structures and the transport capacity in the sheltered area is found by a simple reduction of the corresponding undisturbed transport rate.

The wave climate around off-shore breakwaters is calculated including diffraction effects, after which the local transport capacities are found by interpolation in the transport tables. Revetments prevent coastline retreat behind the position of the revetment. The depth in front of the revetment may increase
through further erosion until a value close to the active depth of the profile is reached.

The main equation in LITLINE is the continuity equation for sediment volumes

\[
\frac{\partial y_c}{\partial t} = \frac{1}{h_{act}} + \frac{\partial Q}{\partial x} + \frac{Q_{sou}}{h_{act} \Delta x}
\]

in which, \(y_c\) is the distance from the baseline to the coastline, \(t\) is the time, \(h_{act}\) is the height of the active cross-shore profile, \(Q\) is the longshore transport of sediment expressed in volumes, \(x\) is the longshore position, \(\Delta x\) is the longshore discretization step and \(Q_{sou}\) is the source/sink term expressed in volume/\(\Delta x\). The active depth, a height of the beach above mean water level which moves forth and back with the coastline position and finally possible dunes, which may erode if the coastline reaches their position during erosive states but will not accrete again. The continuity equation for sediment volumes is solved using an implicit Crank-Nicholson scheme, giving the development of the coastline position in time.

Application

LITLINE can be applied to the study of evolution of a coastline, influenced by various structures, sources and sinks. Some specific applications for LITLINE are
LITLINE is therefore a powerful and reliable tool for impact assessment and the design and optimization of many coastal engineering projects.

**Features**

The main features of the LITLINE coastline evolution module are

- Deterministic description of transport rates and distribution over the profile
- Influence of structures automatically included
- Measured timeseries as input
- Time varying sediment sources
- Wide range of coastal structures and
- Graphics of results while calculating
A.6.3 Details of LITDRIFT module in the LITPACK model

Description

LITDRIFT is a comprehensive deterministic numerical model which consists of hydrodynamic model and sediment transport model. The hydrodynamic model includes a description of propagation, shoaling and breaking of waves, calculation of the driving forces due to radiation stress gradients, momentum balance for the cross-shore and longshore direction giving the wave set up and the longshore current velocities. The model can be applied on complex coastal profiles with longshore bars. In the case of a longshore bar the broken waves can reform in the trough onshore of the bar. The waves can be treated as regular or irregular and the effect of directional spreading can be included in the description. It is assumed in the model that the conditions are uniform along the straight coast.

Having computed the longshore current by the hydrodynamic module, points are selected which are representative for the littoral drift. The sediment transport calculations carried out by the sediment transport module are made to reflect the local conditions with respect to the energy dissipation, the percentage of non-breaking waves and the rms of the wave heights. By considering the variation on the hydrodynamic climate (i.e. the yearly wind, wave, tide, storm surge and profile conditions), it is possible to determine the net/gross littoral climate at a specific location (sediment budget).
Application

LITDRIFT can be applied to the study of wave driven currents and longshore sediment transport of non-cohesive sediment on a long uniform beach. The assessment of wave conditions —wave heights, wave periods and wave directions— is essential for the estimation of the wave forces at a shoreline. Another important problem in coastal engineering is the simulation of the sediment transport, which for a large part is determined by the wave-induced littoral current. The wave-induced current may be generated by the strong gradient in radiation stresses which occur in the surf zone. LITDRIFT can be used to calculate the radiation stresses, the wave generated longshore current and the longshore sediment transport rate. LITDRIFT enables the user to calculate the annual sediment budget for the location, based on timeseries as input.

Features

The main features of the LITDRIFT littoral drift module are

- Deterministic approach
- Local hydrodynamics for sediment transport
- Measured timeseries as input and
- Graphics of results while calculating