World Academy of Science, Engineering and Technology
International Journal of Marine and Environmental Sciences
Vol:9, No:03, 2015

An Unified Model for Longshore Sediment Transport Rate Estimation

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Abstract : Wind wave-induced sediment transport is an important multidimensional and multiscale dynamic process affecting coastal seabed changes and coastline evolution. The knowledge about sediment transport rate is important to solve many environmental and geotechnical issues. There are many types of sediment transport models but none of them is widely accepted. It is bacause the process is not fully defined. Another problem is a lack of sufficient measurment data to verify proposed hypothesis. There are different types of models for longshore sediment transport (LST, which is discussed in this work) and cross-shore transport which is related to different time and space scales of the processes. There are models describing bed-load transport (discussed in this work), suspended and total sediment transport. LST models use among the others the information about (i) the flow velocity near the bottom, which in case of wave-currents interaction in coastal zone is a separate problem (ii) critical bed shear stress that strongly depends on the type of sediment and complicates in the case of heterogeneous sediment. Moreover, LST rate is strongly dependant on the local environmental conditions. To organize existing knowledge a series of sediment transport models intercomparisons was carried out as a part of the project “Development of a predictive model of morphodynamic changes in the coastal zone”. Four classical one-grid-point models were studied and intercompared over wide range of bottom shear stress conditions, corresponding with wind-waves conditions appropriate for coastal zone in polish marine areas. The set of models comprises classical theories that assume simplified influence of turbulence on the sediment transport (Du Boys, Meyer-Peter & Muller, Ribberink, Engelund & Hansen). It turned out that the values of estimated longshore instantaneous mass sediment transport are in general in agreement with earlier studies and measurements conducted in the area of interest. However, none of the formulas really stands out from the rest as being particularly suitable for the test location over the whole analyzed flow velocity range. Therefore, based on the models discussed a new unified formula for longshore sediment transport rate estimation is introduced, which constitutes the main original result of this study. Sediment transport rate is calculated based on the bed shear stress and critical bed shear stress. The dependence of environmental conditions is expressed by one coefficient (in a form of constant or function) thus the model presented can be quite easily adjusted to the local conditions. The discussion of the importance of each model parameter for specific velocity ranges is carried out. Moreover, it is shown that the value of near-bottom flow velocity is the main determinant of longshore bed-load in storm conditions. Thus, the accuracy of the results depends less on the sediment transport model itself and more on the appropriate modeling of the near-bottom velocities.

Keywords : bedload transport, longshore sediment transport, sediment transport models, coastal zone
Conference Title : ICCOE 2015 : International Conference on Coastal and Ocean Engineering
Conference Location : London, United Kingdom
Conference Dates : March 14-15, 2015