Abstract

The mathematical modelling of sediment transport in open channel turbulent flow is the subject of this thesis. A number of flow velocity models, sediment concentration models and parameters required to compute those features, have been developed. Each of the mathematical models derived in the thesis is validated with available laboratory data in literature. Chapter 1 of the thesis is the introductory chapter.

Chapter 2 and Chapter 6 investigate the vertical profile of streamwise mean velocity in a steady-uniform and unsteady-nonuniform open channel turbulent flow, respectively. Both the models are extended further to address the velocity distribution for a sediment-mixed flow. Effect of secondary current and concentration dependent von Kármán constant κ_s are considered. Homotopy Analysis Method and numerical method are used to solve the velocity models in Chapter 2 and Chapter 6, respectively. Chapter 2 mainly focuses a particular previous work that exiting in literature that introduce a lot of assumptions.

Chapter 3 and Chapter 4 revisit the diffusion equation that comes from the continuity equation of sediment and water to determine the vertical distribution of suspended sediment concentration in a turbulent flow carrying sediment using Homotopy Perturbation Method and Homotopy Analysis Method respectively. Chapter 3 presents a closed (compact) form series solution for sediment concentration equation. Chapter 4 considers the Hunt diffusion equation incorporating the concept of shear-induced diffusion. Homotopy Analysis Method is used in order to obtain a convergent series solution for a highly non-linear differential equation governing the vertical sediment concentration distribution for both dilute and high concentrated sediment-laden flows. In addition, the effects of important turbulent factors such as inverse of Schmidt number, hindered settling velocity on concentration profile, are investigated.

Chapter 5 focuses on the derivation of depth-averaged β, inverse of turbulent Schmidt number, through modified expressions of sediment and turbulent diffusion coefficients. A regression analysis is done to establish the relation between β and normalized settling velocity and the relation is used to determine suspension concentration.

A model on one-dimensional unsteady suspended sediment transport is developed in Chapter 7 by including the effect of hindered settling velocity from mixing length point of view. The sediment diffusion term is related to mixing length, which is taken as a function of concentration. The mixing length and settling velocity are reduced due to the presence of particles in the flow. By considering these effects in the governing equation, the partial differential equation becomes highly non-linear and the resulting partial differential equation is solved numerically using the most generalized boundary conditions. Furthermore, effects of damping function and hindered settling velocity are explained both graphically and physically.

Keywords : Turbulent flow; Streamwise velocity; Secondary current; Suspension concentration; Settling velocity; Mixing length; Homotopy Analysis Method.