« Research Note »

Simulation of the Steady Shocks using Finite Volume and Finite Difference Methods

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Abstract

In this article the behavior of steady oblique shocks in open channels is studied using both the finite volume (FVM) and the finite difference (FDM) methods. In the FVM, the Van Leer scheme with an advanced slope limiting function is implemented on unstructured triangular grids. The bed slope is modeled using an upwind method including a modified hydrostatic pressure term. The Manning equation is used for the bed friction and the mixing length is applied for turbulence modeling. In the FDM, the two step MacCormack scheme with the Jameson's artificial viscosity algorithm is applied. These schemes are used to simulate the oblique shocks produced by a lateral barrier in an open channel. comparison of the numerical results with laboratory measurements proves robustness of both the schemes in simulation of shock fronts. However the Van Leer scheme is more consistent with experimental findings.

Key words: Shallow Water Equations, Reimann Solvers, Van Leer Scheme, MacCormack Scheme, Steady Shocks.

Experimental Study on Effect of Bend Curvature and Location of the T Shaped Spur Dike on Scour in a 90° Channel Bend

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Abstract

Spur dikes are used for preventing river banks erosion. The flow and scouring pattern around the spur dikes used in the outer bank are complicated especially when spur dikes are used in the bends. This is mainly due to the interaction between the flow pattern associated with the spur dike and the helical currents in the bend. In this paper result of experiments on scour around a T shaped spur dike and the effect of spur dike location on the amount of scouring and the effect of curvature of bend on the variation of bed topography are reported. Experiments were conducted in a re-circulating rectangular channel having 0.6 m width, 0.7 m height with different values of radius of bend to centerline (R/B=2,3,4). The main channel consisted of a 7.1 m long upstream and a 5.2 m long downstream straight reaches. A 90 degree channel bend was located between the two straight reaches. The bed and sides of channle were made of glass supported by metal frames. Natural uniform sediment with median size d_{50} =1.28 mm was used with a thickness of 0.35 m and covered the whole length of channel. Experiments were conducted for 25 l/s discharge. Results show that when spur dike installed at section 75 degree, the amount of scour is maximum. Also, by increasing the curvature of bend the amount of scour increases. But the lateral development of scour hole decreases.

Key words: Shape Spur Dike, Scour Pattern, Bend, Installation of Location, Curvature of Bend.

Trading Discharge Permisions in Rivers and Reallocating the Treatment Costs: Application of the Normalized Nucleolus Game

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Abstract

This paper presents a Trading Discharge Permisions (TDP) model for equitable treatment cost allocation among dischargers in rivers. The model consists of two principal steps. In the first step, a trade-off curve between objectives is developed using a recently developed multi-objective technique namely Nondominated Sorting Genetic Algorithm-II (NSGA-II). The objective functions are average value of the treatment levels of dischargers and a fuzzy risk of violating the water quality standards. The best non-dominated solution on the trade-off curve, which shows an initial treatment cost allocation, is defined using the Young conflict resolution theory. In the second step, using the Normalized Nucleolus cooperative game, the maximum saving cost of cooperating dischargers in a coalition is allocated to them fairly. This saving cost allocation provides a fair optimal trading discharge permisions policy. To illustrate applicability of the proposed methodology, it is applied to the Zarjub river system in north of Iran. The efficiency of the methodology is also evaluated using some well-know criteria in the field of trading discharge permisions such as existence of hot spots and free riders.

Key words: Trading Discharge Permit, Game Theory, Reallocation of Treatment Costs, Zarjub River.

Compressible Smoothed Particle Hydrodynamics for Numerical Simulation of Impulsive Waves

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Abstract

In this work, Compressible Smoothed Particle Hydrodynamics was used for numerical simulation of impulsive waves generated by landslides. SPH is a mesh-less method, which was introduced for astrophysical applications, but rapidly extended and used in engineering fields, including free surface flows and wave propagation. Laboratory investigations have been performed on the landslide generated waves at Sharif University of Technology to study impulse wave characteristics. The effects of submarine and sub-aerial landslide on the wave characteristics were considered and studied. Also, a wide range of effective parameters including geometry and deformation of wedge on impulsive wave characteristics have been inspected. In this paper, first, general features of laboratory experiments are described. Then, a general model based on C-SPH, "SPHysics", is used for two and three dimensional numerical simulation of impulsive wave. Comparison between experimental and computational results proves applicability of the C-SPH method for simulation of these kinds of problems.

Key words: Lagrangian Methods, Compressible SPH, Impulsive Waves, Landslide.

Application of Optimizied Fuzzy System by Genetic Algorithm to Predict Air Demand Downstream of Bottom Outlet Gates

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Abstract

Bottom outlet conduits are one of the main components of high dams to control the reservoir capacity, sediment discharge and downstream requirements. With high velocity flows and discharges within the bottom outlet conduits, the potential for cavitation damage, especially downstream of the outlet gates is also increased. Amongst various methods, aeration has been found as a cheap and easy way to reduce the cavitation tendency. Based on complicated phenomena of two phase flow downstream of outlet gates, the estimation of air demand without model studies mainly results in substantial errors. On the other hand, in recent years the application of artificial intelligence in the forms of artificial neural networks and fuzzy logic have been found as a powerful technique for simulation of nonlinear systems. A combination of fuzzy systems and genetic algorithms and optimization based on experimental data is an effective way for nonlinear problems. In this paper, a model based on genetic-fuzzy algorithm has been developed and used to predict air demand downstream of bottom outlet gates of high dams. The model make uses of 243 data consisting the data collected from various hydraulic models of outlet dams in Iran and the data of Folsom dam in USA. The model shows satisfactory results and proves to be a reliable technique to predict air demand downstream of bottom outlet gates, compared with the various relationships which are developed by regression analysis of experimental and field data.

Key words: Fuzzy-Genetic, Aeration, Bottom Outlet, Fuzzy Logic, Cavitation.

Variation of Manhole Minor Head Loss Coefficient in Sub-surface Drainage Network and its Influence on Water Surface Profile.

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Abstract

Manholes are commonly used in subsurface drainage networks while the hydraulic characteristics of this structure for design purposes and for determining the discharge capacity of the network have not investigated yet. In this research a prototype scale experimental setup was prepared using drainage corrugated pipes in order to determine the minor head loss coefficient of the manhole and to investigate its influence on the water surface profile. Data was gathered for a wide range of pipe longitudinal slopes and main pipe to lateral pipe discharge ratios. The data indicated that when the discharge ratio tends to unity the head loss coefficient decreases to a constant value. Accordingly، an average value was proposed for practical design purposes. The impact of applying such average value on the water surface profile directly upstream of the manhole was investigated and reported herein. The results indicated that applying such average value predicts the water surface elevation within a maximum error of ±15%. Higher errors belong to lower discharge values which are not of practical importance. Therefore، the application of proposed average head loss coefficient is recommended for design procedures.

Key words: Manhole, Minor Head Loss, Corrugated Pipe, Subsurface Drainage Networks.

Experiments on Transverse Waves Formation from Circular Obstacles in Open Channels

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Abstract

Transverse waves are produced due to the overlap of vortices resulted from the streamlines separation when fluids flow passes through a cluster of vertical circular cylinders. The direction of waves propagation is perpendicular to the fluid flow path. These waves are categorized in standing oscillatory waves type. In the present study, attention is focused on transverse waves formation in a rectangular laboratory flume. The flow path obstructions are wooden rods with height of 0.35 m height and diameter of 0.025 m. They are screwed on the plexiglass plate covered all bottom of laboratory flume in the staggered and in-line arrangements and with different intervals of rods. After establishment of the flow when the circular cylinders are submerged, no wave oscillations occur, when the water level is reduced slowly, 4 types of surface waves are seen across the laboratory flume. The current study compares the formation of transverse waves in different arrangements of rods. The maximum wave amplitude observed during experiments was 43 % of mean flow depth.

Key words: Vortex, Transverse Wave, Flow Oscillation, Wave Amplitude, Natural Channels.

Fractal Analysis of River Discharge Time Series: Case Study on Kor River

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Abstract

Meteorological and hydrological time series are examples of natural phenomena which can be analyzed via fractal geometry as a powerful statistical method. Fractal object has a structure that is repeated in different time scales. In this paper primary concepts of fractal geometry regarding time series are described and four classic methods for fractal dimension calculation are mentioned. Then average daily discharge of Kor River, a large river in Iran, for duration of 38 years is investigated using the correlation dimension estimation method. A dimension of 1.29 is obtained for the time series of this river. The results show that in different time scales there are a relative correlation between values of river discharge variation and these values are not independent. The results also imply that for time series larger than 3 to 4 years, fractal features exist in the time series and for smaller time series it is difficult to detect fractal feature in time series.

Keywords: Fractal Geometry; Time Series; Fractal Dimension; Self-Similar; Hurst Exponent; Kor River.

The Analytical and Numerical Solutions of the Shallow Water Equations with the Concentrated Discontinuities in the Bed

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Abstract

In this article the influence of the concentrated bed discontinuities (i.e. raising or falling steps) on the solution of the Reimann problem in the shallow water equations is studied. First, the analytical solution of one-dimensional dambreak problem, using the mass-momentum equations over a continuous flat and frictionless bed is reviewed. Next this solution is extended to a discontinuous bed (i. e. a step), using the mass momentum equations at the continuous places and the mass-energy equations at the discontinuities. Then, for the first time, the dambreak problem over a rectangular bump is solved, analytically. In the next section, the mass-momentum equations are numerically solved over the bump. For the discretisation of these equations over the flat continuous bed, the finite volume Roe-TVD scheme with a minmod slope limiter is applied. At the discontinuities, however, the mass-energy equations are discretised. The numerical results are found close to the analytical solution. Finally, the dam break problem in a cavity is similarly investigated both analytically and numerically.

Key words: Source Terms, Finite Volume, Mass-Energy Method, Shallow Water.