« Research Note »

Application of high order one dimensional equation for predicting open channel flow properties with lateral contraction

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Abstract

Canal structures with lateral contraction are commonly used to measure discharge in an open channel. Because of three dimensional nature of the flow, extracting rating curve for these structures is done by using a physical or three dimensional mathematical model. A considerable amount of time and money is required when utilizing these models. Boussinesq equations, extracted by considering streamline curvature and slope, exhibit high accuracy in predicting hydraulic properties in structures with varying bed level. In this paper, the Boussinesq equations are developed for the lateral contraction in a rectangular channel. The extracted equations are used for obtaining the rating curve of Parshall flume and predicting water surface profile of Khafagi flume. Comparing experimental data with the results of the developed equations showed the high accuracy of Boussinesq equation to predicting the water surface profile and the rating curve of structures with contraction and varying bed. The time for solving this one dimensional equations is much less than those of three dimensional model of FLOW3D.

Keywords: Rating curve, Boussinesq equations, lateral contraction, Parshall flume.

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Experimental study on the fine sediments shear stress erosion threshold of (case study: Karkeh dam reservoir)

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Abstract

Investigating on the shear stress threshold of erosion and the erosion rate of the fine sediment are essential to carry out sediment flushing in dam reservoirs. This work focuses on the determination of shear stress threshold of erosion of fine sediments deposited in Karkheh dam reservoir. For this propose, an annular flume was used and the sediment samples were taken from Karkheh dam reservoir. At the first stage, the trends of sedimentation and consolidation were tested using sedimentation columns for different periods of 3, 14 and 30 days. Experiments in the flume were conducted at different flow shear stress and different initial sediment concentrations. The results showed that concentration of the eroded sediment varied as a function of consolidation age of bed sediments and bed shear stress. It was also indicated that threshold shear stress of starting erosion were obtained at 0.16, 0.22, and 0.31 N/m^2 for consolidation ages of 3, 14, and 30 days, respectively. The results showed that the erosion rate is in a inverse relation with the period of consolidation, so that in the same stresses, the increase of the consolidation period will reduce the erosion rate.

Keyword: Erosion, Cohesive sediment, Critical shear stress, Annular flume, Consolidation.

Flow Modeling Using Meshless Local Petrov-Galerkin (MLPG) Method Based on Radial Basis Function

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Abstract
In this study, as a first step, the MLPG method based on Radial Basis Function (RBF) has been comprehensively introduced. In this regard, various flow governing equations such as fluid motion in porous media and dam break using mathematical fundamentals of meshless method are derived. The Results show that the MLPG method presented high accuracy and capability for solving the governing equation of the problem. Also, using the written code in MatLab, the steady state seepage problem is analyzed. Furthermore, for flow in channel problem, the velocity field is approximated in middle of nodes by RBF (MatLab code was adopted) in the uniform flow with slope. Finally, for dam breaking problem, the mass and momentum conservation laws are flow governing equations which are solved by pressure correction in Lagrangian approach and compared with the results of another methods. The obtain results demonstrate high accuracy of the meshless local Petrov-Galerkin method by RBF method in modeling and analysis of various hydraulic problems and no need to any background mesh and suitable compatibility with boundary condition.

Keywords: Sloped channel, Meshless local Petrov-Galerkin (MLPG) methods, Fluid flow modeling, Radial basis function.

Study of hydraulic characteristics of circular vertical spillway using numerical model

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Abstract

Circular vertical Spillway with various inlet forms is an effective structure where there is not enough space. Flow types in vertical circular spillway can be classified into three groups: free, orifice and under pressure (submerged) spillways. In this research, hydraulic characteristics of circular vertical Spillway investigated using numerical simulations. Specifically, upper and lower nappe profiles, relation between discharge and upstream water levels, and discharge coefficient in numerical modeling are investigated and compared with the experimental data. The model with mesh block of 10602 nodes, turbulent model k-ε standard and the standard wall function provides the best results. Also, there is a good agreement between numerical and experimental results in the upper and lower nappe profiles. Results show that while in low water levels water, the results of numerical modeling are good agreement with experimental, in general, between numerical and experimental results, the coefficient of R^2 is equal to 0.991, and also the root mean square error (RMSE) is 35.136. However, the difference between the numerical and experimental discharge through increasing water level is enhanced. In the study of the flow coefficient, decreasing of P/R leads to the increase in the difference of the numerical and experimental results.

Keywords: Circular vertical Spillway, Numerical model, Turbulent model, Discharge coefficient, Wall function.

Experimental study of the effect of bed's coarse sediment on the deposition and entrapment process of suspended cohesive sediment

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Abstract

Bed material is one of the factors affecting the deposition and entrapping of cohesive sediments. In present research, the entrapment of cohesive sediments was studied for two beds with coarse grains (i.e., D_{50}= 2.4 and 9.4 mm) and also a smooth bed in a circular flume. The effects of coarse bed sediments on the entrapping and deposition of suspended sediments have been tested for different concentrations and different shear stress. The experiments were carried out in two modes of smooth and rough beds for three initial concentrations 5, 10 and 20 g/l and three flow velocities 0.14, 0.24 and 0.34 m/s. The results showed that, for both smooth and rough beds, the concentration of suspended sediments decreases with time, although the roughness beds cause to increase the amount of the deposition rate and the time of reaching to an equilibrium concentration. The results also showed that, with increasing shear stress and initial concentration, the entrapping coefficients in bed containing grains with D_{50}= 2.4 and D_{50}= 9.4 respectively are about 5.7 and 3.5 times more than that of the smooth bed. Increasing the entrapping coefficient in larger shear stresses can be explained by considering the effects of coarse-grained bed sediments on reducing the flow velocity and generating bursting - sweep phenomena due to flow turbulence.

Keywords: Deposition, Entrapment, Cohesive Sediment, Circular Flume

Experimental investigation of adding clay and PAM on scouring reduction near bridge piers with river materials removal

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Abstract

Scouring damage around bridge piers is considered as a foremost detriment and researchers proposed hydraulic or non-hydraulic treatment to solve scouring problems. In this research, a new eco-friendly method has been proposed to reduce not only length and depth of scouring near circular bridge piers, but also volume of pits created by removal of river bed materials. Since clay and cationic poly acryl amid (PAM) have a good compatibility with the riverine system, the sediments of the mobile bed was combined with two different grains size included %10 clay and %5, %10 PAM injected into clay. Their effects on scouring reduction in four different discharge and three different pit depths were investigated. The results indicate that the enhancing effects of adding clay and PAM in reducing the length and depth of scouring. The best performance in the present research is observed for the mixture of clay and PAM %10 with scouring depth was %27.24 and %46.78 for grain size 0.6mm and to %26.9 and %45.18 for grain size 0.15mm. The scouring length for both grain sizes shows respectively %17.73 and %31.22 reduction. This investigation shows that the utilization of clay and PAM has a positive effects on reducing scouring and its treatment in rivers, while being compatible with the ecology of the system, it will have an acceptable performance in reducing the depth and scour length.

Keywords: Scour, Clay, PAM, Pit, Bridge piers.

Experimental study on the effect of distance of suction tube mouth from sediment surface on the hydrosuction system performance

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Abstract

In recent decades, the hydrosuction technique is known as one of the efficient methods that has been used for dredging sediments deposited in dams' reservoirs. This technique has obvious advantages compared to other sediment removal techniques such as no need for extra energy (due to the use of the difference between water surface energy at the upstream and downstream of the dam) and the possibility of transporting dredged sediments to a specific area. This technique is influenced by several geometric and hydraulic factors such as the suction tube diameter (D_p), the water head or the difference between the water height at the upstream and downstream of the dam (H), and the distance of the suction mouth from the surface of the sediment (h_p). In the current research, the effects of suction opening intervals on sediment (SP class) surface was studied using a physical model. The results of the experiments showed that by increasing the h_p factor, the discharge rate of the sediment and also the sediment concentration of the outlet flow would be increased. The results also indicated that the sediment evacuation process continued with the minimum value for h_p/D_p=-1.33; for values less than -1.33, the tube obstructed due to accumulation of sediments in the inlet opening.

Keywords: Scour hole, Hydrosuction, Physical model, Dam reservoir, Desilting.

Investigation the changes of bed shear stress and flow energy around impermeable and permeable angular barriers and gabion in a movable bed straight channel

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Abstract

The presence of barriers in the flow path causes significant changes in the wall shear stress distribution of the channels and rivers. In this research, the distribution of shear stress around permeable and impermeable angular barriers with two arrangement of consecutive and zigzag were experimentally investigated. The experiments were carried out in a rectangular channel with a Froude number of 0.26 with clear water and a flow velocity ratio to the threshold of the particle motion. The results show that the shear stress distribution of the bed in the impermeable barrier is higher about 14.6% of the shear stress in gabion with a porosity of 30%. Also, in the consecutive and zigzag double rod permeable barriers, the shear stress distribution are almost the same. Calculations of kinetic energy dissipation around angular barriers indicates that in impermeable barriers, energy dissipation is about 14% higher than gabions. Also, in permeable barriers with the same opening percentage, energy dissipation in gabions is about 80% higher than double rod barriers. These calculations also show that energy dissipation depends on the geometric arrangement of the rods, as the energy dissipations of the zigzag bar is 18 percent higher than the consecutive barriers.

Keywords: Bed shear stress, Kinetic energy, Impermeable barrier, Rod barriers, Scouring, Energy dissipation.

Numerical investigation of flow pattern, erosion and sedimentation around parallel unequal spur dikes under different geometric and hydraulic condition

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Abstract:

Spur dikes are known as the most popular hydraulic structures which utilize to reduce shores and river banks erosion. These structures change the flow pattern and sediment transport; so they can control hydraulic conditions and prevent shores erosion and cause sediment trapping. In this paper, effects of changes in angles and various arrangement of spur dikes (small to large or vice versa) for group of parallel, unequal, non-submerged and impermeable spur dikes on flow pattern, bed erosion and sedimentation are numerically investigated. Validation of the numerical results simulated in Flow-3D model with experimental data, shows the high precision of the numerical model. Also, the results show that scouring depth in large to small arrangement of the spur dikes and 45 degrees orientation has 55% reduction and in small to large arrangement and 135 degrees orientation has 72% reduction in comparison with group of equal length spur dikes perpendicular to the shore.

Key words: Group of spur dikes with unequal lengths, Numerical simulation, Erosion, Sedimentation, Flow pattern.

Determination of Form Friction Factor of Armored Gravel-Bed Rivers

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Abstract

Friction factor plays a substantial role in hydraulic computations. In coarse-gravel bed rivers, friction factor depends on grain size and bed forms. A wide range of particle sizes and developing armor layer have great effects on friction factor. To this end, determination of the form friction factor of armored river beds has been investigated in this study and, a friction equation was developed based on computing grain friction factor of the total friction factor. Analysis of obtained equation showed that the friction factor is rather independent of grain-size distribution of the bed material and the maximum grain size of this material. The major controlling parameter is the slope of the energy grade line. These results are explained by the coupling of the friction factor with the incipient motion problem and the rearrangement of the grains of the coarsest fraction in the armor coat. To verify the equation, Keulegan method was used which results 80% agreement between two methods. Also, including the major part of total friction factor to form friction factor (40%) shows the significant effects of bed form on flow resistance. The results of the current study showed that formation and development of armor layer increase bed roughness and friction factor and decrease average flow velocity causing a reduction in threshold Shields parameter and augmentation in bed stability. Field observations are employed to test the methods.

Keywords: Armor layer, Bed form, Gravel-bed river, Friction factor, Shields parameter.