« Research Note »

Experimental Investigation on the Effect of Curvature of Bend on Secondary Flow in 90 Degree Bend under Equilibrium Bed Condition

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Abstract
Flow pattern in the bend channels is different from that in the straight channels. Flow is affected by both pressure gradient and centrifugal forces in the bend of rivers and their interaction leads to form secondary flow. In the channel bend, radius of curvatures of the bend cause changes in the formation of secondary flow and consequently the flow pattern in the bend. This paper presents variation of flow through measurement of three dimensional velocities of the flow in the layers and different sections of a 90 degree bend under equilibrium bed condition. Experiments were conducted in an experimental channel with three different radius of curvature, i.e. mild, moderate and sharp. Vecterino, a three-dimensional velocity meter, is used to measure the three dimensional velocity of the flow. Formation and changes of secondary flow pattern in the three bends with different radius of curvature is discussed. The results indicate that power of secondary flow and vorticity in the second half of the bend increase with decrease in the radius of curvature of the bend. Also, a flow called second secondary flow forms near the outer bank and in the opposite direction of the main secondary flow. This flow is evident in the middle sections of first half of bend up to the end of the bend.

Keywords: Flow Pattern, 90 Degree Bend, Power Of Secondary Flow, Curvature Of Bend, Vortices, 3 D Velocity.

« Research Note »

Estimation of Brink Depth for Prismatic Channels in Sub- critical Approach Flow

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Abstract
To measure flow discharge and study erosion at the brink of free overfalls, computation of End Depth Relationship (EDR) is required in civil engineering practice. Based on the energy equation, a method is presented to estimate EDR in channels for different cross sections. Using available experimental and theoretical results of other studies, the proposed relationships were examined. This method yields good results for rectangular, triangular, parabolic, inverted semicircular and inverted triangular channels but fairly agrees with the experimental results in the case of trapezoidal and circular cross sections.

Keywords: Open Channels Hydraulics, Flow Measurement, Free Overfall, Brink Depth, End Depth.

Multi Criteria Calibration of Pipelines under Unsteady Flows

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Abstract

Partial differential equations of continuity and momentum govern the transient flows in pressurized pipes. These equations are numerically analyzed using the method of characteristics that consists of some important uncertainties such as friction loss modeling and wave speed. This work introduces a calibration methodology to estimate precisely the uncertain parameters and, consequently, the numerical modeling results. For this purpose, a transient state is generated by closing the downstream end valve. A numerical model for transient analysis in the pipe is also developed. In that model, four correction coefficients are considered to be calibrated including; pipe roughness, local and convective accelerations in the unsteady friction loss model and wave speed. Afterward, a non linear programming is developed in which the correction coefficients are decision variables. The objective function is defined as the summation of squares of differences of the observed and calculated pressures at the valve location. The problem is then solved using a simple genetic algorithm, and the uncertainties are finally calibrated to the best conditions. The capability of the method is investigated by solving a well-known experimental pipeline. The approach is found easy to use and results are satisfactory.

Keywords: Calibration, Pipelines, Unsteady Flow, Method of Characteristics.

Investigation of Wall Shear Stress Distribution in Open Channel Uniform Flow using an Accurate Instrument and Numerical Simulation

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Abstract

With the aim of investigating the distribution of wall shear stress in an open channel with a rectangular cross section and a smooth bed, an accurate needle type probe has been developed and after verification, it has been used for shear stress measurement in various cases of open channel uniform flows. In this instrument, capacitive type pressure transducers with 0.1 Pascal accuracy and 100Hz sampling rate were used to measure pressure fluctuations. Measured bed shear stresses are compared with the result of available analytical models and CFD simulations using FLUENT code for instrument verification. Variations of the measured local bed shear stresses at channel centerline with respect to channel aspect ratios, mean bed shear stresses and the lateral distribution of local bed shear stresses compare favorably with the previous experimental and analytical results and with the results of the present numerical simulations. Experimental measurements and numerical simulations show that the secondary currents affect the distribution of side wall shear stress more than the bed shear stress. Because of the presence of the alternate low-high velocity zones at the near bed region, the lateral distribution of the bed shear stress exhibits an oscillatory pattern.

Keywords: Wall Shear Stress, Needle Probe, Turbulence, Pressure Transducer, Numerical Simulation, Fluent.

Effect of Bed Protection Length on Local Scour Downstream of Horizontal Jets

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Abstract

Local scour occurs due to interactions between water current, erodible bed and hydraulic structures which can endanger performance and stability of these structures. To control this phenomenon downstream of structures such as control gates, various engineering measures such as aprons and rip-rap protections have been applied so far. However, investigation on the effect of lengths of these measures requires further studies which are dealt with in the current experimental research. For this purpose, scour profile due to a horizontal jet issued from a sluice gate was initially measured the (without protection) under different hydraulic conditions. The same tests were then repeated separately for the cases of application of aprons and rip-rap protections to achieve an insight about their effects on the maximum scour depth. Results showed that increasing relative length of aprons ($\tilde{L}a \geq 1$) and rip-rap protections ($\tilde{L}R \geq 2$), decreased the maximum scour depth considerably so that for $\tilde{L}a \geq 27$ and $\tilde{L}R \geq 7$, it decreases up to 100 percent. On this basis, a properly designed and constructed rip-rap protection ($\tilde{L}R \geq 2$), is more effective on decreasing maximum local scour depth than the apron measure. In this paper, suitable empirical relationships (in non-dimensional form) for estimation of maximum scour depths (considering lengths of the apron and rip-rap protections) are proposed. A comparison of the results of the proposed relationships with those of the previous researches shows that most of the data are within acceptable (±20%) error interval.

Keywords: Hydraulic Structures, Horizontal Jets, Local Scour, Apron, Rip-Rap.

Experimental Assessment of Submerged Vanes Effect on Scour Reduction Located on the Upstream Face of Cylindrical Pier

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Abstract

Scouring is one of the destructive factors in the hydraulic structures such as bridges. It occurs mainly during flood events. To find the most effective countermeasure to protect water structures against scouring phenomena, extensive investigations have been performed. One of such methods is to use submerged series of vanes which is not fully investigated yet. In this study, two series of submerged vanes were used either separately or attached to the upstream face of bridge pier and arranged symmetrically on different positions and angles of attack to control scour at cylindrical pier under clear water condition. The results showed that the highest reduction in scour depth occurs as the vanes series stands closer to the pier. Under the best condition, scour depth was reduced by 80.9 percent.

Keywords: Angle of Attack, Cylindrical Pier, Scouring, Submerged Vanes.

Armored Layer Bed Effect on Local Scouring Around Bridge Abutment

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Abstract

In this study the effects of armored-bed layer on local scouring around semi-circular and semi-elliptical abutments have been studied based on model experimentation. The main objective of this research includes the effect of armor layer on mechanism of clear-water scouring around bridge abutments. Experiments were performed under different conditions such as bed shear velocities, flow depths, dimension and shape of abutments, as well as grain size of the bed and armor layer materials in a glass-wall channel of 6.5 m length, 0.3 m width and 0.3 m height. Two types of abutments, semi-circular and semi-elliptical with b/l=3 and 2 respectively were used. Results show that by increasing the bed material diameter for a constant armor layer, maximum scouring depth (d_{sa}) increases and by increasing the grain size of the armor layer for a constant bed layer, d_{sa} decreases. For a given armor layer thickness, by increasing the grain size of the bed layer, d_{sa} increases. While small bed particles are under the protective effect of armor layer, increasing the water velocity increases the secondary armor layer depth provided that the armor layer itself is not influenced by the flow. The maximum scour depth for semi-elliptical abutment is less than that of semi-circular abutment.

Keywords: Local scouring, Abutment, Armor layer, Flow Hydraulics.