« Research Note »

Analysis of the Shear Stress on Bed in Bottom Outlet of Dams During Sediment Transportation by Numerical Model

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Abstract

Although water and soil conservation activities reduce reservoir sedimentation, it is inevitable that reservoirs fed by rivers transporting high amounts of sediment will experience sedimentation. The Ghezel-Ozan and Shahroud rivers, which flow into the Sefidroud reservoir dam, are both highly sediment-laden and transport significant amounts of sediment in both forms of bed and suspended load to the reservoir. Hence, it seems that the only practical way to remove the sediment from the reservoir is to flush it out using the chasse method. But it consists of a highly-concentrated water flow of the soil mass move through the bottom outlet that is called a density current. The flow causes significant damages to the boundaries of the conduit by soil erosion and corrosion. In this paper, density current in bottom outlets and its related problems are evaluated and the effects of concentration on wall shear stress are studied. To obtain the requirements for numerical modeling of three phase air-water-sediment flow pattern, the model was first calibrated with the experimental measurements of two phase air-water flow taken at Water Research Institute of Iran. Therefore, a numerical model based on multi-phases systems and available theories of numerical models for sediment transport was developed without applying empirical coefficients. Two different concentrations of suspended sediment have been used and the results are compared. The results showed that wall shear stress increases by sediment concentration. For both cases, the shear stress increases up to a maxima after a short distance from the gate. The quantity of these maxims is higher than those measured by flow of pure water. Thus, it is concluded that the sediment flow causes intense shear stress, which is a major threat to the tunnel walls. These damages stimulate the pressure field, which also may trigger cavitations.

Key words: Numerical Model, Bottom Outlet, Shear Stress, Sedimentation & Erosion, Density Current.

Annular Aerators in Tunnels with Horse shoe section

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Abstract

Aeration is one of the most practical and economical methods for prevention of cavitation attack in high speed flows. Many research works are conducted on aerators. Although a general method is not available for aerator design, many aerators are designed and constructed all over the world. Cavitation danger in tunnels also makes the designers to consider aerators for tunnels. Since tunnel sections are usually circular or horse shoe, a specific type of aerator is required for tunnels. Lack of information on application of aerators in tunnels makes some of designers to change the tunnel section to rectangular by subsequent concrete operation and then design the same type of aerators used in spillways. This method is expensive and time consuming. In the present work, annular aerators are studied in a physical model of a tunnel with horse shoe section. The effect of aerator geometry on jet length and spray formation is studied. Experimental results showed that to reduce spray formation, the aerator geometry should follow the tunnel section. It was also concluded that to reduce spray formation in the range of Froude numbers tested, it is better to keep the ramp angle less than 5 degrees. To increase the jet length and efficiency of the aerator, the ramp height should also be increased.

Keywords: Bottom Outlet, Horse ShoeTunnel, Cavitation, Aeration, Annular Aerator.

Comparison of Turbulence Models for Simulation of flow Around the Submerged Bridge Decks

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Abstract

During a critical river flood event, a bridge deck may become partially or completely submerged by the flow. The deck submergence may be a critical condition for structural stability of river bridges. In this paper, the mean flow fields around a submerged bridge deck and the time averaged drag coefficient on it have been simulated by using FLUENT software. The turbulence models considered are the standard $k-\varepsilon$, renormalization group (RNG) $k-\varepsilon$ and Realizable $k-\varepsilon$. In these simulations, the VOF and rigid lid methods have been used for free surface simulation. Reconstruction and Finite volume schemes have been used to determine the position of the free surface in VOF method and the results have been compared. Simulation results of time averaged drag coefficient show that in the case of partially submerged deck, Geometric Reconstruction Scheme in VOF method with standard $k-\varepsilon$ turbulence model is in better agreement with the experimental results. In the case of fully submerged deck, RNG $k-\varepsilon$ and Realizable $k-\varepsilon$ turbulence models provide better accuracy than standard $k-\varepsilon$ turbulence model. Also, simulation results show that Reconstruction based schemes in VOF method are not capable to simulate mixing of water and air and finite volume schemes have to be used for mixing of water and air simulation.

Key words: Numerical Simulation, Turbulence Model, Fluent, Drag Force, Bridge Deck.

Mathematical Semi-analytical Model of Combined Flow over Weir and under Gate by Different Geometries

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Abstract

The most important advantage of applying the combined weir and gate is to maximize its performance under sedimentation conditions. In this paper, a new mathematical model is presented to determine the relationship between stage and discharge for structures consisting of the weirs and gates by different geometries in different flow conditions. Since the geometry of these structures has lateral compression, velocity distribution in transverse section is not uniform. Therefore, the energy and momentum correction coefficients should be used, and in this research, these coefficients are calculated using optimization approach. One great important advantage of this procedure is the use of relatively simple hydraulic principles. To verify the given method, different combinations of weir and gate as a physical model are tested in the laboratory. From the laboratory data it is concluded that the proposed method is capable of calculating stage-discharge relationship by reasonable accuracy.

Keywords: Weir-Gate, Simultaneous Flow, Stage-Discharge Relationship, Energy Correction Factor, Momentum Correction Factors, Semi-Submerged Flow, Fully-Submerged Flow.

Numerical Modeling of the Freshwater Lens in Small Islands (Case Study of Kish Island)

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Abstract

The groundwater system in many small islands consists of a freshwater lens surrounded by seawater. A transition zone exists between the freshwater and the seawater in which relative salinity gradually changes from zero to 100 percent. Saltwater intrusion is the most important hazard to groundwater quality in small islands. Kish Island is one of the few islands in the Persian Gulf with extractable fresh groundwater resources. This paper presents details of a comprehensive study conducted to model seawater intrusion in Kish Island. Three dimensional numerical simulations were carried out using SUTRA a density dependent flow and transport numerical model. Model calibration was performed by Inverse modeling. For this purpose the PEST inverse code was combined with SUTRA. Finally model sensitivity was evaluated for aquifer recharge and permeability. This study shows that SUTRA can be regarded as a valuable tool in saltwater intrusion modeling. This is mainly due to the model`s ability to simultaneously solve flow and solute transport equations, as well as other key features of the model such as its ability to simulate the transition zone and the unsaturated layer above the main aquifer and to model the groundwater system in three dimensions.

Keywords: Numerical Modeling, Freshwater Lens, Saltwater Intrusion, Inverse Modeling, SUTRA.

Risk Analysis Method for Computation of Height of Flood Walls

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Abstract

One of the structural methods for flood control is construction of levees on the banks of rivers. In traditional design method, the height of floodwall is computed for a fixed design discharge and uncertainties in design flood determination, river hydraulic conveyance and economic analysis are ignored whereas in the risk analysis method effects of these uncertainties are included. In this paper, details of this method were firstly described and then the heights of floodwalls in Qeshlaq River, as a case study, were calculated by application of the risk analysis method. For this purpose, parameters of the load function were calculated by fitting statistical distributions on maximum daily flows and parameters of the wall resistance function were estimated by consideration of uncertainties associated with Manning coefficient, slope of energy line and geometric characteristics of the sections. Furthermore, in economical analysis effects of hydraulic and hydrologic uncertainties were considered. Results showed that application of the traditional method provided underestimated design values and were less reliable compared with the risk-based design method for the floodwalls of Qeshlaq River. In conclusion, application of risk analysis method for design of floodwalls was recommended taking all technical and economical aspects into consideration.

Key words: River Engineering, Flood Walls, Uncertainties, Risk Analysis.

Determination of Rivers` Flood Plain Risk`s Level by Multi Criteria Decision Making

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Abstract

Flood plain is the preferred place for agricultural and other socio-economic activities. High density flood plain's residential region shows this fact. These advantages encourage societies to invade river's bed and right-of-way. Lots of changes occur due to this invasion and cause some morphological and ecological damages. On the other hand, rivers are subject to floods. Therefore, determination of risk of river's bed and right-of-way directly relate to flooding damages and flood management plans.

In this paper, a new method for hazard and risk determination of river bed and right-of-way is proposed. The approach is Integrated Flood Management (IFM). IFM not only concerns to river hydraulics and technical issues, but it considers other issues like legal, environment and socio-economic conditions. This study tries to create a new method for determination of flood risk in the floodplain. We have composed ordinary flood zone mapping (technically using numeric hydraulic models) for Fordo River in Qom province in IRAN. We have also used a Multi Criteria Decision Making (MCDM) approach, which represents IFM aspects to produce another set of flood zoning map by IFM approach. In this procedure, we have benefited from an Analytically Hierarchy Process (AHP) to define land use flood risks. Final map was produced by merging technical map and IFM map.

To sum up, new proposed method shows moderate and reasonable zoning instead of hydraulic flood hazard and risk mapping because it uses more criteria for determining the level of flood`s risk in floodplain. Furthermore, this method is more reliable for flood insurance and early flood warning systems or flood damage mitigation, particularly in metropolitan areas.

Key words: Floodway and fringe's risk, Integrated Flood Management, Flood risk, Analytical Hierarchy Process.

Effect of Nominal Stone Diameter on Stability of Reshaping Berm Breakwaters

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Abstract

Berm breakwaters are structures that reshape under waves action and reach to a stable profile. In this type of breakwaters the units of the armor layer are allowed to move in order to take a final form without changing the serviceability performance of the structure. The remaining berm width - after rescission - is the main criterion for stability of these structures. If the rescission become more than the initial berm width, the breakwater will be unstable and failure will occur.

In this paper the effect of nominal diameter on stability of reshaping berm breakwaters is investigated by experimental studies. In order to consider the effect of this parameter in comparison with other parameters, 120 tests have been carried out in the wave flume of Tarbiat Modares University Hydraulic Laboratory. The waves in all tests are irregular waves conforming JONSWAP spectral energy. The amount of $f_g = \frac{D_{n50}}{D_{n15}} = 1.82$ is assumed for graining.

Results indicate that water depth has a considerable effect on berm rescission comparing to nominal diameter. However, the initial berm width has the same effect as nominal diameter. The results also show that by raising the position of berm to water level, rescission effect is reduced. On the other hand by decreasing nominal diameter and increasing the initial berm width the same percentage of rescission could be expected.

Key word: Berm Breakwater, Nominal Diameters, Stability of Breakwater.