Modeling and Estimation of Fatigue Damage Accumulation in Marine Risers of Fixed Platforms

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Abstract

Offshore gas and oil fields are being discovered and exploited nowadays in water depths of more than 2000 m. The operation in depths increases the external forces so that the equipments should be more advanced and expensive. Fatigue damage accumulation is one of the most important problems about marine structures that are exposed to the alternative loads. Riser is one of these structures. The surrounding environment of riser causes alternative stresses and fatigue in riser. To obtaini these stresses, the analysis of the vortex induced vibration in two direction, in-line and cross flow, is necessary. The risers are long relative to their cross sections so that the Euler-Bernoulli theory is applicable for description of the pipe dynamic bending. The flow and riser motion in x direction forms a vortex shedding in front of riser. These vortices cause the drag force in x direction and the lift force in y direction. These forces are time dependent. The drag force is obtained from Morison's formula. The lift force excites the vibration in y direction. After obtaining the equation of motion and solving it by using numerical methods such as Galerkin, finite difference and Runga-Kutta fourth order method, the riser deflection in two directions will be obtained and the stress at the outer diameter of riser will be calculated. The fatigue damage accumulation in the riser can be obtained by using Shigley theory and Palmgren-Miner rule.

Keywords: Fatigue Damage, Marine Riser, Alternative Stress.

Calculation of Pressure Distribution over Flip Buckets

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Abstract

Flip buckets are used as terminal structures at the end of chute spillways or bottom outlets. Flow after a bucket is issued in the form of a jet to a location far from the bucket where it impacts the river bed and forms a plunge pool. Energy of high speed flow is dissipated in the plunge pool and flow enters the river with a low velocity. Design of buckets and calculation of dynamic pressures over a bucket is usually done by physical model studies or design charts based on field measurements. Physical model studies are expensive and modification of the model takes time and is also difficult. Design charts are also developed based on limited field measurements. In the present study dynamic pressures over flip buckets are calculated using a numerical model. To simulate the free surface high speed flow over buckets, FLUENT computer code is employed. The numerical model was verified using existing experimental data. Free surface location, as well as pressure distribution over buckets were compared with measurements and very good agreement was obtained. The effect of Froude number and ratio of flow depth to bucket radius was also investigated. The results of analytical models for pressure distribution over buckets were also analyzed, discussed and compared with numerical data.

Keywords: Flip Bucket, Numerical model, Dynamic pressure, Spillway, Fluent.

Control of Hydraulic Jump in Trapezoidal Stilling Basin by Basin Blocks

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Abstract

Over the decades, extensive data have been gathered for the design of stilling basins but most of these data are restricted to jumps in rectangular channels. However, geometries different from the rectangular such as trapezoidal cross sections are also considered for stilling basins. On the other hand, unsteadiness of jump and increase in jump length are unwanted changes in the characteristics of such basins. In this study, the effect of basin blocks on the jump characteristics in a stilling basin of trapezoidal cross section is investigated. Five different block sizes corresponding to Froude numbers of 4, 5.5, 7, 8 and 9 for three different block locations of $0.8d_2$, d_2 and $1.2\ d_2$ from the jump toe were studied (d_2 is the sequent depth). The results show that the installation of a set of basin blocks may improve the jump condition and decrease the unsafe transverse waves and vortices. It was also found that the basin blocks cause a significant reduction in the sequent depth ratio and jump length, and an increase of the energy loss in the jump relative to those observed in the jumps occurring in a trapezoidal stilling basin without blocks.

Keywords: Hydraulic Jump, Stilling Basin, Trapezoidal Basin, Basin Block.

Development of Downstream Fuzzy Control System for Irrigation Canals

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Abstract
Limited water resources and poor performance of irrigation networks has attracted the attention of experts to improve water delivery management by application of improved control systems. Improved control systems in irrigation canals, because of complex hydraulic behavior, should be developed and tested using mathematical and hydrodynamic models. Fuzzy theory has been widely and successfully applied in several engineering control problems. In this research fuzzy theory has been applied for control of irrigation canals. For the development of fuzzy control system, the ICSS hydrodynamic model which could simulate unsteady hydraulic behavior in response of control systems in irrigation canals is used. The performance of developed mathematical model of fuzzy control system is tested in canal standard no. 2 introduced by ASCE, considering large flow variations. The performance of fuzzy control system is evaluated using several indicators such as, maximum absolute error, cumulative absolute error, and response time. The figures of flow, depth, and gate opening variations in time are analyzed as well. The results show that by applying large flow variations, the maximum depth deviation was 1.9%. The maximum response time for water depth to be stabilized within 1% range of target depth was 1.8 minutes. The results indicate that the developed fuzzy control system was successful in downstream control of irrigation canal and could be introduced for practical applications.

Key words: Irrigation Canals, Mathematical Model, Fuzzy Control System, Downstream Control, ICSS.

Estimation of Travel Time in Overland Flow via Diffusive Wave Approximation

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Abstract

Different analytical methods such as kinematic wave (KW) and diffusive wave (DW) approximation can be used to investigate the overland flow mechanism. In this article, for the first time, the results of these two methods are compared in calculating the travel time of flow over a rectangular plane. Positions of isochrones and the effect of bed slope on travel time are also investigated. It is elaborated that travel time of the rectangular plane in diffusion wave approximation is greater than that of the kinematic wave approximation. For example, by decreasing bed slope from 0.01 to 0.001 the travel time will increase by 99% in kinematic wave approximation and 130% in diffusive wave approximation. Also, the relative difference of the two methods will increase by 14%. It is also deduced that by decreasing the bed slope, the difference between the two subsequent isochrone distances will become greater in diffusion wave approximation than that of the kinematic wave approximation. On the other hand, with 10% of relative difference between kinematic and diffusive waves the criterion of $K_0 F_0^{\ 2} < 5$ would be fulfilled.

Keywords: Diffusive Wave, Kinematic Wave, Equilibrium Time, Isochrones, Friction slope.