Soil-Water-Structure Interaction on Diaphragm Quay-Walls

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ABSTRACT

Keywords: *Soil, Water, Structure, Hydrodynamics, Pore-water.*

The interaction between the soil, water and structure on various water-front Structures cannot be over-emphasized as it not only influences static actions induced behavior of structures but the trio also affects the dynamic action induced behavior.
The stability of the soil formation behind the wall and that under-water is being assessed with respect to the water and the retaining structure. The various non-linear stress-strain relationships are accounted for and the effect of pore-water pressure on the overall soil formation is investigated.
Nevertheless, the Morrison Equation was applied for the damping coefficient calculation on subjection to excitation by seismic actions. The overall safety analysis which includes the hydrodynamic effect is then conducted with the finite element model of the wall.
The importance of the consideration of the hydrodynamic influence and the internal pore-water pressure of the soil is revealed by the analysis results.

Investigation of the Flow Field inside a Drainage System: Gully-Pipe-Manhole

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ABSTRACT

Keywords: *Computational Fluid Dynamics (CFD), Urban drainage, OpenFOAM®, Gully-Manhole*

The performance of an urban drainage system largely depends on the linking elements of the system. Gully drop connected with manhole is one crucial structural part in several urban drainage systems. This paper will analyse the flow pattern and flow hydraulics of a gully-manhole drainage system in a view of further research to investigate pollutant transport to the system. The overall aim of this research is to analysis the performance of urban drainage structures in case of water quality and quantity towards quantifying uncertainty in an integrated catchment. Analysis will be done numerically using computational fluid dynamics CFD tools OpenFOAM® to simulate the gully-pipe-manhole. The Dual Drainage and Multi Link Element installation (DD-MLE) at the University of Coimbra hydraulic lab will be used to validate the numerical simulations. The experimental model setup consists of a 0.6 × 0.24 × 0.32 [m] (L × W × D) gully, a gully outlet with an 80 mm diameter pipe and a manhole of 1 [m] diameter. The flow pattern will be observed under different flow conditions. Both drainage condition and surcharged condition will be analysed to check the hydraulic performance of the system. The distribution of gully flow in the manhole-pipe system will also be analysed.

Increasing Piano Key Weir efficiency by fractal elements

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ABSTRACT

Keywords: *Piano Key Weir, PKW, discharge coefficient, efficiency, fractal elements*

Piano Key Weirs (PKW) are hydraulic structures which can be used for flood release systems on dams or for in-channel weir replacement. The efficiency can be increased compared to regular weirs, since the effective overfall length will be majorly increased by arranged piano keys. This research investigation deals with experimental model results of small scaled PKW models and compares resulting discharge coefficients. One PKW will be manufactured with included fractal elements with the main aim to increase the structure's efficiency (cmp. Laugier et al. 2011). The paper will include a discussion on PKW efficiency in general and gives information on the experimental model, including measurement techniques and collected measurement values. Thereby, the paper focuses on future concepts and possible PKW adaptions.

REFERENCES

Laugier, F., Pralong, J., Blancher, B. & Montarros, F. (2011). Development of a new concept of Piano Key Weir spillway to increase low head hydraulic efficiency: Fractal PKW, Proc. Workshop on Labyrinth and Piano Key Weirs (Liège), Taylor & Francis Group, London.

Numerical investigation of the pressure on a spillway crest

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ABSTRACT

Keywords: *Spillway, free surface evolution, critical section, pressure, potential flow*

Spillways are important hydraulic structures for controlling the water elevation in a reservoir. Improving their design could lead to even more efficient elements. A good knowledge of flow parameters, such as velocities and pressures, distributed in the flow as well as at the boundary with the structure, is the key for a better understanding. Traditional tools are computationally expensive. The implementation proposed in this paper aims to minimize the computational time for a 2-D vertical configuration. The assumption of irrotational flow is made. Following a first experience presented at IJREWHS 2014 in Spa, Belgium, this paper shows new techniques and improvements to compute the velocity at the domain limits and to determine the free-surface position and shape leading to a more robust code. The computation of the stream function in the (x, z) space is based on an irregular grid at the boundary neighborhood and a finite difference discretization scheme is used. Velocity and pressure fields are derived from the stream function distribution. A special treatment is applied for boundary nodes. After validation on typical test cases, such as flows over a bump, the algorithm is used to compute pressures on a spillway crest, for various head ratios. Numerical results, including pressures on the structure and velocity profiles, are compared to experimental data.

Numerical Modeling of Hydraulic Jump in Some Types of Prismatic Channels

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ABSTRACT

Keywords: *Saint Venant equations, hydraulic jump, MacCormack scheme, free surface flows*

The numerical modeling of free surface flows is important to understand the behavior of flows. The Saint-Venant equations are most commonly used for modeling this type of flows. There are many methods and numerical schemes used for the numerical solution of these equations.
In our work we used the 1D Saint-Venant equations and the MacCormack finite difference method with TVD extension scheme to calculate the characteristics of the hydraulic jump which is formed in prismatic sloped channels at different sections, such as rectangular sections, triangular and trapezoidal.
We used Matlab as a programming tool, to simulate several flows based on experimental trials that allow us to impose different initial depth and velocity (Froude number) and we were able to validate results comparing the characteristics of a hydraulic jump such as conjugate depths and length of the jump. We present a matrix of flows ranging Froude numbers from 4 to 11, initial depth from 0.035 m to 0.05 m and velocities from 1.3 m/s to 4.5 m/s Results are better for low Froude numbers as expected and the changing of slope has a direct relationship with the location of the hydraulic jump. The extension TVD plays an important role in minimizing the oscillations of the flow in the channels.

Inlet capacity of street inlets with partial severed grate openings

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ABSTRACT

Keywords: *street inlets, inlet capacity, supercritical flow*

Due to an increasing number of extreme rainfall events managing urban flooding requires new design approaches concerning the underground drainage systems as well as the temporary surface water runoff. Latest developments on bidirectional coupled models, 1D-1D as well as 1D-2D models, are still employed in practice. Connecting elements between the surface and the underground system are street inlets – offered in different constructions types and designs. Depending on the longitudinal and transversal slope of the street as well as the street inlet type the hydraulic efficiency of grate inlets is hardly available, thus, physical model test runs were done. Due to steep longitudinal slopes up to 10 % only supercritical flow conditions occur with flow depths up to 3 cm and flow velocities of approximately 1 to 2 m/s. In previous physical model test runs the overall gutter capacity of selected grate inlets was measured. The aim of the present paper is to investigate the inflow conditions in detail. Severing defined parts of the grate openings the main inflow regions with their efficiency can be determined – depending on the flow velocities and flow depths upstream of the inlet. A typical street inlet used in Germany is investigated. The grate inlet openings are divided into eight parts where the intercepted flow is measured for each part separately. The main inflow areas of the grate inlet are located in a typical triangular pattern on the curbside. In order to calibrate and validate a numerical model to calculate the efficiency of street inlets the physical model results were compared to the numerical results.

Vertical Slot Fishway: Evaluation of numerical model quality

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ABSTRACT

Keywords: *Fish passage, Vertical Slot Fishway, numerical modeling*

Numerical modeling is taking a growing part in constructing complex hydraulic structures. Especially structures where standard design or analytic calculation isn't applicable numerical investigations can provide important knowledge of flow parameters.
Fish passage structures are subject of research for several decades but still not extensively described. Vertical Slot Fishways (VSF) have shown a wide application range and are well documented. But particularly for slight slopes less than 5 %, which is needed for most fishes in Europe, fundamental knowledge is leaking. Numerical modeling, if of good quality, can provide a cost-effective tool to investigate flow on VSF.

This paper presents an investigation on quality components of numerical 3D simulation of VSF. Four pools constructed as standard design are modeled and examined. Large-eddy simulation, second order, with four mesh resolutions was used. The study focused on velocity fields, flow patterns and dimensionality of flow affected by mesh resolution. Besides that attention was paid to maximum velocity at the slot, turbulent intensity and energy dissipation as parameters to evaluate the performance of VSF.

Nappe Vibration Characteristics for Free-overfall Structures

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ABSTRACT

Keywords: *Spillway, nappe vibration, nappe oscillations, physical modelling, flow characterization*

Under relatively low-head discharges, the behavior of nappe oscillation, otherwise known as nappe vibration, is observed on hydraulic structures with a free overfall, such as weir, crest gates and fountains. This phenomenon, which has been early identified as undesirable and potentially dangerous, is characterized by oscillations in the thin flow nappe cascading downstream of the weir. In addition, these oscillations produce a significant level of noise and acoustic pressure waves that increase the environmental and societal impacts of the structure. A review of the scientific literature shows a lack of consensus regarding the causes and source of the oscillations development. In this context of relatively poor understanding of the dominant processes, a detailed investigation has been undertaken to identify and quantify the nappe vibration mechanism. The research is being performed with a prototype-scale linear weir (weir length of 3.5 m and a fall height of 3 m) located at the Engineering Hydraulics laboratory of the University of Liège. The study employs high-speed cameras and audio equipment to characterize the nappe vibration. This paper presents first characteristics of the nappe vibrations based on image and sound analysis, especially in terms of frequency vibrations, for a quarter round weir crest. The impact of the air cavity behind the nappe and upstream conditions have been analysed for the purpose of identifying the nappe vibration cause.

Water waves measurements at Bellsund in the western Spitsbergen

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ABSTRACT

Keywords: *water waves, coastal erosion, field measurements, Arctic area*

The Arctic coasts in times of progressing global warming are exceptionally vulnerable to erosion. Arctic sea-ice extend is decreasing dramatically leaving coasts exposed to destructive action of waves. On the other hand, the Arctic region is very intensively explored in the last few decades and coastal settlements are exposed to great risk. In order to study the effect of water waves on coastal erosion in Arctic areas field measurements were carried out in the area of Calypsobyen, Bellsund, west Spitsbergen. The field measurements were conducted by the team of Institute of Hydroengineering during summer season of 2015 in the vicinity of Polish Polar Station. Acoustic Wave and Current (AWAC) measuring system was deployed 1 km away from the coastline at the depth of 8-10 m depending on the tide level. The device registered free-surface oscillations for 89 days at the frequency of 4 Hz and current velocity vertical distribution. It resulted in over 5300 wave records of 1200 seconds. Spectral and statistical analyses were applied to the available datasets in order to evaluate parameters and characteristics of measured wave fields. Wave measurements were supported by bathymetry surveys and coastline position tracking. Bathymetry changes were evaluated on the basis of available historical data and measurements collected during the expedition. Taking into account wave climate parameters and morphological characteristics of the Arctic shore determined in the course of the study, an assessment of coast vulnerability to wave-induced erosion was performed. The results of the present work constitute a unique and valuable source of information on coastal erosion in polar regions.

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Flow around a cylindrical pier: large eddy simulation and validation against PIV data

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ABSTRACT

Keywords: *CFD, LES, Ansys Fluent, cylindrical pier*

The main goal of this study is the numerical simulation of the 3D turbulent flow around an isolated circular pier, a generic case that is relevant for the study of flow and scour around bridge piers. In this contribution, only a fixed and flat bed configuration will be considered, representative for the beginning of the scour process. A Large Eddy Simulation model has been set up in Ansys Fluent, the results of which will be compared with experimental data obtained by Particle Image Velocimetry (PIV) in the work of Nogueira et al. (2008), as well as other data published in literature. The main focus will be on time-averaged velocity and vorticity fields, Reynolds shear stress profiles, the bed shear stress and the drag coefficient of the pier.

REFERENCES

Nogueira, H. Franca, M. Adduce, C. Ferreira, R. (2008) “Bridge piers in mobile beds: visualization and characterization of the surrounding and approaching flows” Proc. River Flow 2008, Turkey.

Coupling Process for 1D-2D Numerical Flash Flood Simulation: A Parameter Study of Involved Variables for Gullies and Manholes

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ABSTRACT

Keywords: *Gullies, flash flood, discharge coefficient, inlet capacity, inlet area*

Urban flash floods and hydro numerical coupled modelling for their analysis is influenced by various parameters and assumptions made during the setup and implementation. Hence in this paper the coupling details of 1D-sewer and 2D-overland coupled models are analyzed and parameters involved are varied and their effect on the computed results are compared regarding flood level, the discharge rate (bi-directional) between the models and the flooding duration respectively. Parameters involved are the inlet area, the limitation of the discharge capacity according to Ras-Ew and the discharge coefficient. Comparisons between limited and unlimited numerical computation of discharge capacity at the coupled nodes show that the flood duration is influenced more than flood level. The numerical computation of the coupled nodes is implemented as outlets after the equation of Torricelli who is also defined by the mentioned variables amongst others.
The changes of the flood level, the flood duration and the discharge rate computed are reasonable and can be used in order to define (default) values for the different parameters involved.

Analysis of clearance gap losses on the hydraulic pressure machine

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ABSTRACT

Keywords: *Small Hydropower, Gap Loss, Hydraulic Pressure Machine*

The Hydraulic Pressure Machine (HPM) is an energy converter to exploit head differences between 0.5 and 2.5 m in small streams and irrigation canals. The HPM looks similar to a classic breast shot water wheel but has a smaller number of blades, a relatively large central hub and the wheel runs at variable speeds (2 to 12 min^{-1}). Preliminary results show that the HPM is an economically and ecologically viable technology for small hydropower generation.
The clearance gap between the blade tip and the shroud at the bottom of the wheel are very important regarding power losses. A theoretical approach has been developed which considers a stationary wheel to quantify the leakage losses. However, no validation of this theory has been done.
The goals of this research are quantify the leakage at operating condition and to improve the HPM blade design to further reduce gap losses. Thus a large scale physical model is tested at laboratory conditions. The HPM model is 1.1 m in diameter, 0.8 m wide and has 12 flat blades. Variable blade tips machined from steel and EPDM rubber are investigated with gap sizes of 1, 5 and 10 mm.
The physical model results show that the flow rate passing the wheel during operation is approximately one third of the flow rate calculated by the theoretical approach. EPDM rubber offers advantages regarding gap losses compared to other tested materials. The variation of different gap sizes revealed the importance of small clearance gaps to reach high efficiencies.

Experimental and theoretical studies on the formation of freak waves over a sloping bottom

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ABSTRACT

Keywords: *freak waves, coastal structure, sloping bottom*

Precise prediction of waves and their interactions with structures is of significant importance for coastal and offshore engineers. Information on the propagation of water waves and wave interaction with structures can be obtained from available models. Far less information is available on extreme waves and their impact on coastal and offshore structures. In fact, the knowledge on the propagation of extreme waves and the attack of extreme waves on coastal and offshore structures is in an infancy. In this study experimental and theoretical investigations were conducted to provide insight into the physics of the formation and evolution of extreme waves. A series of laboratory experiments were conducted in a wave flume of Institute of Hydroengineering Polish Academy of Sciences to study the formation and transformation of freak-type waves over a sloping bottom. The studies are supported by theoretical investigations. The relevance of the results for practical applications is discussed.

An investigation of the velocity field over rippled sand bottom

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ABSTRACT

Keywords: *sand ripples, velocity field, PIV method*

Ripples at the sandy seabed are the consequence of the oscillating movement of the water particles. They are the reason for the increase of the roughness of the bottom becoming an important factor in the sediment transport process. Better understanding of the processes taking place in the near-bottom flow field will allow accurate description of the mechanism of sediment transport.
The investigation of the velocity field over rippled sand bottom has been carried out in the wave flume of the Institute of Hydroengeenering of the Polish Academy of Sciences in Gdańsk. The measurements were performed using the technique of Particle Image Velocity (PIV). The results obtained describe the instantaneous velocity field of sandy sediment particles constituting the bedload and the instantaneous velocity field of water particles. Both vertical and horizontal components of sand velocity field were obtained. Experiments covered the region in the immediate vicinity of the sandy bottom coated by ripples.
The velocity field of sediment grains over ripples has been determined. It can be concluded that the PIV method of measuring the movement of sediment particles at the bottom proximity has proven itself. The instantaneous velocity field of sediment particles has been recorded with reliable accuracy.

Feasibility Study and Optimization of the Structural Design of Locks made out of Plain Concrete

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ABSTRACT

Keywords: *Ship-lock structures, plain concrete, feasibility, optimization*

Modern ship locks are constructed through steel reinforced concrete and similar to other hydraulic structures the lock structure interacts with high variation in physical and chemical environments. Processes like carbonation, freezing and thawing and acid attack progressively reduces the durability of concrete structure. Rapid deterioration of concrete cover leads to an increasing ingress of chloride, oxygen and moisture causing excessive corrosion of the embedded steel reinforcement and exponential decrease in structural strength and durability is inevitable.
Viewing the problem German Federal Waterways Engineering and Research Institute (Bundesanstalt für Wasserbau, BAW) initiated a feasibility study in cooperation with Department of Hydraulic Engineering and Water Resources Management, University of Stuttgart in which only plain concrete is used for construction. This construction method had been used successfully long time ago and was replaced by reinforced concrete constructions in the 1960. The study targeted on design and analysis of a typical lock structure without any reinforcement and with length of 190 m, width of 12.5 m, a fall of 10 m. The study emphasized on lock chamber walls as they are the most labour and cost intensive components, whereas locks head and gates were excluded. The structural and geotechnical static verifications were made along with Finite Element Analysis using ANSYS. These processes were followed in accordance to standards and design philosophies of Eurocodes (EN 1990, 1992, 1997) and German standards (i.e. DIN 19702). The structure was designed for three operating conditions, when the water level is at maximum, minimum and no water in the lock chamber (maintenance condition). Dimensional optimization is preformed through linear programming and sensitivity analysis for variation of groundwater level, concrete type and soil type to assess their impact on dimensions of the designed lock structure.

References

DIN19702 (2013) Deutsches Institut für Normung. Solid structures in hydraulic engineering, Berlin: Beuth Verlag GmbH.
EN 1990 (2013) European Committee For Standardization. Eurocode -Basis of structural design, Brussels: European Committee for Standardization.
EN 1992 (2013) European Committee for Standardization. Eurocode - Design of concrete structures, Brussels.
EN 1997 (2013) European Committee for Standardization. Eurocode - Geotechnical design, Brussels

Air concentration measurements and velocity estimation with a single tip conductivity probe

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ABSTRACT

Keywords: *air-water flows, air concentration measurement, air-water interfacial velocity, chord sizes, stepped spillways*

Air-water flows can be found in different engineering applications (Chanson, 2013): from nuclear engineering to huge hydraulic structures. When air is found dispersed in the water body, carrier phase properties change, yielding different energy dissipation, turbulence properties and macroscopic quantities (i.e.: bulk flow depths and bulk density). Consequently, proper characterization of such flows may improve structures safety and reduce design costs.
In this paper, a novel technique is investigated allowing estimation of air concentration and interfacial velocity by complementing hardware deficiencies with most advanced numerical techniques. In this case, a single tip optical fiber probe is employed to describe both air concentration and velocities; the latter based on a rising times estimation.

REFENRECES
Chanson, H. (2013). Hydraulics of aerated flows: qui pro quo?. Journal of Hydraulic Research, 51(3), 223-243.