Technical workshop TW 5

Physical and Numerical Modelling – – Role and Limits

Friday, July 7, 13:00 – 16:30, Hall Leo

Designated organizers:

- Miroslav BROUCEK (Faculty of Civil Engineering, Czech Technical University in Prague)

- Jiri HODAK (VD-TBD, Inc.)

Workshop attendants are invited to visit the Water Management Experimental Centre at CTU in Prague, where physical models of Decin locks, Tesetice dam and Tokyo white water Olympic channel will be introduced. The excursion will take place on Friday from 10 to 11 am. Please register for this excursion with Miroslav Broucek, contact detail follows, as the number of visitors is limited. A guide from Clarion Hotel to CTU laboratories will be provided.

Advancements in computer capacities allowed for numerical modelling to be preferred to physical models in some areas of civil and mechanical engineering. Considerable decrease in the costs of computational time is even more important for the expansion of computational fluid dynamics (CFD). Although direct numerical simulation of complex geometries is still unattainable the turbulence models currently used provide sufficient level of accuracy the variables of interest. Despite the described advancements in CFD, physical models, even with all the limits resulting from dynamic similarity, are still competitive, especially, when unsteady conditions are applied and dynamic response is expected.

The workshop focuses on practical examples of recent projects while addressing the important issue of limits and roles of both numerical and physical modelling in modern design and operation of hydraulic structures.

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Programme:

13:30 – 13:40 Invitation (M. Broucek + J. Hodak)

13:40 – 14:00 Malm, R. (KTH Royal Institute of Technology)

Guideline for finite element analysis

14:00 – 14:20 Sevieri, G. (TU Braunschweig & University of Florence)

Seismic assessment of existing concrete gravity dams: Model selection and uncertainties quantification

14:20 – 14:40 Höll, J. (VD – TBD, inc.)

3D spillway numerical modelling in OpenFOAM

14:40 – 15:00 Yang, J. (KTH Royal Institute of Technology)

The Tale of an Intake Vortex and its Mitigation Countermeasure

15:00 – 15:30 Coffee break

15:30 – 15:50 Haselsteiner, R. (Björnsen Consulting Engineers)

Fish passages in Germany – Numerical Modelling and Projects

15:50 – 16:10 Mool, P. (IHE Delft, Institute for Water Education)

Delft3D morphological modeling of sediment management in daily peaking run-of-the-river hydropower (PROR) reservoirs in Nepal

16:10 – 16:30 Broucek, M. (CTU in Prague)

Dam engineering modelling projects at CTU in Prague - Lessons learned

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Short abstracts:

13:40 – 14:00 *Malm, R.*

Guideline for finite element analysis

Numerical 3D finite element (FE) analyses allow the engineers to perform more accurate and detailed analyses, compared to the traditional design methods. Today, FE-analyses are a common tool for assessment, design etc. of concrete dams. However, there are not only positive aspects of this development. These numerical analyses require a solid theoretical background of the applicability of methods, both from the FE-engineer performing the analyses but also for the reviewers of the results. In addition, the results obtained require careful interpretation with respect to the underlying assumptions and their practical relevance.

This presentation is based on a newly developed guideline for finite element analyses (FEA) of concrete dams. It describes and gives practical recommendations for the aspects that engineers are facing when performing mechanical analyses of concrete dams. The main focus of this presentation is regarding progressive failure analyses; such as when it may suitable to perform these with FEA but also give tips and recommendations on how these can be performed.

14:00 – 14:20 *Sevieri, G.*

Seismic assessment of existing concrete gravity dams: Model selection and uncertainties quantification

Nowadays dams are still a key component of our infrastructures for energy production, water regulation and irrigation. In our time, due to economic and environmental reasons, just few new dams are now being built, so older ones, which are inexorably ageing, are required to have a longer life expectancy. For these reasons, our community is growing in a better understanding of the seismic risk of the existing infrastructures. There are no case histories of dams collapsed after seismic events, then numerical models are necessary tools to evaluate their seismic behaviour. In this regard, a good opportunity to calibrate the model is provided by the monitoring data recorded during normal operation of the dam, varying the water level and temperature. This topic is the object of the presentation, presenting a methodology developed to calibrate the models.

14:20 – 14:40 *Höll, J.*

3D spillway numerical modelling in OpenFOAM

Introduction of process used for numerical 3D CFD model in OpenFOAM environment. Presentation of Slušovice dam spillway case study which consist of geometry model creation, meshing, running simulation and results verification. Advantages, disadvantages and simulation demands will be introduced and discussed. Comparison with physical model will be shown.

14:40 – 15:00 *Yang, J.*

The Tale of an Intake Vortex and its Mitigation Countermeasure

The upgrade of Akkats power station included construction of a new, separate waterway for addition of a 75-MW generating unit. The vertical intake of the headrace was formed by means of so-called lake tapping. During its commissioning, swirling flows occurred unexpectedly at the intake. The vortex formation limited the power output and also led to other objectionable results. Echo-sounding showed that the blasted piercing resulted in an irregular intake shape. A physical model in scale 1:30 was constructed, with the purpose to examine potential countermeasures for vortex suppression. The solution was the use of a segmented wall placed from the intake perimeter to the dam. The wall was anchored into the bedrock and stretched to below the lowest legal reservoir level. It was composed of five fabricated steel segments; an opening was left between two neighboring sections to reduce the load resulting from the swirling flow. The model tests showed that the segmented wall effectively suppressed the flow circulations at the intake; only minor intermittent vortices were left. The local headloss at the intake was also reduced. The implemented solution was tested under full turbine loading with satisfactory results. Even during winter seasons with ice cover above the wall, the power station ran normally.

15:30 – 15:50 Haselsteiner, R.

Fish passages in Germany – Numerical Modelling and Projects

15:50 – 16:10 Mool, P.

Delft3D morphological modeling of sediment management in daily peaking run-of-the-river hydropower (PROR) reservoirs in Nepal

Himalayan rivers are known to have very high sediment yield when compared to similar river basins around the world and the same applies to the rivers in Nepal. Therefore, reservoir sedimentation is one of the most serious concerns for all kinds of existing and planned reservoirs in the region. This is particularly important for relatively smaller daily peaking reservoirs as their daily peaking storage volume can be diminished at very high annual rates. But, unlike in the large reservoirs, the operation of gates can have significant impacts on the long-term sediment management in peaking run-of-river (PROR) reservoirs. The research has been conducted for a planned peaking run-of-the-river reservoir (Kabeli-A HEP) in Nepal. The reservoir has total planned storage capacity of 1.05 Mm3 with 0.504 Mm3 as the live storage volume for the peak energy generation during dry season.

The objective of this study is to explore the performance and application of a state-of-the-art Delft-3D morphological model coupled with Real Time Control (RTC) tool for reservoir gate operation, to address the problems associated with sediment management in PROR reservoirs. The main focus of the research is on following issues: (i) sedimentation in PROR reservoirs in the hilly region of Nepal; (ii) sediment management options in PROR reservoirs; (iii) reservoir sustainability for PROR reservoirs in the hilly region.

The research has attempted to establish the background for application of numerical models as a supplementary tool to physical models for reservoir operation and morphological processes of planned as well as existing reservoirs. The morphological model, coupled with RTC tool, has been used with graded sediment transport. The reservoir gate operation policy, suggested based on the physical hydraulic model study, has been used to develop the reference model. The results of the reference model simulations for the reservoir sedimentation rates, reservoir deposition pattern and reservoir sediment distribution have been analyzed.

16:10 – 16:30 Broucek, M. (CTU in Prague)

Dam engineering modelling projects at CTU in Prague - Lessons learned

Czech technical university in Prague has over 60 years tradition in physical modelling of dams and appurtenant structures. Numerical modelling is also used for research and consulting projects and nowadays quite often hybrid modelling is applied. The contribution focuses on practical examples of hybrid, physical and numerical models carried out at CTU in Prague with particular emphasis on unexpected outcomes and issues dealt with during the projects.Contacts:

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