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# FLOW BASED VIBRATIONS OF SLUICE GATES – PHYSICAL AND NUMERICAL MODELLING

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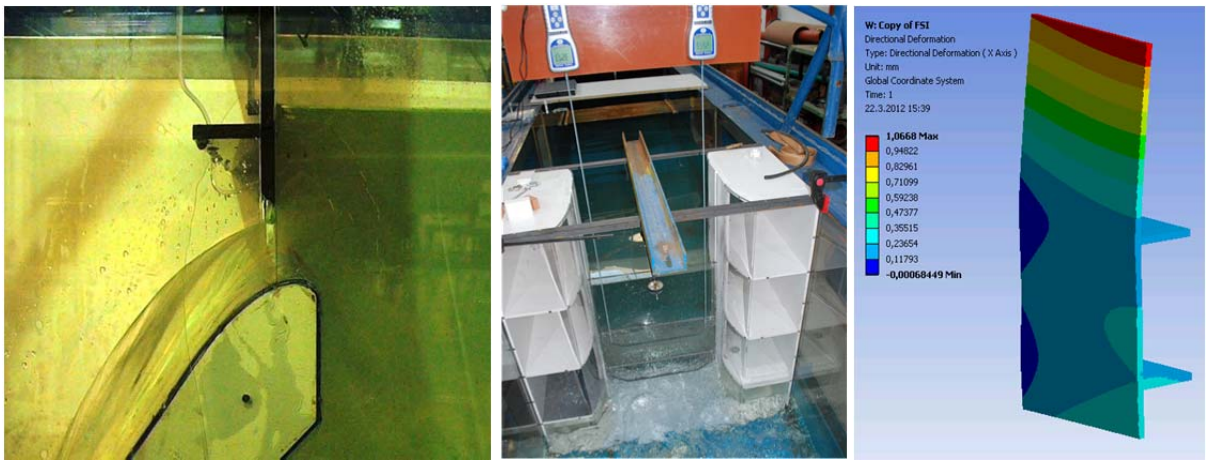
**Abstract:** *The first part of the paper presents results from laboratory experiments simulating hydrodynamic load acting on the large model of sluice gate located on spillway. Vibrations of the gate as one of the key aspects of durability and reliability of sluice gates as outlet works were measured together with forces in operating mechanism and pressures in surroundings. The second part is focused on numerical modelling of the executed experiments and aims at possible approaches for reliability assessment of sluice gates. The influence of the shape of the gate bottom on induced vibrations and possible cavitation is discussed in both parts.*

**Keywords:** ***Sluice gates, Physical modelling, Numerical modelling, Vibration***

Reliability of flood gates installed on emergency spillways of hydraulic structures become widely discussed topic after major flood events struck Czech Republic in 1997 and 2002. Malfunction of flood gates followed by overtopping of the dam with all the related impacts is a primary cause in more than 25 % cases worldwide (Cassidy, 2000). Although no serious case of malfunction on important hydraulic structures during floods was reported in Czech Republic so far, increased probability of accidents can be expected despite regular maintenance as most of the gates are rapidly approaching the end of their designed service life (Bubeník, 2000).




*(a)* *(b)* *(c)*

*Fig. 1: Laboratory and numerical models: (a) spillway no. 1, (b) spillway no. 5, (c) sluice gate*

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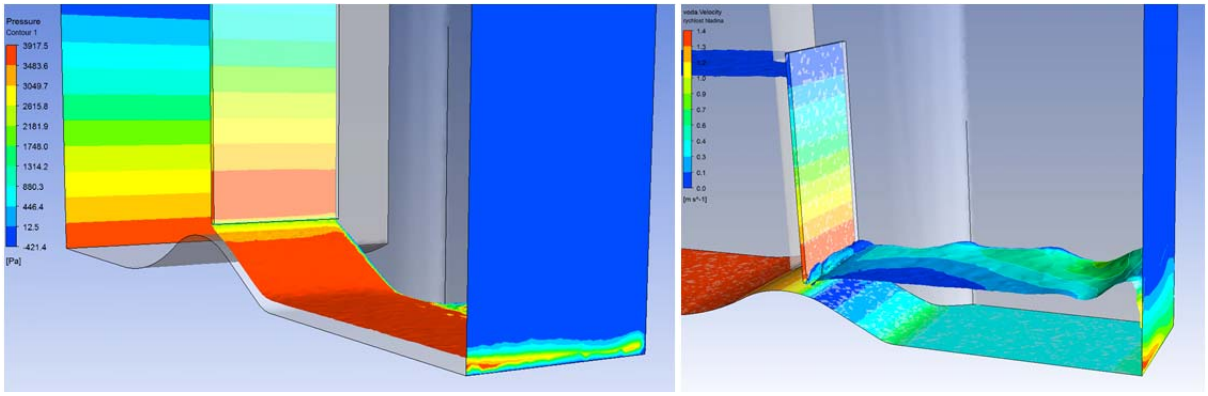
The scope of the present contribution involves hydraulic and dynamic analysis of flow under the sluice gates. The importance of the issue of discharge under the sluice gate and possible vibration of the gate and foundation structure follows from operational grounds as well as from the reliability point of view. Hygienic standards also influence the necessity for deep understanding of this topic. Theoretical part of the paper is aimed at discharge under and over the sluice gate.

The experimental part focuses on description of principles used for measurement and evaluation of values on physical models constructed in the hydraulic laboratory at the CTU in Prague, Faculty of Civil Engineering, see Fig. 1 (a) and (b). Standard calculations were implemented in the design of the models (see. Gabriel et. al., 1989). Pressures acting on the foundation structures and vertical forces acting on the gate structure under the steady state, gate lifting or lowering conditions measured on the physical model are presented in the experimental section.

The last section of this paper describes numerical model of sluice gate created in ANSYS Workbench environment while using ANSYS CFX code for modelling of flow (see Fig. 2) and ANSYS Mechanical code for structural analysis, see Fig 1. (c). It comments on the results obtained by applying one-way fluid-structure interaction where hydrodynamic forces calculated in fluid part are used as boundary condition for the structural part. First ten eigenfrequencies and corresponding shapes of the laboratory model were determined by modal analysis and are presented in the final part of the numerical section.




*(a)* *(b)*

*Fig. 2: CFD model: (a) Pressure acting on the gate without the tailwater influence, (b) hydrostatic pressure (water surface) with the rising tailwater level*

Even with no calibrating procedure employed the hydraulic results are in reasonably good agreement with measured values of discharge and pressures. The results obtained from structural analysis show, however, the necessity of calibration of the material characteristics and model topology. The obtained results will be compared with the extensive program done by (ICOLD, 1996).

Hydrodynamic loading acting in the horizontal direction on the gate structure is mainly caused by the upstream water surface wave action and tailwater influence which shifts the hydraulic jump backwards to contact with the gate. Oscillations of the pressure in the hydraulic jump are then transferred to the gate structure. Hydraulically sharp or unsuitably shaped bottom edge of the gate can be the source of vibration even without the tailwater influence.

**Acknowledgement**

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**References**

Bubeník, M. (2000) Maintenance concerning the reliable operation of spillway gates on dams in Czech Republic. Q79. R20. *20th ICOLD Congress*. Beijing. China.

Cassidy, J. J. (2000) Gated spillways and dam safety. *Hydropower & Dams*. **6**. 71-75

Gabriel, P. et al. (1989) *Jezy - Weir structures*. Czech Republic. (in Czech).

International Commision of Large Dams – ICOLD (1996) Vibrations of hydraulic equipment for dams. *ICOLD Bulletin 102*