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Eco-friendly Design of Stilling Basins Geometry for Flood Mitigation Dams

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Problematic: Recently floods are being experienced in areas where there were no floods in the past. Therefore, it is inevitable to construct Flood Mitigation Dam (FMD) and update its design. FMD is a gateless outlet dam designed only for flood control whose bottom outlets are installed at the original river bed level. FMD are considered eco-friendly because of their peak reduction reputation without rupturing the normal flow regime and facilitate sediment transport as well. Stilling Basin (SB) is an energy dissipater placed at the dam outlet. There are several problems in the present design of SB of FMD: a) blocking of the fish passage by the end sill; b) negative impacts on the landscape design; c) high cost. Therefore, updated planning and design of SB has become a significant issue from above points of view.

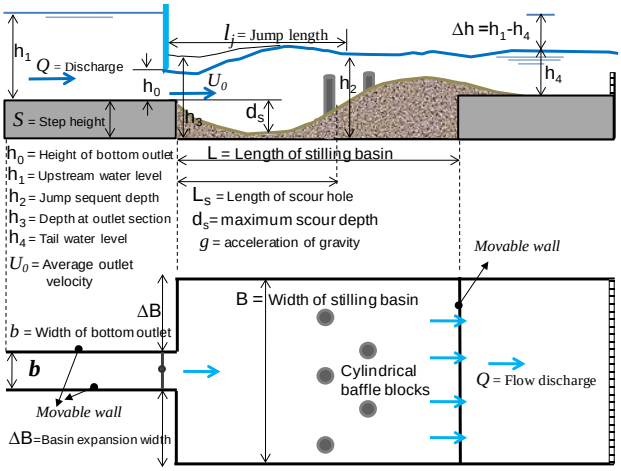

Figure 1. Concept of the in-ground stilling basin

Concept and purposes: The present study introduces a new concept to create and design in-ground SB combined with cylindrical baffle blocks as shown in Fig. 1, which complying with both flood mitigation and biodiversity preservation requirements. The main question is what are the optimal SB configuration and upstream conditions to maximize the energy dissipation (ΔE), fish passage and minimize the cost? That will be possible via a natural expanded SB with abrupt drop where the SB bed is covered by original rock or artificially placed large stone and boulders which will be trapped in the SB. Then, the clear water phase will erode the movable layer of previous deposited sediment and scour hole will be generated. During the high flood a free and submerged hydraulic Jumps (HJ) will be developed according to the tail water depth. A scour processes will take place, which form a natural pool and morphological features within SB and also has a fundamental ecological advantage.

Key parameters: The scour depth (d_s) and energy dissipation in SB with sudden expansion are strongly affected by SB geometry, flow conditions and configuration of the bottom outlet characteristics. Figure 1 summarizes parameters that influence SB design criteria and dissipation of energy is $\Delta E = f(U_0, b, h_0, h_4, B, L, S)$. The flow conditions of HJ are governed by non-dimensional factors: the inflow Froude number $F_0 = U_0/\sqrt{g h_0}$, the expansion ratio B/b, the aspect ratio of SB L/B, the aspect ratio of bottom outlet b/h_0, the relative downstream depth h_4/h_0, and the relative step height S/h_0.

Methodology: Physical model combined with 3D numerical modeling will be investigated for both clear-water and sediment phases. Finally some challenge aspects regarding the design will be tested, i.e. number of dam outlets, SB bed roughness, movable sediment grain sizes, and flexible water levels in the upstream reservoir.