

PhD research project - Unstructured block ramps



Fig. 1: Unstructured block ramp at Landquart River (Canton Graubünden, Switzerland).

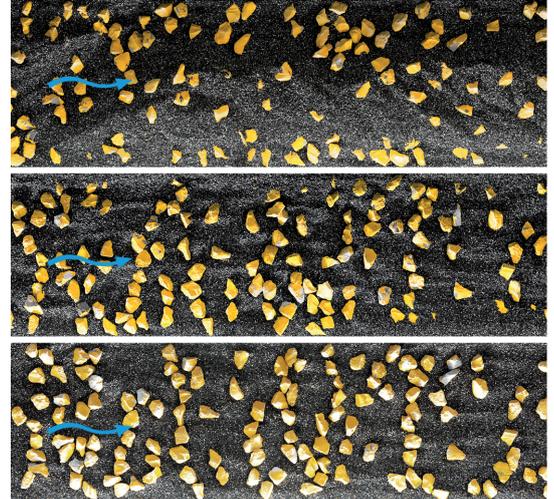


Fig. 2: Top view of the central part of the ramp after various hydraulic loads under clear water conditions. From top to bottom: specific discharge $q = 6.7 \text{ l/sm}^2$, 26.7 l/sm^2 , and 60 l/sm^2 .

Block ramps are engineering structures used for river bed stabilization. The gradually change of geodetic height combined with moderate flow velocities enable for passage of fish and other species, while controlled energy dissipation is achieved. During the last decades many existing drops and sills have been replaced by block ramps and many more are planned. However, during the last flood events many of them failed, pointing at insufficient design.

As a special type of block ramps, unstructured ramps (Fig. 1) are characterized by large isolated blocks randomly placed on the river bed. Typical applicability ranges are a ramp slope $S < 3\%$, a maximum block weight up to 5 t, a block placement density $I < 30\%$, and a specific discharge $q < \approx 12 \text{ m}^3/\text{sm}^2$.

Since ecological requirements for river engineering measures are becoming more and more eminent, the applicability of block ramps is not only depending on stability criteria, but also on their ecological behavior, where structural heterogeneity and flow conditions are important. The ecological functionality, particularly in terms of fish migration corridors and habitat for macroinvertebrates, of unstructured block ramps is not yet fully proven.

Therefore this research project is focused on two major aims, namely (i) to analyze the hydraulic conditions on unstructured block ramps to improve existing stability criteria and (ii) to prove if: a) fish and other species can overcome the ramp, and b) appropriate habitat conditions for certain species are generated. For a detailed understanding of (i), the laboratory tests are divided in two test phases. In test phase one, the ramp behavior is studied under movable bed conditions related to bed structures that occur during various discharge and bed load transport conditions (Fig. 2). In a second phase, turbulence characteristics on the ramp particularly between the blocks are studied applying 2D LDA on a fixed bed topography derived from the first test phase.

Based on the characterization of the hydraulic conditions, the ramp stability and the ecological functionality are analyzed, e.g. by describing the presence or absence of migration corridors representing the needs of different species. The laboratory study is supplemented by field tests where the migration capacity of two different fish species is investigated.

- Understanding the flow and sediment transport processes occurring on the ramp
- Defining the ramp roughness depending on the block placement density, the equivalent block ball diameter, and the submergence level h/D
- Providing comprehensive design guidelines
- Verifying the ecological functionality

Keywords: block ramp, roughness elements, ecological functionality, design guidelines
 Commissioned by: Federal Office for the Environment (FOEN)

