

Debris flow barriers



**Flexible ring net barriers preferred to concrete dams:
the Riale Buffaga experience (Ronco s./Ascona, Switzerland)**

Flexible ring net barriers preferred to concrete works: the Riale Buffaga experience (Ronco s./Ascona, Switzerland)

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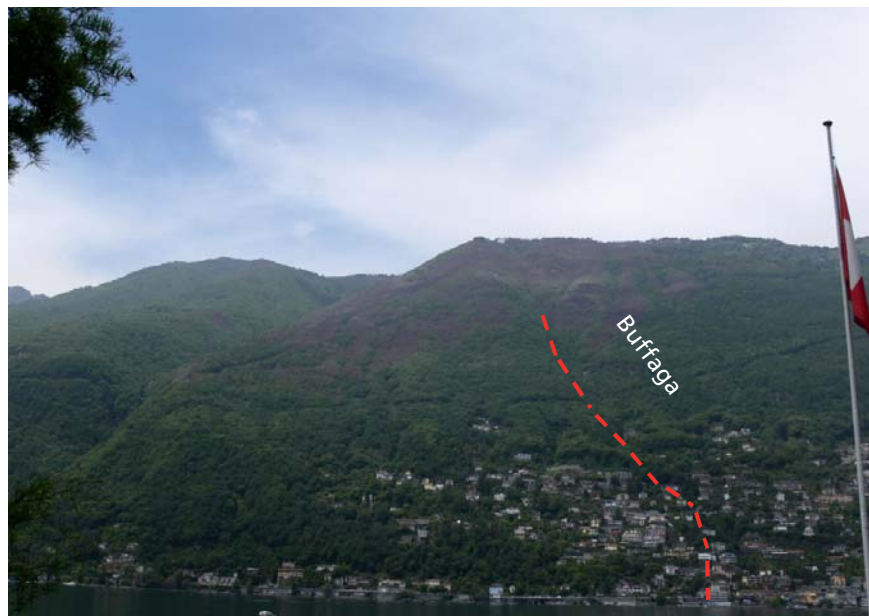
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INTRODUCTION

The work described below is located on the territory of Ronco s./Ascona (Switzerland), on the banks of Lake Maggiore and is part of the urgent works carried out after the fire of April 23-26, 2007. This event widely affected the mountain slopes above the inhabited localities creating the problem of possible consequences from battering rainfalls over the catchment basin of the Riale Buffaga. Such an event took place in August 1997, when the Riale Buffaga produced a debris flow that reached and obstructed the cantonal road of Ascona-Brissago causing considerable damage to structures. The volume of material transported during this event was estimated at approximately 4,000 m³.

Fig. 1: View of the lake of Buffaga; situation after the 2007 fire; a red traced line of the torrent channel



Material already present on the torrent bed can be moved in the case of intense precipitation, or solid material on the slopes of the banks can also be eroded in the case of flow surges.

The consequences of the fire to the vegetation cover considerably increased the quantity of erodable material. The Swiss Federal Institute for Forest, Snow and Landscape Research (WSL) conducted suitable studies of the above terrain after the fire of March 1997. The results show how the average surface meteoric runoff during the first year after the fire, is almost double as opposed to the unburned forest, and then, in the second year, the balance is restored. The average erosion of the surface during the first and second years after a fire is by far higher than that of an unburned forest. Studies done in the field after the April 2007 fire have quantified the transportable materials in the basin of the Riale Buffaga at approximately 3,300 m³. For these reasons, the need arose to proceed with extremely urgent works that could be carried out in a short time period. These solutions are economically feasible and expected to ensure the achievement of an adequate safety standard with respect to



Fig. 2: View from above the area involving the works

the hydraulic risk. A reinforced concrete debris collector with a capacity of 3,000 m³ was considered as an alternative to the flexible barriers finally selected.

DESCRIPTION OF THE WORKS

The solution involves three GEOBRUGG flexible ring net barriers, UX and VX type, with a width ranging from 21.7 and 10.8 meters, installed across the axis of the Riale Buffaga: two upstream from the bridge of Barcone Street and one immediately downstream. The position of the barriers was determined following a detailed topographic survey and an accurate inspection with the objectives of optimizing the accumulation capacity, not causing damage to the building situated nearby, and keeping an eye on the feasibility of any cleanout operations.

The ropes and the ring nets are made of high-tensile flexible components (ultimate tensile strength=940 kN, steel wires $f_{p,0.1k}=1,770 \text{ N/mm}^2$). The super coating treatment, 95% zinc coating and 5% aluminum, ensures a resistance to corrosion of 2.5 times higher than normal zinc coating. The anchorages are created in fully locked spiral ropes and polyethylene sheath for the double and simultaneous injection of cement grout, with added accelerants that reduce the fastening time of the cords to them. Injecting is realized simultaneously between the fully-locked spiral ropes and polyethylene sheath and between the polyethylene sheath and the bore hole. This ensures double protection against corrosion. An accelerating additive was mixed with the cement mortar to shorten the hardening duration and, consequently, the installation duration. The protection against corrosion is of level 2 according to the SIA (Swiss Society of Engineers and Architects), regulation no. 267 "Geotechnics", corresponding to the one regarding permanent anchorages. The length of the anchorages is 6 meters.

The barrier downstream from the bridge, because of its width, requires the installation of a center post with HEB 180 metal profiles, hinged on the isolated concrete footing by means of a mounting plate. This plate is anchored to the ground with two SWISS GEWI anchor bars, of a diameter of 32 mm and 3 m long, protected with a polyethylene sheath and injected with cement grout. The downstream anchorage is vertical while the upstream is inclined by 45°.



Fig. 3 (above): Detail of barrier 3 (UX) on the left bank of the torrent



Fig. 4 (above right): Barrier 2 (VX) downstream view, barrier 1 in the background

OPERATIONAL ASPECTS

The implementation of the works is characterized by the particular terrain conditions in which the works were carried out and by accessibility. Equipment and materials were therefore transported exclusively by helicopter rather than building a construction site access trail over the channel. For the downstream barrier, the supply of the construction site was done from the nearby bridge of Barcone Street with the help of a mobile crane. The lateral anchorages in

the banks were inclined approximately 15° vertically as well as horizontally. Double injection also increases the durability of anchorages in this case.

CONTAINMENT CAPACITY

The volume of accumulated materials behind the three barriers was calculated on the basis of the site topography determined through special photos. Neither the additional volume created in the bulge through warping of the nets nor the volume created by an inclined retention slope were taken into consideration. The following retention volumes were thus determined:

- barrier 1 300 m³
- barrier 2 140 m³
- barrier 3 260 m³
- **total** **700 m³**



Fig. 5: Accumulation planimetry and the expected volumes of debris retained by the three barriers

MAINTENANCE AND CLEANING

The normal maintenance activities will mainly consist of visual checks of the components that make up the barriers. Special attention must be given to the removal of the vegetation in the channel to avoid obstruction of the normal water flow under the barriers through floating timber.

With regard to the removal of the deposited materials behind the barriers, the two upstream barriers are provided with a movable protection panel on hooks that allows the downstream sliding of part of the materials and the creation of a passage for an excavator. According to the volume of the material to evacuate, its removal by means of a conveyor belt or a construction trail was provided for up to the Barcone Street bridge. The downstream barrier will instead be emptied directly from the back with a mobile crane placed on the bridge.

CONCLUSIONS

During the course of the summer of 2008, risk mitigation works for debris flow were carried out along the channel of the Riale Buffaga, near Ascona (Switzerland). The works consisted of the creation of three GEOBRUGG barriers expressly developed for that purpose and set up as a result of the geomorphologic and hydrodynamic in-depth studies by the Swiss Federal Institute for Forest, Snow and Landscape Research (WSL) of Birmensdorf. The three barriers were preferred to the more traditional concrete barriers, as they provide advantages when it comes to maintenance and from an aesthetic point of view. They also have less of an effect on the ecological system in the channel.

The works were carried out by the specialized company, Filippi SA of Airolo, under the design and project management of Studio Anastasi SA Engineering, of Locarno to whom the Commune of Ronco s/Ascona has commissioned the task.



Fig. 6: Barrier no. 1 (VX): View from below



Fig. 7: Side view of barrier no. 3 (UX), located upstream from the bridge on Barcone Street



Fig. 8: Details of the barrier



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