EGU22-11094, updated on 09 Jun 2022
https://doi.org/10.5194/egusphere-egu22-11094
EGU General Assembly 2022

Safety assessment of historical barrages and hazard cascades following their failure: the Roggia Morlana case study

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Barrages are low-head dams, used to realize diversion works for irrigation, hydroelectric or human consumption purposes. These in-river structures control the river bed elevation and maintain a prescribed water level upstream, affecting the levees' elevation too if present. Often, they have been present for a long time (in the examined case centuries) and act as an inherent element of the surrounding environment, representing a constraint for the human activities growing through the years along the river.

The Roggia Morlana barrage, which is located across the Serio River in the Province of Bergamo, northern Italy, has for centuries been a fundamental part of the econ life in the area, thanks to the several artificial canals that supply water for irrigation purposes. In the mid-twentieth century, a maximum capacity of 4500 l/s was derive distributed in an extensive area of about 4200 hectares, while nowadays this barrage keeps an important role also for hydroelectric power production.

In October 2020, an event led to the collapse of a part of the barrage and to the subsequent lowering of the river bed and destabilization of the banks. In addition to the stop of the hydropower production and the lack in satisfying the irrigation demand, the retrogressive erosion threatened various fundamental infrastructures crossing the river upstream (a gas pipeline, a water main and a bridge), hence a rapid rehabilitation of the barrage was required.

The stability of the restored barrage depends on the flood discharges and on the related scouring phenomena that could take place immediately downstream. With the aim to assess the exposure and vulnerability of this critical infrastructure to the natural hazard, the effects of different riverbed protection configurations are analysed through physical modelling, testing each configuration against flood events.

The area downstream the barrage is subdivided in frames delimited by bottom sills, filled with material. The physical model allowed to evaluate the effectiveness in scouring mitigation using different size of natural stones, put in place as loose boulders or wired in groups. To reduce the amount of damages and increase the resilience of the riverbed protection boulders have been substituted by concrete blocks in some frames. By this way, the goal to shift the scouring phenomena downstream, localizing the maximum scour depth far from the barrage foundations, is fulfilled.

The cost of the restoration obtained via different riverbed protections, increasing with the resilience of the barrage, is compared with the cost of their failure that can cause complex hazard cascades. This is because a failure of the Roggia Morlana barrage does not have consequences only to the hydropower production and irrigation service, but also on the safety of the infrastructures crossing the river upstream, potentially affected by backward erosion phenomena.

How to cite: Giaretta, P., Trentin, T., and Salandin, P.: Safety assessment of historical barrages and hazard cascades following their failure: the Roggia Morlana case study, EGU General Assembly 2022, Vienna, Austria, 23–27 May 2022, EGU22-11094, https://doi.org/10.5194/egusphere-egu22-11094, 2022.