CASCADING EVENTS FOLLOWING THE ROGGIA MORLANA BARRAGE FAILURE AND MULTI-RISK ASSESSMENT

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1. INTRODUCTION

The Roggia Morlana barrage [1]

The Roggia Morlana barrage is an ancient structure located along the Serio river in the province of Bergamo, northern Italy. Since 1200, it was used for irrigation purposes in combination with several artificial canals that derive water from it. The areas surrounding the barrage are urbanized on the left of the Serio river and host industrial settlements on the right. Nowadays, it has an important role also for hydroelectric power production. Furthermore, several fundamental infrastructures are located 200 m upstream of the barrage, that are a gas pipeline, a water main and a bridge.

The collapse

In October 2020, a flood event of 200 m³/s led to the collapse of the right part of the barrage and to the subsequent lowering of the river bed and destabilization of the banks. The barrage failure caused the stop of the hydropower production and the lack in satisfying the irrigation demand, and the retrogressive erosion threatened the upstream infrastructures which failure induces remarkable issues.

[1] Barrages are low-head dams realized to divert a prescribed amount of flow from the river. These structures control the riverbed elevation and maintain a prescribed water level upstream, affecting the levees' elevation too if present. When, as in the case of the Roggia Morlana, have been present for centuries, they act as an inherent element of the surrounding environment, representing a constraint for the human activities growing through the years along the river.

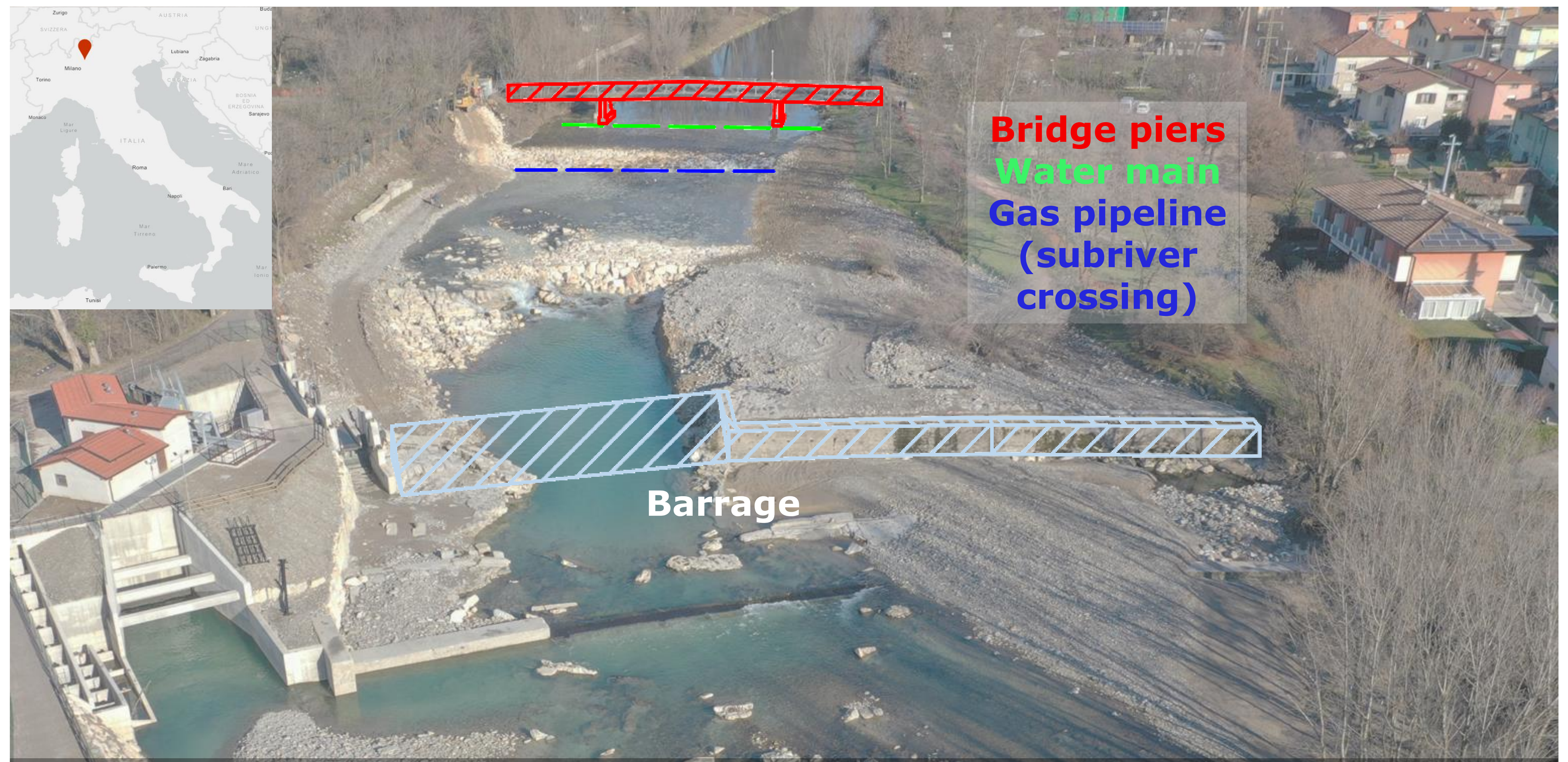


Fig. 1.1: the upstream infrastructures and the barrage immediately after the 2020 event

Side view of the remaining part of the Roggia Morlana after the 2020 event. It is possible to recognize works developed along the centuries

2. METHOD

A proper riverbed protection downstream the barrage grants its stability, but due to the non-standard realization of the Roggia Morlana, its failure during the 2020 event characterized by the 71% of exceedance probability, can be assumed independent from the extension and size of the riprap. Anyway a well designed and realized protection plays a fundamental role in the failure cascading events greatly affecting their probability. The probability that a flood event trigger the instability of the upstream gas pipeline, water main and crossing bridge is here investigated by physical model experiments developed considering flood events of different probability and two different riverbed protection, the original one existing before the 2020 event, and the new one designed for the rehabilitation works.

Fig. 2.1: original riverbed protection a) before and b) after the experiments and designed riverbed protection c) before and d) after the experiments

3. RESULTS AND CONCLUSIONS

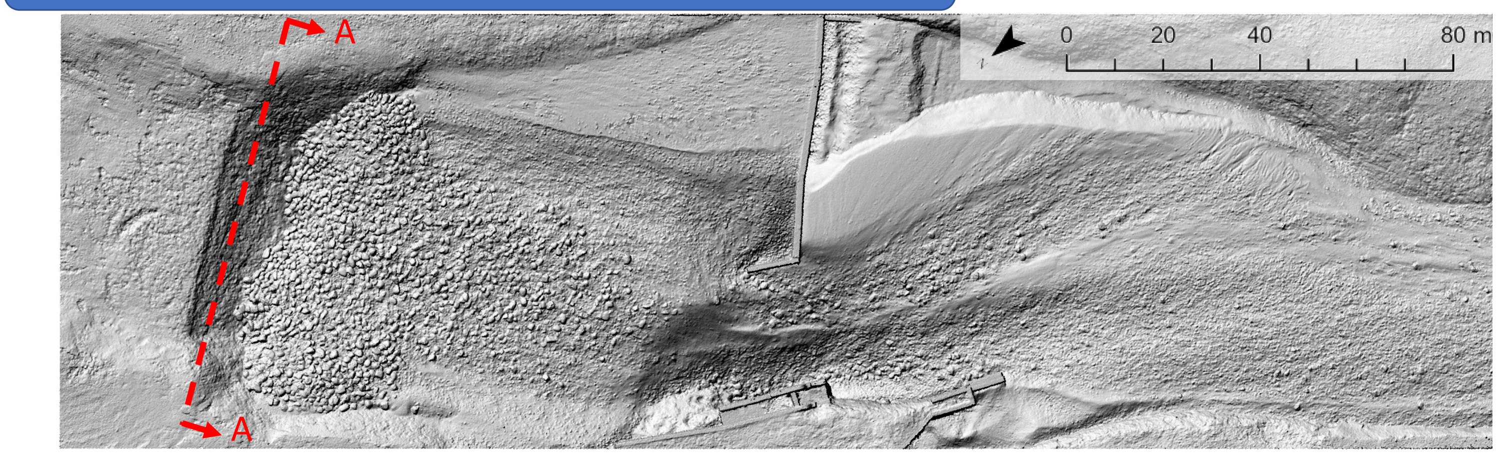
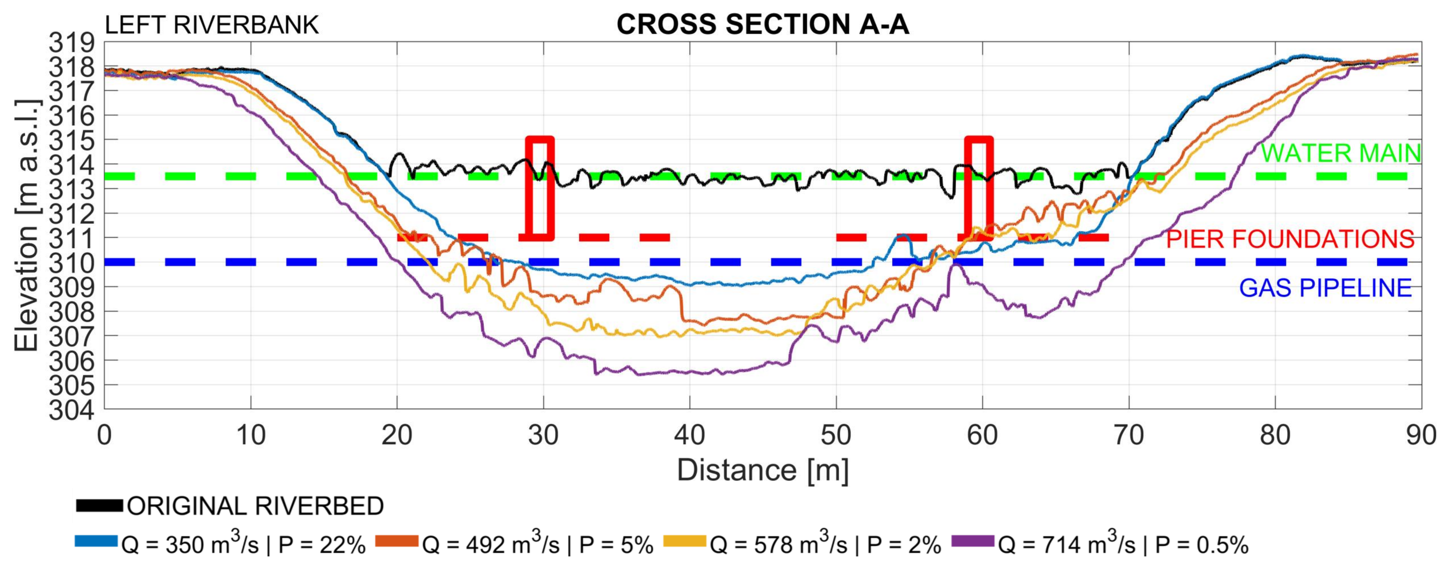


Fig. 3.1: effects of the Q = 714 m³/s with the original riverbed protection



The triggering of the cascading events (regarding the gas pipeline, the water main and the crossing bridge) is assumed to be related to the deepening in the section A-A immediately downstream the pipeline. To evaluate the probability of failure of the infrastructures, a comparison between the sections and the probability distribution of the flood events is made. With the original riverbed protection, a flood event of 350 m³/s leads to the collapse of all the infrastructures, so the failure probability is of 22%, in accordance to the exceedance probability. Using the well-designed riverbed protection, the value of 714 m³/s must be reached for the flood event to lead to the bridge failure, resulting in the failure probability equal to only 0.5%, and being that of the pipeline even smaller. The water main failure probability remains of 22%, corresponding to the 350 m³/s flood event.

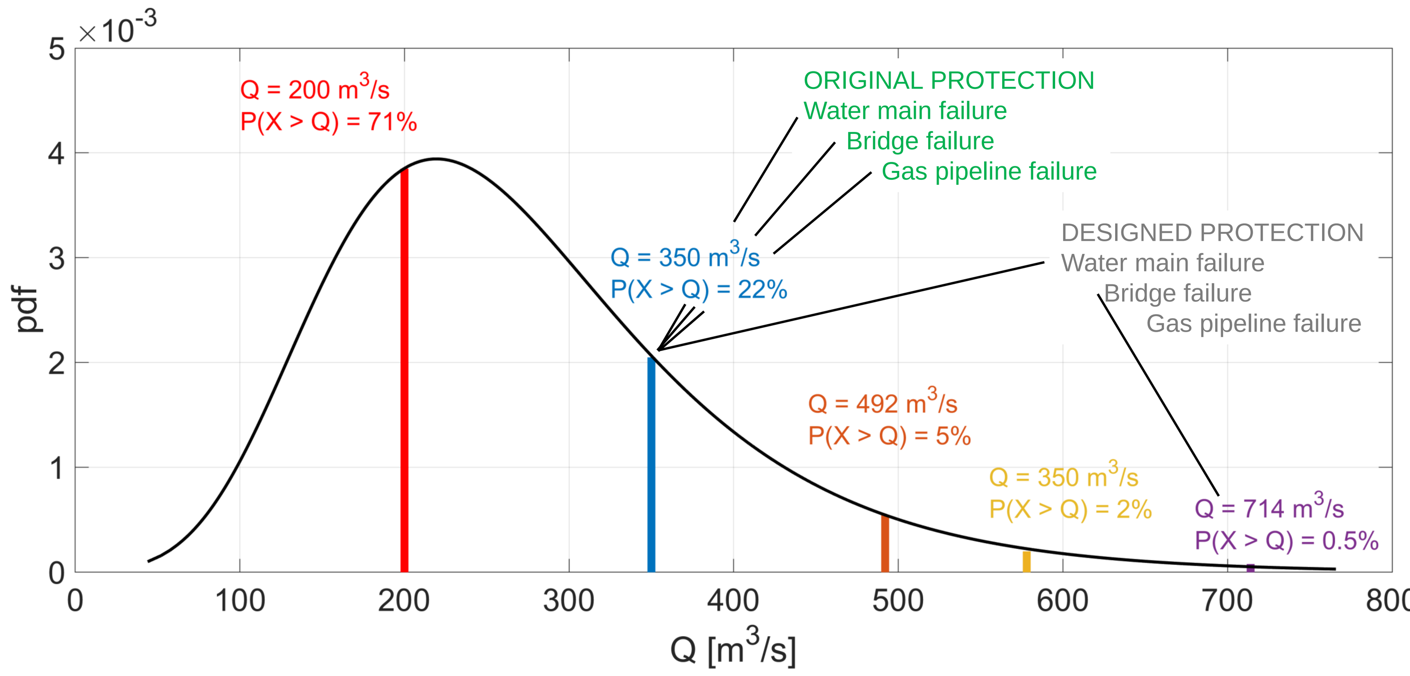


Fig. 3.2: probability distribution of the flood events

Fig. 3.3: effects of the Q = 714 m³/s with the designed riverbed protection