

AN INNOVATIVE APPROACH FOR HAZARD ASSESSMENT AT DIKED RIVERS

Corrado Lucarelli¹ and Walter Gostner²

INTRODUCTION

In the Autonomous Province of South Tyrol each municipality has to elaborate hazard assessment maps for natural dangers such as floods, debris flows, landslides, rock falls and avalanches.

Return periods of 30, 100 and 300 years are usually considered. The hazard zones are defined combining the return period of an event with its intensity. There is a distinction in 3 different levels of hazard: red for very high hazard, blue for high hazard and yellow for medium hazard. Moreover, areas with residual risk are also defined.

However, at rivers that are trained with dikes, according to Italian laws a return period of 200 years has to be considered. The construction of dikes was the basic condition for the economical and urban development of floodplains which could be used by mankind only after these important river training works. On the other hand, in the floodplains nowadays high values are present, and due to failures of dikes often huge damages have at houses, industry, infrastructures and other good have to be faced. Therefore it is of utmost importance to reliably evaluate flood hazards for areas along diked rivers.

HAZARD SCENARIOS AND FAILURE PROBABILITY

Two major scenarios can be differentiated for hazard assessment: either the dikes are overtopped or piping through the dike occurs. In both cases the dikes are eventually destroyed causing the inundation of the floodplains. Whereas the first case is a straightforward one to evaluate, for the second case differentiated considerations have to be made.

In order to assess the probability of flooding due to piping and subsequent failure of dikes an innovative approach has been developed. In fact, the probability of piping and dike failure lies between 0% and 100%. In order to calculate the probability of dike failure, the semi-probabilistic safety concept of the Eurocodes have been used (i.e. limit state equation of reliability analysis), by taking into consideration geotechnical and other characteristics of the dikes, such as dike geometry, presence of a counter dike, friction angle and cohesion of the soil types forming the dike, cover of the dike crest, protection of dike toe, presence of diaphragm walls or other sealing systems, etc. The establishment of a best estimate fragility curve, by taking into consideration also the variability of parameters with the help of a Monte-Carlo analysis, served to correlate water depth in the river with failure probability of the dike. Since flow depth in the river can be related to a certain discharge, the failure probability of the dike can be correlated to the return period of the flood event occurring in the river (Fig. 1).

With the help of event trees the probability of a dike failure was then combined with the probability of the appurtenant flood event (return period) occurring in the stream. From these calculations it was possible to define the probability for flooding of the affected areas.

In order to define the hydrographs inundating the floodplain a historical analysis of the length of the breaches was conducted. The length and the duration of formation of the breaches served to calculate the hydrographs flowing through the breaches. These hydrographs were used as input for numerical 2d-modelling of the floodplains. The 2d-modelling provides maximum water depths and flow velocities, allowing to determine the intensity of the inundation for each of the cells forming the calculation grid. 2d-modelling was carried out for each potential dike failure along the considered river reach.

¹ Ing. Corrado Lucarelli, Patscheider & Partner Engineers Ltd., Bozen, South Tyrol, Italy

² Ing. Walter Gostner, Patscheider & Partner Engineers Ltd., Bozen, South Tyrol, Italy (e-mail: w.gostner@ipp.bz.it)

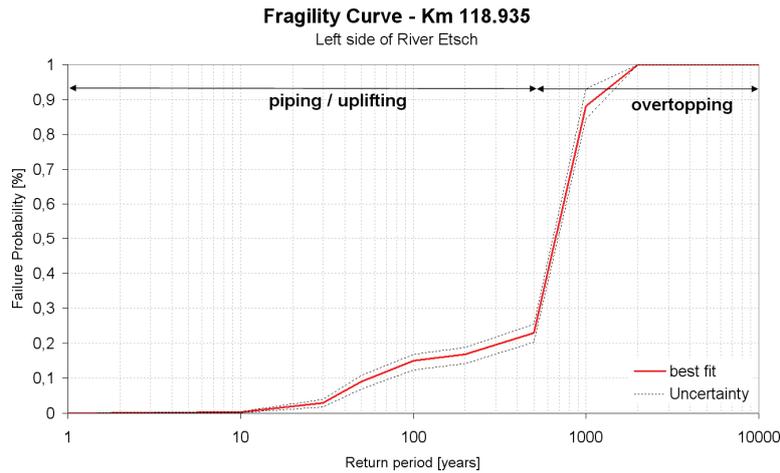


Fig. 1 Correlation between return period of flood event and failure probability of dike

Dike failure at different locations causes the inundation of different areas. Nevertheless, there are also areas that can be flooded by dike failures at different locations (for example point A in Fig. 2, left). Therefore, the flooding probability of a certain cell concerned by dike failures at different locations is the sum of the probabilities of these different failures. Hazard zones are defined for areas where the combined flooding probability is less than 200 years, whereas areas with a flooding probability of less than 200 years are classified as residual risk zones (Fig. 2, right).

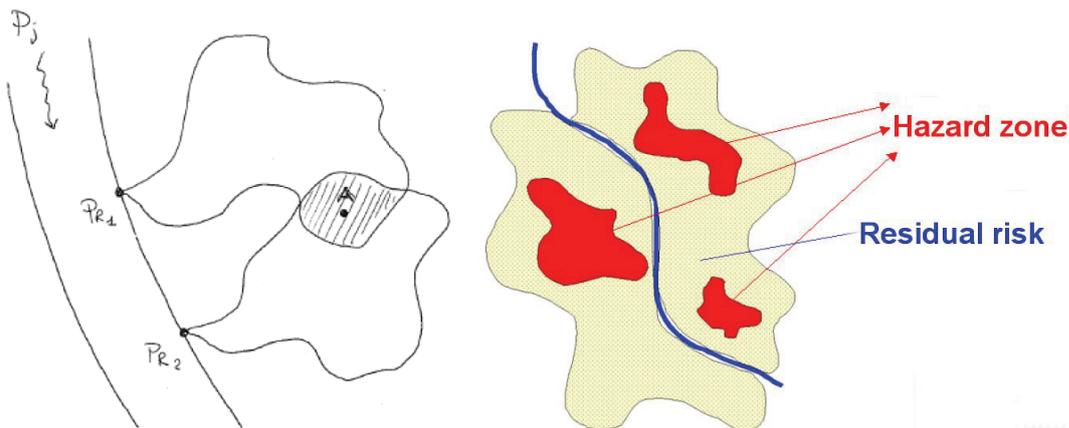


Fig. 2 Definition of hazard zones due to dike failure

CONCLUSIONS

The approach allows a pragmatic application of hazard assessment for future land use planning and definition of flood protection measures. Considering a probability of 100 % of dike failure in fact would lead to quite conservative results with areas of high hazard in the whole floodplain, limiting a sustainable economic activity due to strict laws valid for hazard zones. On the other hand, assuming that the probability of dike failure is 0% doesn't respect the reality (considering that in the past dike failures have caused large inundations and severe damages) and designs a too optimistic picture. Therefore to combine probabilities of extreme hydrological events with the probability of dike failure is an excellent tool to reflect the real situation in hazard maps.

Keywords: hazard assessment, return period, dikes, failure probability, 2d-modelling, inundation probability