



On mechanisms triggering the levees failure along the Foenna stream on 1st January 2006 and which caused the flooding in the urban area of Sinalunga, Tuscany Region (Italy). A case study

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On 1st January 2006, during an ordinary flood event, a levee failure along the Foenna stream caused the flooding in the urban area of Sinalunga, a small town located in Tuscany region (Italy). The event was monitored by a public agency with the responsibility for the control and maintenance of the natural channel networks. Long time before of flooding, people living in the surrounding area of the stream blamed the presence of wild animals and of numerous burrows along the levees. Although the numerous actions of maintenance along the levees mainly for removing the burrows, a levee seepage occurred during that flood. The presence of an outflow located on the downstream face, almost 2 m below the levee top, caused the spurt of brown water denoting the presence of sediment erosion. On the upstream face of levee, a little hole of about 30 cm at the same height of the outflow was discovered. Although the agency workers tried to close the hole by using appropriate blankets, in short time the top of the levee subsided and the overtopping flow caused a trapezoidal breach typical for an earth-fill embankment. The formation of breach was so fast that in a little more of one hour the urban area near to the Foenna stream was flooded causing high economic damages. Mechanisms triggered the levees failure are the object of this work.

The analysis of the event has been first addressed to assess the state-of-fact of levees conditions along the Foenna stream, thus to understand how much the activity of wild animals, in particular that of porcupine, may have affected the hydraulic safety of the embankment. At the purpose, after the event, topographical surveys of cross sections have been done along with tomographic surveys by geoelectric technique for investigating the possible presence, besides of burrows, also of tunnels dug into the levees by animals. Then, the analysis of hydrometeorological conditions of the event has allowed to better understand the evolution of the flood and if its magnitude was able to affect the hydraulic holding of levees. Finally, the seepage vulnerability of these levees has been also assessed to address their hydraulic safety applying two models based on a steady and unsteady infiltration, respectively.

Based on the obtained results, the following findings can be drawn. 1) The levees failure near the Sinalunga urban area is certainly due to the presence of the porcupine burrow at middle height of upstream face of levee that has addressed the flow into the embankment and then triggered the seepage phenomenon. 2) The works of the maintenance finalized to the closure of the burrows carried out before of the flood event were necessary but not sufficient to prevent the failure of levees. 3) To prevent the failure due to burrows presence, the levees maintenance should have been addressed through both the closure of burrows and the capture of wild animals; if this action had been done for the Foenna stream then the probability of failure would have been truly low. This last aspect has been also inferred through geoelectrical tomography surveys that showed the possible presence of at least two tunnels along both faces of levees, so emphasizing as the various closure of burrows made in the past by maintenance agency were totally useless. 4) The seepage vulnerability analysis has shown that levees might be to risk of failure for floods whose durations are consistent with the ones might occur in the Foenna basin. However, for this particular event the levees failure can be only ascribed to wild animals activity, seeing that the seepage was caused by a burrow hole.