SAFETY AND RISK ANALYSIS OF FLOOD PROTECTION LEVEES BASED ON RESERVOIR SEDIMENT TRANSPORT MODELLING

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Prediction of future flood risk on river morphology and safety of levees is considered to be a major challenge for hydraulic engineers. Flood risk analysis can be characterised by taking some factors into account that lead to appropriate decisions of risk assessment. These factors are related to field measurements of flow and transport, lack of data (uncertainties) and human interference in river channels and on floodplains. Numerical simulations are often used to estimate the flood risk that the physical processes are very complex occurring during flood flows.

This paper presents a numerical study of a reach of the River Inn, in Germany, where uncertainties of inflow suspended sediment conditions exist. The area of investigation extends over 7 km (from the km 98.0 to km 91.0) with a hydropower station at the downstream end of a reservoir. Along this reach, wide left and right floodplains at the upstream and levees with high level at the downstream are located. Due to the River Inn restoration plan, levees located at the very upstream, at ~ km 128, were destructed during the year 2002 and 2003 and also flushing process took place in one of the very upstream reservoirs. These reasons led to a transport of huge amount of fine sediments along the reach and a high deposition of 600 000 m^3 of fine sediments was found and measured in June 2004.

The aim of the study is, in case that the design discharge (HQ_{100} = 3000 m^3/s) occurs,:

to numerically investigate the maximum water level and the safety of levees located at the downstream of the reach; and

to understand the sediment erosion processes and to estimate the spatial distribution of eroded sediments along the reach of investigation.

In addition to these tasks, the general trend of the river bed behavior in the future is estimated under considering the typical inflow discharge hydrographs.

To do this aim the following steps is proceeded:

field measurements of the water level and inflow discharge at 5 gauge stations along the reach and at the downstream reservoir every 15 min during the period of 1999-2004 were done. River bed profile measurements and 25 sampling cores from the river bed to determine the grain size distribution and the sediment properties were also performed; and

two one-dimensional numerical programs, i.e. HEC-RAS ([3 and 4]) for unsteady state hydrodynamic simulations and WSPSED ([2]) for quasi-steady state suspended sediment calculations, are used.

Using these models, calibration of water level (by determining the appropriate Manning coefficient considering the bed forms effect ([1 and 6])), an estimated inflow suspended sediment and sedimentation and erosion parameters ([5]) for three flood events occurred in 1999, 2002 and 2004 is performed. Based on good calibrated parameters of flow and transport, a predicted spatial distribution of eroded sediments and the total mass/volume of sediments could be numerically calculated under the flood design discharge conditions.

The numerical results show that an amount of 330 000 m^3 of fine sediments might be eroded if the HQ_{100} occurs, however, the safety of the levees is confirmed since the highest computed water level is lower than the levees level by about 2 m. Also, the numerical calculations prove that the river bed level under considering typical normal discharge hydrographs, after the flood event occurred in 2004, is approaching its equilibrium situation in a reasonable period time of three years, see Fig. 1.

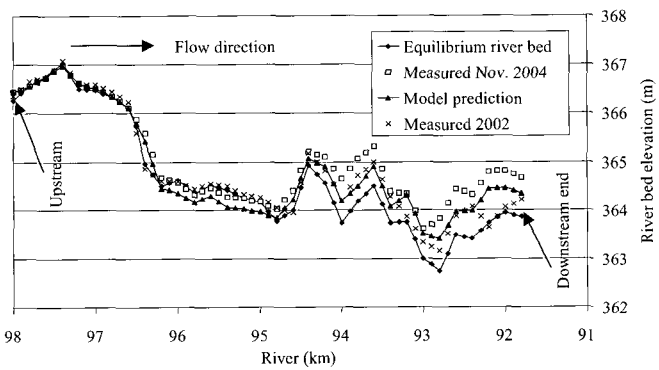

Fig. 1 Prediction of the river bed behaviour after the flood event occurred in Nov. 2004

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