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Experimental analysis of the levees safety based on geophysical monitoring

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Several flood events brought river levees into the focus of attention for some disasters due to their collapse. This phenomena is quite complex to investigate, because of different factors that can affect the stability of levees, among them the non uniformity of material properties, which influencing the permeability of the embankment, might induce high percolation velocity of flux thus triggering the unstability.
Thus, to apply a fast and integrate investigation methods with a non-destructive characteristics should have a large interest, if they are able to furnish ready and usable information necessary to hydrogeological models. In order to achieve this goal, the University of Perugia (Department of Civil and Environmental Engineering) and the National Research Council (IRPI and IMAA research institutes) developed a collaborating project on the study of the internal structure of the river embankment by carrying out experiments in laboratory. The purpose of this study is to show the preliminary results of the experimental investigation. The laboratory embankment was built using material coming from a real levee and gathered inside a 1.5m x 1.2m plexiglas box. The box has two compartments: a water reservoir at one hand where a constant water head was reached after some time and a soil simulating the presence of levee. We perform a geoelectrical multichannel acquisition system with three parallel profiles characterized by 16 mini-electrodes connected to georesistivimeter Syscal Pro. An automatic acquisition protocol has been performed to obtain time slice electrical tomographies during the experiments. The geophysical results show the effect of the water table inside the embankment during the wetting and emptying. In order to assess the capability of the geophysical monitoring for addressing the soil parameters estimate, the resistivity results are investigated by using two analytical and one hydraulic numerical models. The analytical models represent a linear solution of Laplace's equation where Dupuit hypothesis holds (the vertical gradients of the flow velocity in the medium are neglected). In particular, the Marchi and Supino solutions are investigated here by assuming the upstream water level variations in the river negligible with respect to the ones inside the groundwater under the steady state condition. Two different seepage fronts are calculated and compared with the ones inferred from the resistivity maps.
The experimental data have been also compared with the results computed by a numerical code. The governing equation for the unsaturated-saturated medium is the continuity equation written in terms of the piezometric head unknown while the Brooks-Corey law relates the water content and the relative hydraulic conductivity to the piezometric head. The numerical model is a time splitting technique and the solution is obtained by solving consecutively a convective and a diffusive component. The medium has been discretized in space using a generally unstructured triangular mesh. The governing equations are discretized using the edge centred mixed hybrid finite element scheme. The computational domain is schematized as 1D network of cells located at the middle point of each edge and linked by fictitious channels and the storage capacity is concentrated in the cells. A linear variation of unknown is assumed inside each triangle. The positive outcomes of hydraulic model application have certainly had benefit from the information coming from the geophysical monitoring.
Based on these preliminary results it was noticeable as the geophysical monitoring can be conveniently adopted for addressing the levee safety control and to provide information on soil parameters.