INFORMATION SYSTEM FOR HYDROGEOLOGICAL RISKS (IHR)

A PROCEDURE FOR THE CREATION OF HAZARD INDICATION MAPS FOR ALPINE RIVERS

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INTRODUCTION

In the field of natural hazard protection and management there is an increasing need for the water authorities for instruments that allow an identification of natural phenomena on a regional level. On the one hand the planning of active protection measures in torrents and rivers and on the other hand a natural hazard compatible land use management would require ad hoc instruments like hazard indication maps.
Recently a hazard indication map for debris flow phenomena and alpine torrent's inundations has been developed. This map has been realized with a completely automatic GIS integrated procedure, adopting standardized methods that has been applied in other Alpine Regions, e.g. Swiss. This map indicates the most plausible phenomena that could be expected on the basis of the available data. The adopted procedure is based on simplified mathematical descriptions of the physical phenomena that do not take into account the hydraulic behavior. Concerning alpine rivers with a slope less than 1.5 %, the up to now adopted procedures do not produce satisfactory results due to an increased importance of the rehologic description compared to gravity forces. This required the development of a new approach that on the basis of the available data describes in a proper way the physics of the phenomena. Furthermore it should be remarked that due to the presence of artificial levees in alpine rivers, dam failure becomes a major triggering cause of inundation phenomena. In South Tyrol and particularly on the Adige river a backward indication clearly showed that dam failure is the principal hazard factor, in case of rivers with artificial dams, therefore the proposed procedure takes this phenomena into account, to complete the hazard indication maps also for the river case.
Another key point, what hasn't been solved previously, in the creation of hazard indication maps for rivers consists in the detection and delimitation of the potentially inundated areas at a regional scale. The proposed procedure was developed in order to overcome all this difficulties and permits the creation of hazard indication maps also for the river case.

METHODS

The proposed method consists of three main steps: The search of weak points in case of bankful discharge and overtopping, the weak points for dam stability, and the perimeter of the potentially inundation affected areas. The available data consists of topographical surveys on a cross sectional base, documentation of historical floods, inundations and dam failures, historical maps with old water courses, the database of protection structures and bridges and their geometrical and reliability data. First a hydraulic steady flow simulation is performed neglecting the presence of bridges in order to recognize the bankful discharge of all cross sections, say the discharge value for which the water starts overtopping the lover dam.

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For that reason the liquid discharge is assumed to be constant over the whole length of the water course. The flow resistance coefficients values are taken from the literature indications, if no calibrated values are available or cross section restrictions are absent. Then the hydraulic behavior of the bridges is analyzed, in order to obtain an estimation of the dangerousness level, applying a specified criterion based upon a point rating system that considers both the flow regime (say supercritical or subcritical flow conditions, formation of hydraulic jumps and backwater effects) and the possibility of obstruction due to the presence of woody debris: the lover the distance between the water level and the bridge lower cord, the higher the bridge obstruction probability.
After this first level of analysis a map can be obtained that shows all the weak points, with the corresponding value of the overtopping discharge, distinguishing between right and left overtopping direction and the dangerousness level in case of the presence of bridges.
The second step of the analysis deals with the estimation of the dam failure probability. Taking into account that the geotechnical properties of the dam material are unknown in most cases, a classical geotechnical stability analysis can't be performed on a regional scale. Therefore a new simplified approach has to be taken into consideration. In many cases the positions of the dam failures seem to be related among other causes to the path of the old watercourses and to the macroscopic condition and geometry of the dam. A point rating system covers the estimation of those factors. The output of this step is another map with the representation of the failure probability of the single dam segments.
Finally the potentially inundated areas have to be detected. A combined procedure is adopted, that considers historical floods and available results of detailed hydraulic analysis performed with respect to very high return periods of at least 200 years.
The relative important of the potentially inundated areas is updated. Historically inundated areas in the presence of high safety level of the dam and discharge capacity of the river, that is in absence of weak points, are not considered in the successive hazard zone mapping. On the other hand, where either the discharge capacity is low and the dam condition is bad and no historical floods evidence or non simulation results are available, the surrounding floodplain has to be located through a simple topographic method. This method permits to locate the so called hydraulic active areas outside the river and the weak points connected to these areas.

RESULTS

The proposed procedure was tested on the Adige river, in order to produce hazard indication maps, focusing two specific areas located in the Municipalities of Egna and Lana in South Tyrol. Starting from the available data two maps could be created in relatively short time that show all the weak points and the relative active potentially flooded areas. Those maps were used as indication maps for the realization of hazard zone maps in those Municipalities.

CONCLUSIONS

The two tests performed show that the proposed procedure is consistent, simple and applicable on the whole territory of South Tyrol. One of the most important information that is required for the creation of this kind of maps are the historic inundation events. Their recognition and documentation is the most expensive step in the proposed procedure. All other steps are fully automatic and can be implemented in a GIS environment with help of a simple steady flow model.
The derived information about weak points can be a used either as basis for hazard zone mapping or for planning of control measures against river floods and dam break.