Interfaces of Disaster Control in the City of Graz using Example of Flood Events

R. Strukely[2], A. Hammer[1] and G. Zenz[1]

[1] Institute of Hydraulic Engineering and Water Resources Management, Stremayrgasse 10/2, A-8010 Graz, Austria

[2] Bachstrasse 5, CH-6010 Kriens, Lucerne, Switzerland

E-mail: robert.strukely@gmail.com

Abstract

Flood disasters repeatedly pose a threat for the population of Austria. Especially in the last few years, flood events have increasingly challenged disaster control organizations. Civil engineers and disaster control organizations share many tasks in preventing and handling disaster situations, which necessitates close collaboration between both groups. This article describes the different approaches of handling a flood event according to the different points of view of both disciplines. The potential to further strengthen the cooperation between disaster control organization and civil engineers is demonstrated by using the specific example an examination.

Introduction

With next to 300.000 residents is the provincial capital Graz the largest city in Styria. [1] Aside from the main river, the river Mur, Graz is characterized through in total 52 named brooks. These present in the urban area a total length of approximately 125 km and flow into the river Mur with a total drainage area of approximately 140 km², which reaches far beyond the borders of the city. [2] The development processes of the city caused, that the brooks were continuously forced to retreat. Thus, brooks were partially canalized or influenced in their route. This effected, that flood drainage has not been feasible anymore in many areas. The consequences were multiple massive floods, which last caused heavy damages in parts of the urban area in the years 2005 and 2009. The municipal authorities of Graz responded to the potential danger of floods on the one hand with engineering technical measures, i.e. infrastructure. The „Documentary Brooks in Graz“ is representative for a project of wide scope of the municipal authorities of Graz together with the regional government of Styria in order to improve the flood protection in the regional capital. So, there are for example retention basins and straightening measures projected, which cannot always be realized without the opposition of land owners.

Particular challenges present the previously mentioned flood events on the other hand also for the disaster control management. In 2005, as well as in 2009, the state of emergency had to be exclaimed in the urban area of Graz. Over the past years, led the experiences gathered from these events consequently also to an intensive occupation with the threat of floods on the part of the urban disaster control management. In the prevention, as well as in the overcoming, of such events the tasks of disaster control organizations overlap with those of civil engineering. Out of this interest, focuses this article on this interface of these two – though nonetheless very independent – organizations of flood control. By means of the example of run off research the potential of an enforced collaboration between disaster control and civil engineering shall be demonstrated. [3]

Subject matter

For the tasks of the disaster control organizations in the provincial capital Graz the municipal department „Department of Disaster Management and Fire“ recognizes its responsibility. A significant part of this municipal department is the professional fire service Graz, which undertake to a great extent the preventive measures of disaster control in respect of flood events. The flood events of the past years caused, that the emergency services of Graz, and in particular the professional fire service Graz, today, has elaborate experiences on this area of expertise at disposal. Observations, debriefings, and technical documentations resulted in a continuous improvement process among the employees over the past years. Thereby, the approaches to the subject matter flood protection differ on the part of civil engineering to that of disaster control management. In civil engineering basically a probable measurement event is elaborated, which defines the protection goals and thus also the precise design of the protective measures. In disaster control management, though, a more general approach has to be chosen. The preparations also often refer to relatively unlike scenarios. Although, for example in the preparations of disaster control management a high calculative preciseness is often attributed less importance to, than it generally is in civil engineering. Therefore, for instance, for the aim of projecting far too imprecise drainage tests results can still contain valuable information, which might be of use to the disaster control management in case of flood.

In case of floods in residential areas with their consequential damages, usually the painstaking work for the fire services begins, i.e. to pump dry uncountable cellars. The intention to help possibly everywhere at the same time, usually leads to a horrendous battle for personnel- and material resources, with which is attempted to gain control over exceptional circumstances. The cause for this is mainly, that the today’s available possibilities for emergency services are generally very time- and work force intensive (Comp. [4]). Especially, in the drainage area of smaller brooks, and everywhere else where flood events can occur rapidly, are adequate advance warning times, in order to protect all affected areas, with the presently available means not feasible. Likewise, are early warning systems for small drainage areas still subject for research projects and especially refer to rapidly growing intensive storm rainfall cells, which still present a problem that is difficult to solve.

In order to be able to minimize damages already in advance, it is the wish of those in charge of disaster control management, to be able to intervene already earlier in case of floods. In the best case scenario should measures prevent damages before they come into existence, for which, though, a certain information advantage has to be available.

Inter-disciplinary collaboration exemplified on the preventive fire protection

In the past decades it became apparent especially on the example of preventive fire protection, how immensely important the collaboration between fire services and civil engineering is. On account of the progress on both sides, this necessity increased continuously. The constructional engineering in building construction developed increasingly towards the integration of new materials, and especially towards a form of lighter construction, the buildings reached also continuously greater dimensions.

The fire services could due to shortened ways of report intervene quicker and advance further into buildings due to newer technology, the fire fighting does not restrict its activities to the extinction of fire from the outside of the building, but instead transferred the conduct directly to the source of fire. Due to the nowadays already common collaboration can defensive measures be taken more precisely and more safely. Even if the preventive fire protection can still be elaborated in many areas and details have not been solved entirely in a satisfactory way, it can still serve, nevertheless, as model for a symbiosis of fire services, disaster control management, authorities, and civil engineering for flood protection.

Analysis of a drainage research as specific example

Such assistance offers for example information about the sequence of a flood event. By the means of well-directed reporting systems, as stated in the following example, can emergency services be provided with especially prepared information. The analysis of a drainage research is usually based on a specific measurement event. That means that the analysis of such a research refers always to one particular discharge rate. The results are most of the times determined as flood marks for the 30-year-flood, as well as the 100-year-flood events. This way the emergency services would learn to retrieve from the depiction, at which places of the map excerpt it will come to a bursting of the river's bank for these two analyzed events. It is not evident, though, which areas will be affected in any other year-flood event. If preventive measures were to be taken, then first, all accounted flood areas of a 30-year-flood event should be protected. In case the event in question is such that the duration of recurrence is about 20 years, then many of these precaution efforts might possibly not have been necessary.

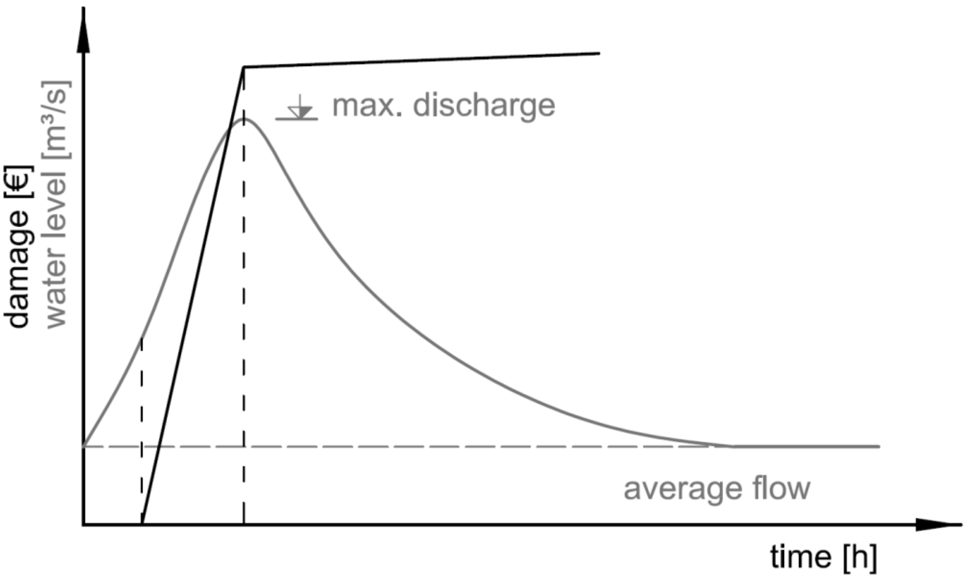

Figure 1: Correlation between a flood wave and its thereby resulting damages

Respectively, the maximum intensity of a flood plays for the emergency serves a rather minor role. Much more important is the information in which sequence the individual areas will be affected, in order to be able to conduct a priority ranking of the individual measures. In exactly this point the approaches of the civil engineer and the disaster control manager differ: The civil engineer erects to a great extent time independent measures for all in a previously determined measurement event endangered areas. The disaster control manager, on the other hand, has to implement time critical measures, because of which to him the knowledge about the priority of individual measures plays an important role. If one assumes, that the damages resulting from a flood correlate with the rising water level and stagnates with reaching the maximum discharge, then the research of the civil engineer should concentrate on the rising limb of a flood wave and not on the maximum discharge (Comp. Figure 1).

Referring to the previous analysis example makes evident, that already with the analysis of two year-flood marks such a priority ranking is feasible. Since the extent of a flood event and with it its yearly-flood in case of event is not known usually, a ranking of measures according to emergency can be determined primarily according to the flood sequence. Areas, which only will be affected in case of a 100-year-flood event, would have to be treated secondary in case of event. That implies that for a further specification of this consideration a discretization of the analysis of a run-off examination is necessary. This is achieved with the additional readout of a certain amount of differing flood marks. For the disaster control management is in further consequence especially the change in flood extent with each new flood mark of interest. Therewith, those areas are of relevance, which lie in between two consecutive flood marks. Such areas are depicted shaded in Figure 2 and are formed from the "subtraction of two flood marks". The area depicted on the left figure would have to be protected primary, whereas only afterwards measures along the areas marked on the right figure would be necessary.

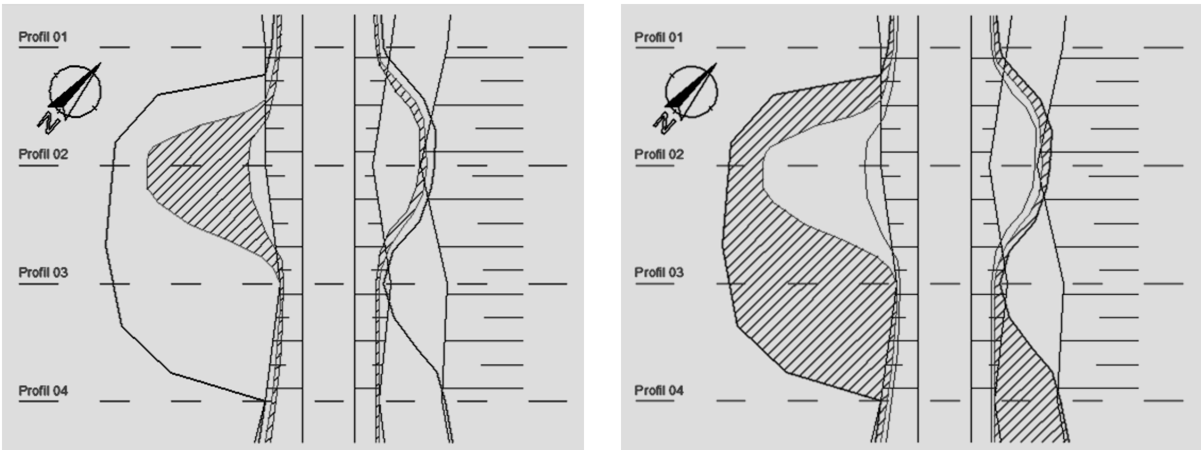

Figure 2: Readout of consecutively affected areas by floods

The user of this scenario concept can, thus, "anticipate" the further course of the flood. Therewith, decisions for taking precisely directed measures can be made much easier. Such analysis, though, can hardly be evaluated in real-time in practice. A drainage calculation with current input data implicate an enormous amount of time, further the application of a complex calculation program in respect of failure safety, user friendliness, and reliability for use in case of disaster would be hardly until not be applicable at all.

Out of this reason it would be thinkable to determine through multiple calculations on a flowing water flooding areas for as many different flow discharge rates as possible. These particular areas can be implemented in a graphical information system (GIS). For land-use planning purposes this has been implemented already frequently, although most frequently for the 30-year-flood and the 100-year-flood mark. If more flooding areas in relation to the flow discharge rate were available, it would require only a few adaptations on the respective GIS platform. As a result several flooding areas were easily accessible, independent of a calculation program. The previously described method of the subtraction of flood affected areas could be implemented also directly into the respective systems. Many advantages arise therewith: Due to the vector-based depiction particular excerpts can be arbitrarily scaled depicted and with extensive layer structures individually determined flood marks can be viewed separately. Additionally, a simple user-friendly interface is very often already given. Even without extensive adaptations of the GIS system a depiction similar to that of Figure 3 could be displayed.

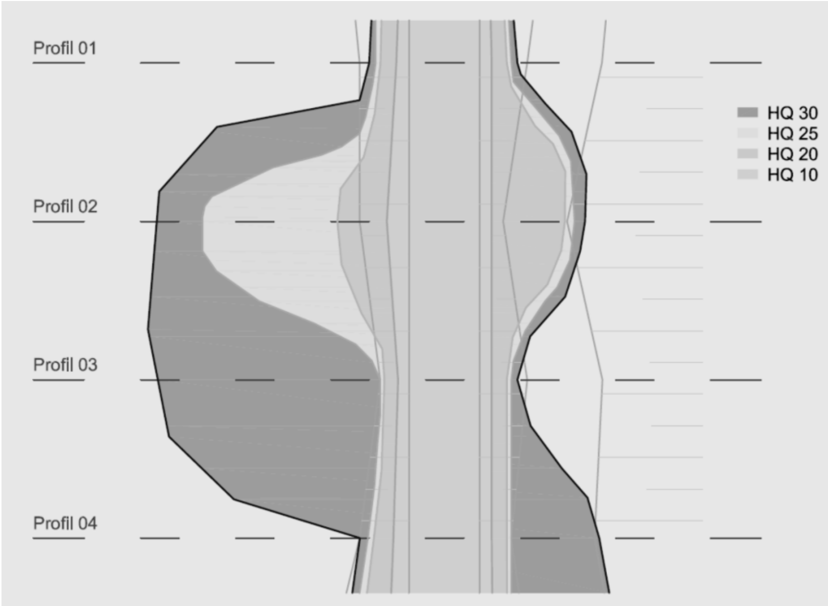

Figure 3: Depiction of multiple flood marks by the means of discretization

What is very well identifiable due to the more precise analysis is that some areas will be actually flooded only in the course of a 30-year-flood. This implies a clear priority ranking concerning the protection measures of the individual sections: The 10-year-flood (green) can still be drained without the bursting of a river's banks. If the water level still rises there is in the course of the 20-year-flood (cyan) the first bursting of a river's banks in the north-eastern region. A further rise of the water level until the 25-year-flood (yellow), would affect first the areas in south-west around the profile 02, etc. Of course, this kind of depiction can be arbitrarily discretized.

Particularly for planning purposes in disaster control management, especially the planning of measures for flood events, an implementation of this form of depiction could provide a significant simplification. By viewing the individual areas does not only surface the so far gathered "sum of defects", but also the sequence in which these damages will occur. For example, it might have been possible so far referring to a 100-year-flood drainage research to determine, that in a certain area 16 buildings might be affected by a possible flood event of this magnitude. Based on the presented form of this research something else becomes apparent, namely in which sequence the houses will be affected by floods. This information advantage would support the planning of protective measures significantly.

Conclusion

As this contribution illustrates at hand exist in disaster control management, and especially in flood protection, applicable interfaces, for which a specific collaboration between civil engineering and disaster control management is very promising. With an optimized analysis of incoming data during the planning process, a significant additional value can be achieved ultimately for the emergency services of flood protection. Like this, information can be created at an earlier planning stage in a relatively simple way, which at a later point in time could only be created by the persons in charge of protection against threats to public safety themselves most probably only with difficulty and not in the same quality. Conversely, are the experiences and reports of the emergency services in case of flood an important tool for the calibration of models and the calculations of the civil engineers. Special emphasis ought to be attributed, therefore, also in future to observations and extensive documentations, thus, also to the potential of the emergency services should be attributed more attention for the purpose of an integrated flood- and disaster control management.

Requirement for such an application is, though, a more detailed observation of flood events in the planning process like it had been recognized already in a similar way as most important tool in the planning of measures by Braunstein et al. [5] in the course of the project Flood Risk II. Through the analysis of a sequence of flood events can the practical benefit of complex water body models be increased significantly at only a minor additional effort. Particularly such relatively simply realizable adaptations confirm the still great potential for optimization in regard to the collaboration of disaster control management and technical sciences.

Acknowledgements

The master thesis that this article is based on was written under the supervision of the Institute of Hydraulic Engineering and Water Resources Management at Graz University of Technology (Strukely 2011). The master thesis was elaborated in close cooperation with the municipal department of the government of Graz the „Department of Disaster Management and Fire“, special acknowledgement is attributed to the deputy department head Mr. Ing. Dr. Alfred Pölzl, MSc. The authors express their gratitude cordially for the valuable support.

References

[1] Stadt Graz (2010): Bevölkerung der Landeshauptstadt Graz. Stand: 2011-02-28, http://www1.graz.at/Statistik/Bev%C3%B6lkerung/Bev%C3%B6lkerung_2009_ohneWanderung.pdf

[2] Ingenios ZT GmbH (2006): Sachprogramm Grazer Bäche. Maßnahmenprogramm 2006. Zusammenfassender Bericht. Unveröffentlicht.

[3] Zenz G.; Hammer A., Strukely R., (2011): Schnittstellen im Katastrophenschutz der Stadt Graz am Beispiel Hochwasser. Österreichische Wasser- und Abfallwirtschaft, Volume 63, Numbers 7-8, August 2011.

[4] Strukely R. (2011): Schnittstellen im Katastrophenschutz der Stadt Graz am Beispiel Hochwasser. Masterarbeit am Institut für Wasserbau und Wasserwirtschaft der TU Graz. Unveröffentlicht.

[5] Braunstein Ch., Gabler R. (2009): Analyse der Hochwasserereignisse vom August 2002 – Flood Risk. Workpackage A_Meteorologie/Hydrologie. TP1.3 – Hochwasserwarnsystem – Lamellenprognose. Unveröffentlicht.