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SURFACE FLOODS IN COIMBRA: simple and dual-drainage studies

J. P. Leitão (1), N. E. Simões (1,2), R. Pina (3), A. Sá Marques (2), Č. Maksimović (1), and Gil Gonçalves (2)

(1) Imperial College London, London, UK (j.leitao@imperial.ac.uk; nsimoes@imperial.ac.uk; c.maksimovic@imperial.ac.uk), (2) University of Coimbra, Coimbra, Portugal (jasm@dec.uc.pt; gil@mat.uc.pt), (3) Polytechnic Institute of Leiria, Leiria, Portugal (rui.pina@estg.ipleiria.pt)

Surface water flooding occurs due to extreme rainfall and the inability of the sewer system to drain all runoff. As a consequence, a considerable volume of water is carried out over the surface through preferential flow paths and can eventually accumulate in natural (or man-made) ponds. This can cause minor material losses but also major incidents with obvious consequences in economic activities and the normal people's life. Unfortunately, due to predicted climate changes and increase of urbanisation levels, the urban flooding phenomenon has been reported more often.

The Portuguese city of Coimbra is a medium size city that has suffered several river floods in the past. However, after the construction of hydraulic control structures, the number of fluvial flood events was greatly reduced. In the 1990s two new problems started. On one hand, houses started to be built on flood plain areas; on the other hand, some areas experienced a boom in the degree of urbanisation. This created flood problems of a different type dislocating the flood areas from the traditional flood areas along the river to new areas that did not reported flood in history.

The catchment studied has a total area of approximately 1.5 km^2 and discharges in the Coselhas brook The catchment can be divided in three regions with different characteristics: (i) the "Lower City" which is a low-lying area with 0.4 km^2 and with a combined sewer system; (ii) the "Upper City" which is a considerably hilly area, highly urbanized and with an area of approximately 0.2 km^2; and (iii) the remaining area which is also highly urbanized, with an area of 0.9 km^2, where the main flood problems are generated. The sewer system is 34.8 km long; 29 km are of the combined type, and only 1.2 km is exclusive for storm water. The time of concentration of the catchment is estimated to be 45 min.

On the 9 June 2006, an extreme rainfall event caused severe flooding in the city. After the rainfall had stopped, water continued to flow along the roads towards the Praça 8 de Maio, which is the lowest point in the whole catchment and where water tends to accumulate.

As presented in Table 1, the return periods calculated for durations shorter than 30 minutes are not high. In fact, this rainfall event is characterised by an extreme heavy intensity regarding its total duration; thus it cannot be considered a short period event with a high intensity. As its total duration is approximately the time of concentration of the catchment, the flooding event was very significant. A 50 year return period was estimated for the event with 45 minutes duration.

Table 1: Return period interpretation of the 9 June 2006 rainfall event

	Duration				
	5 (min)	10 (min)	15 (min)	30 (min)	45 (min)
Maximum rainfall intensity (mm/h)	122.4	76.8	72.4	61.6	47.6
Return period[1](year)	10	8	20	> 50	50

[1]the return period was estimated based on the Portuguese Drainage Standards.

Comparing the simulation results and the actual flood locations, it is concluded that the main cause of flooding is not the capacity of the sewer system. Despite the high slopes and the high level of imperviousness of the catchment, the flood seems to be mainly caused due to the limited capacity of the sewer inlets.

It suggests that the correct analysis of the hydraulic behaviour of the catchment drainage system should contemplate the analysis of the overland flow system, either using a one- (1D) or two-dimensional (2D) approaches.

Hence, simulation of the 9 June 2006 event were also carried out considering the 1D sewer model, an 1D/1D model and an 1D/2D model. The methodology developed at the Imperial College London to generate overland flow networks was used in the 1D/1D model. Infoworks CS was used to do the hydraulic simulations of the 1D/1D and 1D/2D models. The results of the simulations taking into account the overland flow system will be presented in this paper. Local community reports and photos are then used to validate the simulation results obtained.

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