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A database and analysis of bridges clogged by floating debris during the 2021 floods

Daan Poppema[1], Loïc Benet[2], Lisa Burghardt[3], Davide Wüthrich[1], Elena-Maria Klopries[3] and Sébastien Erpicum[2]

[1] Delft University of Technology, [2] Liège Université, [3] RWTH Aachen

Topic: B

In July 2021, a catastrophic river flood occurred in West-Europe. In parts of Belgium, Germany, and the Netherlands, rainfall of more than 150 to 250 mm in 48 hours transformed small streams into raging rivers. In Germany for instance, the discharge of the river Ahr increased from approximately 10 m^3/s to 1000 m^3/s in just a few hours, destroying entire town districts built in the narrow river valley. As a result, large amounts of floating debris from building rubble were carried into the rivers, together with other trash and natural driftwood from trees. Part of this debris accumulated at river bridges, where it constricted openings, lowering the discharge capacity and raising upstream flood levels.

In this context, the EMFloodResilience project aims to determine the role of floating debris during the 2021 floods. The first part of the project focussed on characterizing debris accumulations and locations during the floods. This has resulted in a database of bridges with debris clogging, presented in this contribution. The second part aims to experimentally determine how backwater rise at debris accumulations depends on bridge design, flow conditions and debris properties.

Within this project, we built a database on debris clogging at 71 bridges by analysing photos of debris accumulations in Belgium and Germany. For every blocked bridge, the database describes its geographic location, bridge characteristics (geometry of bridge, openings and piers), hydraulic conditions, and the accumulation characteristics (accumulation size and volume, debris contents, location at bridge).

Analysis of the database showed a number of interesting correlations of debris volume with pier span, flow width, pier properties and railing type. Most large accumulations occurred at bridges with limited pier spans (i.e. distance between piers), allowing long logs to be blocked at multiple piers. However, for high water levels, the bridge deck and railing also block debris. Consequently, bridges with flow at or over the bridge deck showed substantially larger debris accumulations. Most previous experiments focussed on the role of bridge piers, so this calls for further studies on the effect of the bridge deck and railing during flood events.

Moreover, the debris content of the different accumulations is shown to be atypical. Accumulations studied in literature generally consist of natural wood, so this is also most often studied in experiments. However, accumulations in the database showed that about half of the debris was of anthropogenic origin: building rubble, anthropogenic wood, vehicles (cars and caravans), tanks, etc. These objects differ in size, shape and material from natural logs, and can create very dense accumulations. Hence, their effect in terms of flow resistance and backwater rise should be further examined.

Building on the database analysis, flume experiments will be performed to determine how backwater rise at debris accumulations depends on debris properties and bridge geometry. The database results and experiments will then both inform management strategies and design guidelines to prevent and mitigate debris accumulation at hydraulic structures; and allow for the consideration of bridges' blockage effects in inundation maps.