The British Dam Society

British Hydrological Society

UK reservoir spillway flood hydrology

Joint BHS-BDS National Meeting
Institution of Civil Engineers, One Great George Street, London, Thursday 7th March, 2019

Speakers' Abstracts

Reflections on the use of the FSR/FEH rainfall-runoff model for reservoir design flood estimation

David MacDonald

The presentation will provide:

- Some background information about UK dams and the need for reservoir design flood and wave surcharge standards;
- A brief outline of the original FSR rainfall/runoff model, plus some key changes contained in the FEH; and
- Reflections on the overall usefulness of the current FSR/FEH model for reservoir design flood estimation and some of the several shortcomings identified with its use.

Flood Studies of Reservoirs: General Guidance and Two Case Studies

João Correia

The presentation will provide an overview of current guidance for the assessment of the overflow capacity of reservoirs, focusing on the derivation of the Reservoir Flood Inflow Hydrographs and Reservoir Flood Routing. This will be followed by two recent case studies: a reservoir with an urban catchment; and a large reservoir in a mountainous region, highlighting the impacts of the recent changes on the proposed methodology (FEH13/ReFH2) on the design floods.

Revised estimates of Probable Maximum Precipitation (PMP) and Standard Percentage Runoff (SPR)

Colin Clark and James Dent

Reasons why some of the standard techniques used for reservoir spillway hydrology need to be changed or updated are suggested, including (a) observed rainfalls that exceed recommended PMP and (b) information from direct field measurements leading to better estimates of SPR. Examples will be presented, e.g. for the upper Brue.

Flood estimation for reservoir safety: an Inspecting Engineer's perspective

Alan Warren

The presentation will explore the importance of flood evaluation in assessing reservoir safety. It will cover:

- How flood events can affect the safety of dams
- Flood-related incidents at dams: examples and statistics
- Flood safety considerations during reservoir inspections
- Historical and current guidance on reservoir flood safety
- The impact of changes in guidance and tools on the reservoir industry

Practical experience from hydrology and engineering from reservoir flood studies across the Canal & River Trust's network

David Mould and Dr Richard Dun

First, fundamental hydrological parameters to reservoir flood studies will be discussed, and their importance to reservoir safety reviewed. This includes issues such as ensuring the contributing area to reservoir inflows is given appropriate consideration; undertaking a comprehensive site visit to understand local influences; and the impact of differences in rainfall depths from difference models will be assessed, all with practical experiences from across the Trust's network. Second, an overview will be provided of the range of reservoir-related hydraulic assessments that have been undertaken at the Trust in recent years. These include appraisals of weirs, chutes, draw-offs and siphons as well as wave overtopping and out of chute flow assessments. Such studies have included the use of 1 & 2-dimensional numerical models as well as physical ones and many have resulted in major improvement works. Once more, case studies will then draw on specific lessons to be learnt that are relevant to the wider industry.

Investigating dependence between ReFH model parameters and event magnitude for extreme events

Thomas Kjeldsen

This study investigates the impact of event characteristics on runoff dynamics during extreme flood events observed in an 8.5 - km^2 experimental catchment located in South Korea. A high-quality data set containing the 31 most extreme flood events with event rainfall in excess of 50 mm were analysed using the revitalised flood hydrograph (ReFH) model, routinely used for design flood estimation in the United Kingdom. The ReFH model was fitted to each event in turn, and links were investigated between each of the two model parameters controlling runoff volume (Cmax) and response time (Tp), respectively, and event characteristics such as rainfall depth, duration, and intensity, and also antecedent soil moisture. The results show no link between Cmax and any of the event characteristics, but identified a possible dependence between response time (Tp) and rainfall depth. These results show that the linear unit hydrograph fails to adequately represent a reduction in response time (Tp) observed for the more extreme events. A new and dynamic link between the unit hydrograph shape and rainfall depth is introduced. The consequence of the observed nonlinearity in response time is to increase design peak flow by between 50% for a 10-year return period, and up to 80% when considering the probable maximum flood.

Modelling the runoff from extreme hydrological events: an inter-comparison of data and methods

Lisa Stewart, Andy Young and Gianni Vesuviano

The fourth edition of Floods and Reservoir Safety (ICE, 2015) provides updated guidance to reservoir engineers and hydrologists on the estimation of reservoir flood inflows for the assessment of dam safety. The recommended procedures are based on the construction of design flood hydrographs generated by the most extreme events such as the estimated probable maximum precipitation (PMP) and the 1 in 10,000-year return period storm. Since the guidance was published, some of the key components of the hydrological methods have been revised. In particular, a new Flood Estimation Handbook (FEH) rainfall depth-duration-frequency model known as FEH13 has been released via the FEH Web Service (https://fehweb.ceh.ac.uk) and the ReFH2 design hydrograph method based on the Revitalised Flood Hydrograph (ReFH) model has been upgraded. The presentation discusses the results of an inter-comparison study of design hydrographs of extreme events generated by various combinations of currently used design rainfall estimates and rainfall-runoff models. Since reservoirs in the UK are nearly always located in headwater catchments, the analysis has focused on a set of small catchments for which peak flow data are available. The results of the analysis are used to suggest priority areas for future research on estimating the risk of extreme hydrological events.

Centennial scale records of extreme floods in the British uplands and their potential application to reservoir and spillway design

Mark Macklin, Duncan Faulkner and Sean Longfield

This paper provides a critical review of palaeoflood techniques and data for environmental management agencies and other water industry practitioners involved in reservoir safety. In high-gradient UK catchments, the timing and magnitude of flood events, episodes, and multi-decadal phases can be reconstructed by analysis of fluvially deposited boulder berms. Boulder size is indicative of flood magnitude, and lichenometry can be used to date events that occurred in the last few centuries. Event-based palaeoflood records are now available for all upland areas in England and Wales back to 1750 with more than 550 dated deposits associated with flood magnitudes generally approaching or exceeding those recorded in Boscastle in August 2004 and northwest England in December 2015. These records can be directly related to past and present short-term climate change and show a flood 'rich' period since 2007 associated with a shift in North Atlantic Oscillation phase most notably in the summer. As most small upland catchments in the UK are ungauged for rainfall and streamflow, the reconstruction of extreme flood events from sedimentary evidence can be used to complement traditional hydrological approaches based on rainfall-runoff models. Palaeoflood methods can be used to evaluate estimates of the Probable Maximum Flood from reservoir flood inflow where a dam breach is likely to endanger life, as well as for dam failures associated with a lower risk to communities and infrastructure where there may be non-stationarity in the frequency and magnitude of extreme floods resulting from land-use or climate change.

Precision and accuracy of Unit Hydrograph parameters for gauged and ungauged basins: can we do better?

Ian Littlewood

Aspects of precision and accuracy components of uncertainty associated with Unit Hydrograph parameters for gauged and ungauged basins are discussed, with a view towards possible improvement in the rainfall–streamflow model recommended for systematic UK design flood hydrograph estimation.