Research Institute for
Water and Environment

University of Siegen

Protection of Nuclear Power Plants against Flooding

Considerations for the Determination of a 10.000 Years Return Period Flood between Tidal and Inland River Regimes

T. Frank, J. Jensen, Ch. Mudersbach, B. Schubert, M. Wörner

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Content

- Introduction
- Influencing factors
- Differentiation between Coast and Inland
- Coastal Locations Method
- Inland Locations Method
- Further applicable Methods
- ProMuse Method
- Concluding Remarks

Introduction

Demand:

- Determination of design values, like flood levels or storm surges, with extreme low rates of occurrence below 10^{-4}/a
- Target: highly vulnerable objects along rivers or coast lines like reservoir dams, nuclear power plants,…
- Example: KTA-Standard 2207 (Protection of nuclear power plants against flooding 2004)

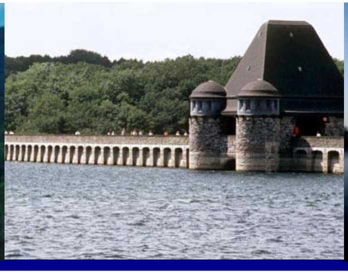
Meets:

- Available time series of varying quality and length of just a fraction of the demanded time frame of extrapolation (50 to 100 years of data against a 10.000 years return period)

Result:

- Very high „uncertain“ extrapolation range
- Typically leads to high bandwidth of results from distribution functions applied by the hydrological community
- And therefore difficulties in the determination of meaningful results or the parameters of the applied distribution functions




Introduction

- The Nuclear Safety Standards Commission (Kerntechnischer Ausschuss, KTA) has the task to issue nuclear safety standards for topics in the area of nuclear technology in Germany.
- Flooding: standard KTA 2207 “Protection of Nuclear Power Plants against Flooding”, re-issued in Nov 2004

- Primary subject of the standard is the determination of a design criteria with a probability of 10^{-4}/a or a return period of 10.000 years, respectively.

- KTA 2207 consists of the following topics:

⇨ Design basics

  ⇨ Design storm surge water level and design storm flood

  – Appendix A: Derivation of storm floods and storm surge water levels of exceedance probability of 10^{-4} /a

⇨ Load combinations and Evidences of conformity

⇨ Flood protection measures

Influencing Factors

Influencing factors at river and inland waters locations

a) Precipitation,

b) Snow- and Glacier melt,

c) Condition and characteristics of the catchment area,

d) Retention in the vicinity of the location and in the catchment,

e) Backwater effects,

f) Ice blocking,

g) Overtopping of and failure of levees,

h) reservoirs,

i) Wind setup and wave runoff,

k) Duration and form of the flood event.

Influencing Factors

Influencing factors at coastal locations:

a) Tide,

b) Overtopping and failure of sea dikes,

c) Wind setup and surge,

d) Wave runoff,

e) Secular rise,

f) far reaching waves,

g) Duration and form of the storm surge event.

Influencing factors at locations along tidal rivers and estuaries:

- Influencing factors from coastal and inland waters combined

Differentiation between Coast and Inland

- Different approaches necessary for different types of locations because of different situation and generation of hazardous flood events
- Therefore differentiation is made in KTA 2207:
  - Locations along coastline and tidal estuaries → direct determination of storm surge water levels
  - Locations along inland waters → determination of storm flood discharges and derivation of the respective design water levels
  - Locations along tidal rivers, which are subject to flood events generated as well from flood events in the catchment as well as storm surges from the sea
- KTA 2207 names one method each for coastal and for inland locations and describes it in the appendix A. Depending of the situation of an inland waters location other methods are applicable also.

Coastal Locations Method

Basics of the Method:

The derivation of a storm surge water level for nuclear power plants at coastal and tidal estuaries is given according to KTA 2207:

- Storm surge water level SFWH(10^{-4}) is the sum of a base value BHW(10^{-2}) and a so called extrapolation difference ED
  SFWH10^{-4} = BHW10^{-2} + ED
- The base value BHW with probability of occurrence of 10^{-2}/a is to be determined with statistical extreme value analysis of by use of the classic hydrological methods or distribution functions, respectively (i.e. Pearson III, Gumbel etc.).
- Advantage: low bandwidth of the results of BHW
  - Available gauges at coastal sites very likely to have long history of good quality records (but beware of trends, dredging works etc. especially in estuaries)
  - BHW10^{-2} lies in interpolation or in low extrapolation range / Water level with physical as well as numerical models verifiable

Coastal Locations Method

- The extrapolation difference ED has to be derived out of further research for the respective coastal area or the tidal estuary
- Appropriate are investigations of one or more representative gauge stations with extensive recording history for the specific region taking into account routing, correlation methods and special situations (e.g. possibility of ice jam)
- Suitable methods used in such investigations are combined analysis of wind set up and tidal high water levels or the ProMUSE method
- For the German tidal estuaries, typical extrapolation differences between 100 and 150 cm were given by *Jensen and Frank* (2003)

Inland Locations Method