Introduction

Best Practices in Dam and Levee Safety Risk Analysis

July 2019
Definitions

• Risk – probability of adverse consequences
  • $P(\text{load}) \times P(\text{failure}) | \text{load} \times \text{Consequences} | \text{failure}$

• Risk Analysis – A quantitative calculation or qualitative evaluation of risk

• Risk Assessment – The process of deciding whether risk reduction actions are needed
“The possibility of failure must not be lost sight of. To sum up in a concrete manner, it is my judgment that the chances of failure with the water at varying elevations will be substantially as follows:

<table>
<thead>
<tr>
<th>ELEVATION</th>
<th>CHANCES</th>
</tr>
</thead>
<tbody>
<tr>
<td>3795</td>
<td>1 in 5000</td>
</tr>
<tr>
<td>3800</td>
<td>1 in 2000</td>
</tr>
<tr>
<td>3805</td>
<td>1 in 500</td>
</tr>
<tr>
<td>3810</td>
<td>1 in 100</td>
</tr>
<tr>
<td>3815</td>
<td>1 in 10</td>
</tr>
</tbody>
</table>

In case of failure, while there might be no loss of life, yet the loss in time, in property, in money and in prestige would many times over exceed the cost of even an entirely new structure.”

Thaddeus Merriman, New York, February 21, 1912
Why Risk Analysis?

• Teton Dam failure in 1976-- Reclamation begins developing risk analysis methodology for dams
• Hurricane Katrina in 2005-- USACE recognized need to implement risk analysis following failure of levees in New Orleans
• Improve and balance risk reduction benefits with limited budget (e.g. upgrading a few dams to pass the PMF vs. using available budget to reduce risk at many dams)
• Transparency and justification for dam and levee safety decisions
Workshop (Some Highlights)

• First in Casper, Wyoming in 2009 (Pathfinder)
• 2010 at TVA Offices
• 2011 in Denver – Reclamation in co-op with USACE
• 2012 info added to address levees and related structures
• 2015 workshop in Denver for USSD
• 2018 in Denver
Typical Workshop Attendance

- Civil
- Construction Management
- Dam Instrumentation
- Dam Safety
- Economist
- Engineering and Lab Sciences
- Geologist
- Geotech
- Hydrology and Hydraulics
- Mechanical
- Structural
- Waterways and Concrete Dam
Workshop Evolution

2017
• Exercises added
• Modified presentations
• Added new presentation topics

2018
• Updated chapters
• New chapters
  • Concrete material properties, Levee closure sections

2019
• Very similar to 2018
• Considering some changes for future training so give feedback
Day 1

Guidelines

Basics

Geo Needs

Failure Mode Analysis & SQRA

Event Trees
Day 1 (Event tree)

Loading

- Flood or EQ Load
  - Stage < 1520
    - Slope Instability
      - Life Loss
      - Consequences: 30
  - Stage 1520-1550
    - Internal Erosion
      - Life Loss
      - Consequences: 60
    - Non Breach
      - Life Loss
      - Consequences: 5
  - Stage > 1550
    - Slope Instability
      - Life Loss
      - Consequences: 80
    - Internal Erosion
      - Life Loss
      - Consequences: 140
    - Non Breach
      - Life Loss
      - Consequences: 15
Day 1 (Cont.)

Subjective Probabilities

<table>
<thead>
<tr>
<th>Descriptor</th>
<th>Associated Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Virtually Certain</td>
<td>0.999</td>
</tr>
<tr>
<td>Very Likely</td>
<td>0.9</td>
</tr>
<tr>
<td>Likely</td>
<td>0.9</td>
</tr>
<tr>
<td>Neutral</td>
<td>0.5</td>
</tr>
<tr>
<td>Unlikely</td>
<td>0.1</td>
</tr>
<tr>
<td>Very Unlikely</td>
<td>0.01</td>
</tr>
<tr>
<td>Virtually Impossible</td>
<td>0.001*</td>
</tr>
</tbody>
</table>

Probabilistic Approaches

Estimating Consequences

Loadings
Day 2

PFM’s related to Soil & Rock
Day 3

PFM’s related to Hydraulics

PFM’s related to Concrete

PFM’s related to Steel
Day 4
Smokey Ridge Exercise

PFM’S of levee related structures

Mechanical & Electrical

Other Risks and Big Picture stuff
Example of Building the Case

• Claim:
  • The lift joints near the spillway crest are well bonded and have significant strength. This leads to a low likelihood (0.1 or less) of cracking through the section at 1/10,000 AEP or smaller ground motions.

• Evidence:
  • All lift joints near the spillway elevation were recovered intact in core drilling
  • There were a large number of tests indicating high tensile strength across joints (cite reports)
  • Construction control procedures were excellent (describe from docs)
  • Stresses are less than estimated strength (quantify from reports)
Objectives

• Risk analyses performed by:
  • people with experience on dams, levees and related specialties.
  • cross disciplined teams to perform risk analyses of dams and levees.
• We encourage individuals to develop cross discipline expertise.
Some basic rules

• Please sign in daily
• Handouts
• Feedback forms—fill out often, and be detailed
• Honor bar (pay as you go!)
• Restrooms and door code
• Laptop free zone
• Breaks and 2 min. warnings
• PDH certificates
• Jargon and acronyms: if you don’t know, ask!