“Risk-informed dam safety management: lessons learned from portfolio risk analyses in Europe”

Emergency action plan for dams towards disaster resilience

19 February 2017

Jessica Castillo, Adrián Morales and Ignacio Escudero

www.ipresas.com

iPresas Risk Analysis, Spain
Risk-informed dam safety management: motivation

- Dam safety legislation influenced by past dam failure events.
- EU Directives: Flood risk and Critical Infrastructure Management.
- International dam safety guidelines.

Picture: Failure of Tous Dam, Valencia, Spain, 1982
Risk-informed dam safety management: process in Spain

- Spain is the 9\textsuperscript{th} country in number of large dams.

![Number of dams chart](source)

Source: ICOLD Register of dams
Risk-informed dam safety management: process in Spain

- Spain is the 9\textsuperscript{th} country in number of large dams.

Source: MAGRAMA (Spanish Ministry of Agriculture, Food and Environment)
Risk-informed dam safety management: process in Spain

Modern Dam Safety Program/Standards
First Loop: 1996-2008

DAM SAFETY FILE
- Safety review
- Normal operation
  Maintenance
  Monitoring
- Emergency action plans

RISK MODEL
- LOADS
  Floods
  Earthquakes
  Reservoir levels
  Outlet works and spillways
  Routing
- SYSTEM RESPONSE
  Failure mechanisms
  Failure probabilities
- CONSEQUENCES
  Outflow hydrographs
  Loss of life
  Economic losses
  Environmental damages

Risk Tools, Procedures
& Capacity building
First Loop: 2008-2012

Risk-Informed Decision Making
First Loop: 2012-....

What is the remaining risk
after implementing the risk
reduction alternatives?

Which alternatives can be
implemented in order to lower
the risk (failure probability
and/or consequences)?

Spanish National Committee on Large
Dams (SPANCOLD)
Technical guide on Dam Safety
2012
Lessons learned from real implementation of risk-informed dam safety management strategies

Risk analyses conducted in:

- Spain
- Sweden
- Albania
- United States
- Uruguay
- Argentina
- Brazil
- Honduras
Lessons learned from real implementation of risk-informed dam safety management strategies

Albania
2014 - [...] Case example B

Spain
2008 - [...] Portfolio of 27 dams
2014 - [...] Case example A
Others
CASE EXAMPLE A: PORTFOLIO OF 3 DAMS OWNED BY THE GOVERNMENT OF EXTREMADURA (SPAIN)

40 dams in Extremadura region owned by the regional government. Risk analyses applied to 3 dams:
• Hervás dam (2000)
• Membrío dam (1960)
• Jaime Ozores dam (1962)

Picture: Hervás (left) and Jaime Ozores dam (right), Spain
CASE EXAMPLE A: PORTFOLIO OF 3 DAMS OWNED BY THE GOVERNMENT OF EXTREMADURA (SPAIN)

Risk model architecture

Loads
- Day/Night
- Sp Avail.
- Previous WL
- BO Avail.
- Routing

System response
- High Uplift
- No detection
- Degradation
- Failure
- Overtopping

Consequences
- M€ fail
- lives fail
- M€ no fail
- lives no
- M€ inc
- vidas inc

Picture: Jaime Ozores risk model
CASE EXAMPLE A: PORTFOLIO OF 3 DAMS OWNED BY THE GOVERNMENT OF EXTREMADURA (SPAIN)

Risk model

Failure mode identification

Dam break modeling

Consequences

Spillway performance
CASE EXAMPLE A: PORTFOLIO OF 3 DAMS OWNED BY THE GOVERNMENT OF EXTREMADURA (SPAIN)

<table>
<thead>
<tr>
<th>Dam</th>
<th>Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2. Surveillance improvement of uplift pressures with piezometers.</td>
</tr>
<tr>
<td></td>
<td>3. Improvement of spillway gates reliability.</td>
</tr>
<tr>
<td></td>
<td>4. Drainage system improvement under the spillway.</td>
</tr>
<tr>
<td></td>
<td>5. Emergency Plan focused on protecting downstream WTP.</td>
</tr>
<tr>
<td></td>
<td>6. Remote spillway gates operation.</td>
</tr>
<tr>
<td></td>
<td>7. New operation rules during flood events.</td>
</tr>
<tr>
<td></td>
<td>8. Reinforce parapet wall to increase dam crest level.</td>
</tr>
<tr>
<td></td>
<td>2. Public risk awareness campaigns</td>
</tr>
<tr>
<td></td>
<td>3. Dam surveillance improvement.</td>
</tr>
<tr>
<td></td>
<td>4. Drainage system improvement at downstream dam face.</td>
</tr>
<tr>
<td></td>
<td>5. Installation of monitoring devices (piezometers)</td>
</tr>
<tr>
<td>El Horcajo dam</td>
<td>1. Lowering the spillway crest by 1.65 meters</td>
</tr>
<tr>
<td></td>
<td>2. Upgrading monitoring</td>
</tr>
<tr>
<td></td>
<td>3. Emergency Action Plan implementation</td>
</tr>
<tr>
<td></td>
<td>4. Improving dam foundation</td>
</tr>
<tr>
<td></td>
<td>5. Public risk awareness campaigns</td>
</tr>
</tbody>
</table>
CASE EXAMPLE A: PORTFOLIO OF 3 DAMS OWNED BY THE GOVERNMENT OF EXTREMADURA (SPAIN)

Results from risk models were used to prioritize a set of 18 dam safety measures.

Variation of risk in a $fN$ graph following the proposed implementation sequence.
# CASE EXAMPLE A: PORTFOLIO OF 3 DAMS OWNED BY THE GOVERNMENT OF EXTREMADURA (SPAIN)

<table>
<thead>
<tr>
<th>Dam</th>
<th>Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2. Surveillance improvement of uplift pressures with piezometers.</td>
</tr>
<tr>
<td></td>
<td>3. Improvement of spillway gates reliability.</td>
</tr>
<tr>
<td></td>
<td>4. Drainage system improvement under the spillway.</td>
</tr>
<tr>
<td></td>
<td>5. Emergency Plan focused on protecting downstream WTP.</td>
</tr>
<tr>
<td></td>
<td>6. <strong>Remote spillway gates operation.</strong></td>
</tr>
<tr>
<td></td>
<td>7. <strong>New operation rules during flood events.</strong></td>
</tr>
<tr>
<td></td>
<td>8. Reinforce parapet wall to increase dam crest level.</td>
</tr>
<tr>
<td><strong>Membrío dam</strong></td>
<td>1. Emergency Action Plan implementation.</td>
</tr>
<tr>
<td></td>
<td>2. Public risk awareness campaigns</td>
</tr>
<tr>
<td></td>
<td>3. <strong>Dam surveillance improvement.</strong></td>
</tr>
<tr>
<td></td>
<td>4. Drainage system improvement at downstream dam face.</td>
</tr>
<tr>
<td></td>
<td>5. Installation of monitoring devices (piezometers)</td>
</tr>
<tr>
<td><strong>El Horcajo dam</strong></td>
<td>1. Lowering the spillway crest by 1.65 meters</td>
</tr>
<tr>
<td></td>
<td>2. <strong>Upgrading monitoring</strong></td>
</tr>
<tr>
<td></td>
<td>3. Emergency Action Plan implementation</td>
</tr>
<tr>
<td></td>
<td>4. Improving dam foundation</td>
</tr>
<tr>
<td></td>
<td>5. Public risk awareness campaigns</td>
</tr>
</tbody>
</table>
CASE EXAMPLE B: PORTFOLIO OF 3 DAMS OWNED BY KESH (ALBANIA)

Drini river
Private dam owner

Fierze Dam (162 m high); Koman Dam (120 m high); and the ‘Vau i Dejes’ system of dams (three dams ranging from 21 to 60 m high).

Picture:
Working session, Albania
CASE EXAMPLE B: PORTFOLIO OF 3 DAMS OWNED BY KESH (ALBANIA)

Risk model architecture (system of dams)
Overtopping failure modes
Variation of risk in a fN graph following the proposed implementation sequence.
CASE EXAMPLE B: PORTFOLIO OF 3 DAMS OWNED BY KESH (ALBANIA)

Results from risk models were used to prioritize dam safety measures for the 3 dams.
Lessons learned

✓ Better knowledge of the system,
✓ Enhanced emergency management,
✓ Capacity building from real cases,
✓ Improved risk communication to the public,
✓ Improved information for defining activities for dam operation and maintenance,
✓ Better knowledge of business/governance risks.
Dam Safety Risk Governance: the way forward

Journal of Risk Research

Overcoming failure in infrastructure risk governance implementation: large dams journey

Ignacio Escuder-Bueno & Eric Halpin

To cite this article: Ignacio Escuder-Bueno & Eric Halpin (2016): Overcoming failure in infrastructure risk governance implementation: large dams journey, Journal of Risk Research
Dam Safety Risk Governance: the way forward

• A changing society, environment and regulatory context.
• Highly dynamic and complex scenarios → participation of all concerned actors.
• A new and integrative risk paradigm provides dam owners with information that is essential to establish strategies for dam safety management.

Successful pilot cases → first steps of a journey for dam owners, aiming at achieving efficient, transparent and robust dam safety governance.
“Risk-informed dam safety management: lessons learned from portfolio risk analysis in Europe”

Thank you for your attention

Jessica Castillo
iPresas Risk Analysis, Spain
www.ipresas.com
jcastillo@ipresas.com