DAM SAFETY MANAGEMENT IN SPAIN

REGIONAL COOPERATION MEETING
DAM SAFETY IN CENTRAL ASIA

Almaty, Kazakhstan
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General Manager OFITECO
Member of the Spanish Committee on Large Dams and
Vice chairman of ICOLD Technical Committee on Dam Surveillance
1. Introduction. Water in Spain
2. Large Dams in Spain
3. Dam Safety Legislation
4. Guidelines on Dam Safety
5. Dam Safety Management
6. Conclusions
1. INTRODUCTION . WATER IN SPAIN

<table>
<thead>
<tr>
<th>Country</th>
<th>Area (Km²)</th>
<th>Population (million)</th>
</tr>
</thead>
<tbody>
<tr>
<td>España (Spain)</td>
<td>504,645</td>
<td>47,2</td>
</tr>
<tr>
<td>Kazakhstan</td>
<td>2,717,300</td>
<td>17</td>
</tr>
<tr>
<td>Kyrgyzstan</td>
<td>198,600</td>
<td>5,5</td>
</tr>
<tr>
<td>Tadjikistan</td>
<td>143,100</td>
<td>6,5</td>
</tr>
<tr>
<td>Uzbekistan</td>
<td>447,400</td>
<td>29,4</td>
</tr>
<tr>
<td>Azerbaijan</td>
<td>86,600</td>
<td>9,1</td>
</tr>
</tbody>
</table>
Climate and hydrology

- Highly irregular rainfall and river flow, both in time and space.

- Temporal variation is not only seasonal but also from year to year.

- Only an 8.3% of the renewable resources is available in natural regime (9.19 km\(^3\)/year).

- That means that there are only 239 m\(^3\)/person/year available in natural regime.
1. INTRODUCTION. WATER IN SPAIN

Facts and Data on Water in Spain

- Humid Spain
- Dry Spain

Only 70l/day

WATER RESOURCES IN NATURAL REGIME (1996), PER CAPITA (m3/person/year)

TOTAL SPANISH PENINSULA 239 m3/person/year

m3/person/year
< 10
10 - 50
50 - 100
100 - 200
200 - 500
> 500
1. INTRODUCTION . WATER IN SPAIN

Facts and Data on Water in Spain

- Spain has required, since ever, an enormous effort in water resources planning.

- Dams and reservoirs made it possible to increase the natural regulation of only 8.3% up to 40% of the water resources.

<table>
<thead>
<tr>
<th>Natural resources</th>
<th>Available without regulation</th>
<th>Available with regulation</th>
<th>Reservoir capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>112 km³</td>
<td>9,19 km³</td>
<td>46 km³</td>
<td>56 km³</td>
</tr>
</tbody>
</table>
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Dam construction in Spain has a long history of more than 2000 years, starting in the Roman period.

Roman dams still under operation

Proserpina

Cornalbo
2. LARGE DAMS IN SPAIN

967 (80%) dams built in the period 1950 - 2000
2. LARGE DAMS IN SPAIN

- At present there are more than 1200 large dams under operation:
  - 1/3 aprox. are operated by the government
  - 2/3 operated by private companies under temporal license

- Irrigation demand for irrigation: 24,2 billion m³

- Water supply demand: 4,3 billion m³

- Industrial demand: 1,9 billion m³

- Irrigated area: 3,7 million hectares (37.000 km³)

- Benefits produced by Spanish Dams: ~ 30 billion € (= 3% of GDP)
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3. DAM SAFETY LEGISLATION

Legislation on Dam Safety: Historic Development

- **1905** Spain adopts the first European standards related with dams: “Instructions for developing reservoir projects”

- **1959** Failure of Vega de Tera buttresses dam killing 144 persons in Ribadelago. This fact promoted:
  - The constitution of the Commission of Large Dams Regulations
  - **Commitment: To develop new standards for dam projects**
  - The creation of the National Service of Surveillance and Inspection of Dams
  - **Commitment: To survey safety of dams**

- **1967** The “Instruction for the Project, Construction and Operation of Large Dams” is adopted.
Tous Dam failure in October 1982

Tous Dam after failure in 1982
Tous dam failure in 1982 originated a complete review of Dam Safety regulations:

1982 The failure by overtopping of Tous Dam originated the starting of a “Safety Program for Large Dams” that are state owned.

1992 The General Directorate of Hydraulic Works decided to prepare new standards for dam safety, commending this task to the Commission of Large Dams Regulations.

1995 The “Directive on Civil Protection in the case of flood risk” was published, including a section dedicated to emergency planning for the risk of failure or malfunctioning of dams.

1996 The “Technical Regulation on Dams and Reservoirs Safety” was approved, summarizing the works of the Commission of Large Dams Regulations and integrating the requirements of the “Directive on Civil Protection in the case of flood risk.”

2008 A Royal Decree came into effect to establish common obligations and responsibilities for all dam owners. The text mentions that dam safety management should be risk based.
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Guideline collection prepared by the Spanish Committee on Large Dams (SPANCOLD):

http://www.spancold.es/Paginas/lista_publicaciones.asp?Categoria=Guias_Tecnicas

<table>
<thead>
<tr>
<th>SPANCOLD Technical Guidelines</th>
<th>Year of Publication</th>
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<tbody>
<tr>
<td>Dam Safety</td>
<td>2005</td>
</tr>
<tr>
<td>Design criteria for dams and complementary works</td>
<td>2002</td>
</tr>
<tr>
<td>Geologic-geotechnical aspects and material studies</td>
<td>1999</td>
</tr>
<tr>
<td>Design Flow</td>
<td>1997</td>
</tr>
<tr>
<td>Spillways and Outlets</td>
<td>1997</td>
</tr>
<tr>
<td>Dam Construction and Quality Control</td>
<td>1999</td>
</tr>
<tr>
<td>Monitoring of dams and their foundations</td>
<td>2004</td>
</tr>
<tr>
<td>Operation and maintenance of dams: Vol. I: Risk Analysis applied to dam safety management</td>
<td>2012</td>
</tr>
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</table>
Guideline collection prepared by SPANCOLD
Guidelines by the General Directorate of Water

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<tr>
<td>Dam classification according to potential risk</td>
<td>1996</td>
</tr>
<tr>
<td>Elaboration of Emergency Action Plans</td>
<td>2001</td>
</tr>
<tr>
<td>Operation and Maintenance</td>
<td>Draft version</td>
</tr>
<tr>
<td>Annual Report</td>
<td>Draft version</td>
</tr>
<tr>
<td>Safety Review</td>
<td>Draft version</td>
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5. DAM SAFETY MANAGEMENT

Tous dam failure in 1982 originated a complete review of Dam Safety regulations:

- Main focus on risk potential in the downstream areas of dams

- Implementation of non-structural measures such as:
  - Real time hydro meteorological information systems
  - Emergency action plans

- Comprehensive Dam Safety Management Programs
  - Detailed review of safety conditions of existing dams
  - Review and improvement of operation and maintenance procedures
  - On-going dam surveillance activities
Fundamental tools:
Real time early warning and flood forecast systems & DSS

Quantity and Quality
Fundamental tools: Dam monitoring and on-going safety assessment

Web-based tool for an integrated management of real time & on-site monitored data
Basic elements in a Dam Safety Process according to ICOLD:

- **Diagnosis and Accountability**
  - **Évaluation de la Sécurité Dam Safety Review**
    - Periodical safety review
    - Assessment studies
    - Hydraulic studies
  - Dam safety data management

- **Regulation & Guidelines**
- **Programming**
- **Surveillance**
  - Visual inspections
  - Monitoring
  - Flow control equipment assessment
  - Performance monitoring

- **Safe Water Management**

- **Emergency Preparedness**

**Dam Safety Program**
5. DAM SAFETY MANAGEMENT

Detailed tasks and actions:

- Constitution of Dam File containing all relevant documents
5. DAM SAFETY MANAGEMENT

Detailed tasks and actions:

- Constitution of Dam File containing all relevant documents
- Potential Risk Classification
Detailed tasks and actions:

- Constitution of Dam File containing all relevant documents
- Potential Risk Classification
- **Operation & Maintenance rules**

![Graph showing the relationship between water level and aperture](image)

**Caudales del río Turia tras su confluencia con el Tuejar para T=500 y T=100 años, variando el estado de humedad antecedente del suelo.**

**Caudal (m3/s)**

- T500SINEMBHUM
- T500SINEMB
- T500SINEMBSECA
- T100SINEMBHUM
- T100SINEMB
- T100SINEMBSECA

![Graph showing the variation of flow rate with time](image)
Detailed tasks and actions:

- Constitution of Dam File containing all relevant documents
- Potential Risk Classification
- Operating procedures
- **Emergency Action Plan**

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**Action protocol**

- **PROTOCOLO P.3**
  - PROTOCOLO PARA ACTUACIÓN EN SITUACIÓN DE AVENIDAS
  - Se recibe aviso de posible avenida por parte de la C.H.J.
  - La C.H.J. recibe aviso de posibles lluvias intensas
  - No hay aviso por parte de la C.H.J., pero se detecta una subida anormal del embalse

  **ACTUACIONES**

  - EN LA PRESA
    - 1. Comunicación con C.H.J.
    - 2. Intensificación de los controles en la presa y el embalse.
    - 3. Preparación y comprobación de los desagües.
    - 4. Se estará a la espera de las órdenes de la C.H.J.
    - 5. Se realizará el seguimiento de la avenida
      Con el formulario F.09

  - **CAUDALES A EVACUAR:**
    - Los caudales recomendados en función del caudal de entrada y la cota de embalse se presentan en el gráfico siguiente.
    - No obstante, está una posibilidad de muchas que se pueden utilizar para la actuación en caso de avenida.
    - El Comité Permanente con el mayor conocimiento de las características de la avenida, actuará en consecuencia.

  **PREAVISOS**

  - **PROTOCOLO P.1**
    - Fallan las comunicaciones?
      - SI
        - **PROTOCOLO P.6**
          - De confirmarse la situación de avenida, deberá constituirse el Comité Permanente, que deberá:
            1. Obtener información para conocer la situación en la presa y aguas abajo.
            2. Determinar las actuaciones en la presa.
            3. Determinar los preavisos y alarmas.

  - **PROTOCOLO P.1**
    - **SI**
      - **PROTOCOLO P.6**
        - De confirmarse la situación de avenida, deberá constituirse el Comité Permanente, que deberá:
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          2. Determinar las actuaciones en la presa.
          3. Determinar los preavisos y alarmas.

---
5. DAM SAFETY MANAGEMENT

Detailed tasks and actions:

- Constitution of Dam File containing all relevant documents
- Potential Risk Classification
- Operating procedures
- Emergency Action Plan
- *Inspection Reports*

*Images:
- Dam and reservoir inspection
- Hydromecanical equipment
- Galleries and foundations*
Detailed tasks and actions:

- Constitution of Dam File containing all relevant documents
- Potential Risk Classification
- Operating procedures
- Emergency Action Plan
- Inspection Reports
- Safety Review
5. DAM SAFETY MANAGEMENT

Detailed tasks and actions:

- Constitution of Dam File
- Potential Risk Classification
- Operating procedures
- Emergency Action Plans
- Inspection Reports
- Safety Review
- Annual Reports
Future trends

- The dam engineering community agrees on the importance to update and unify regulations and safety requirements for both, state-owned and non-state dams.

- Currently there is a clear trend towards a Risk-Based Dam Safety Decision Process.

- A dam safety law based on new technical regulations and the risk analysis methodology is under preparation.
Future trends: Overall holistic approach – on-going process

Current Safety Profile

Organizational Integration

Routine Activities:
- Monitoring & Surveillance
- Visual Inspections
- Operation & Maintenance
- Staff training, etc.

Periodic Safety Reevaluation:
- “TRADITIONAL” Safety Reviews
- RISK-BASED APPROACH

Mid & Long-term Measures:
- Structural / Non structural fixes
- Investigations & Studies
- Operation Optimization
- Budget & Phasing, etc.

Short-term Measures:
- Trigger EAP
- Heightened surveillance
- Operating restriction, etc.

Source: G. Membrillera, 2011
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Spain has more than 1200 large dams and therefore a strong tradition and technical capability in this type of infrastructures and specifically in dam safety management.

Dam safety regulations are basic and fundamental to establish dam safety programs aiming to reduce risk.

All type of dam safety regulations should consider not only technical aspects but also available economical resources and technical capabilities of dam owners and regulators.

Training and capacity building of all personnel involved is of crucial importance.

A modern Dam Safety Program should have a risk approach and is an on-going process.

Spanish organizations and institutions (e.g. General Directorate of Water belonging to the Ministry of Agriculture and Environment and the Spanish Committee on Large Dams SPANCOLD) are pleased to share the experience gathered over many years with other countries (exchange and training programs).
Thank you very much for your attention

Useful websites:

www.spancold.es

www.icold-cigb.org

www.damsafety.com