DAM SAFETY MONITORING & SURVEILLANCE IN MALAYSIA

Ir. Liew Shaw Shong | En. Mohd Hizan Kamaruzaman | En. Othman bin Darjad
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• Dam Safety Management (Monitoring & Surveillance)
• Future Trend
• Problems in Current Dam Safety Practice
• What Malaysia Needs?
INTRODUCTION
INTRODUCTION:
WHY DAM SAFETY IS IMPORTANT IN MALAYSIA?

- Last two decades - steady increase in numbers of dam
- More than 50% of existing dams are constructed more than 25 years
- Dams subject to ageing process
- Changing natural forces
DAM BREACH:
SOME CASE HISTORIES
Teton Dam (1975 – 1976)
Immediately following the disaster, Mulholland said he “envied those who were killed” and went on to say, “Don’t blame anyone else, you just fasten it on me. If there was an error in human judgment, I was the human, and I won’t try to fasten it on anyone else.”

"the construction and operation of a great dam should never be left to the sole judgment of one man, no matter how eminent."

St Francis Dam, US 1924-1928
(Killed 600 people)

Vajont Dam, Italy 1959-1963
(Killed 2000 people)
Situ Gintung Dam, Indonesia (1933 –2009)
CURRENT INVENTORY OF DAMS

• Total of about 75 dams built in Malaysia
• Purpose & Owner:
  – Irrigation (MADA/JPS)
  – Water supply (JKR/JBA)
  – Flood Defense (JPS)
  – Hydropower (TNB/SESCO/SEB)
  – Recreation (PJC)
  – Mine Tailing & Ash Deposition (Mining Companies)
## CURRENT INVENTORY OF DAMS

### Summary of Dams in Malaysia (as at 2006)

<table>
<thead>
<tr>
<th>No</th>
<th>Purpose</th>
<th>Dam Operator</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Flood Control</td>
<td>JPS</td>
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</tr>
<tr>
<td>2</td>
<td>Hydroelectric</td>
<td>TNB</td>
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<td>3</td>
<td>Water Supply</td>
<td>Private &amp; Water Board</td>
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<td>4</td>
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<td>MADA</td>
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<td></td>
<td><strong>Total</strong></td>
<td></td>
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DAMS IN PENINSULAR MALAYSIA

- Timah Tasoh
- Padang Saga
- Malut
- Ahning
- Pedu
- Muda
- Beris
- Telok Bahang
- Ayer
- Mengkuang
- Itam
- Bukit Merah
- Temenggor
- Pergau
- Gopeng
- Sultan Abu Bakar
- Sg Tinggi
- Repas Lama
- Repas Baru
- Putrajaya
- Batu
- Klang Gates
- Upper Muar
- Kenering
- Chenderoh
- Langat
- Terip
- Semenyih
- Pedas
- Air Keroh
- Durian Tunggal
- Pontian
- Anak Endau
- Juaseh
- Labong
- Chongok
- Bekok
- Semberong
- Macap
- Linggiu
- Lebam
- Upper & Lower Layang
DAMS IN EAST MALAYSIA

- Bakun
- Belaga
- Linau
- Merjawah
- Ulu Air
- Batang Ai Extension
- Baleh
- Belepeh
- Murum
- Baram
- Belaga
- Bakun
- Merjawah
- Murum
- Linau
- Baram
- Limbang
- Tutoh
- Lawas
- Babagon
- Sg Pagar
- Bkt Kuda
- Kerupang
- Ulu Air
- Batang Ai Extension
<table>
<thead>
<tr>
<th></th>
<th>Name of Dam</th>
<th>State</th>
<th>Purpose</th>
<th>Year Completed</th>
<th>River System</th>
<th>Type</th>
<th>Height (m)</th>
<th>Crest Length (m)</th>
<th>Reservoir FSL Storage Level (m)</th>
<th>Reservoir Storage at FSL (MCM)</th>
<th>Design Flood (m³/s)</th>
<th>Weir Type</th>
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**Dam Purpose:**
- W-Water Supply
- I-Irrigation
- H-Hydropower
- F-Flood Control
- Re-Recreation
- SR-Silt Retention

**Type of Spillway:**
- G-Gated
- U-Ungated
- C-Chute
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<th>Design Flood (m³/s)</th>
<th>Weir Type</th>
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<th>Design Flood (m³/s)</th>
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<tr>
<th>Name of Dam</th>
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CURRENT INVENTORY OF DAMS

Water Supply Dam – Klang Gates (Taman Melawati)

Water Supply Dam (Sg. Selangor)
CURRENT INVENTORY OF DAMS

Irrigation Dam – Pedu Dam (Alor Setar)

Flood Defense Dam – Beris Dam (Kedah)
CURRENT INVENTORY OF DAMS

Recreation Dam
(Putra Jaya)

Hydropower Dam - Bakun
(SESCO)
OBJECTIVE OF DAM SAFETY MONITORING & MAINTENANCES
OBJECTIVE OF DAM SAFETY MONITORING & MAINTENANCES

- Prevent **disastrous consequences** to:
  - National Security
  - Public Safety
  - Social Economy
  - Environmental

Diagram:
- Surveillance
- Monitoring
- Field Instrumentation
- Metrology
**OBJECTIVE OF DAM SAFETY MONITORING & SURVEILLANCE**

**Dam Safety Monitoring & Surveillance** should include identifying:

- **Factors** that influence
  - **Safe operation** of dam / appurtenant structures
  - **Dam’s potential** to adversely affect human life, human health, property, and the environment surrounding it.

- **Adequacy** of operations, maintenance & emergency plan of the dams
ROLE & RESPONSIBILITY OF STAKEHOLDERS
ROLE & RESPONSIBILITY OF DAM REGULATOR

• **Regulator**
  – Monitor obligatory tasks \((\text{monitoring} \ & \ \text{surveillance})\) by dam owner
  – **Review & approve competency** of technical staff by the owner for monitoring & surveillance
  – Organize scheduled **independent inspection** for compliance check
  – Review & approve **surveillance report**
ROLE & RESPONSIBILITY OF DAM OWNER & OPERATOR

• **Owner**
  
  – Collect and storage of up-to-date documentations:
    • **Static data** in Data Book - design, as-built, operating manual
    • **Dynamic data** in Dam Safety & Surveillance Report - maintenance, monitoring, repair & incident reports of dam
  
  – Implement **Monitoring & Surveillance**
  
  – Implement **Maintenance Scheme**
ROLE & RESPONSIBILITY OF DAM OWNER & OPERATOR

- **Operator**
  - Perform *regular visual inspection*
  - Perform *periodical check and maintenance* of control systems, discharge structures, etc
  - Annual reporting
ROLE & RESPONSIBILITY OF DAM ENGINEER

- **Engineer**
  - Perform comprehensive **technical inspections**
  - Plan additional **monitoring** & taking measurements at scheduled interval or changes in **operational conditions**
  - **Interpret, analyze data** collected & visually present outcome in graphical form
  - **Highlight** any slowly developing but rapid deteriorating **dangerous trends** or signs (**anomalous behaviors**)
  - Prepare surveillance report
ROLE & RESPONSIBILITY OF DAM CONTRACTORS

• **Contractor**
  – Assist the **Engineer** on their tasks
  – **Repair** damaged **instruments** or **install** additional instruments
  – **Improve** precision & reliability of **instruments** & measurements
  – Take measurements & **compile data** collected
  – Prepare factual monitoring report
DAM SAFETY MANAGEMENT
DAM SAFETY MANAGEMENT

• Responsibilities of dam owners in Malaysia:
  1. *Guidelines for Operation, Maintenance and Surveillance of Dams* (Malaysia Inter-Departmental Committee on Dam Safety, 1989)
  2. *Guideline of ICOLD* (International Committee on Large Dams)

• However, a holistic dam safety policy for the country is required:
  – Legislation ➔ **Lack of Institutional Power**
  – Regulator ➔ **Need of One Stop Agency**
  – Enforcement
DAM SAFETY MANAGEMENT

• **Safety Inspection**
  – Routine Safety Inspection
  – Periodic Safety Inspection
  – Special Safety Inspection

• **Dam Safety Management Plan**

• **ERP – Emergency Response Plan**
  – Prepared based on dam break study
  – ERP during construction and operation phases
  – Avoid and minimized injury/loss of life to employees and public during emergency incidents
DAM SAFETY REGULATORY FRAMEWORKS

Emerging Trends

Desirable Elements

Essential Elements

International Dam Safety Regulatory Frameworks
ANCOLD (1976 & 2003) defines:

- **Monitoring**
  - Acquiring data from measuring devices
  - Recording of data
  - Deducing performance and behavioral trends

- **Surveillance**
  - Continuing examination of conditions
  - Reviewing operation, maintenance and monitoring procedures and results
  - Determining whether hazardous trend is developing or appears likely to develop
Monitoring & Surveillance shall be continued as long as the hazards associated with the existence of the dam present.

Level of Monitoring & Surveillance depends on consequences of failure.
MONITORING

- **Survey** on:
  - Deformation of dam
  - Reservoir level & rainfall
- **Measurements** on:
  - Seepage & pore pressure
  - Foundation pressure
  - Stresses in dam & structures
- **Spillway performance** & condition
- Monitoring on:
  - Cracks
  - Erosion
  - Seismicity (esp. for large reservoir or at seismically active areas)
Monitoring

Frequency depends on

Consequence of Failure
Nature of Behavior being monitored

Special Incidents (Extreme climatic condition, earthquake)
Stage of Maturity of Dam
SURVEILLANCE

• Safety Inspection
  – Routine Safety Inspection
  – Periodic Safety Inspection
  – Special Safety Inspection

• Dam Safety Management Plan
UNCONTROLLED LEAKAGE/SEEPAGE
CRACKS ON DAM STRUCTURES
TENSION CRACKS ON DAM CREST
EROSION ON EMBANKMENT SLOPES

Erosion at the Downstream Face of Dam

Erosion due to Dam Overtopped
INSTRUMENTATION MONITORING OF DAM
STATE-OF-ART & FUTURE TREND OF INSTRUMENTATION

Instruments
- Fiber Optic Sensors
- Automated Total Station
- LiDAR Terrestrial Survey
- GPS Displacement
- Real Time Data Acquisition & Communication Systems

Problems & Solutions
- Electromagnetic Interference (EMI)
- Damages during Electrical Storms
- Data Reliability
- Longevity of Instruments

Analysis & Software
- Early Warning System
- Data Processing, Interpretation & Presentation Software
- Databases & Data Management System
TYPICAL INSTRUMENTATION FOR EARTH DAM

Source: http://www.geokon.com/products
TYPICAL INSTRUMENTATION FOR CONCRETE DAM

Source: http://www.geokon.com/products
DAM LEAKAGE/SEEPAGE MEASUREMENT

Flow Through a V-Notch Weir

\[ Q = \left( \frac{g}{2} \right)^{1/2} \left( \frac{5}{2} \right)^{5/2} \frac{V^2}{\gamma_c} = \frac{V^2 \gamma_c}{1.267 H^{2.5}} \] (H in m)
SEISMOGRAM
HYDROLOGICAL INSTRUMENTATION

Flip Bucket Rain Gauge
DISPLACEMENT SURVEY USING 3D GROUND BASED TERRESTRIAL LiDAR

3D Light Detection and Ranging Equipment (LiDAR)
BEHAVIOURAL ANALYSIS
BEHAVIOURAL ANALYSIS
Seepage Analysis (FEM Modelling)

FEM - 0.2 lit/s to 0.4 lit/s
More future dam development due to:
- Energy shortage & green energy encourage hydropower dam development
- Climate change & urbanisation lead to development of dams with multi-purposed water supply, irrigation & flood defense dams

More dam projects under private initiated fund

Uncontrolled development within water catchment (lack of development land)
CLIMATE CHANGE & WATER CRISIS

- March 2010
- Dried-out reservoir in Kunming, China
UNDERLYING PROBLEMS OF CURRENT MALAYSIA DAM SAFETY PRACTICE

- Lack of legal institutional power in Regulatory Frameworks
- Unclear line of responsibility among the stakeholders
- Inconsistent practice & reporting of Dam Safety
- Lack of inter-agency coordination hinders efficient development of multi-purpose dams with combined interests
- Tailing dams are exclusive under the current guidelines
- Landslides, siltation & water quality problems arise from uncontrolled development within water catchment
- Lack of Central Regulatory Agency
WHAT MALAYSIA NEEDS FOR DAM SAFETY REGULATORY FRAMEWORKS?

• Regulatory frameworks for Dam Safety
  – Legal form of the regulation
    *(Statue/acts, regulations, decrees or guidelines)*
  – Institutional arrangement
    *(position of regulatory authority within government structure, their independence from policymakers & regulated entities, relationship with other government bodies)*
WHAT MALAYSIA NEEDS FOR DAM SAFETY
REGULATORY FRAMEWORKS?

• Regulatory frameworks for Dam Safety (Cont’d)
  – **Powers of regulating entity**
    (advisory function or regulation binded decisions [issue License/Permit to construct & operate], rule and policymaking & enforcement power of the regulator, ability to monitor & inspect the operations of the regulated entities)
  – **Content of regulatory scheme**
    (regulated entities’ obligations, scope of regulations, consequences of non-compliance)

• Classify **essential elements, desirable elements & emerging trends** in the regulatory frameworks
Lord Kelvin (1827 - 1907):

When you can measure what you are speaking about, and express it in numbers, you know something about it; but when you cannot measure it, when you cannot express it in numbers, your knowledge is of a meagre and unsatisfactory kind; it may be the beginning of knowledge, but you have scarcely in your thoughts advanced to the state of Science, whatever the matter may be.