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Basic Studies
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Basic Studies

- Flood Hydrology
  - Statistical Flood Hydrology
  - 10,000 yr flood: 33,500 m³/s
  - PMP/PMF Study
  - PMF: 41,100 m³/s

- Seismic Hazard Assessment

<table>
<thead>
<tr>
<th>Design Earthquake</th>
<th>Analysis Method</th>
<th>Return Period (year)</th>
<th>Peak Ground Acceleration (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
<td>Horizontal</td>
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<td>Probabilistic</td>
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<td>Probabilistic</td>
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<td>SEE</td>
<td>Probabilistic</td>
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<tr>
<td>SEE</td>
<td>Deterministic</td>
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<td>0.49</td>
</tr>
</tbody>
</table>
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Geological Investigation Program

Reservoir

Access Road

Boreholes Location
- Phase 1
- Phase 2

250 m
0
250

BH-33  BH-32  BH-31  BH-30
BH-29  BH-28  BH-27  BH-26
BH-25  BH-24  BH-23  BH-22
BH-21  BH-20  BH-19  BH-18
BH-17  BH-16  BH-15  BH-14
BH-13  BH-12  BH-11  BH-10
BH-09  BH-08  BH-07  BH-06
BH-05  BH-04  BH-03  BH-02
BH-01  BH-00

DECEMBER 2019
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Design Criteria

- Seismic Design Criteria
  - Dam Safety Relevant Structures -> SEE
  - All other structures -> DBE

- Hydraulic Design Criteria
  - Design Flood: 10,00 yr flood, (n.1)-rule
  - Safety Check Flood: PMF

- Hydraulic Model Tests
  - Flume tests for the Spillway carried out
  - Spillway Capacity is given
  - Test on overall model are ongoing
Stability Checks
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Stability Checks

- Standards
  - USACE manual
  - LEPTS (Lao Electric Power Technical Standards)
- Load Cases
  - Usual, Unusual and Extreme Load cases
  - Floatation, Sliding and Rotation/Otverturning
- Dam Safety relevant Structures
  - Navigation Lock
  - Spillway
  - Powerhouse, incl. Right and Left Pier
  - Closing Structure
- Results of Stability Checks
- Navigation Lock
  - Upper Lock not critical
- Spillway
  - Current design is conservative
- Right Pier
  - Right Pier is not critical (potential for optimization)
- Powerhouse
  - Relevant and already optimized
  - Safety requirements are fulfilled
  - Revision after layout is revised (hydraulic contours of draft tube as per equipment supplier)
- Left Pier
  - Left Pier is not critical (potential for optimization)
- Closing Structure
  - Relevant
  - Safety requirements are fulfilled
Monitoring Program
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Monitoring Program

- Relevant during impounding and operation
- General
  - Visual Inspections: Regular inspections by O&M staff
  - Survey Monitoring: Measurement of surface displacements and deformations
  - Monitoring Instruments: Deformation, water pressure, etc.
- Dam Instrumentation
  - Parameters and Instruments as below:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Monitoring Instruments</th>
</tr>
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<tbody>
<tr>
<td>Displacement, movement, settlement</td>
<td>Jointmeter, Rocmeter, Inclinometer, Levelling bolt, Stationary light reflector</td>
</tr>
<tr>
<td>Water level, water pressure</td>
<td>Gauge, Observation well, Piezometer</td>
</tr>
<tr>
<td>Leakage/ seepage</td>
<td>Flowmeter, Piezometer</td>
</tr>
<tr>
<td>Climate</td>
<td>Weather station</td>
</tr>
<tr>
<td>Dynamic response (seismicity)</td>
<td>Strong Motion Accelerator</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Monitoring Instrument</th>
<th>Behaviour</th>
<th>Reading</th>
<th>No</th>
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</thead>
<tbody>
<tr>
<td>Flowmeter (FM)</td>
<td>Water Leakage</td>
<td>Automatic</td>
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<tr>
<td>3D-Jointmeter (TJM)</td>
<td>Movement Displacement Settlement</td>
<td>Automatic</td>
<td>75</td>
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<tr>
<td>Rocmeter (RM)</td>
<td>Movement Displacement Settlement</td>
<td>Automatic</td>
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</tr>
<tr>
<td>Inclinometer (IM)</td>
<td>Movement Displacement Settlement</td>
<td>Manual</td>
<td>3</td>
</tr>
<tr>
<td>Groundwater Observation Well (OW)</td>
<td>Water Level Uplift Pressure</td>
<td>Manual</td>
<td>10</td>
</tr>
<tr>
<td>Strong Motion Accelerometer (SMA)</td>
<td>Dynamic Response</td>
<td>Automatic</td>
<td>2</td>
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<tr>
<td>Leveling Bolt (LB)</td>
<td>Movement Displacement Settlement</td>
<td>Manual</td>
<td>50</td>
</tr>
<tr>
<td>Stationary Light Reflector (SR)</td>
<td>Movement Displacement Settlement</td>
<td>Manual</td>
<td>30</td>
</tr>
<tr>
<td>Weather Station</td>
<td>Rainfall Intensity Temperature Relative Humidity Barometer Wind Velocity Evaporation Pyranometer</td>
<td>Automatic</td>
<td>1</td>
</tr>
</tbody>
</table>
Emergency Planning and Dam Break Analysis
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Emergency Planning and Dam Break Analysis

- Emergency Action Plan
  - Objectives:
    - Guidelines for emergency management
    - For abnormal events, accidents, emergency events
    - Roles, responsibilities, response, communication procedures
    - For all stakeholders of the project
    - Guidelines for O&M
    - Flood operation, training, inspection, …
  - Organization
    - Internal Organization
      - Activities and Responsibilities of Owner
    - External Organization
      - Responsibilities of Lao authorities

- Dam Break Analysis
  - Basis for EAP planning (warning and evacuation planning)
  - Results shown as Inundation maps

- Dam Break Scenarios
  - Natural floods
    - Carried out for different return periods
    - 100, 1,000, 10,000 yr and PMF
  - Mis-Operation of Spillway
    - Cyber-Attack: All gates opened simultaneously
  - Dam Break flood assessment
    - Breach development at RCC Closing Structure
    - Failure of one block and the two neighboring blocks within 0.5 hrs