Phase II Report: Project Definition Options

Dam Safety

Part 2: Hydrology & Flood Control
Review of HPI’s Design
Figure 3.1: Plan view - Diversion and spillway structures – HPI scheme
\[ \Delta H_{\text{MAX}} = 110 \text{ m} \]

\[ \Delta H_{\text{MAX}} = 185 \text{ m} \approx 199 \text{ with respect to gates} \]

\[ \Delta H_{\text{MAX}} = 150 \text{ m} \]

\[ \Delta H_{\text{MAX}} = 150 \text{ m} \]

Segment gates in all cases

\[ \Delta H_{\text{MAX}} : \text{Head at the intake} \]

\[ t_{\text{op}} : \text{whole project life only during wet seasons} \]

\[ t_{\text{op}} : \text{approx. 10-12 years on a permanent basis} \]

Figure 3.3: Operation range of discharge tunnel - HPI
Conclusion:

According to the Consultant criteria, several items appear not to be fully safe:

- The level of protection of the cofferdam is not sufficient.
- The waterhead that all structures (temporary or final) have to support is too high.
- The Ionaksh fault is not mentioned and no remedial measures are proposed to cope with its displacements whereas there is a significant construction period of high dependence on DT3.
- Only two independent structures.
- Vortex dissipation devices have not been tested at this scale.
- There is no provision against GLOFs.
- Impact of sedimentation not taken into account.
Proposed TEAS Design
### Flood Probability

<table>
<thead>
<tr>
<th>TMR (yr)</th>
<th>Peak Discharge (daily; m³/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Lower*</td>
</tr>
<tr>
<td>2</td>
<td>2 200</td>
</tr>
<tr>
<td>5</td>
<td>2 600</td>
</tr>
<tr>
<td>10</td>
<td>2 900</td>
</tr>
<tr>
<td>20</td>
<td>3 100</td>
</tr>
<tr>
<td>50</td>
<td>3 400</td>
</tr>
<tr>
<td>100</td>
<td>3 700</td>
</tr>
<tr>
<td>200</td>
<td>3 900</td>
</tr>
<tr>
<td>500</td>
<td>4 200</td>
</tr>
<tr>
<td>1000</td>
<td>4 500</td>
</tr>
<tr>
<td>2000</td>
<td>4 700</td>
</tr>
<tr>
<td>5000</td>
<td>5 000</td>
</tr>
<tr>
<td>10 000</td>
<td>5 300</td>
</tr>
<tr>
<td>PMF</td>
<td>6 100</td>
</tr>
</tbody>
</table>

* : Conf. Interval of 95% (99%)
The probability of occurrence of a phenomenon with a mean period of return “TMR” within a certain period of time “TE” (time of exposure) can be evaluated with the formula:

\[ P_{occ} = (1 - (1 - \frac{1}{TMR})^{TE}) \]

When \( \text{TE} \ll \text{TMR} \) the value of the probability of occurrence is close to the same ratio \( \text{TE}/\text{TMR} \) and is expressed as “one in N” or “one out of N cases”.

The design flood for each stage of the dam construction is selected on this basis:
1. an acceptable probability of occurrence is adopted,
2. period of exposure of each stage of construction is evaluated,
3. the resulting period of return of the flood is deduced,
4. the upper bound (97,5% confidence) of the peak discharge having that period of return is adopted,
5. evacuating facilities (tunnels, spillways, etc.) are checked or re-designed to provide the required level of safety.

Values of processes 1 through 4 are given in the next table.
Design criteria:

- Tunnels should not operate under heads higher than 120 m. This condition limits forces on gates and flow velocity to acceptable values. Exception is made for extraordinary (rare and short lasting) opportunities when heads up to 150 m are tolerated. Case of difficult operation during and after earthquakes, etc.

- For each construction stage at least two independent evacuating organs (i.e. tunnels) are required.

- For high reservoir levels flood routing effects (peak attenuation) are taken into account.

- No discharge through the turbines is taken into consideration during flood peaks.
Area of location of the possible Surface Spillway
Hydrographs for 10 000-yr Flood and Probable Maximum Flood
Stepped Spillway - Ski Jump Trajectories

\[ H = H^0 - y = H^0 - (x \cdot \tan \alpha + \frac{x^2}{4K \cdot \Delta H \cdot \cos^2 \alpha}) \]

**Sensitivity Study**

<table>
<thead>
<tr>
<th>#</th>
<th>( \Delta H )</th>
<th>( \alpha^* )</th>
<th>( K )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>50</td>
<td>15</td>
<td>0.8</td>
</tr>
<tr>
<td>2</td>
<td>60</td>
<td>15</td>
<td>0.8</td>
</tr>
<tr>
<td>3</td>
<td>70</td>
<td>15</td>
<td>0.8</td>
</tr>
<tr>
<td>4</td>
<td>80</td>
<td>25</td>
<td>0.8</td>
</tr>
<tr>
<td>5</td>
<td>90</td>
<td>25</td>
<td>0.8</td>
</tr>
<tr>
<td>6</td>
<td>100</td>
<td>45</td>
<td>0.8</td>
</tr>
<tr>
<td>7</td>
<td>110</td>
<td>35</td>
<td>0.7</td>
</tr>
</tbody>
</table>

**Elevation of Flow Trajectories (m asl)**

**Distance from the SKI-JUMP Deflector (m)**

**COYNE ET BELIER**

**ELC**

**IPA**

TECHNO-ECONOMIC ASSESSMENT STUDY
FOR ROGUN HYDROELECTRIC CONSTRUCTION PROJECT
5. CONCLUSIONS AND RECOMMENDATIONS

The feasibility of a surface spillway has been proven for each one of the three dam height alternatives, having a discharge capacity equal to the peak of the Probable Maximum Flood, to be implemented in the long term on the right bank of the reservoir, close to the dam.

This surface spillway is to replace the other flood evacuating organs once when the sediments in the reservoir make them useless or reduces their discharge capacities.
... main components are described ....

All these components have been designed and dimensioned on the basis of the state of the art and have been determined to be feasible. Model tests are recommended for design optimization.
Alternative 1290 m asl
Diversion tunnels
Alternative 1290 m asl
Mid Level Outlets
Alternative 1290 m asl
High Level Tunnels

Legend
- High level tunnel spillway with chainage (m)
- Dam layout
Alternative 1290 m asl Surface Spillway
Thank you!