Diversion Tunnel Orifices for Energy Dissipation During Reservoir Filling

Site C Clean Energy Project
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On Peace River, near Fort St. John in Northern British Columbia
Third dam on the Peace River downstream from WAC Bennet and Peace Canyon.

The 2 current dams on the Peace River generate 38% of BC Hydro’s total generation. With Site C it will increase to 44%.
Site C Clean Energy Project

DAM
- Type: Earthfill Dam
- Length: 1,050 metres
- Height: 60 metres
- Capacity: 1,100 MW
- Energy: 5,100 GWh/yr.

RESERVOIR
- Length: 83 km
- Width: 2-3 times current river (on average)
Site C Clean Energy Project
Diversion Tunnels
1. Diversion tunnels designed for up to approx. 3,000 m³/s
2. Minimum downstream flow is 390 m³/s
3. Diversion tunnels must pass min. flow up to approach channel level
4. Spillway takes over downstream discharge after Stage 1 of Reservoir Filling
Key Criteria for Evaluating Alternates

1. Translating hydraulic jump
2. Control gate vibration
3. Impact on diversion
4. Constraints on upstream generation
5. Geotechnical risk
6. Sensitivity to uncertain parameters
7. Total dissolved gas (TDG)
Alternatives Examined

1. Inlet control by gate regulation
2. Modify diversion tunnel diameters
3. 3rd diversion tunnel
4. Modified inlet structure arrangement
5. Right bank LLO through RCC Buttress
6. Outlet control alternatives
7. Forced hydraulic jump location
Alternatives Examined – Baffle Sill

Velocity magnitude and vectors

Flow conditions around the baffle sill
Selected Reservoir Filling Design

- Series of four in-line orifices installed in Tunnel 02 after diversion, prior to filling
- Modeled after successful precedent project in China (Xiaolangdi)
- Flows increase from 390 m$^3$/s at El. 425 m to 535 m$^3$/s at El. 440 m
- Tunnel to be plugged and decommissioned after filling
Selected Reservoir Filling Design
Selected Reservoir Filling Design

- Hydraulic losses and cavitation performance key criteria
- Final orifice diameter to tunnel diameter ratios (d/D) = 0.68, 0.69, 0.72, 0.75
CFD Modeling

- Flow 3D used to provide insight into velocity patterns, pressure distributions, discharge capacities
- Interaction between orifices and orifice spacing
- Excellent agreement between CFD and PHM

Example of Orifice Interaction for Preliminary Layout
Physical Hydraulic Modeling

- Two different sized tunnel models built at the LaSalle lab
- 1/40 scale (10 inch pipe) to test orifices
- 1/20 scale (20 inch pipe) to test alternates
Final Results - Tunnel Rating Curves

Graph showing the relationship between Reservoir level (m) and Flow rate (m$^3$/s) for different tunnels with and without orifices.
Physical Modeling – Diversion Gate

a) Upstream headbox and diversion tunnel.

e) Upstream face of the gate.

b) Gate module.
Example Images - Xiaolangdi
Questions?

Contact us at

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