Piano Key Weir at Giritale Reservoir in Sri Lanka

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Giritale Scheme in Sri Lanka
Location & Linkage to Mahaweli River System

Giritale Reservoir
Located in North-Central Sri Lanka is fed by Mahaweli River System and works as an Online Reservoir
Giritale Scheme
General Context

- Has originally been built in 623 AD restored in 1951
- Augmented in 1963 to current capacity
- Capacity - 23 hm³ (19000 Acft)
- Irrigates 3077 ha (7600 Ac) for two Seasons
- Max. Dam height 14 m (46 ft)
- Ogee Type Spillway – 38 m (125 ft) Long; Un-gated
- Area on One Side Developed and the other side is Wild Life Reserve
Giritale – The Water Uses

- Agriculture
- Domestic and Industrial Water Supply
  - (Note the Exposed Water Supply Intake during Drought)
- Fishing
- Tourism –
  - Hotels around Reservoir and Wild Life Park
Giritale – The Hot Spot
Drought 2012

- The Country-wide Drought 2012 was a national issue and was a concern at the highest level of Government HE the President.

- Giritale was worse affected
  - Crops, Domestic Water Supply, Tourism, Wild Life & entire livelihood in Giritale Area became virtually “Dead”.
Proposed Solutions

- Desilting of around 3000 Small and Medium Reservoirs in the four Drought affected Districts
- Enhancing Capacity by raising Spillway in Giritale “The Hot Spot”
  - “Presidential Order”
Giritale – Not Only affected by Droughts But also by Floods
The Havoc - Floods 2011

- Giritale Nearly Full
- surrounding Main Road inundated and damaged with further inflows
Giritale Spillway
The Old & the New

125 ft Long Existing Creager Type Spillway was proposed to be replaced by a PKW
How Was I inspired

- My Experience of Model Testing of Loggal Oya Crossing at Hydraulics Laboratory of Irrigation Department (1977-78)
- Interaction with EDF at World Water Forum in March 2012 at Marseille
Design of PKW

- Type A Configuration by Lemperiere (2009)
- Assessment of Discharge Enhancement Ratio using Equation by Liete Ribeiro (2011)
- Starting with the Minimum Foot Print that can be fitted to existing Spillway
  - From 2.4 m until “Happy” 3.6 m.

Architectural Models (with card board) helped imagination and explanation and convincing others.
Design of Energy Dissipater

- A Stepped Energy Dissipater incorporated in Downstream
- Both PKW and Stepped Energy Dissipater design changed several times to match variations of site conditions found after model testing and during construction and
  - Such as depth of rock, existing contraction joints etc
Design Considerations/ Limitations

- Discharge Enhancement Ratio of 4-6 (Liete Ribeiro (2011)) in range of operation
- Minimum Key Width of around 2 m considered necessary for placing Concrete
- Pier Thickness of 300 mm to give adequate cover to reinforcement and placing concrete
- To match the existing Contraction joints
## Configurations Studied and the one Selected

<table>
<thead>
<tr>
<th></th>
<th>Foot Print (m)</th>
<th>( N_u )</th>
<th>B (m)</th>
<th>Bi=Bo (m)</th>
<th>P (m)</th>
<th>Pm (m)</th>
<th>( \frac{W_i}{W_o} )</th>
<th>( W_i ) (m)</th>
<th>( W_o ) (m)</th>
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<tbody>
<tr>
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<td>6</td>
<td>6.6</td>
<td>1.65</td>
<td>2.4</td>
<td>1.6</td>
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<td>3.3</td>
<td>7</td>
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<td>3.3</td>
<td>8</td>
<td>6.6</td>
<td>1.65</td>
<td>2.4</td>
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<td>1.25</td>
<td>2.0</td>
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<td>4.0</td>
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<td>6</td>
<td>7.2</td>
<td>1.80</td>
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<td>3.0</td>
<td>2.4</td>
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<tr>
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<td>7</td>
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<td>1.6</td>
<td>4.3</td>
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</table>
Final Design
The Outcome – PKW Design

- Existing Spillway raised by 91 cm (3 ft) without raising dam
- 15% increase in Reservoir Capacity by 3.5 hm³ (2800 Acft)
- 100 Year Design Flood Afflux reduced from 91 (3 ft) to 37 cm (1.1 ft) (1/3 earlier)
- Max Flood observed after 1951 = 0.8 m (2.5 ft) with Creager Weir in place
- 1000 Year Estimated Design Flood 0.45 m (1.5 ft)
- NO EXTRA INUNDATION
Physical Model Studies at 1:15 were done at the Hydraulic Laboratory of Irrigation Department of Sri Lanka and found that Discharge Enhancement Ratio given by Liete Ribeiro (2011) Equation is within 10% Model results - OK
Stepped Energy Dissipater
First Design

- Similar to a one that is already constructed at Deduru Oya in Sri Lanka
- Height of Rise varies
  - 375mm, 590mm, 950mm
- Width of Tread varies
  - 338mm, 675mm, 1013mm
- No Slope in tread
Stepped Energy Dissipater
Second Design

- Outside Piers and drop at exit
- Four Equal Steps
- Rise 375mm
- Tread Width 1125mm
Stepped Energy Dissipater
Final Design

- Similar to Second one four equal steps with a Rise of 375mm and a Tread width increased from 1125 to 1150.

- $5^\circ$ Sloping steps introduced for higher energy dissipation.

- Found by model studies that almost the entire energy is dissipated and no stilling basin is required.
Cost Comparison of Storage with New reservoirs

<table>
<thead>
<tr>
<th>Reservoir</th>
<th>Capacity (hm³)</th>
<th>Cost (LKR*)</th>
<th>Cost (Mn)</th>
<th>Cost (US$ Mn)</th>
<th>Cost/unit capacity (LKR Mn/hm³)</th>
<th>Cost/unit capacity (US$ Mn/hm³)</th>
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<tbody>
<tr>
<td>1 Giritale PKW</td>
<td>3.5**</td>
<td>30</td>
<td>0.3</td>
<td>8.9</td>
<td>0.05</td>
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<tr>
<td>2 Kekiriobada</td>
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<td>445</td>
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<td>202.3***</td>
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</table>

* US$ 1 = LKR 129.55; **Incremental capacity; ***Excluding power house; Data source: Ministry of Irrigation & Water Resources Management and Irrigation Department, Sri Lanka.
CrackStone (Chemical) was used for demolition.
Construction Progress -2
Flank Bunds

- Flank Bund designed as an overtopping section for extra safety with 1.5 m (5 ft) below main dam level.
  - Upstream protection with reno-mattress riprap
  - Downstream with crib work with turf inside
Acknowledgements

- HE the President of Sri Lanka for his order to increase capacity of Giritale by any means.
- Irrigation & Water Resource Management Secretary for trusting me of the outcome.

And last but not least

- Those who conceived PKW and all those who have contributed for its development.
Thank You for Your Attention