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REINTEGRATION OF THE SPILLWAY SHUTTERS OF KRISHNAGIRI DAM TAMIL NADU, INDIA - A CASE STUDY

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10-12 October 2022 at Jaipur, Rajasthan (India)



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INTRODUCTION

- Dams are considered as the life saviour structures.
- Failure of dam and its appurtenances would lead to catastrophic collateral damage not only to the public but to the entire economy.
- Study on the failure and reintegration of the spillway shutter in Krishnagiri Dam

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SALIENT FEATURES OF THE KRISHNAGIRI DAM

- Krishnagiri Dam is constructed across the river Pennaiyar in Krishnagiri District of Tamil Nadu during the period 1955-57.
- It is a masonry cum earthen dam with 8 nos of vertical spillway gates and 3 nos of lift gates in river sluice portion.
- Catchment area 5366 Sqkm
- Total ayacut is 9012 acres

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The dam can be accessed by the rail head Jolarpet at a distance of 50 km and the nearest airport is Bengaluru which can be reached by road at a distance of 95 km.



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HYDRAULIC PARTICULARS	
Catchment area	2096 sq.mile / 5366 sq.km
Full Reservoir Level	+483.11 m (+1585 feet)
Maximum Water Level	+484.63 m (+1590 feet)
Top Bund Level	+487.38 m (+1599 feet)
Water spread area	1294.99 Ha (3200 Acre)
Capacity at F.R.L.	1666.29 M.cft (47.184 M.cum)
Earth Dam	
a) Top bund level	+487.38 m (+1599 feet)
b) Length of bund	713 m (2339 feet)
c) Top width of bund	6.10m (20 feet)
Spill way	
a) Crest of Spill way	+477.01 m (+1565 feet)
b) Nos and size of Spill way gates	8 No's & 40' x 20' (12.19 x 6.10 m)

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HYDRAULIC PARTICULARS – Contd..	
c) Maximum Flood Discharging capacity at MWL (+484.632 m).	145738 cusec (4126.80 cumec)
d) Type of shutters	Vertical Lift gates – Fixed Wheel Type
e) Length of Spill way	118.50 m (388.78 feet)
f) Location	L.S 86.50 to L.S 205m
g) River bed level	+464.21 m (+1523 feet)
River Sluice	
a) Sill level	+467.26 m (+1533 feet)
b) Type of shutters	3 nos Vertical Lift gates – Fixed Wheel Type
c) vent size	5' x 6' (1.52 x 1.82 m)
d) Maximum Flood Discharging capacity at MWL (+484.632 m).	3968 cusec (112.36 cumec)

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REHABILITATION WORKS CARRIED OUT IN KRISHNAGIRI DAM UNDER DRIP-I

- Reconstruction of **parapet wall** on top of earthen bund, **V-notches**, **flood protection wall** in left flank d/s
- Repairs to Rock toe drain, **approach road** to earth and masonry dam, staff quarters and providing basic facilities
- Pointing of masonry dam
- Reaming of drainage holes in gallery
- Construction of generator room
- The **hydro-mechanical works** such as **repairs to spillway shutters**, **river sluice shutter**, **emergency shutter** and **gantry crane arrangements**
- The works were completed before the monsoon of 2017

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OBNOXIOUS CATASTROPHE

- During the month of September 2017 due to heavy rainfall in the upper catchment of the river Pennaiyar the Krishnagiri dam remains in its FRL condition for more than 1.5 month period in the first time during last 10 years.
- The dam officials started releasing water.
- Due to this release of water, the Sathanur Dam located in the downstream attained water level nearer to FRL.

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- To worsen the situation, the Krishnagiri dam catchment received heavy rain due to the cyclonic Ockhi storm.
- In the afternoon of **29th November, 2017**, spillway shutter No. 1 got buckled.
- The Field Engineer heard a **loud band and noticed leakage** in **spillway shutter no.1**, with damages occurring on the lower left bottom edge of the shutter.
- Due to **hydro-static pressure**, gate no.1 shutter heaved in towards the downstream direction and lifted approximately 1m off from the sill beam.
- Fortunately the Stakeholders meeting was conducted in month of August 2017.

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REMEDIAL MEASURES TAKEN

- Hence it was easy to invoke the EAP to ensure necessary downstream protection. No other damages were observed.
- **Temporary stoplog gate** was fixed to the height of **3.6m above crest** to store the water temporarily.
- As the spillway gates served for **more than 60 years**, the State Government decided to **replace** the damaged shutter
- The Gate was replaced successfully and the structural integrity of the dam also restored.

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Dam Rehabilitation & Improvement Project



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Failure of Gate no 1 in Krishnagiri Dam

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U/S & D/S VIEW OF THE REPLACED SPILLWAY GATE NO-1 OF KRISHNAGIRI DAM

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EXPLORATION OF CATASTROPHIC EVENT

Following investigation were rolled out to identify the prime triggering factor for the catastrophic event

- **Water quality test** was carried out by King's Institute, Chennai, CSIR – CECRI, Karaikudi. (CSIR – Central Electrochemical Research Institute) and Soil Mechanics and Research Division (SM&R), TNWRD.
- Vetting the **Structural adequacy** of the **newly erected shutter** was carried out by **IIT, Madras**.
- Vetting the structural adequacy of the **hoisting capacity** of the shutters by the IIT Madras Ocean Department.

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FINDINGS FROM INVESTIGATION

King's Institute

- The Krishnagiri Reservoir water is slightly **whitish and hazy in physical appearance**. Water is slightly hard and is of satisfactorily chemical quality for drinking and other domestic purposes.
- However the **bacteriological quality is not satisfactory** and also the microscopical examination reveals the presence of numerous zoo and algal forms. The **langelier saturation index** indicates that the water is corrosive in nature.



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CENTRAL ELECTROCHEMICAL RESEARCH INSTITUTE (CSIR)

- The preliminary steel analysis including corrosion rates are analysed and reported that the corrosion rate of the shutter near the replaced shutter is nearly 2.5 times more than that in middle of the reservoir
- Bacterial growth was observed.
- Hence recommended to identify appropriate steel coating.

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SOIL MECHANICS AND RESEARCH DIVISION (SM&R), TNWRD

- The pH value of Krishnagiri dam is of 8.5 and high alkaline of 250mg/l resulting in scale forming water. The high chlorides and sulphate will increase the rate of corrosion.

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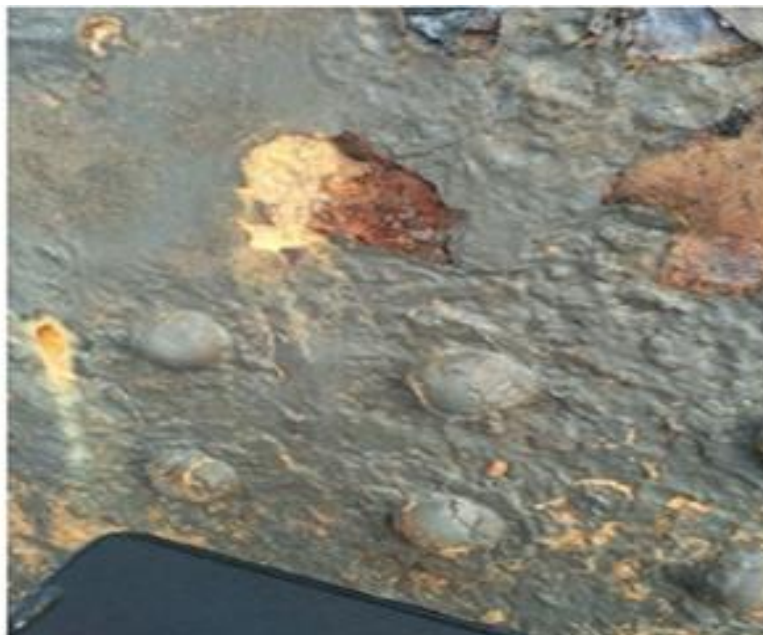
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Corroded portion of the Gate no 1 in Krishnagiri Dam

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RESULTS AND DISCUSSION

After having discussions with the resultsb the IITM,CPMU &TNWRD concluded the following

- ❖ Project needs to initiate an **immediate interim action** for urgent replacement of the failed gate on top priority .
- ❖ To formulate action plan for the review, **replacement of balance 7 gates** in consultation with IIT, Madras
- ❖ The provisional proposal of **providing Ni-Cr metallizing as proposed by IIT Madras** is to be got firmed up on priority.
- ❖ Immediately, the damaged shutter of gate no 01 was replaced by a newly fabricated shutter.

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RESULTS AND DISCUSSION :Contd...

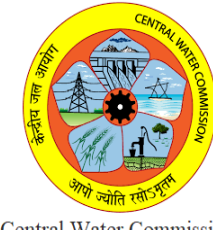
- ❖ The **structural adequacy of the gate no. 01** was ascertained by the **Structural Department IIT Madras**.
- ❖ Following this, the professors of IIT Madras has suggested to use **Zinc-Aluminium Alloy metal coating (metalizing)** followed by polyurethane.
- ❖ The scientists of IGCAR Kalpakkam. identified the key findings on **microbiological corrosion** of Krishnagiri dam spillway shutter based on the analysis of dam water, biofilms and corrosion products of shutter specimen.
- ❖ The **very high density of microbes** in the reservoir appears to have accelerated the corrosion rate of spillway shutter material.
- ❖ Considering the alarming thickness reduction of shutters, **due to micro-biologically influenced corrosion**, it is suggested to **replace all the existing shutters with new ones** having suitable antifouling coatings.

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RESULTS AND DISCUSSION :Contd...

- The **integrity test on the hoisting arrangements** and its supporting operating platform were conducted by IIT Madras.
- Recommended that the **existing hoisting arrangements** and platform of all the vents may be used for a **further period of 20 years**
- Finally the team of **CWC comprising of experts** visited the Krishnagiri dam and provided the suitable recommendations for the replacement of the remaining 7 shutters.
- In line of the above recommendations, the Government accorded Administrative Sanction for the replacement of remaining 7 shutters on 15.07.2019 under DRIP. The work has been successfully completed and robust ensuring the structural integrity of the dam.

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CHALLENGES ENCOUNTERED DURING THE ERECTION OF THE SPILLWAY GATES

- Under DRIP the replacement of the **shutters of gates No. 02 to 08 started by November 2019 and ended by August, 2020.**
- During this period water was kept at 2' below the crest level throughout the replacement duration. It was really challenging to keep the water throughout that level without affecting the downstream stakeholder's essential requirements.
- Considering the **water quality and the nascent odour** from the water, the employees were **finding it hard to stand near the water for more than 6 hours.**
- The **pungent odour suffocated the employees** and the work cannot be **resumed more than 6 hours at a stretch** and took its own phase. Taking care of the employees was of prime concern.

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CHALLENGES ENCOUNTERED DURING THE ERECTION OF THE SEVEN(7) SPILLWAY GATES

- The **fabrication** was carried out **piecemeal**.
- All the individual components fabricated in the shed, transported to the dam
- Then welded individually by keeping over the crest of the dam utilising mobile cranes.
- **Too much care** has been considered while **welding the individual components over the dam structure** as it should not lead to another catastrophic event.
- By the end of June, water level in the reservoir begun to deplete considerably, leading the aquatic life ie., fishes to toil.
- The **decayed fish** and other marine life started to spread the most **pungent order** in addition to the **reservoir water smell**.
- The workers **found it very hard to stand** for a few hours itself near the dam structure even after provided the respective **PPE kits**.

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Spillway Shutters Rear Side - After Completion



Spillway Shutters UpStream Side - After Completion



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CONCLUSION

- After accounting **all the challenges the replacement of the age old shutters with new one had been completed**, with present design standards to withstand the polluted environmental condition.
- As the **DRIP project** felicitates the dam safety, the **detailed investigations and expertise suggestions are obtained Nationwide**. The **reintegration of gates** were done without altering the earlier **designed hoisting** mechanism and also the structural components of the dam.
- A long lasting pioneer has been achieved for the sustainable dam safety .

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Thank You!

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