



Indian National Committee
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Central Water Commission



A Maharatna Company

Koldam Hydropower Station Flip Bucket issue and remedial measures

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



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Koldam Hydropower Station: Flip Bucket issue and remedial measures

Koldam Hydropower station (4*200MW) of NTPC Ltd. is an earth and rockfill dam 167m high, having a spillway length of 460m with 6 radial gates and a flip bucket as an energy dissipating structure. Station was commissioned in July 2015 and since then spillage of water during monsoon season is a regular activity.



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ISSUE

During the 2016 monsoon, a widening of the dilation joint between the spillway and flip bucket was observed. The same was monitored via manual and online Vinchon instruments which were under allowable limits. In 2019 the Joint widening crosses the allowable limits, and it was analyzed that there is some movement in the flip bucket on all axis.



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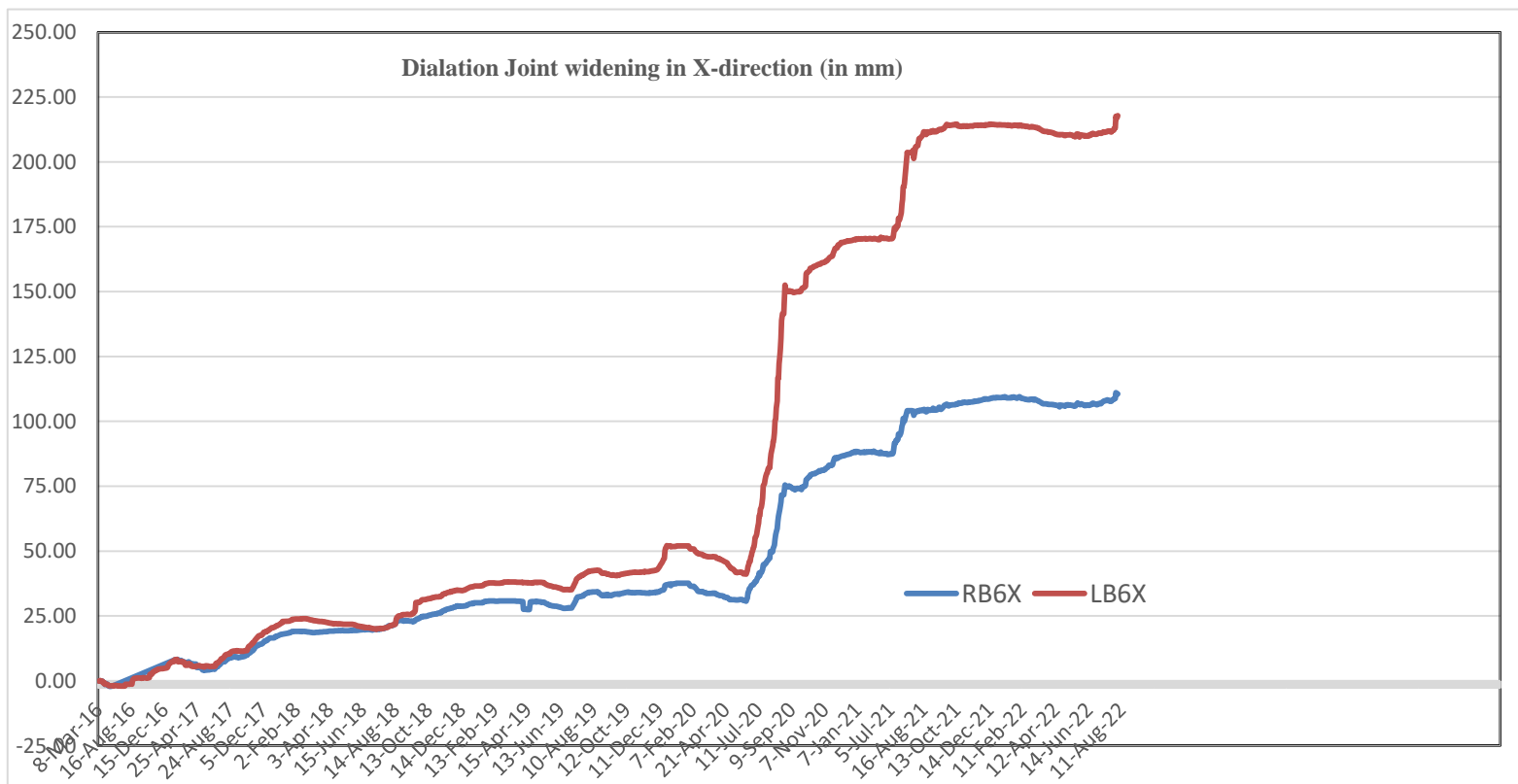
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MONITORING

The readings for widening have been taken using online Vinchon and plotted and trends have been seen showing more widening in monsoon due to spillway discharge and dynamic force acting on the flip bucket.



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INVESTIGATIONS

- GPR (Ground Penetrating Radar) survey was conducted by NIRM (National Institute of Rock Mechanics) of the flip bucket and the plunge pool area up to a depth of 10m from the surface to map any crack or weak zone in concrete and rock.
- GPR survey was done on the spillway and flip bucket in a grid of 10m by 10m.
- Boreholes were carried out including WPT for analysis of rock strength parameters for designing anchors and deciding grout intake around the flip bucket area.
- 2-D Slope Stability Analysis of Central Slope taking shear strength parameters based on core test report & test at site.

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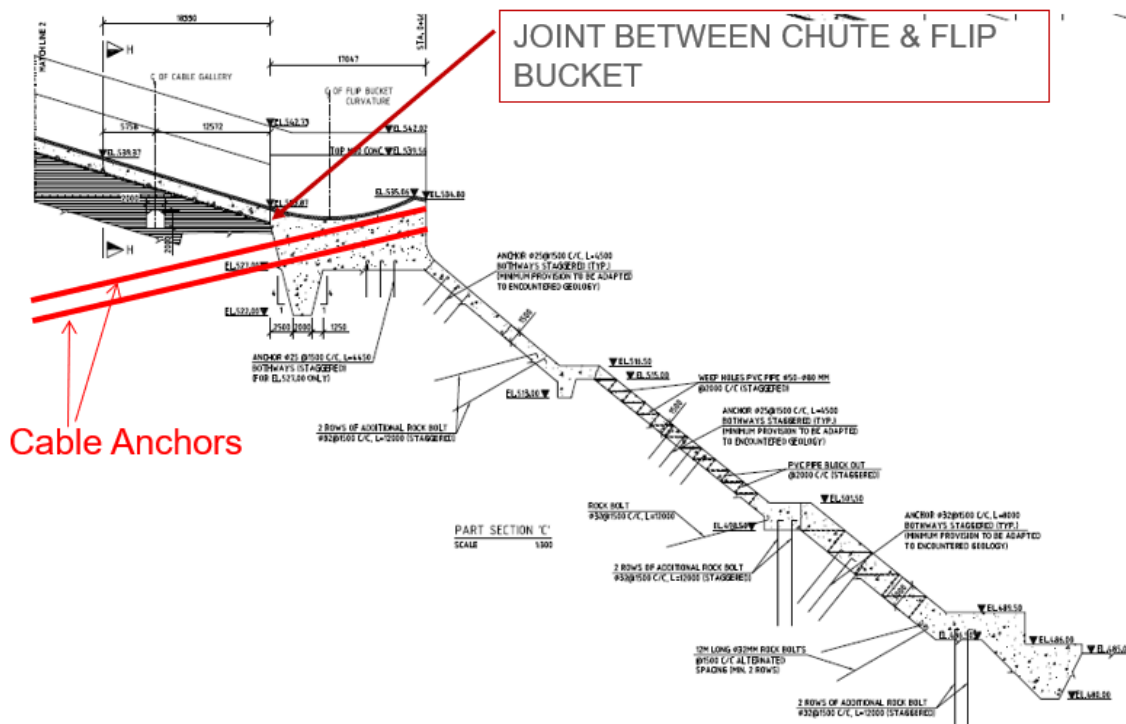
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REMEDIAL MEASURE

This movement was locked by using 100 Ton ultimate capacity 70 nos. 60 meters long 150mm dia. cable anchors for a spillway discharge of 3000 Cum. at a time. The anchors were installed from the front face i.e., from the plunge pool side by way of making a steel platform and using 02 numbers drilling machines for timely completion of work during 2020-21.



- Cable anchors –Numbers- 70+3
- Length – 60 m,
- Spacing : 2.14 m c/c staggered
- End anchorage - 12 m,
- Ultimate Load Capacity- 100 T
- Lock off load- 31.35 T

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FACTORS FOR DESIGN CRITERIA FOR CABLE ANCHORS

Geology

The geology was the main criterion for deciding the length of the cable anchor as the rock was not competent in the range of 30-40 m hence 60m deep anchors were installed. End anchorage was given in Black Carbonaceous slate upstream of Basic Dyke.

Spillway discharge

Based on year-wise spillage, cable anchors were designed for taking the load against 3000 Cum. discharge from the spillway which corresponds to 2700T (horizontal component).

Site constraints

There was a site constraint governing the maximum number of cable anchors, as there is a fixed area for drilling and fixing from the downstream face of the flip bucket.

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INSTALLATION OF CABLE ANCHORS



Based on the design criteria, site constraints and geological investigations **60m long, 150mm dia 100 Ton GUTS 70 numbers** single corrosion protection at a spacing of nearly 2m were proposed and installed.

These cable anchors were installed by making a steel platform on the sloping face of the plunge pool keeping the platform width and loading on cladding.

Two number Casagrande drilling machines C6 XP were used for drilling 150mm dia holes through the heavily reinforced concrete

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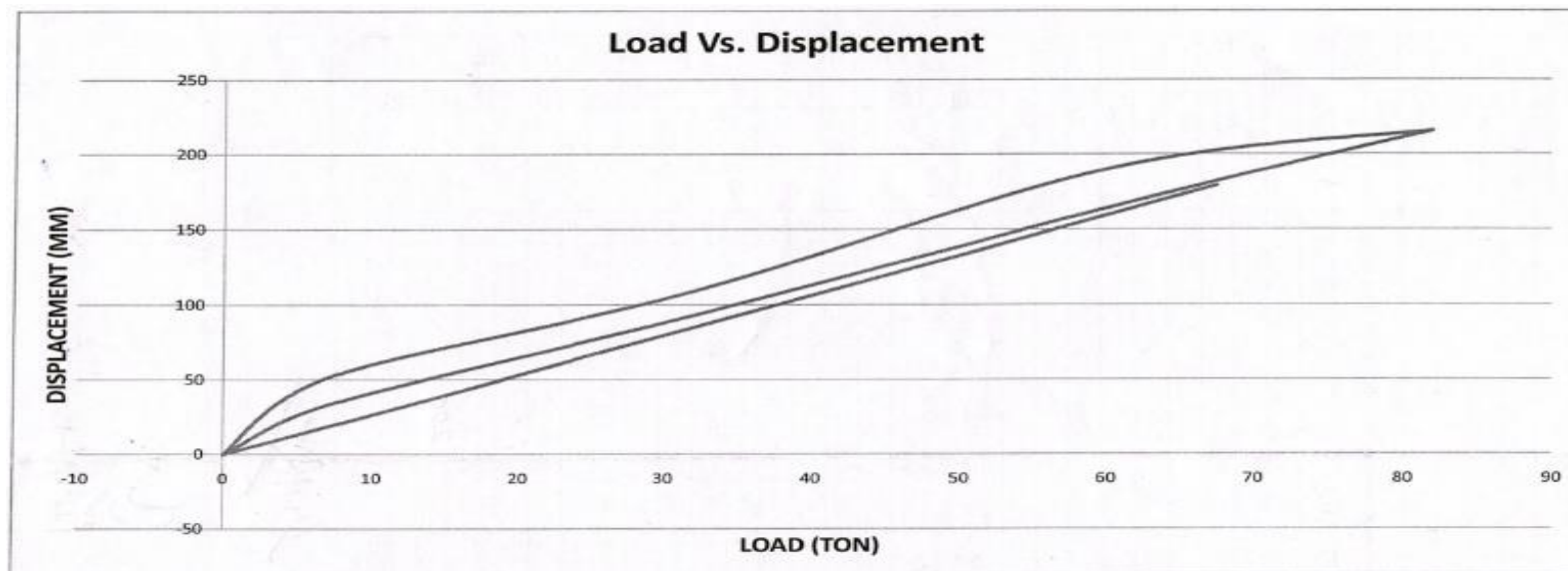
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STRESSING OF ROCK ANCHORS

The test load to which rock anchors were subjected during various tests was 80% of the guaranteed ultimate tensile strength (GUTS) of the tendon, Lock-offload was 60% of GUTS of the tendon, which was then reduced to 30% for maximum anchors. All the cable anchors were tested. Test results are plotted



HOLE NO : C14

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MONITORING THE BEHAVIOUR OF ROCK ANCHORS

04 nos. *Load cells* of Capacity 1200 kN for Tendons were installed for monitoring the behaviour of rock anchors and flip bucket.



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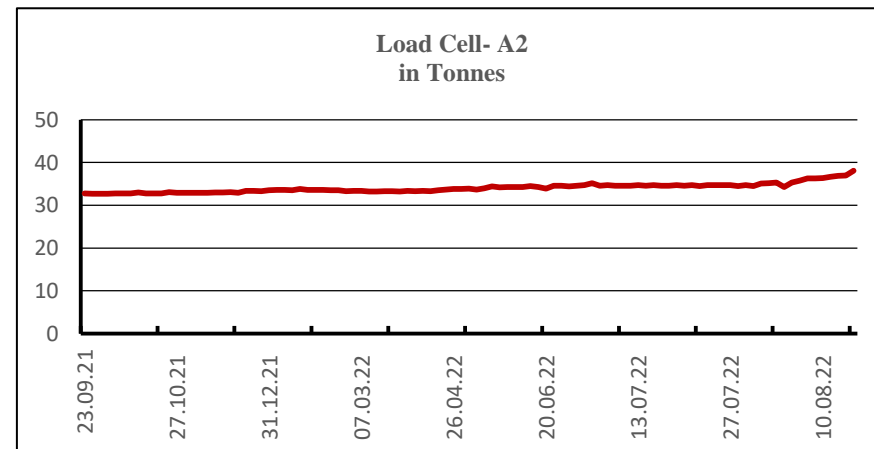
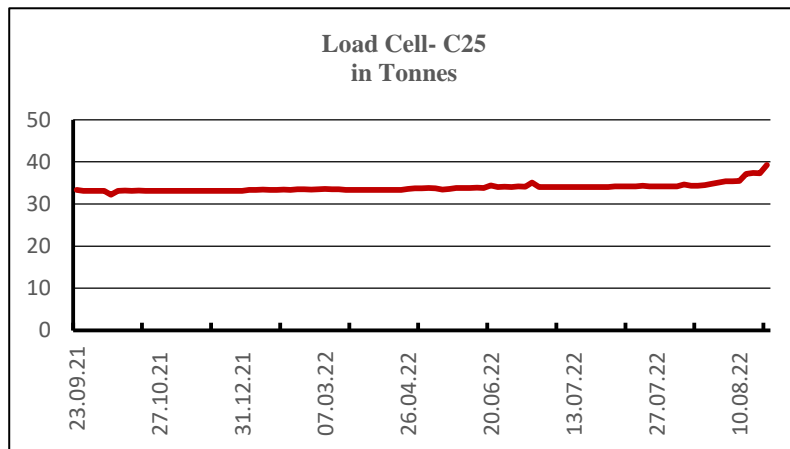
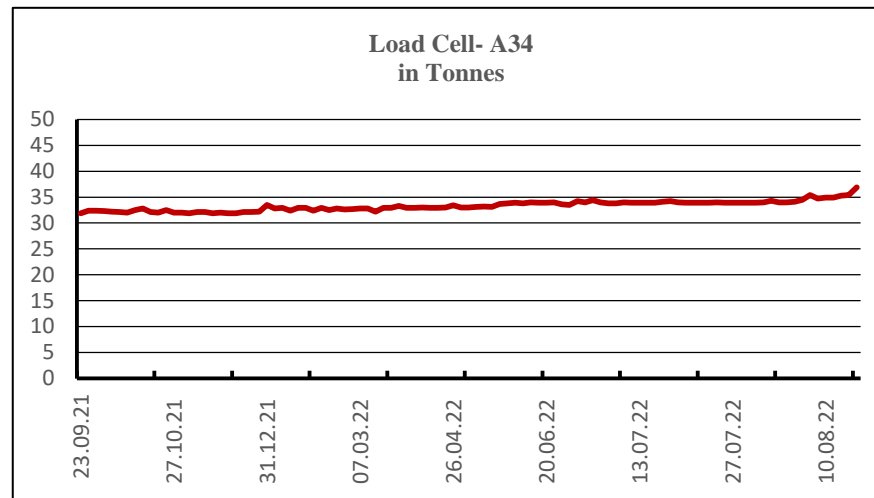
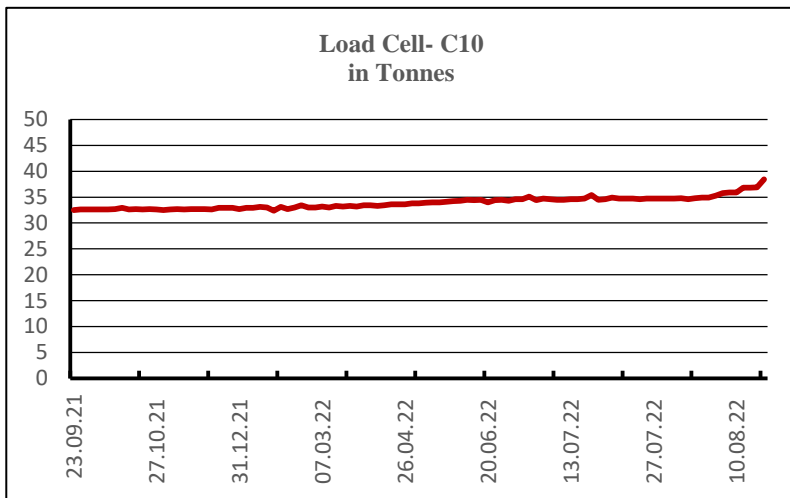
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BEHAVIOR OF FLIP BUCKET AFTER CABLE ANCHORS INSTALLATION



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CONCLUSION

It has been noticed from load cell readings that there is an appreciable restriction in the flip bucket movement after the installation of cable anchors even during monsoon spillway operations in July and August 2022

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