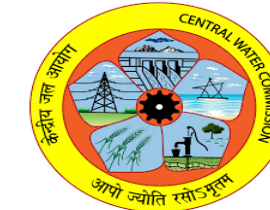




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Best Practices Followed in Dam Safety Management & Governance Subansiri Lower Dam (2000 MW) NHPC Ltd

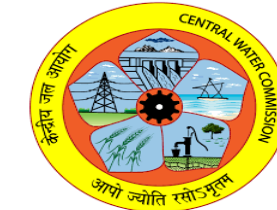
Vipin Gupta, Executive Director
Ramesh Ojha, General Manager
Ram Kewal, Dy. Manager

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- Subansiri Lower (2000 MW) is India's largest Hydroelectric Project under construction and is being Implemented by NHPC Ltd., a CPSU of Govt of India.
- The Project is located at the boundaries of Assam / Arunachal Pradesh on the river Subansiri
- Subansiri River is a major tributary of Brahmaputra River and has origin in central Himalayas in Tibet
- Contribution of Subansiri River is about 10.66% of total discharge of Brahmaputra river
- Total catchment of Subansiri basin is 26419 sq km out of which 16182 sq km (61.25%) lies in India & 10237 sq km (38.75%) lies in Tibet

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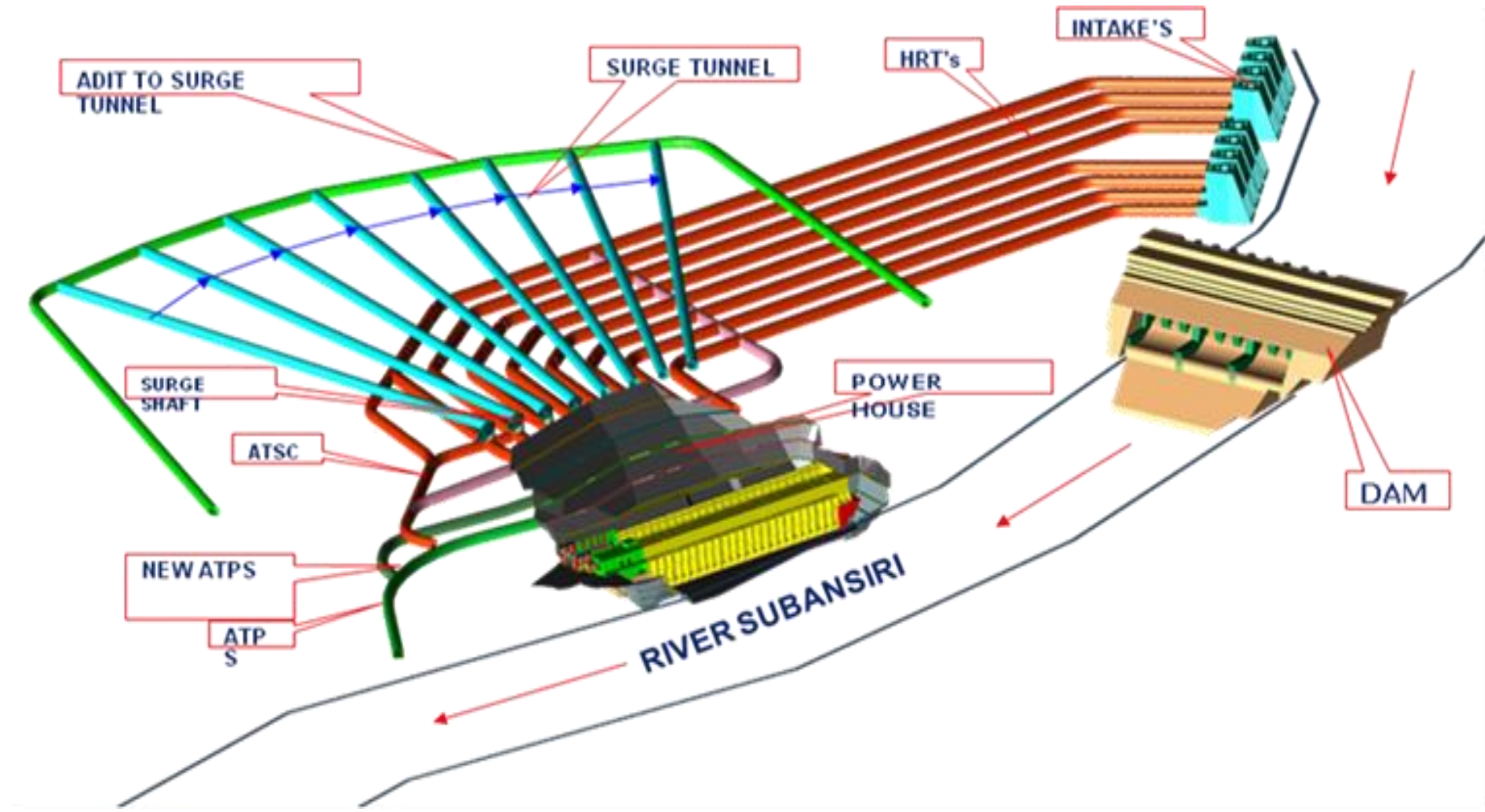
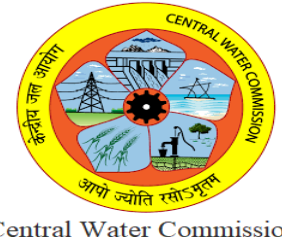
- The Project is a RoR scheme envisaged for providing peaking power.
- Minimum discharge to be released d/s during lean season is 270 cumec
- One unit shall be operated 24 hrs for providing assured d/s discharge of 322 cumec to meet d/s needs of population even during lean season
- The Reservoir to be operated at 15 m below FRL (205 m) during monsoon to absorb any high flood in river during monsoon
- Average annual flood in river is of the order of 7000-9000 cumec
- 1 in 10 year flood - 12400cumec
- 1 in 25 year flood - 14500cumec
- 1 in 50 year flood - 17500cumec
- 1 in 100 year flood - 19600cumec

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3 D Layout of Project

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SUBANSIRI LOWER HE PROJECT SALIENT FEATURES

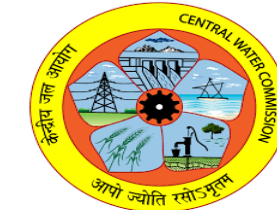
Location	River Subansiri near Assam & Arunachal Pradesh border
Dam	Concrete Gravity Dam 116m high
Spillway radial Gates	9 Nos. 11.5m x 14.0m
HRT Intake Gates	8 Nos. 7.3m x 9.5m
HRT	8 nos., 9.5 m dia, Horse Shoe Shaped, 7124 m total length
Pressure Shafts	8 nos. Vertical Pressure Shafts- each 48m deep.(Circular, 9.5/8/7m dia and length 209m to 231m)
Surge Tunnel	8 nos., 9.5 m dia, Horse Shoe Shaped, 3545 m total length

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SALIENT FEATURES

Design flood	37500 cumec
Annual Energy Generation	7422 MU in a 90% dependable year
Awarded Amount	₹10594.4 Million + € 7.08 Million
Gross storage capacity of reservoir	1365 M cum.
Diversion Tunnel	5 nos., 9.5 m dia, Horse Shoe Shaped with capacity 4,550 cumec
Total area under submergence	33.50 Sq Km
Installed Capacity	2000MW (250MW x 8)
Top Level of Dam	210 M
Height of Dam Above Deepest Foundation Level	133 M

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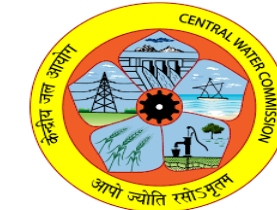


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Dam Rehabilitation & Improvement Project



Central Water Commission

Safety Features of Subansiri Lower Dam

- Cut-off Wall provided at U/s and D/s of Dam
- Base width of Dam increased by 100 m for additional stability and safety
- Extensive Instrumentation in Dam body
- Plunge Pool to safeguard toe erosion
- Cut slope surfaces at d/s abutments on both sides provided with concrete cladding, cable anchors for protection of surfaces from rooster tail
- Net water head to be lowered by 15 m during monsoon as additional Factor of safety

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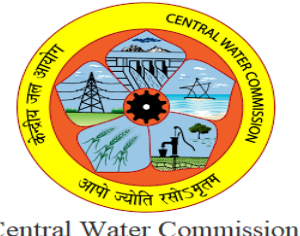
Cut-Off wall at U/s & D/s

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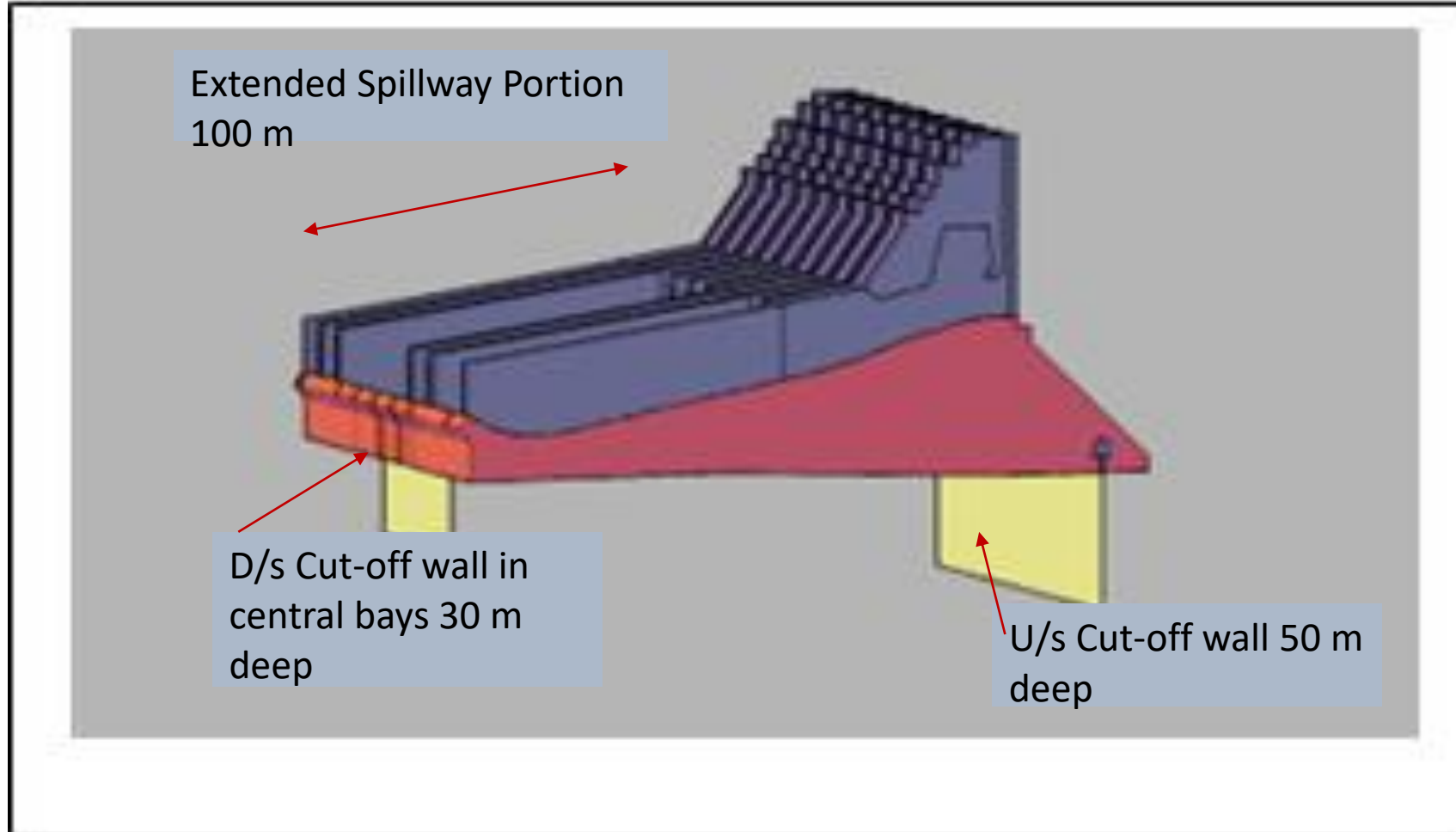


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Schematic view of Cut-off walls

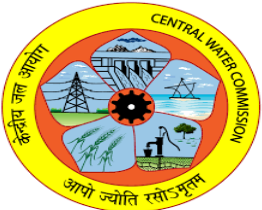


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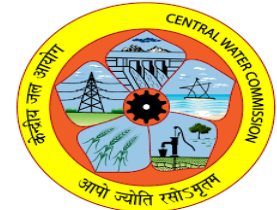
Cut-Off Wall Essentiality & Features

- To dissipate higher levels of water pressure at the dam foundation, due to seepage
- It is a **cast-in-place wall**, excavated under a supporting slurry (**polymer**) with reinforcement steel cages on the top portion.
- Excavation was performed by **reverse circulation** method
- Cut off wall constructed using Trench Cutter into bedrock upto 50 m u/s of dam and 30 m d/s in extended dam
- M20 A20 Grade Concrete wall constructed **panel by panel** (primary and secondary)

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Cut-Off Wall Features

- Executed by Solentanche Bachy, France through Hydrofraise Trench Cutter capable of cutting rocks of strengths well above 160Mpa
- 8 no. cut-off walls at different levels viz. EL 94m, 97 m, 120m (L), 120 m (R), 140 m, 155m, 173m and 185m have been executed
- Nominal width of cut off wall executed is 800mm and each cut-off wall is of 50 m depth at u/s and 30 m d/s
- The total executed area of cut off wall is approx. 18000m²
- Time taken to complete the cut-off wall works was 28 months

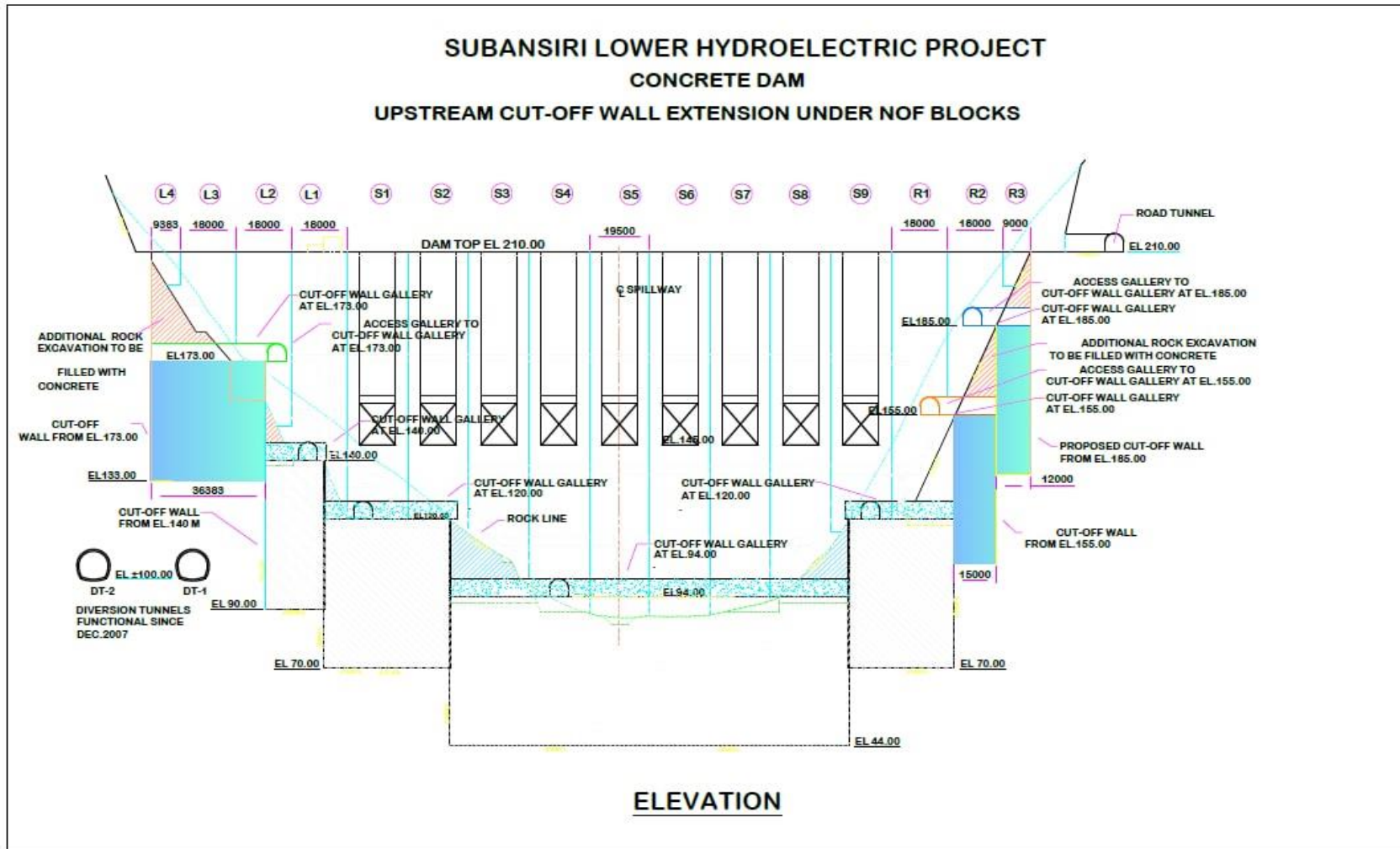


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HC 05 HYDROFRAISE



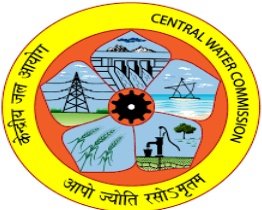
10-12 October 2022 at Jaipur, Rajasthan (India)



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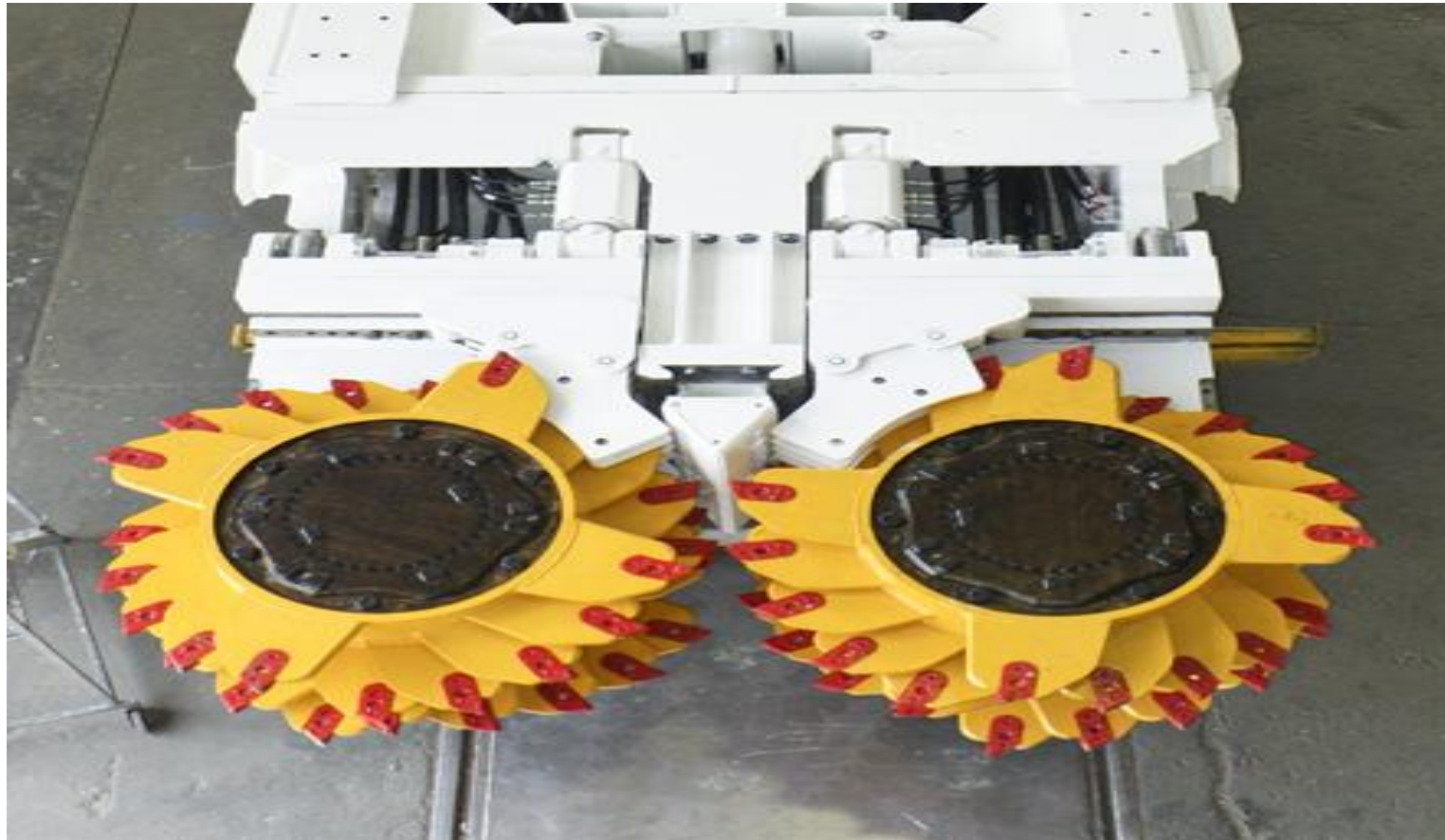
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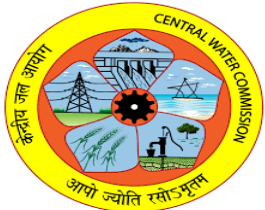
Cutter of HydroFraise



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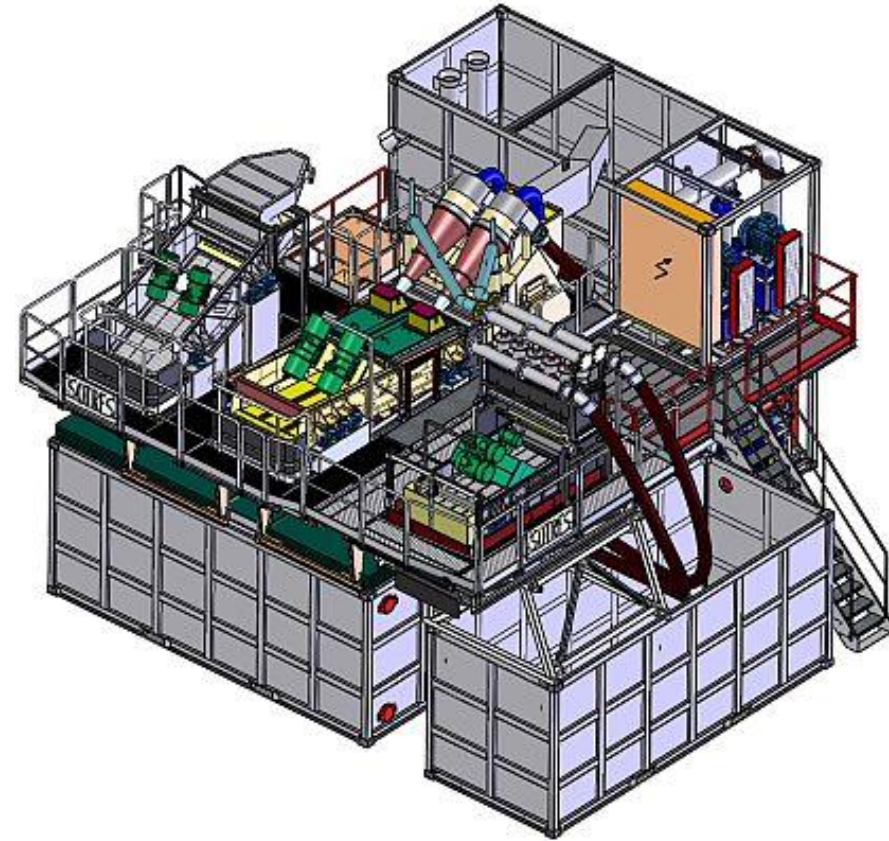


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De-sanding Plant

- Used to extract soil particles from drilling slurry (polymer)
- Fines generated from cutting was removed from slurry in de-sanding unit by system of sieves and centrifuges.
- Recycled slurry was reused





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View of Cut off Wall Gallery at EL94m & Exploratory Drill Holes in Cut Off Wall Gallery



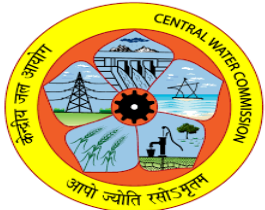
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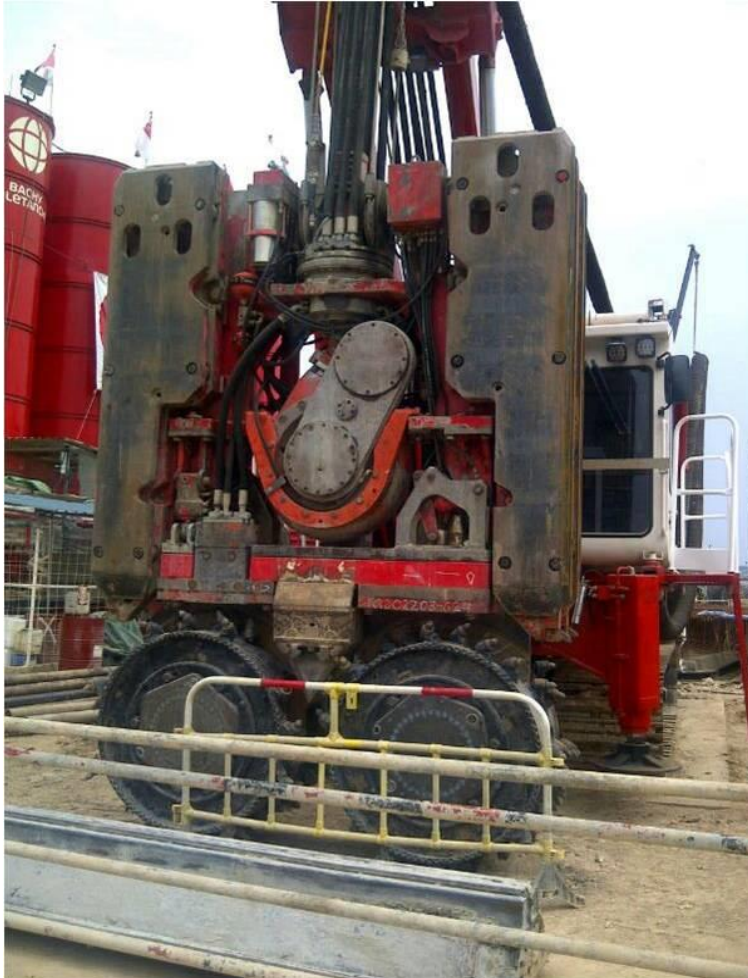
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VIEW OF CUT OFF WALL EQUIPMENT (Trench Cutter)



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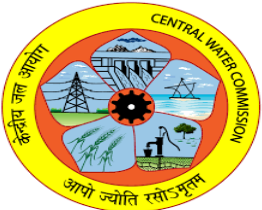


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Dam Rehabilitation & Improvement Project



Central Water Commission

Base Width of Dam increased

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

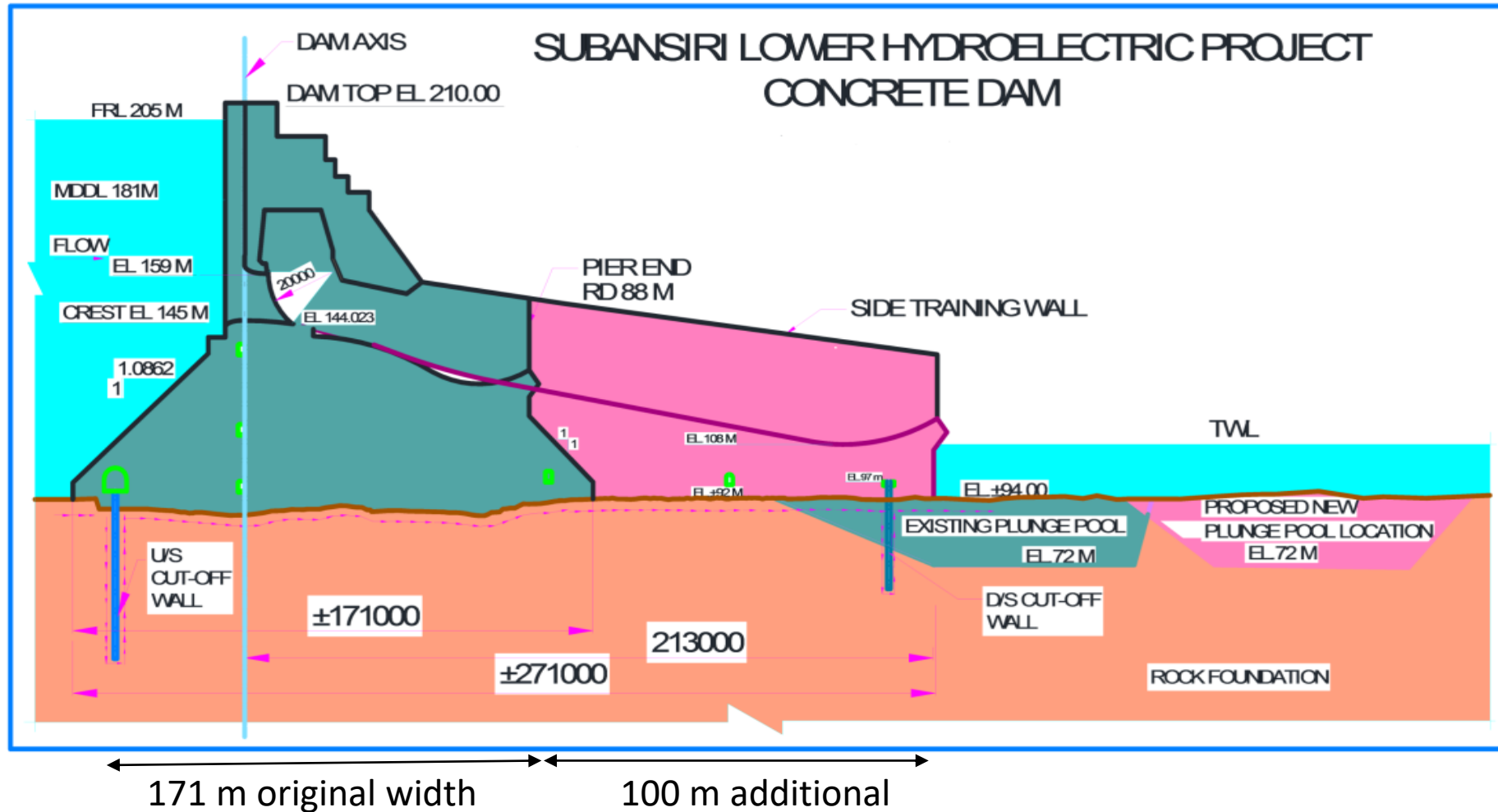


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Additional Base width of Dam for Enhanced Safety



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Additional Base width of Dam & Features

- The original base width of Dam was 171 m
- Additional base width of 100 m added in the form of Extended Dam
- The spillway bucket for central 4 bays (S4, S5, S6 and S7) and the remaining bays such as S3, S8 and S1, S2 and S9 have been placed at different elevations
- Minimized cutting as per the prevailing rock profiles at site was done to avoid cutting of the already stabilized rock cut slopes.
- The C/L of the new proposed plunge pool placed at distance of around 120m from the dam toe of extended section for the central 6 bays (S3 to S8) in the river valley



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Front views of Dam under construction during two different seasons



Side view of Dam showing additional base width

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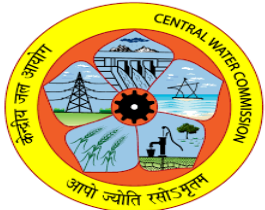


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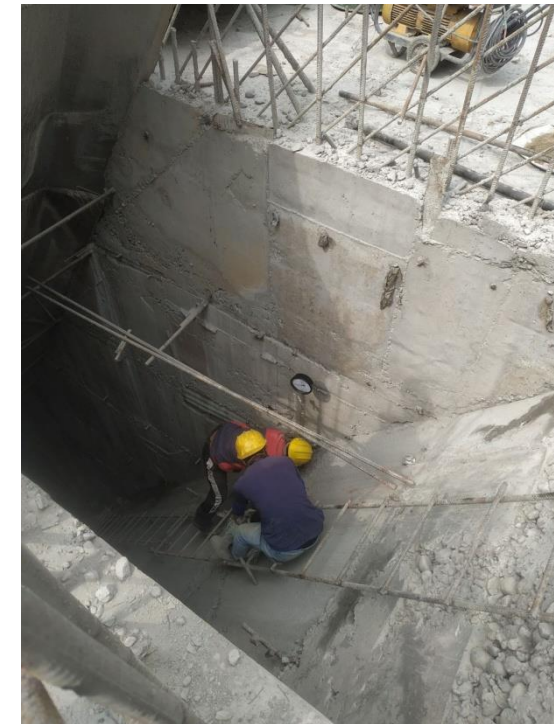


Dam Rehabilitation & Improvement Project



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Instrumentation In Dam Body



Installation and Readings of Instruments

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Role of Instrumentation for immediate safety to the Dam

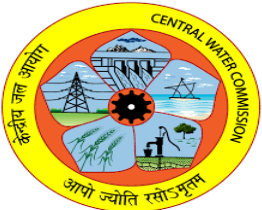
- Instruments are quintessential to Dams for:
 - Measurement during construction and first filling
 - Measurement during operation and monitoring
 - Measurement for technical and scientific purpose
- Measurements of following parameters are important:
 - Measurement indicating Structural Behavior (i.e. the effects of loading on the Dam)
 - Measurements of Internal Loadings
 - Measurements of External Loadings
 - Measurements of Properties (of dam concrete and foundation rock)
 - Weather Parameters

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Major Parameters measured with Instrumentation of Dam

- Horizontal and vertical movements
- Rotation with respect to horizontal plane
- Stresses and Strains in various directions
- Temperatures in dam body
- Seepage and uplift conditions
- Joint movements
- Effect of earthquake
- Weather Parameters

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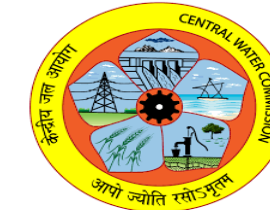


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Dam Rehabilitation & Improvement Project



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Installed Instruments

Sl No.	Name of Instrument	L1, L2 & L3	S-1 & S-2	S-3	S-4	S-5	S-6	S-7	S-8	S-9	R-1	Total
1.	Pore Pressure Meter	3	6	6	10	7	4	4	4	4	3	51
2	Uplift Pressure Meter	3	8	3	4	4	3	4	3	1	3	36
3	4- Point MPBX	2	6	3	4	5	5	7	3	2		37
4	Temperature Meter		2	1	7	7	6	4	1	4	4	36
5	Magnetic Extensometer			1			3	2	1		3	10
6	Group (Strain meter, stress meter, no stress-strain meter & pore pressure meter)					4	1	4			2	11
7	Perimetric joint Meter						1		1			2
8	Total	8	22	14	25	27	23	25	13	11	15	183

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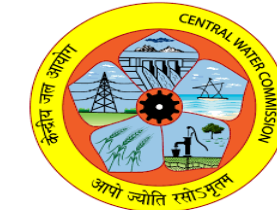


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Dam Rehabilitation & Improvement Project



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Instruments Under Installation

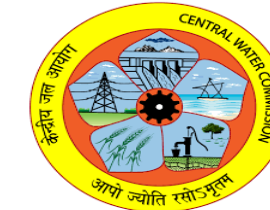
SI No.	Name of Instrument	S-1 & S-2	S-3	S-4	S-5	S-6	S-7	S-8	S-9	R1	L1	L2	L3	L4	Total
1	Uplift Pressure Meter	4	2	4	1		2		4			1	1		19
2	4- POINT MPBX	2		2		1	2		1				1		9
3	Magnetic Extensometer			1	1	1	1								4
4	Perimetric joint Meter	2	1	2	2	1	2	2	2		1	1			16
5	Linear joint meter	1	1		1		1	1		1	1	1			8
6	Tele thermometer			2			2			1		1			6
7	Topographical Marker	4	3		3		3		4	1		1	1		20
8	V-Notch				1		1								2
9	Direct Pendulum			1						1	1				3
10	Inverted Pendulum			1						1	1				3
11	Gauge well									2		1			3
12	Seismometer													1	1
13	Acelero graph					1									1
14	Total	13	7	13	9	4	14	3	11	7	4	6	3	1	95

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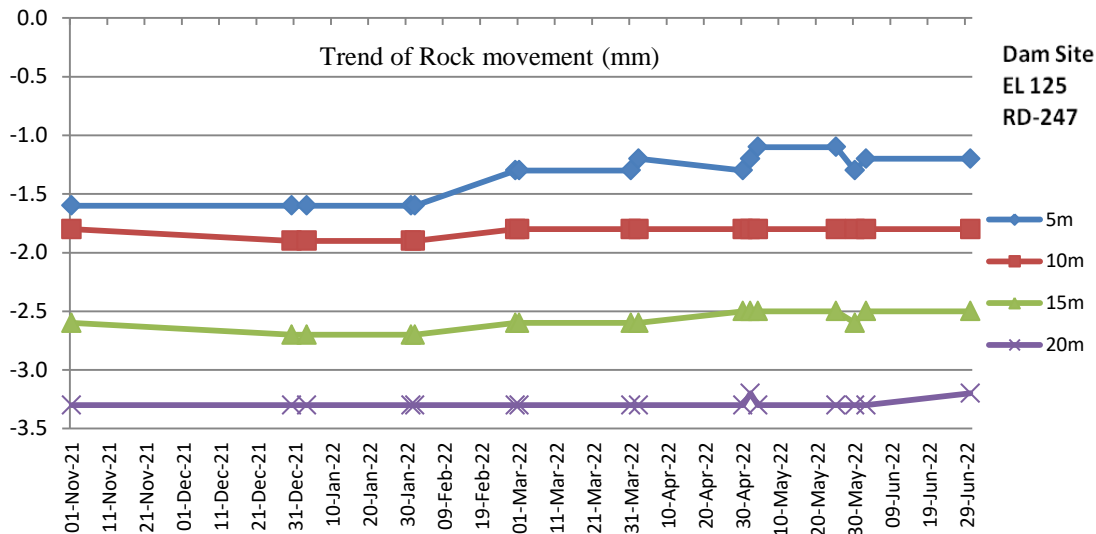


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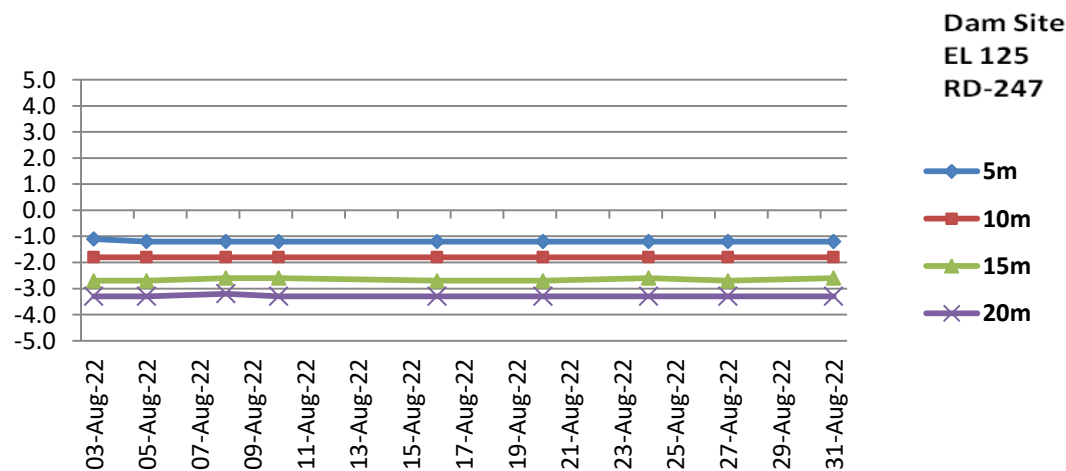


Central Water Commission



Comparison of observation of data to study any Rock Movement at same location in different periods

Results indicate stable condition

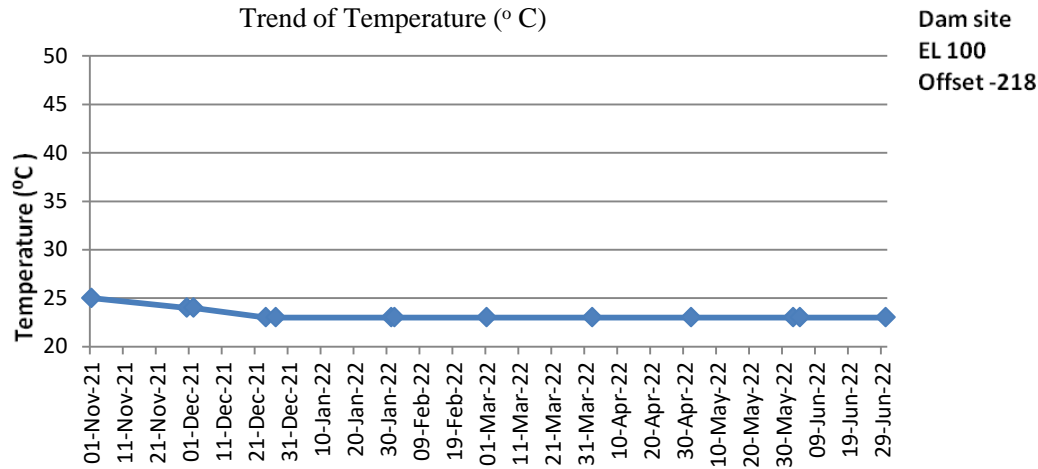
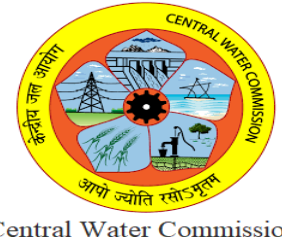


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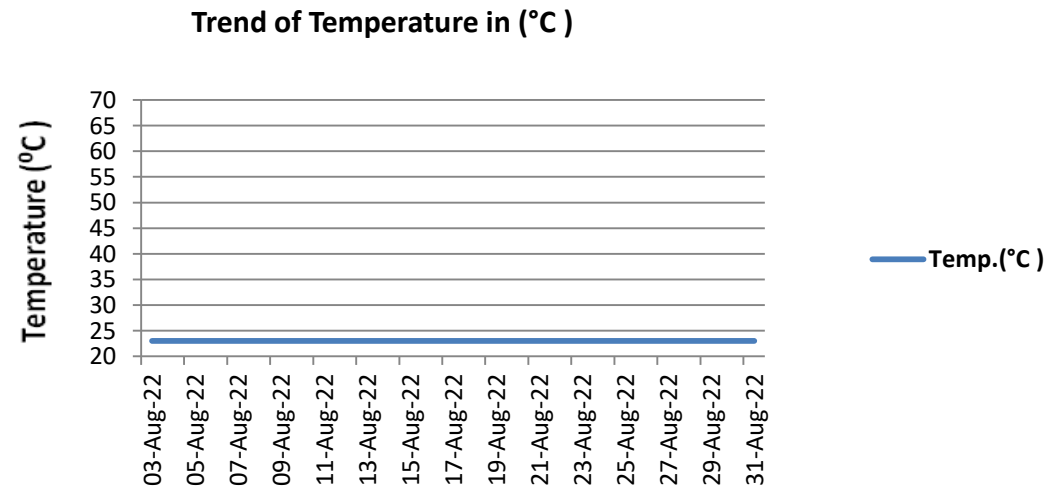
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Trend of data of Temperature at same location in different periods

Results indicate no variation



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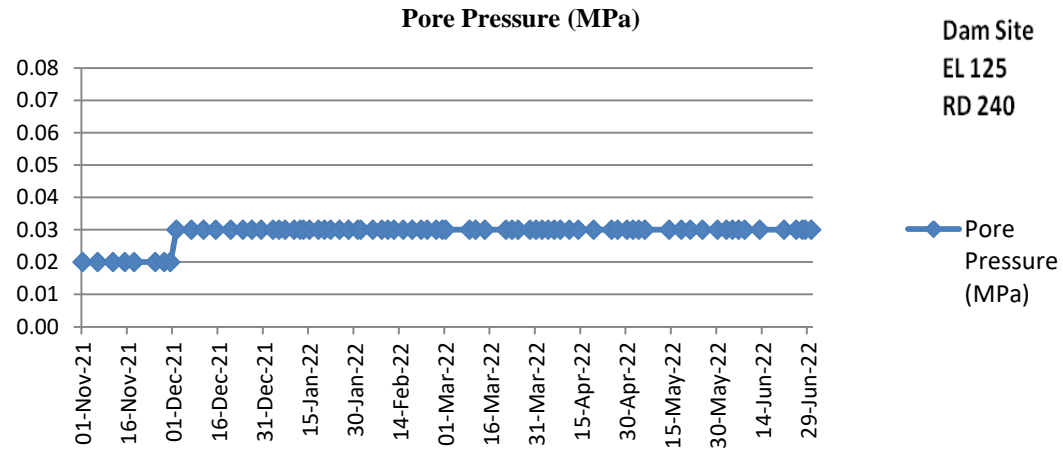


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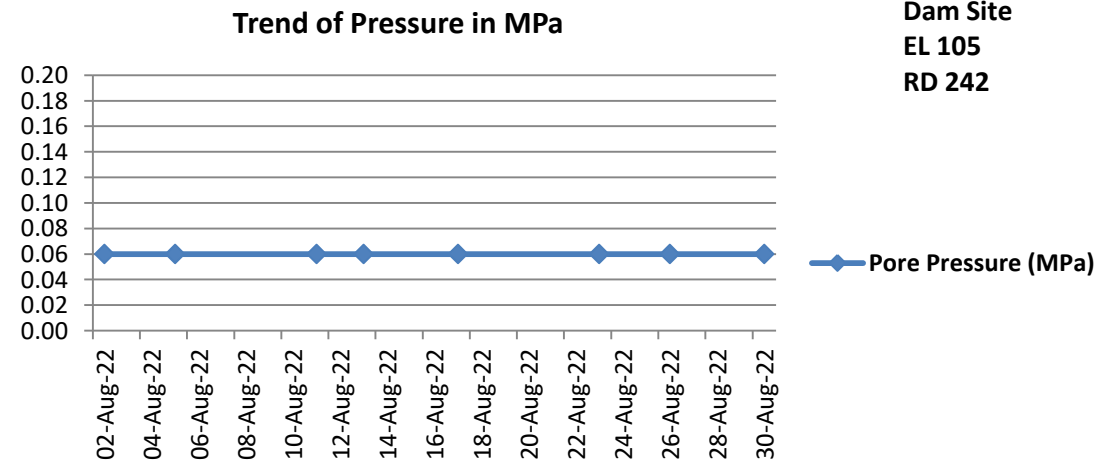


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Trend of data for observing Pore Pressure at two nearest locations in different periods

Results indicate stable condition

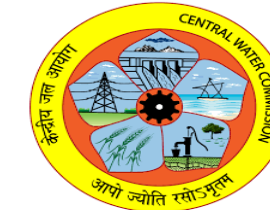


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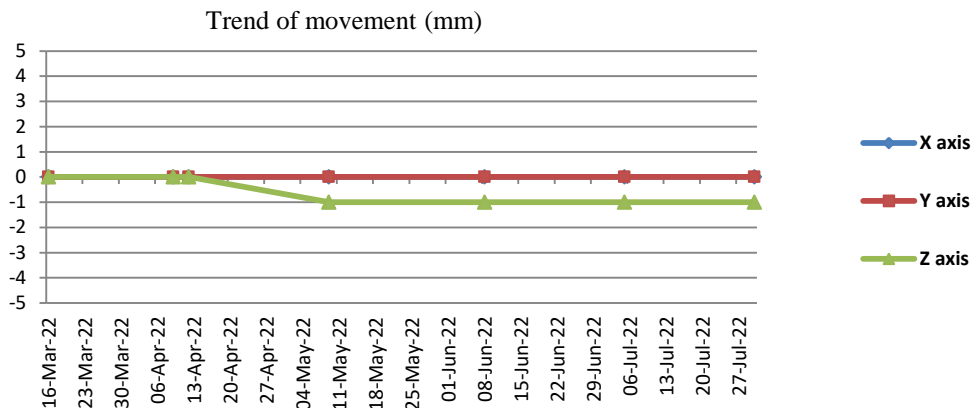


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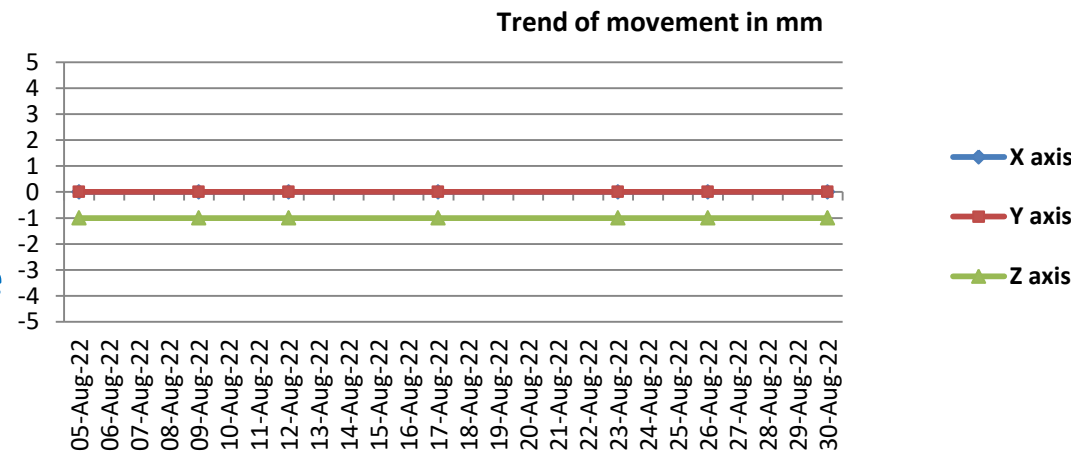


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Trend of linear & Perimetric Joint meter at same locations in different periods

Results indicate stable condition

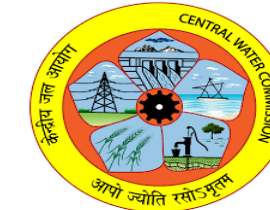


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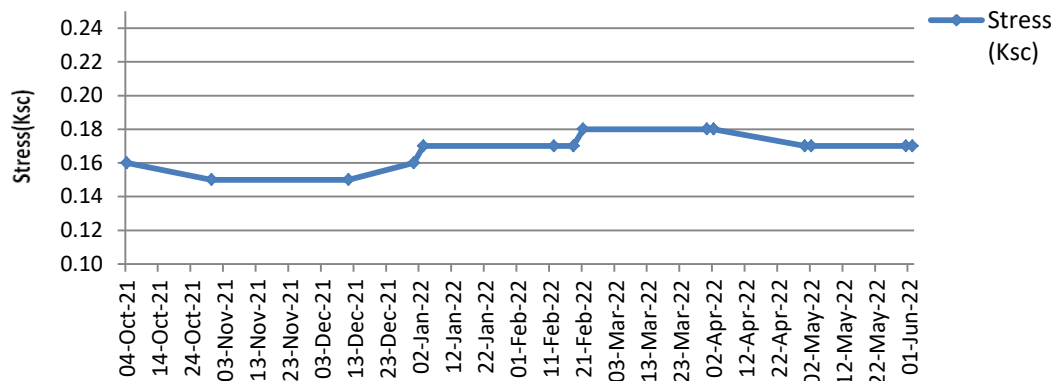
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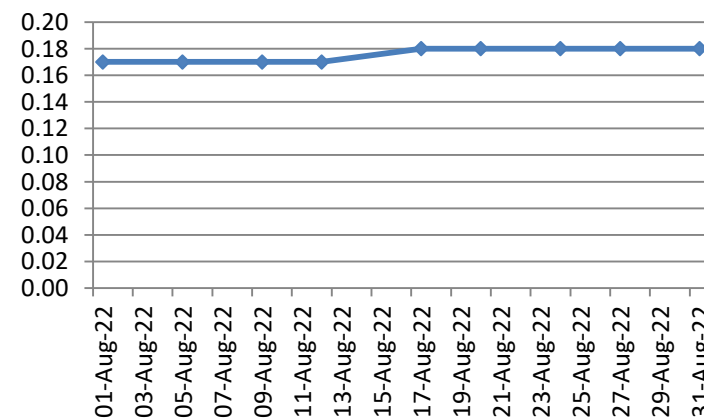
Trend of Stress i



Trend of observed stresses in concrete surface in Dam body at same locations in different periods

Results are within permissible limits

Trend of Stress



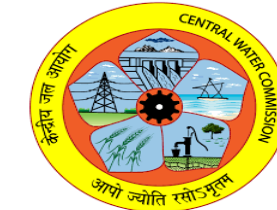
Dam Site
EL 123
RD 207

Stress (Ksc)



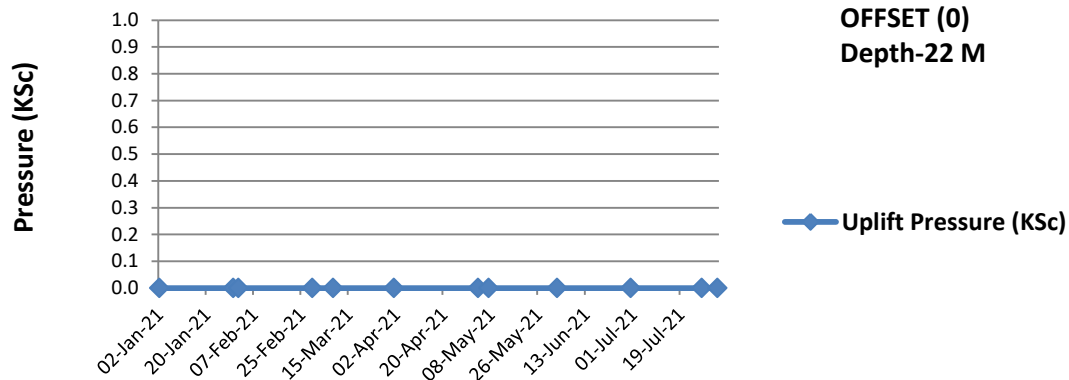
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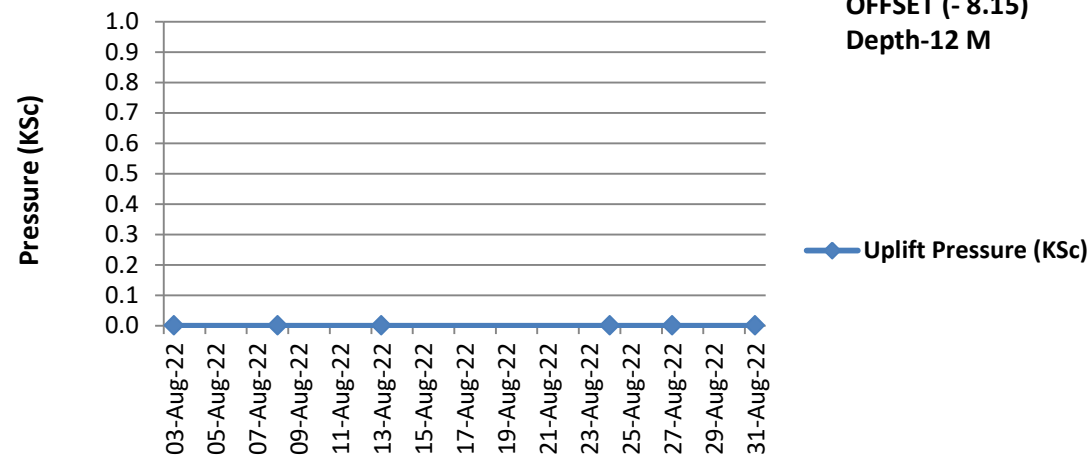
Uplift Pressure in KSc



Comparative study of Trend of uplift Pressure at two nearest locations in different periods

Results indicate stable condition

Uplift Pressure in KSc





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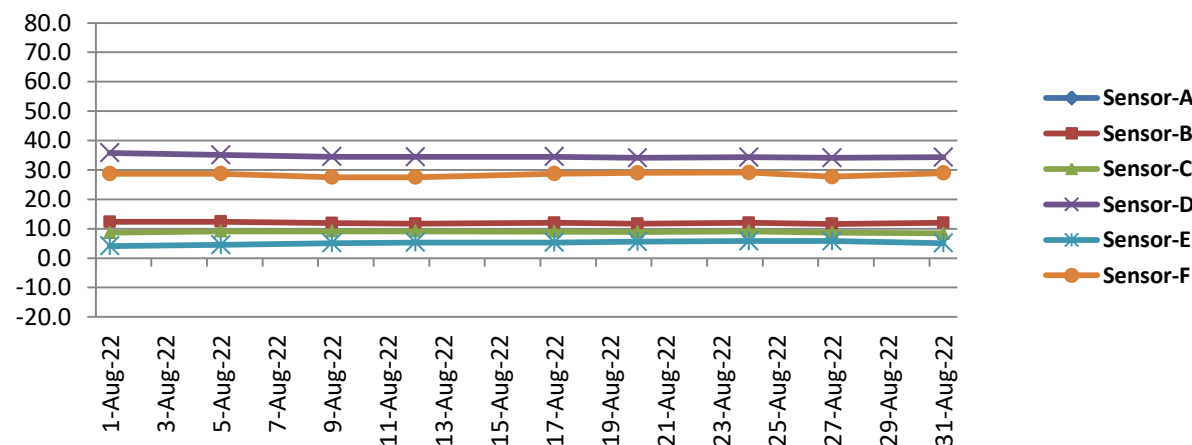


Central Water Commission

Date of Installation- 28.06.11							
Date	Sensor-A	Sensor-B	Sensor-C	Sensor-D	Sensor-E	Sensor-F	Temp. (°C)
	Strain (µε)	Strain (µε)	Strain (µε)	Strain (µε)	Strain (µε)	Strain (µε)	
28.06.11	0.0	0.0	0.0	0.0	0.0	0.0	25
Date	Sensor-A	Sensor-B	Sensor-C	Sensor-D	Sensor-E	Sensor-F	Temp. (°C)
01-Aug-22	88.4	12.3	8.6	35.8	4.1	28.7	24
05-Aug-22	88.2	12.4	9.1	35.1	4.5	28.7	25
09-Aug-22	87.8	11.9	9.1	34.5	5.1	27.5	25
12-Aug-22	87.8	11.7	9.1	34.4	5.3	27.5	24
17-Aug-22	88.1	12.0	9.0	34.5	5.3	28.7	25
20-Aug-22	87.8	11.7	8.9	34.1	5.6	29.0	24
24-Aug-22	88.1	12.0	9.1	34.3	5.8	29.1	24
27-Aug-22	87.9	11.6	8.7	34.1	5.8	27.7	25
31-Aug-22	88.3	12.0	8.4	34.3	5.1	28.9	24

Study of Strain Meter observations during August 22

Results indicate stable condition



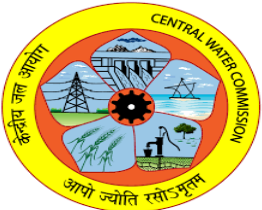
10-12 October 2022 at Jaipur, Rajasthan (India)



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Indian National Committee
on Large Dams

INTERNATIONAL DAM SAFETY CONFERENCE



Central Water Commission

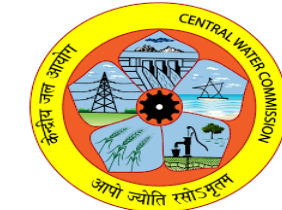
Protection of Cut slope surfaces at
d/s abutments for protection from
rooster tail

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Concrete cladding & Cable Anchors at Cut slopes

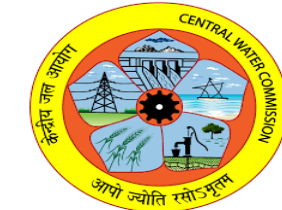


Cut slope surfaces at d/s abutments on left and right sides is being provided with concrete cladding, cable anchors 35 m deep and grouted anchors for protection from rooster tail



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- About 85% of work of Dam works completed & project to commission at least two units during the current FY
- Additional safety measures implemented during construction has proven its forte and tested during successive monsoon season
- Cut-off wall is performing satisfaction by containing downstream seepage
- The Dam galleries have negligible seepage
- Instrumentation readings have shown healthy sign without any abnormalities
- With the completion of Dam, instrumentation readings shall be automated for integrated monitoring of the instruments
- Data shall be utilized to evaluate the performance of Dam

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Dam Rehabilitation & Improvement Project



Central Water Commission

Thank You
For Your Kind Attention

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