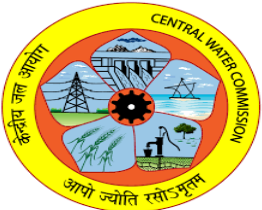




Indian National Committee
on Large Dams

INTERNATIONAL DAM SAFETY CONFERENCE



Central Water Commission

Instrumentation for safety of dams – issues,
challenges and lessons learnt in Indian context

Authors:

Hari Dev, Mahabir Dixit and R.S. Sehra

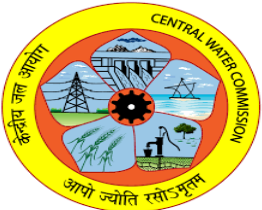
Central Soil and Materials Research Station, New Delhi, India

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



INCOLD
Indian National Committee
on Large Dams

INTERNATIONAL DAM SAFETY CONFERENCE



Central Water Commission

CONTENTS

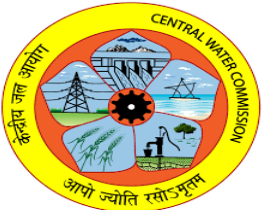
- Instrumentation for safety of dams
- Issues, Challenges
- Lessons learnt in Indian context

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



Indian National Committee
on Large Dams

INTERNATIONAL DAM SAFETY CONFERENCE



Central Water Commission

INSTRUMENTATION

Instruments are *our eyes and ears* inside the media wherever placed.

Instrumentation is used as a tool to ensure safety of dams through continuous monitoring and analysis.

--



INCOLD
Indian National Committee
on Large Dams

INTERNATIONAL DAM SAFETY CONFERENCE



Dam Rehabilitation & Improvement Project



Central Water Commission

OBJECTIVE OF INSTRUMENTATION

- Baseline ground characteristics.
- Construction control.
- Verification of design parameters and assumptions.
- Monitor the long-term effects of environmental changes.
- Carry out research to enhance future design.
- Monitor mitigation measures, and
- Quantification and management of risk to third parties.

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

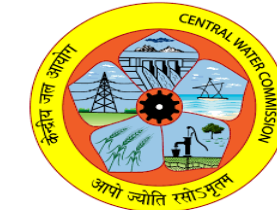


Indian National Committee
on Large Dams

INTERNATIONAL DAM SAFETY CONFERENCE



Dam Rehabilitation & Improvement Project



Central Water Commission

REQUIREMENTS OF GOOD INSTRUMENTATION PROGRAMME

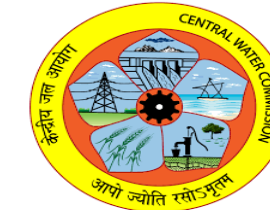
- **Instrumentation Adequacy**
- **Observation of Monitoring Devices**
- **Frequency of Monitoring**

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



Indian National Committee
on Large Dams

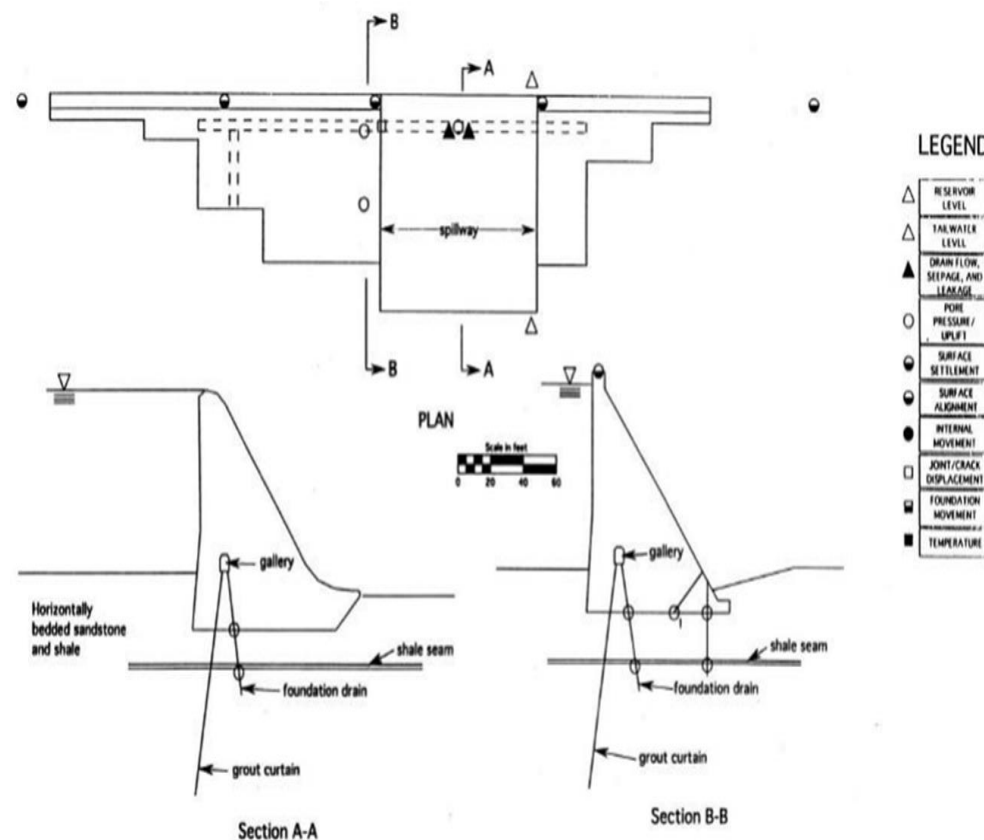
INTERNATIONAL DAM SAFETY CONFERENCE



Central Water Commission

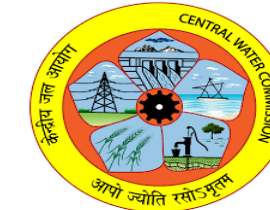
MINIMUM INSTRUMENTATION IN CONCRETE GRAVITY DAM

Instrumentation should be provided in at least one deepest overflow block and two abutment blocks. It should also be indicated that the number of instrumented blocks may be increased with the increase in length / height of dam.



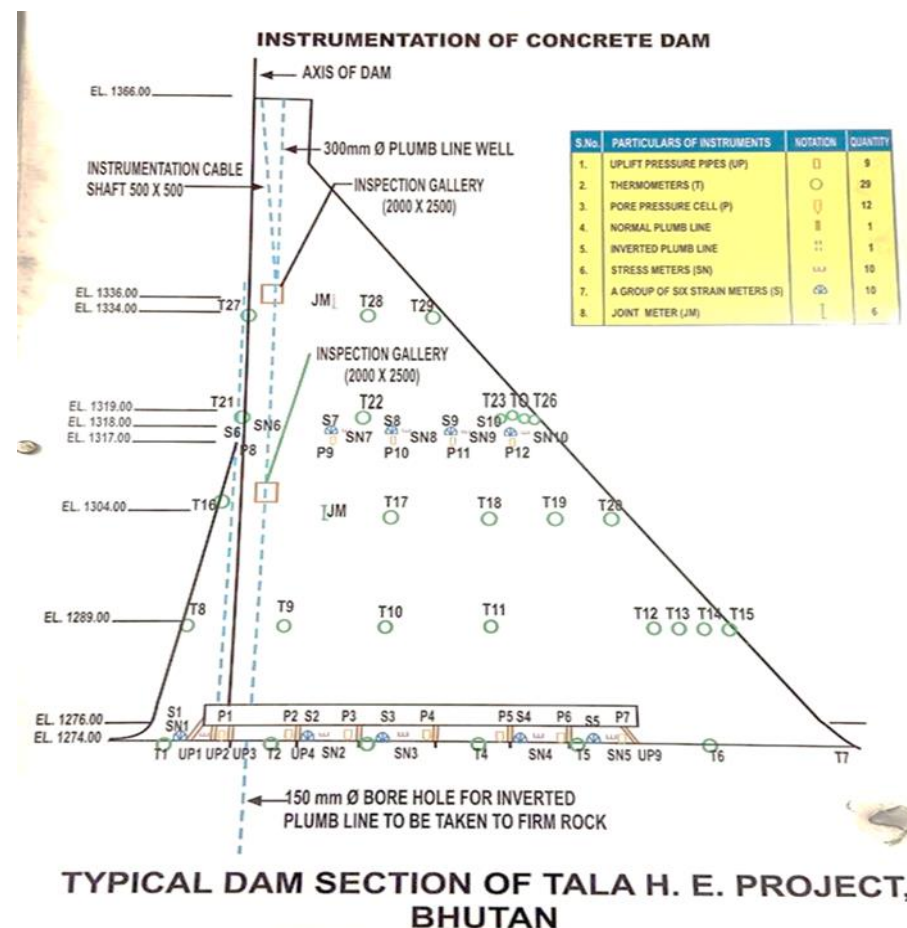


INTERNATIONAL DAM SAFETY CONFERENCE



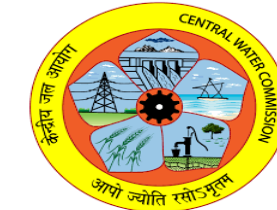
INSTRUMENTATION IN CONCRETE DAM

- Uplift Pressure meters
- Pore Pressure meters
- Joint Movement meters
- Stress/ Strain Meters
- Dam Movement
- Temperature Meters
- Seepage Measurements
- Water Level Measurements
- Seismic Measurements



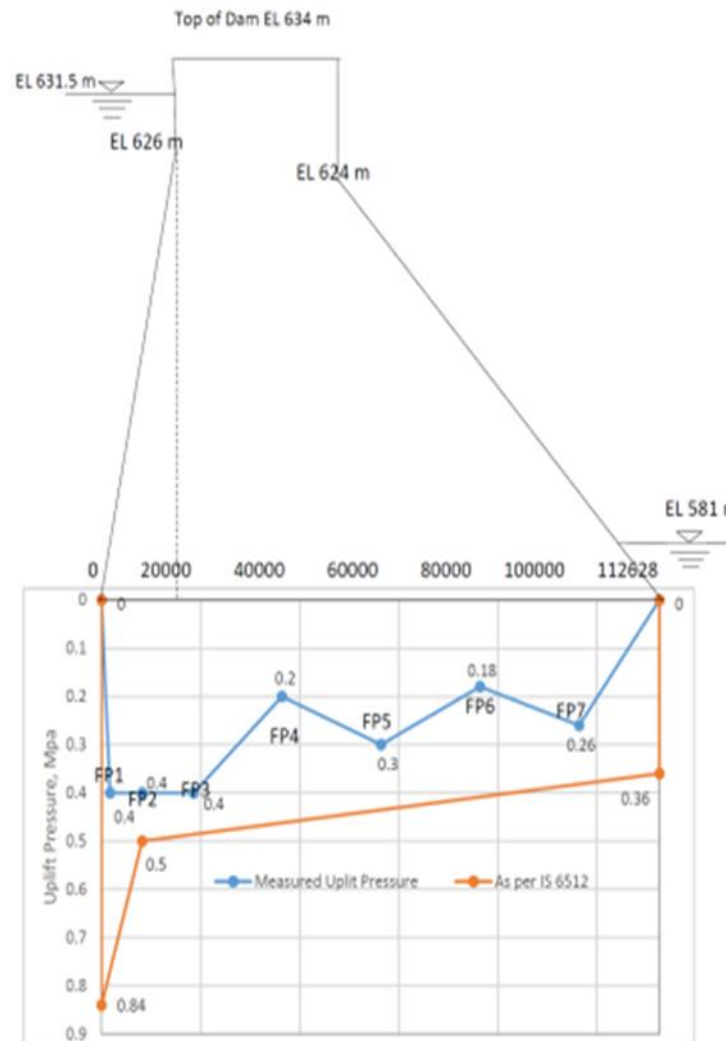


INTERNATIONAL DAM SAFETY CONFERENCE



➤ UPLIFT PRESSURES

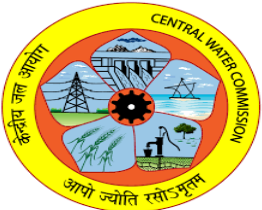
- Pressure meters are installed in the foundation/grouting gallery to monitor the variation in uplift pressures.
- It should be done at least at three cross sections in case of small dams (30 m or less in height) and at least at five cross sections in the case of large dams.





Indian National Committee
on Large Dams

INTERNATIONAL DAM SAFETY CONFERENCE



Central Water Commission

➤ PORE PRESSURE

- In concrete and masonry dams, they may be installed normally at 10 to 15 m spacing along the width of the dam.



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

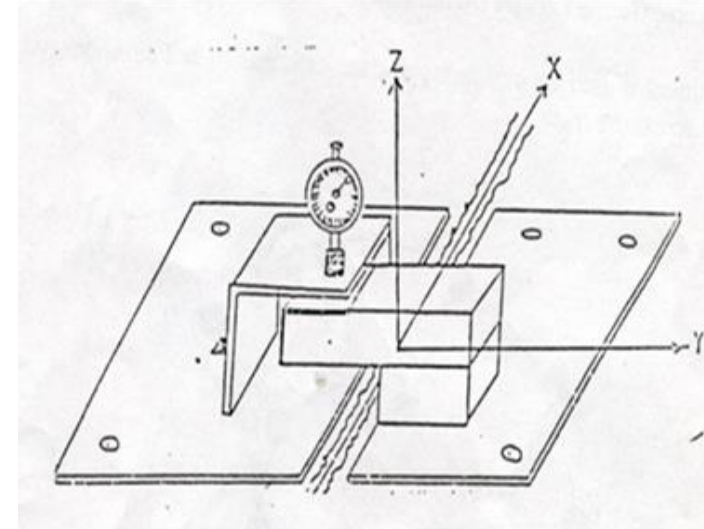


INTERNATIONAL DAM SAFETY CONFERENCE



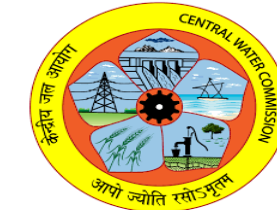
➤ JOINT METERS

- In case of large dams joint meters should be provided in at least three blocks, one in deepest central block and a block each in the abutment.



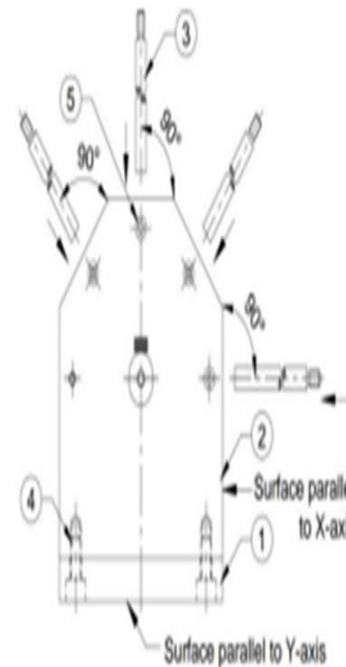


INTERNATIONAL DAM SAFETY CONFERENCE



➤ STRESS/STRAIN METERS:

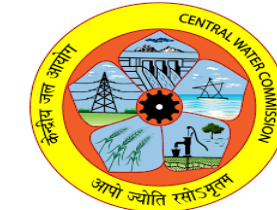
- Stress and strain meters are installed in dam body to monitor the variation in stresses and strains during construction.
- Stress meters are installed alongside the strain meters so that the data can be correlated.
- Strain meters are installed in Rosettes, like 3nos, 5 nos.





Indian National Committee on Large Dams

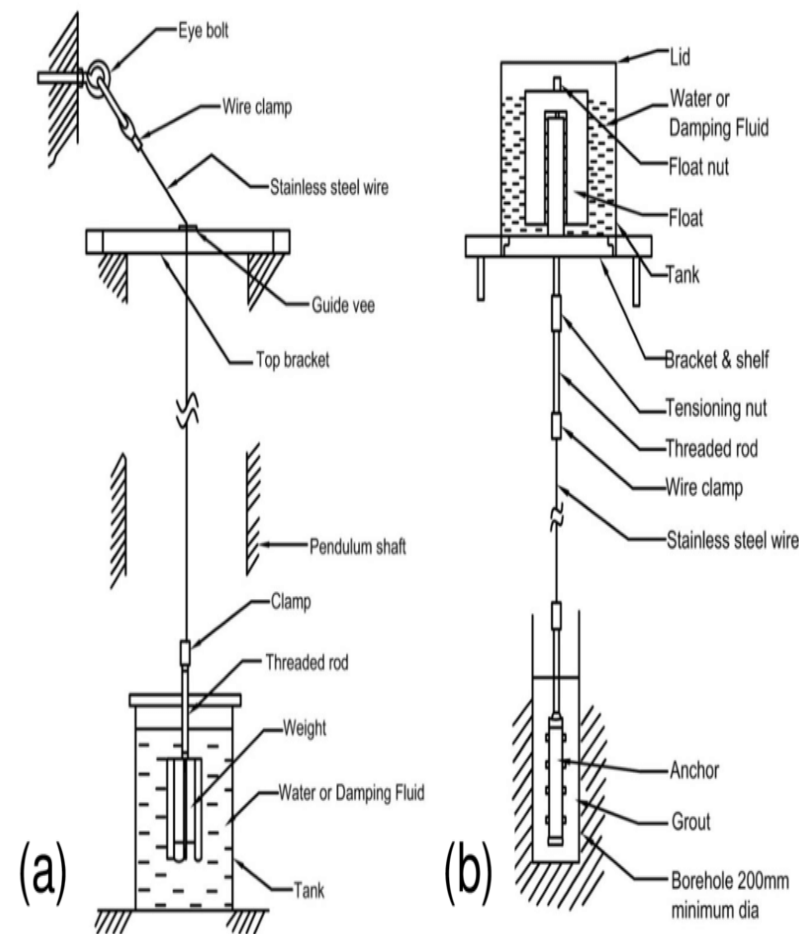
INTERNATIONAL DAM SAFETY CONFERENCE



Central Water Commission

➤ HORIZONTAL/ VERTICAL MOVEMENTS

- Normal and inverted plumb lines are installed in concrete gravity dams to monitor the structural deformations and the movements in the foundation.
- In addition to normal plumb line, optical targets and tilt meters at the dam top can also be fixed before start of reservoir filling so as to record the dam deformations.



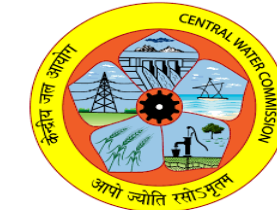


Indian National Committee
on Large Dams

INTERNATIONAL DAM SAFETY CONFERENCE



Dam Rehabilitation & Improvement Project



Central Water Commission

➤ SEEPAGE DISCHARGE MEASUREMENTS

- V-Notches are the simplest devices used for measurement of seepage discharge through dam body (IS 14750).
- These can be installed in drains in inspection galleries.



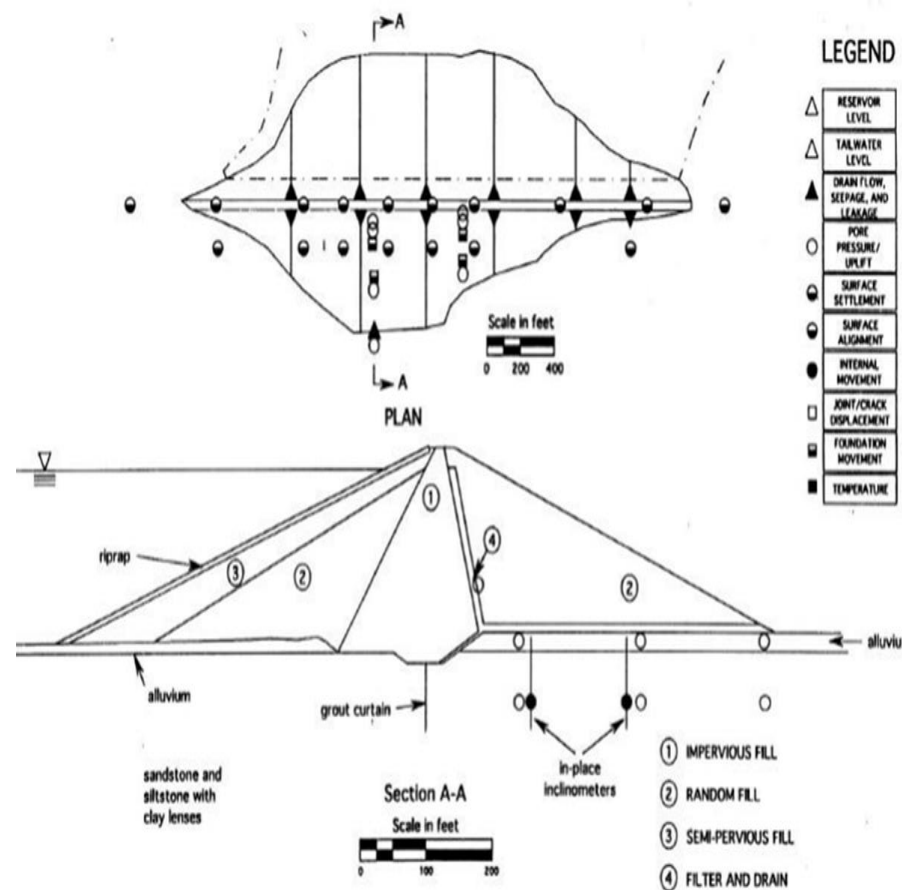


INTERNATIONAL DAM SAFETY CONFERENCE



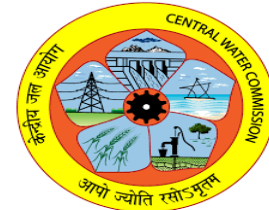
MINIMUM INSTRUMENTATION IN EMBANKMENT DAM

- Where dam lengths are more and foundation strata varies along the length, location of instruments at two or three sections should be considered. points of view of safety and collecting data for future similar designs.





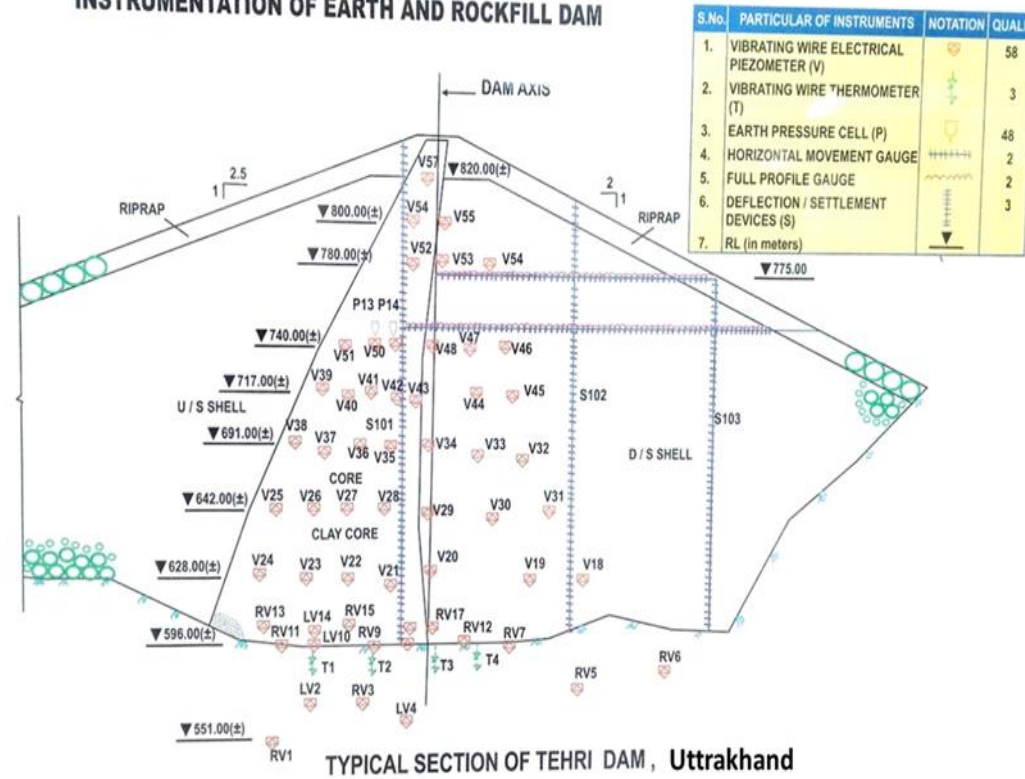
INTERNATIONAL DAM SAFETY CONFERENCE



GEOTECHNICAL INSTRUMENTATION IN EARTH AND ROCK-FILL DAM

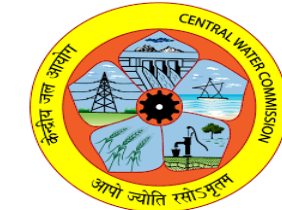
- Pore Pressure.
- Earth Pressure.
- Horizontal and Vertical Movement.
- Seepage Measurements
- Water Level Measurements
- Seismic Measurements

INSTRUMENTATION OF EARTH AND ROCKFILL DAM



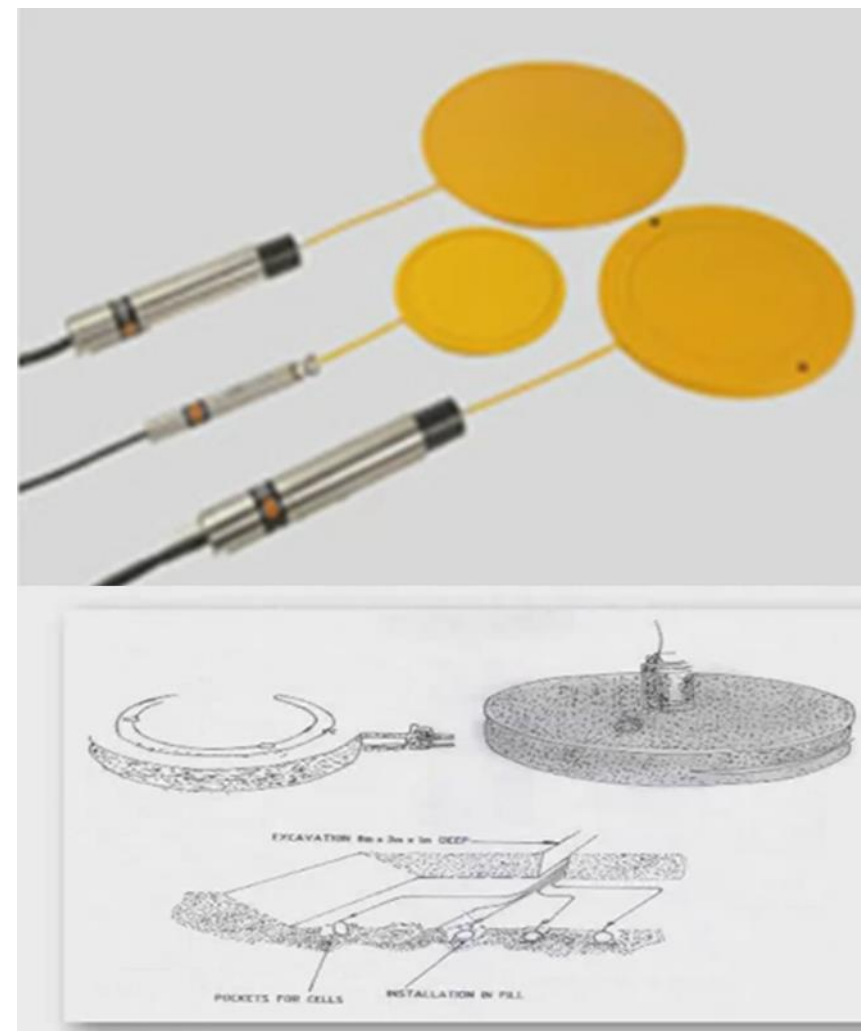


INTERNATIONAL DAM SAFETY CONFERENCE



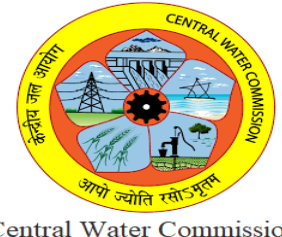
➤ EARTH PRESSURE CELLS

- The earth pressure cell may be designed to measure effective or total earth pressure or both.
- When it measures total earth pressure only, piezometers should be placed by their side to measure pore pressure which when deducted from the total earth pressure to give effective earth pressure.



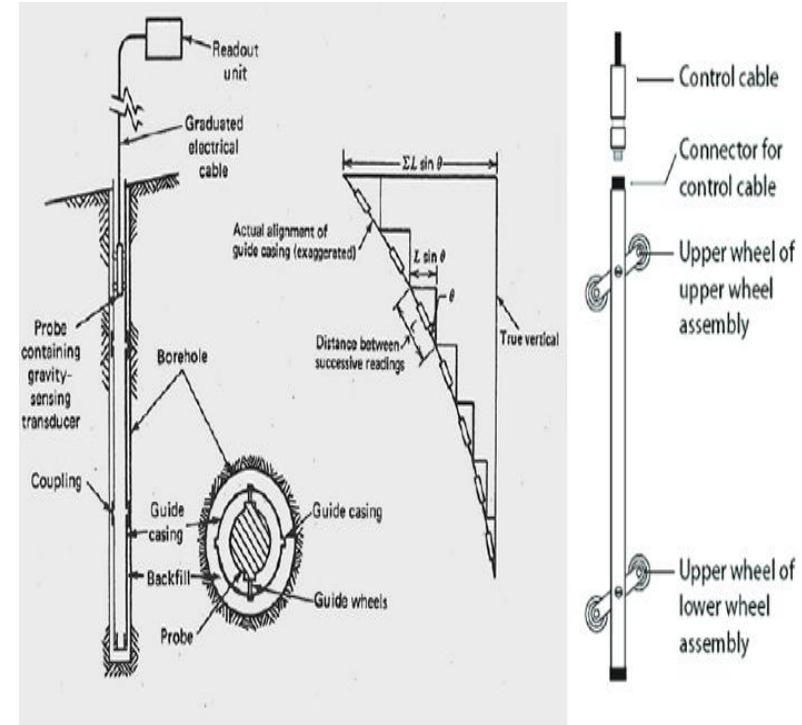


INTERNATIONAL DAM SAFETY CONFERENCE



➤ HORIZONTAL/VERTICAL MOVEMENTS:

- For horizontal movement, inclinometer is superior to give along complete length and its position of sliding surface.
- The cross-arm installation for vertical movement has been a standard practice.





INCOLD

Indian National Committee
on Large Dams

INTERNATIONAL DAM SAFETY CONFERENCE



Dam Rehabilitation & Improvement Project



Central Water Commission

ISSUES AND CHALLENGES IN DAM INSTRUMENTATION

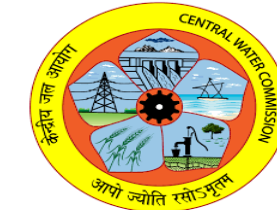
- Selection of Instruments
- Organisational Issues
- Contractual Issues
- Monitoring and Data Reporting
- Data Analysis

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



Indian National Committee on Large Dams

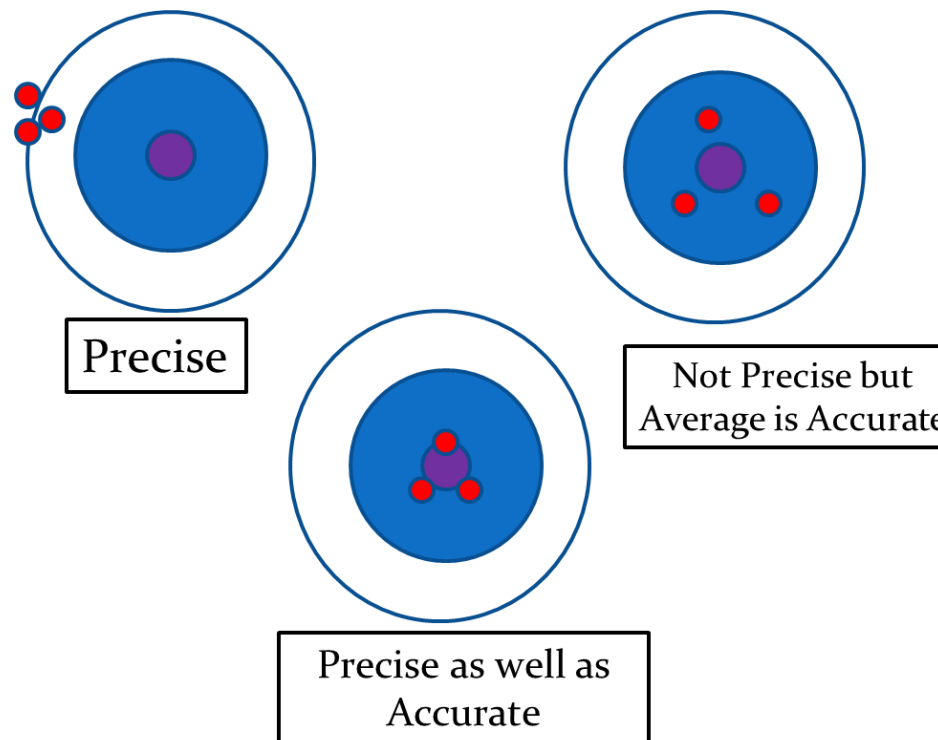
INTERNATIONAL DAM SAFETY CONFERENCE



Central Water Commission

SELECTION OF INSTRUMENTS

- Instruments should be as simple as possible
- Handy
- Durable
- Accurate and Precise



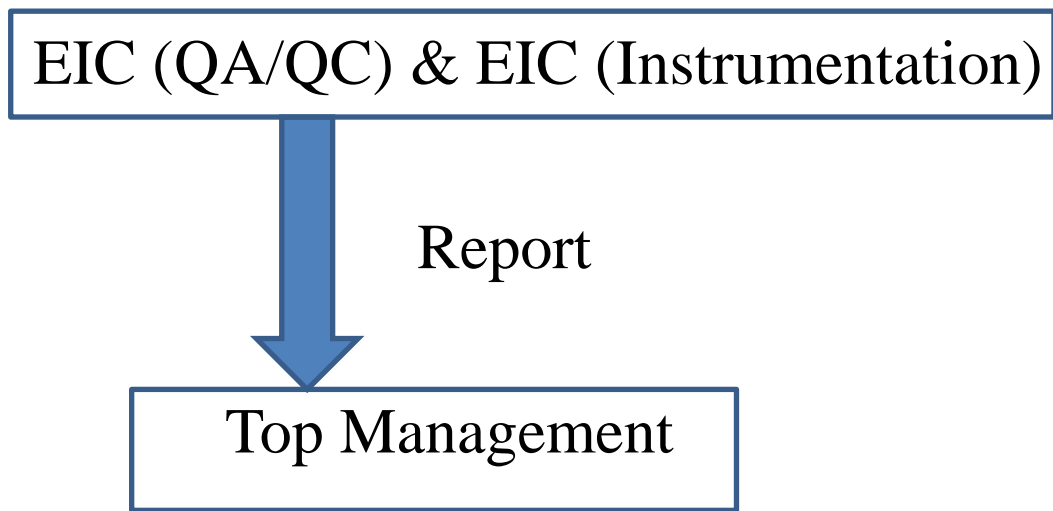


INTERNATIONAL DAM SAFETY CONFERENCE



ORGANISATIONAL ISSUES

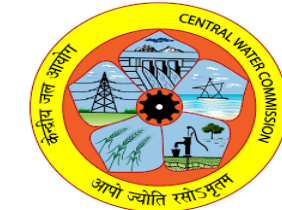
- In any Project:
 - Civil work, QA/QC and Instrumentation are important tasks
 - { EIC (QA/QC) + EIC (Instrumentation) } # EIC Work
 - Likewise:





Indian National Committee
on Large Dams

INTERNATIONAL DAM SAFETY CONFERENCE



Central Water Commission

CONTRACTUAL ISSUES

Co-Ordination between

- EIC (Instrumentation),
 - EIC (works),
 - Contractor (civil works) and
 - Contracting agency (Instrumentation).
-
- Responsibility of Contractor
 - Accountability of Instrumentation agency
 - Study of drawings
 - Monitoring and submission of monthly reports
 - Linkage of payments to the contractor

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



Indian National Committee
on Large Dams

INTERNATIONAL DAM SAFETY CONFERENCE



Central Water Commission

MONITORING AND DATA REPORTING

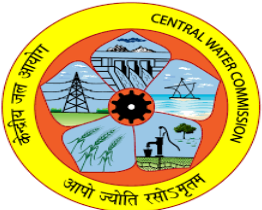
- Monitoring schedule for each instrument should be fixed and implemented in the true spirit.
- Graphical method of presentation is **best** suited to monitor the changes in any parameter over time.
- Apart from cumulative values, the trends can also be reported in the form of **rate of change** in any parameter.

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



Indian National Committee
on Large Dams

INTERNATIONAL DAM SAFETY CONFERENCE



Central Water Commission

DATA ANALYSIS

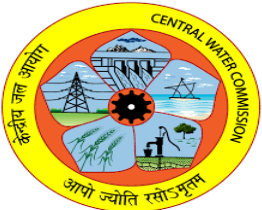
- Data should analysis and interpret and highlight the critical values needing urgent attention.
- Findings should be submitted to Designers /TAC to verify the design assumptions and suggest corrective measures.

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



Indian National Committee
on Large Dams

INTERNATIONAL DAM SAFETY CONFERENCE



Central Water Commission

PROBLEMS FACED IN THE FIELDS

➤ SLIDING



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



Indian National Committee
on Large Dams

INTERNATIONAL DAM SAFETY CONFERENCE



➤ CRACKS IN DIFFERENT PARTS OF STRUCTURE



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



Indian National Committee
on Large Dams

INTERNATIONAL DAM SAFETY CONFERENCE



➤ IMPROPER INSTALLATION OF INSTRUMENTS



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

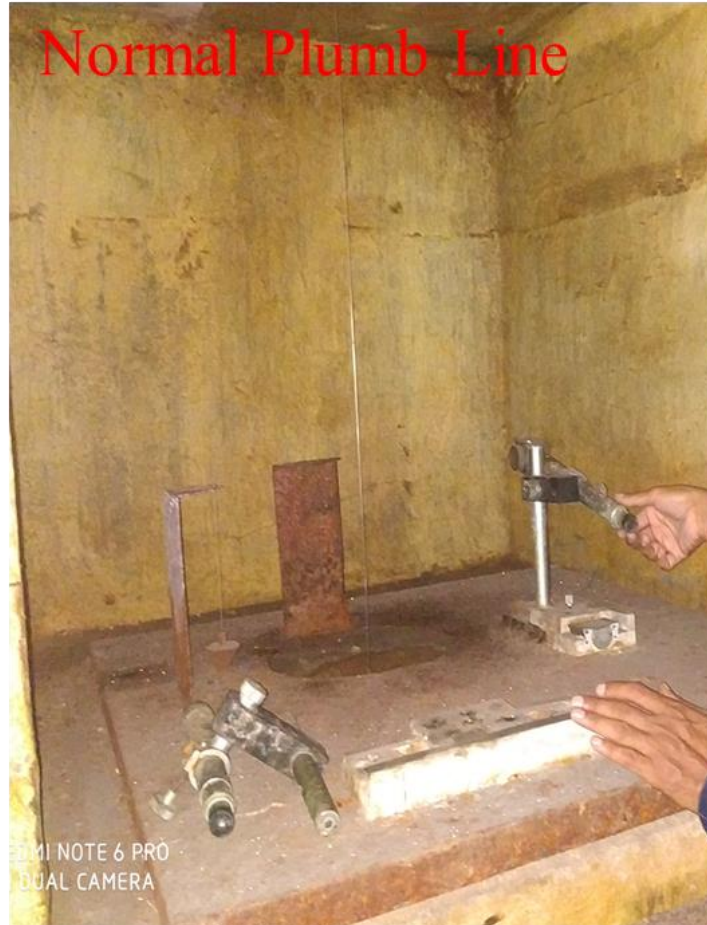


Indian National Committee
on Large Dams

INTERNATIONAL DAM SAFETY CONFERENCE



- Damaged/Choked Instruments

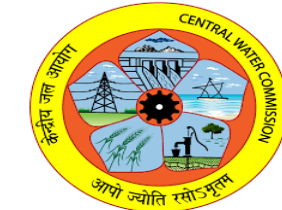


10-12 October 2022 at Jaipur, Rajasthan (India)



INCOLD
Indian National Committee
on Large Dams

INTERNATIONAL DAM SAFETY CONFERENCE



Central Water Commission

CONCLUSIONS

- Instrumentation is used as a tool to ensure safety of dams through continuous monitoring and analysis.
- Proper instrumentation not only helps in safety of the structure, but can also lead to economy in terms of cost, time and materials.
- Proper installation of instrument is as important as the quality of instrument itself since once embedded, can not be taken out.
- The calibration of each and every instrument is very important to ensure measurement of true values of desired parameter intended for.

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



INCOLD

Indian National Committee
on Large Dams

INTERNATIONAL DAM SAFETY CONFERENCE



Central Water Commission

**Thanks a lot for having
patience**

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