

Dam Safety Act, 2021

***... Road Map
for Technical Readiness
in India***





Today

- Dam Safety Basics
- Technical Domains of Human Resources
- Suggested Plan for Dam Safety Assessment in India



Dam Safety Basics

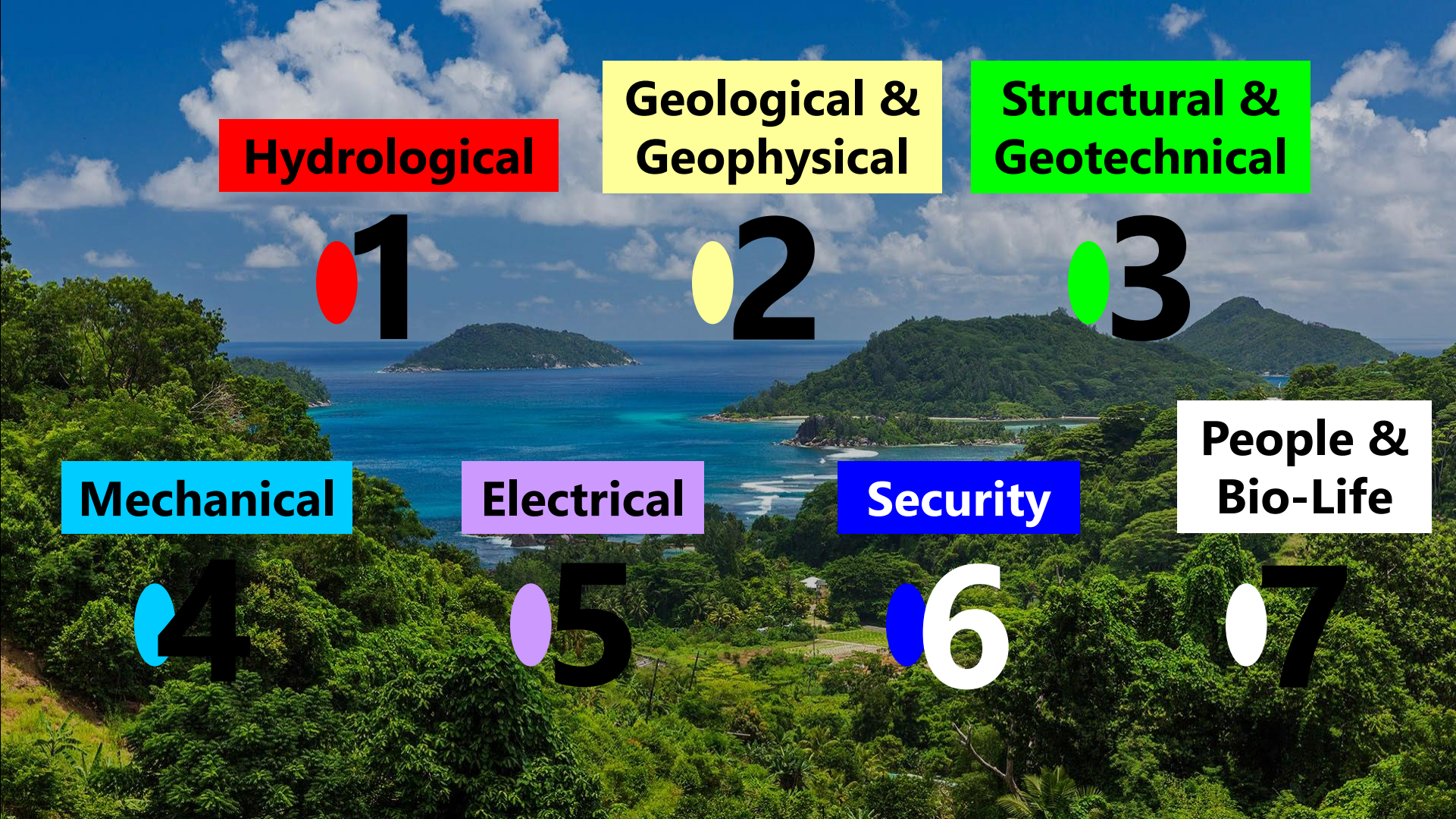
Dam Safety Domains

Geotechnical and Structural Safety Assessment



Lifetime of a Dam

Stages of a Dam



Hydrological

Geological & Geophysical

Structural & Geotechnical

1

2

3

Mechanical

Electrical

Security

People & Bio-Life

4

5

6

7

Domains

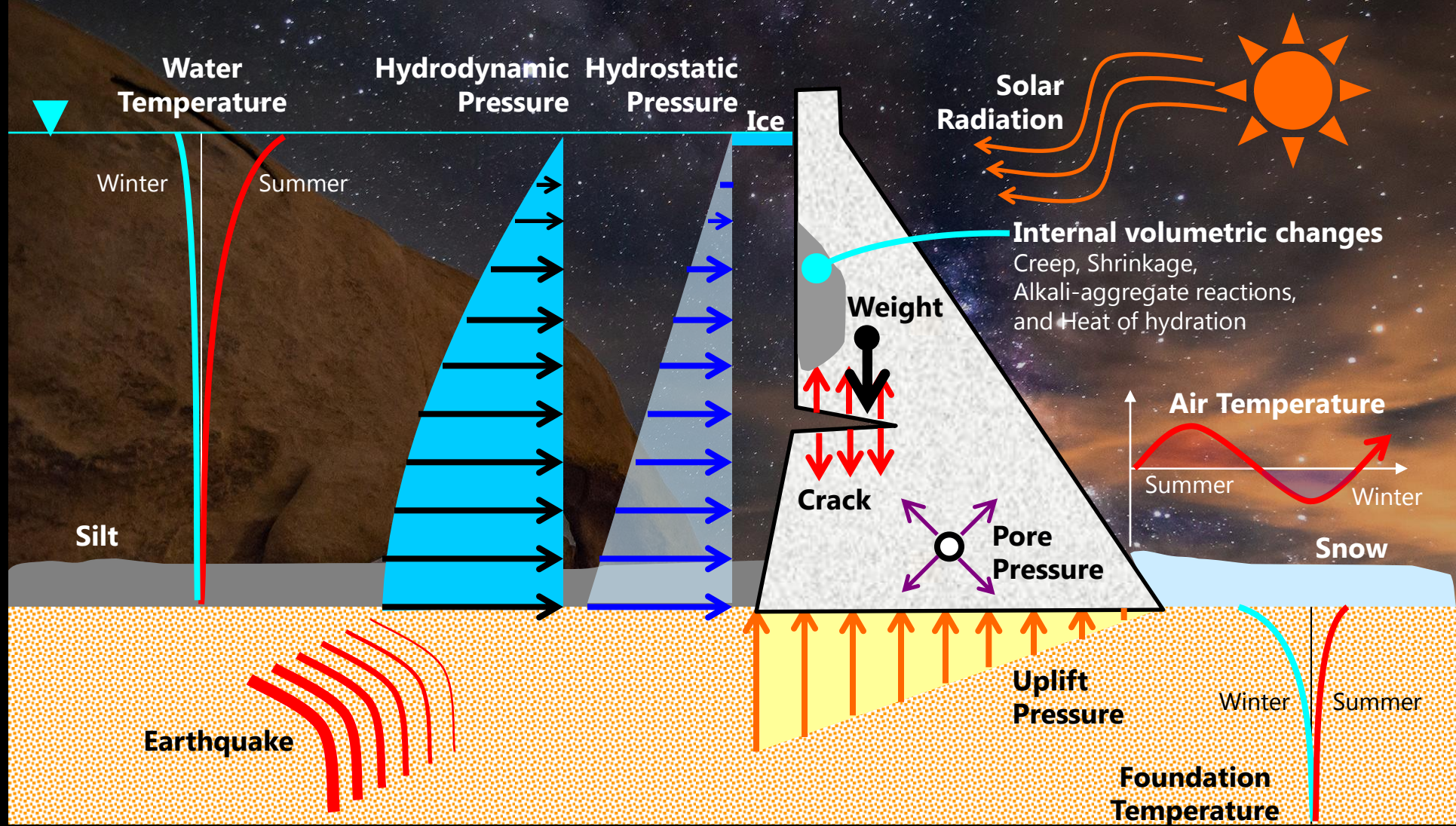
Dam Safety



Each DAM

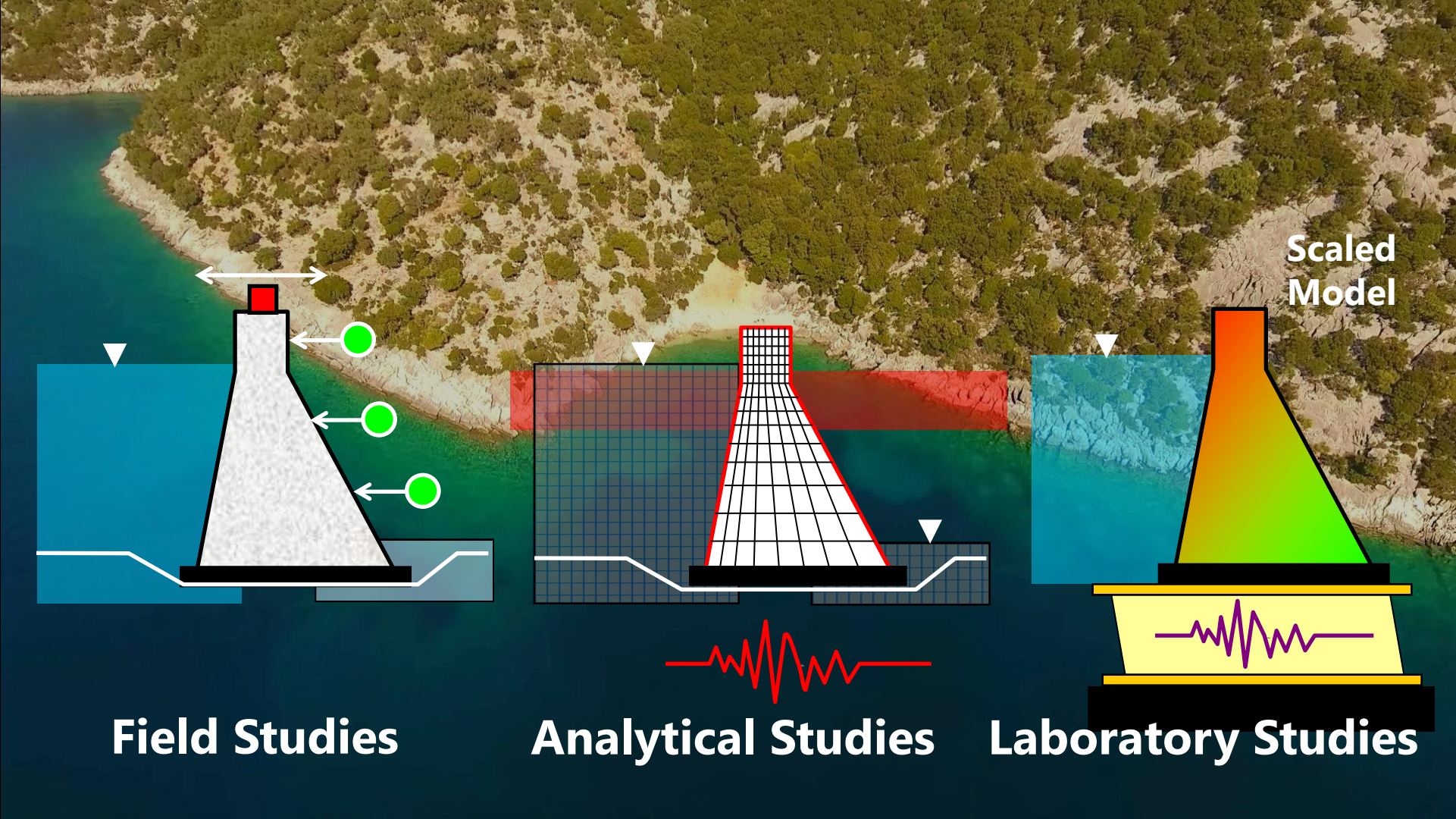
- Geologists**
- Geophysicists**
- Seismologists & Seismotectonists**
- Hydrologists**
- Sedimentation Specialists**
- Material Specialists**
- Snow Specialists**
- Metrology Specialists**
- Biology Specialists**
- Environment Specialists**
- GIS Modelers**
- Geotechnical Engineers**
- Hydraulic Engineers**
- Structural Engineers**
- Mechanical Engineers**
- Electrical Engineers**
- Construction Engineers**
- Maintenance Engineers**
- Instrumentation Engineers**
- ...

Subject Specialists



Loads and deformations of Gravity Dams :: Dam-Foundation-Reservoir System

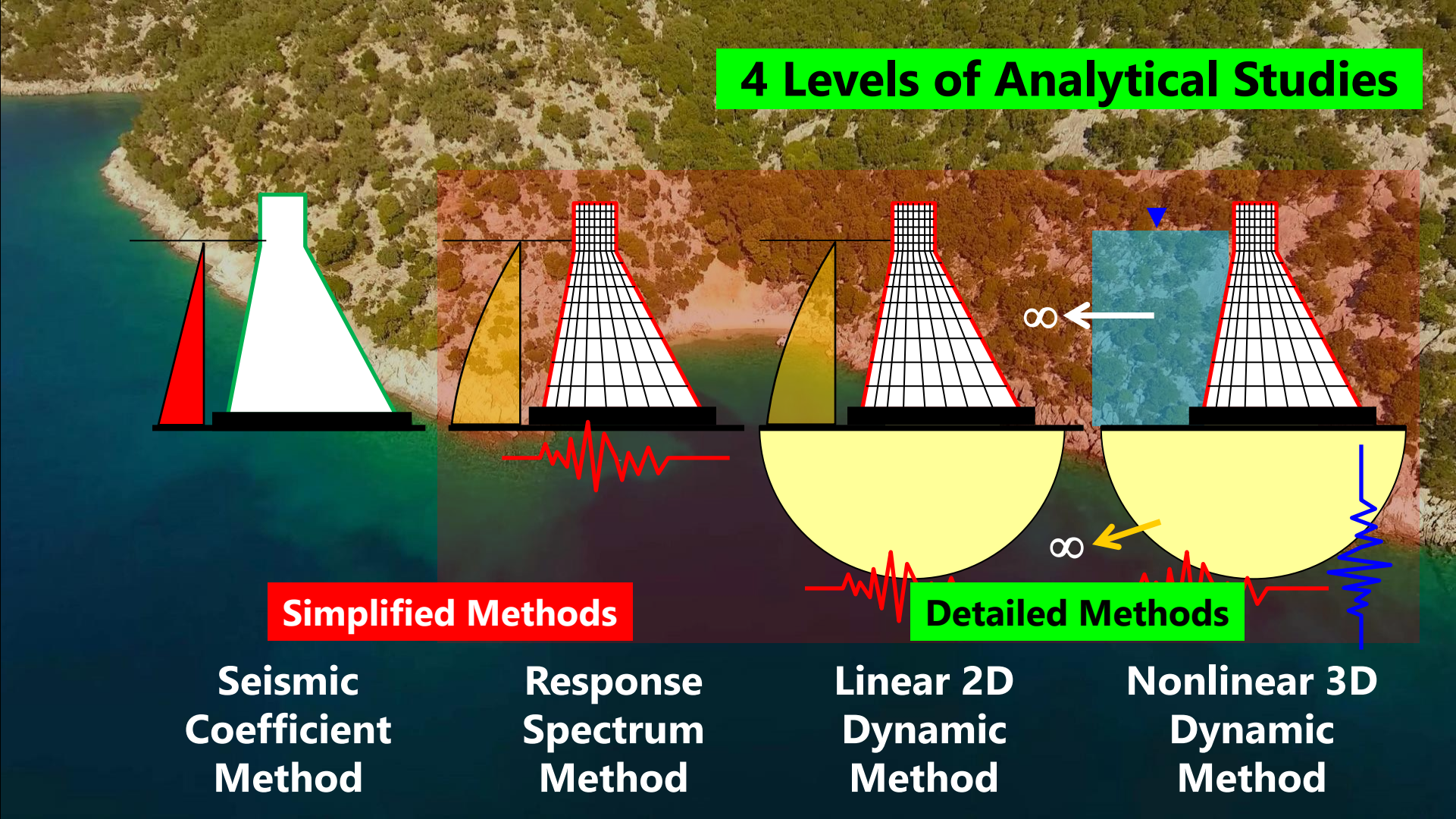
Geotech.-Structural Safety



Holistic Competence needed in all 3

Technology

4 Levels of Analytical Studies



Simplified Methods

Detailed Methods

**Seismic
Coefficient
Method**

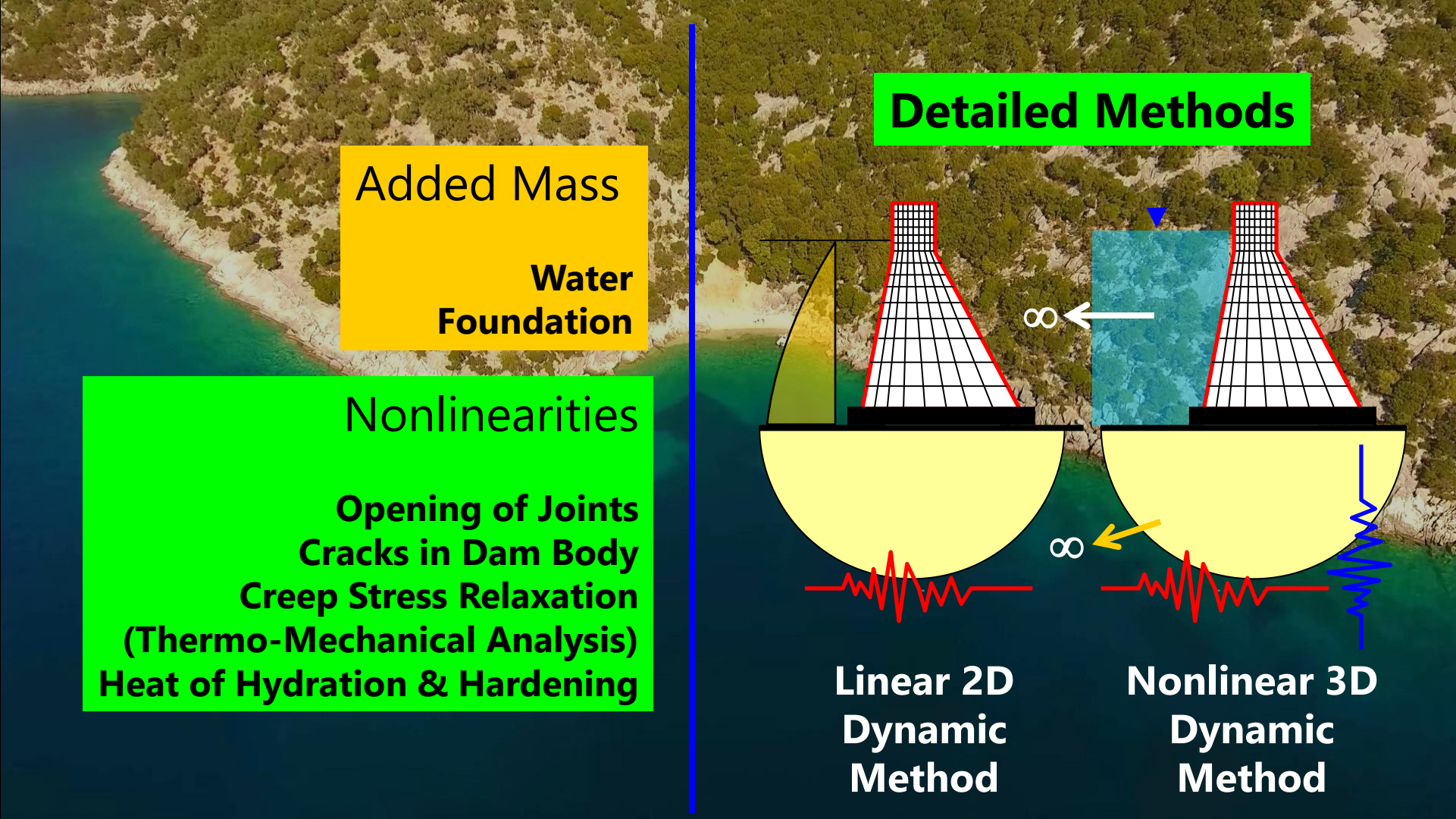
**Response
Spectrum
Method**

**Linear 2D
Dynamic
Method**

**Nonlinear 3D
Dynamic
Method**

Competence abreast with improved tools

Technology



Critical Number of Engineers with competence

Technology

The Dam Safety Act, 2021

- Major Technical Agenda
 - Section 23
 - Training & Capacity Building of Dam Engineers
 - Section 38
 - Comprehensive Dam Safety Evaluation
 - Section 34
 - Installation of Seismological Stations
 - Section 6(1); and First Schedule Item (7)
 - Identification of R&D needs for Dam Safety

The Dam Safety Act, 2021

- Elements of Dam Safety

- Geotechnical and Structural Safety

- 'Main' and 'Safety' items

- Operational Safety

- 'Main' and 'Safety' items

- Monitoring

- Structural & Water Parameters

- Maintenance

- Dam and Appurtenances

- Emergency

- Planning and Evacuation System

Geotechnical & Structural E

ME, EE, Owners, and Elected Rep.

Dam Safety is a Technical Matter

Need Non-technical Competence also

Instrumentation and IT

Visual Inspection

Environmental and Social Issues



Technical Domains of Human Resources Needed

*Geotechnical & Structural Earthquake Dam Safety
Assessment*

Domains of Competence

Hydrological Safety
Geological & Geophysical
Structural & Geotechnical Safety
Mechanical Safety
Electrical Safety
Security
People, Bio-Life & Environmental Safety



Geologists
Geophysicists
Seismologists & Seismotectonists
Hydrologists
Sedimentation Specialists
Material Specialists
Snow Specialists
Metrology Specialists
Biology Specialists
Environment Specialists
GIS Modelers
Geotechnical Engineers
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Structural Engineers
Mechanical Engineers
Electrical Engineers
Construction Engineers
Maintenance Engineers
Instrumentation Engineers
...

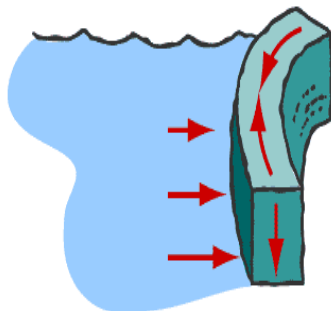
Dam Safety Assessment Strategy

- Task
 - Specialized and involved
- Key
 - Earthquake Loading
 - Tectonic, and Reservoir Triggered
 - Water Surge Loading
 - Revised estimates considering Climate Change
- Most Dam Safety issues
 - Triggered by “Structural Factors”

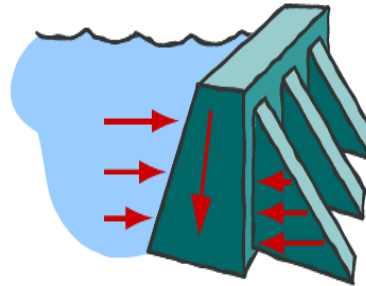
International State-of-the-Art

- High dams evaluated using modern procedures
 - Analytical
 - Experimental
 - Field
 - Laboratory

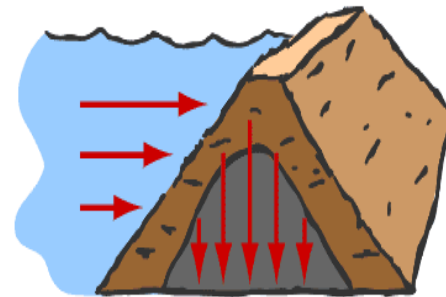
Many dams upgraded to improved earthquake resistance



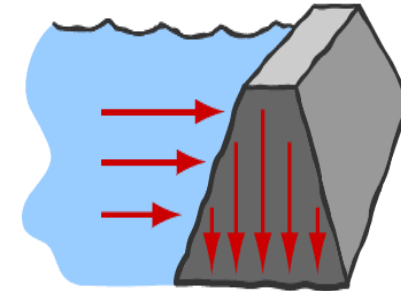
Arch Dam



Buttress Dam



Earthen Dam



Gravity Dam

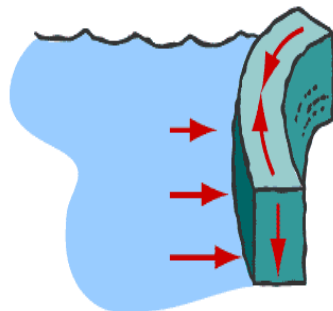
Earthquake Safety in India

• Reasons for Assessing Safety

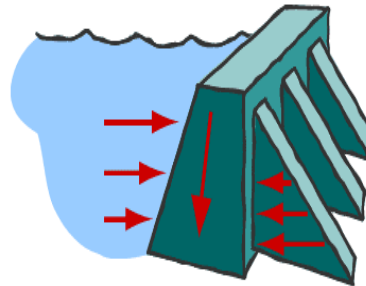
- Deterioration in physical properties due to aging of materials
- Method of Original Design simple
- Earthquake Hazard revised

• Available Tools for Safety Assessment

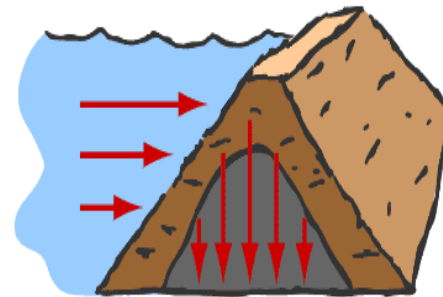
- Advanced methods of nonlinear dynamic earthquake analysis
- Advanced concepts of Eq.R. Design & Retrofit
- Well documented probabilistic risk analysis



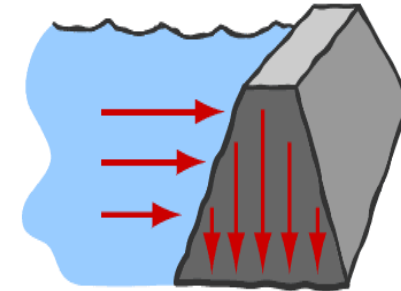
Arch Dam



Buttress Dam

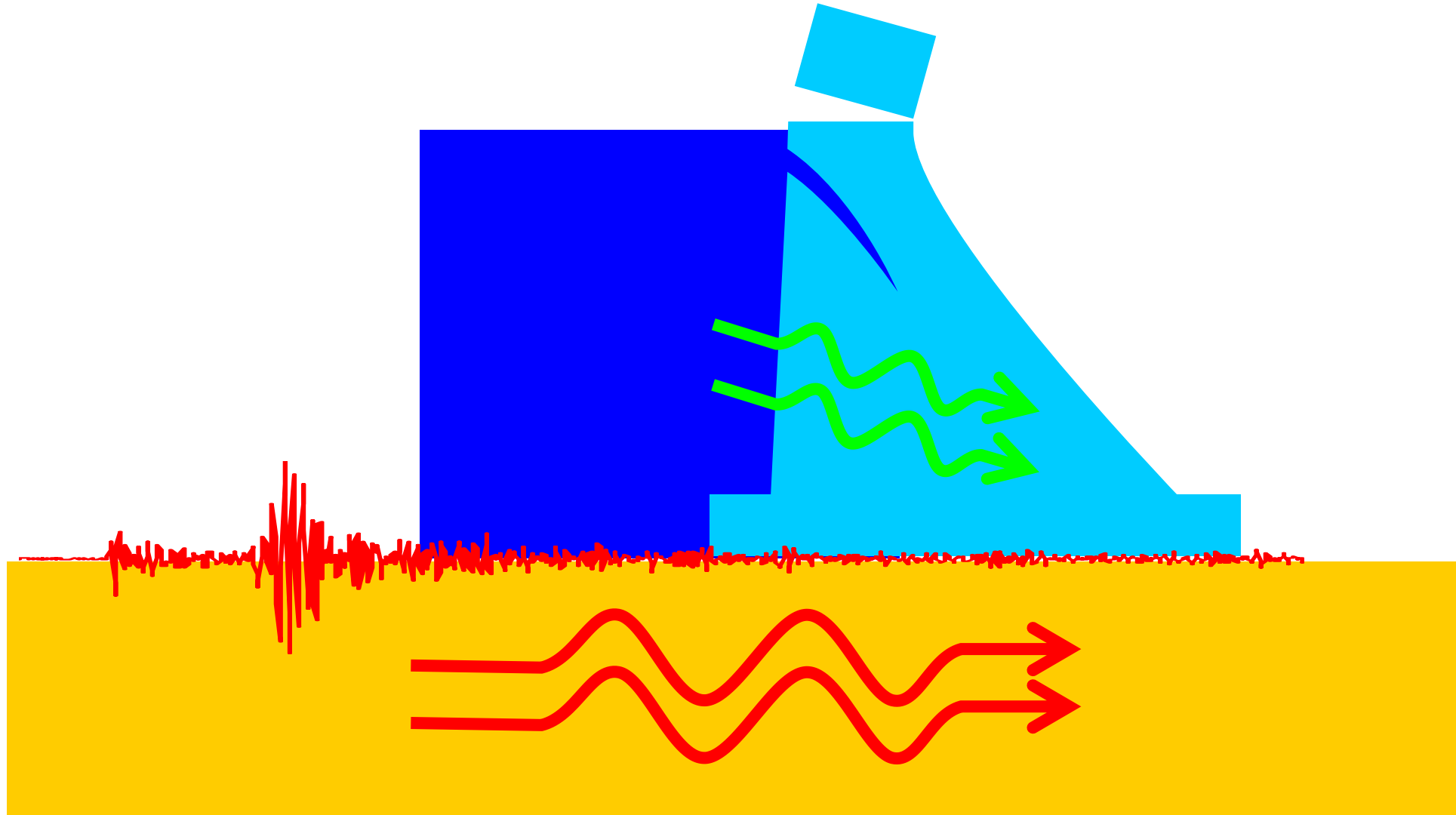


Earthen Dam



Gravity Dam

Geotechnical and Structural Safety

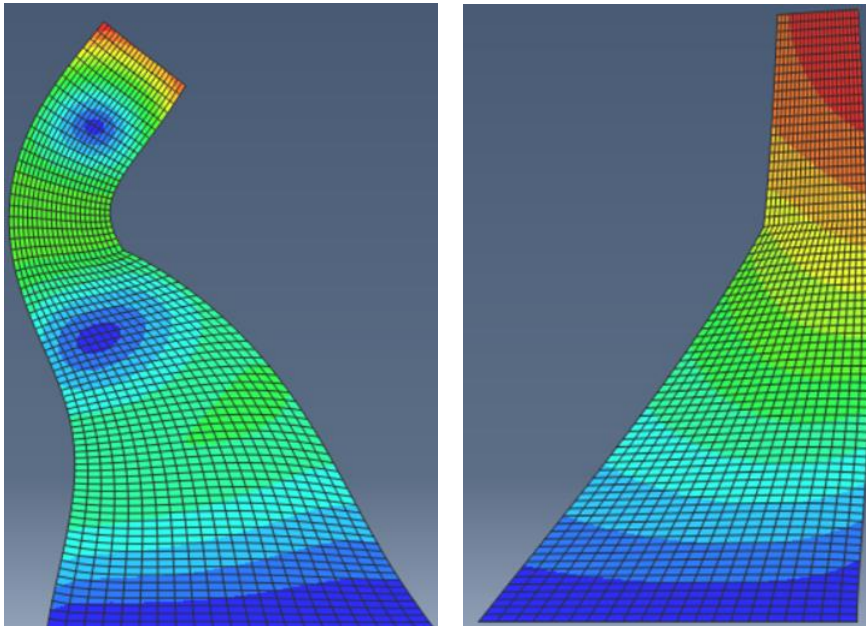


Earthquake Safety Evaluation

- Experimental Studies
 - Field Testing

Analytical Studies

Probabilistic Earthquake Hazard Assessment
Probabilistic Earthquake Dynamic Analysis
Effectiveness of Retrofit measures



Experimental Field Studies

Non-destructive Testing
:: Dynamic Properties (T , ξ , $\{\phi\}$)

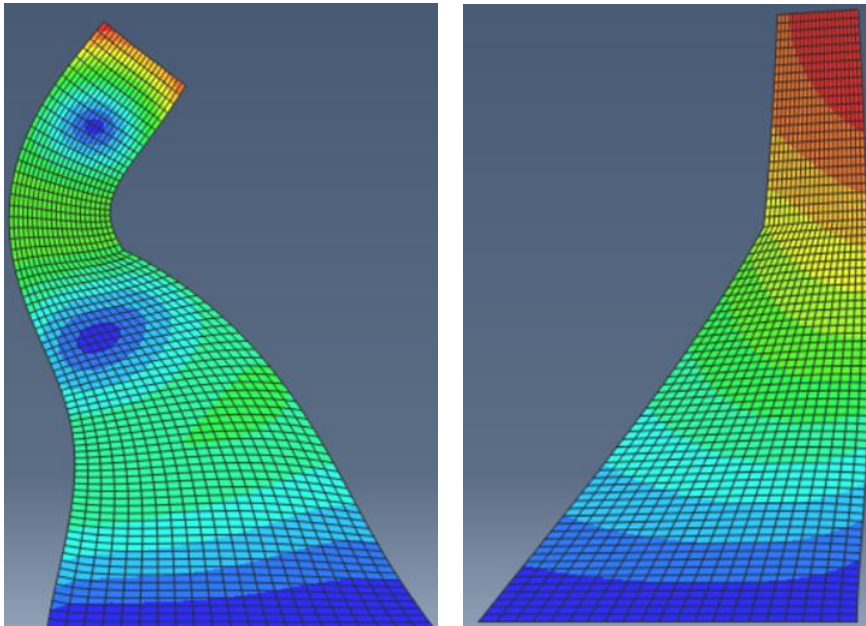


Earthquake Safety Evaluation

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Experimental Field Studies

Destructive Testing
:: Core Samples
:: Strength
:: Modulus of Elasticity

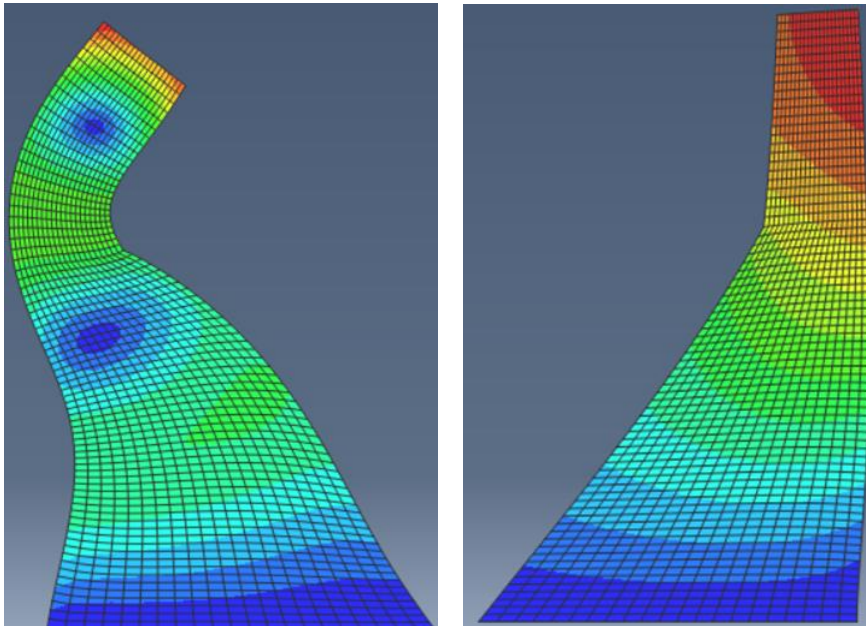


Earthquake Safety Evaluation

- Experimental Studies
 - Field Testing

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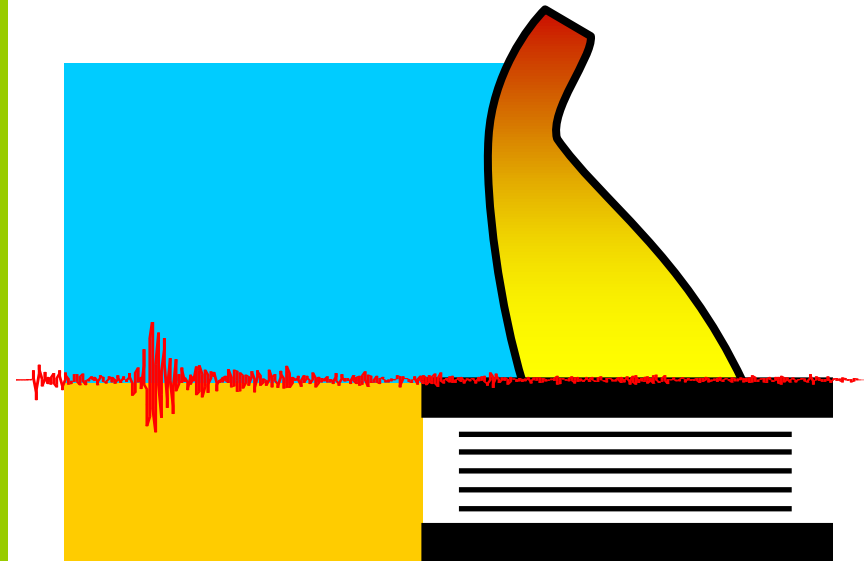


Experimental Laboratory Studies

Destructive Testing

- :: 2D Small-Scale Slices of Dams
- :: Nonlinear Behaviour of Dam under strong earthquake shaking
- :: Without and with water

Validate Analytical Studies





Suggested Plan for Dam Safety Assessment in India

Start “small” grow “BIG”

Review TEAMS & PANELS for Dam Safety Assessment

Stakeholders

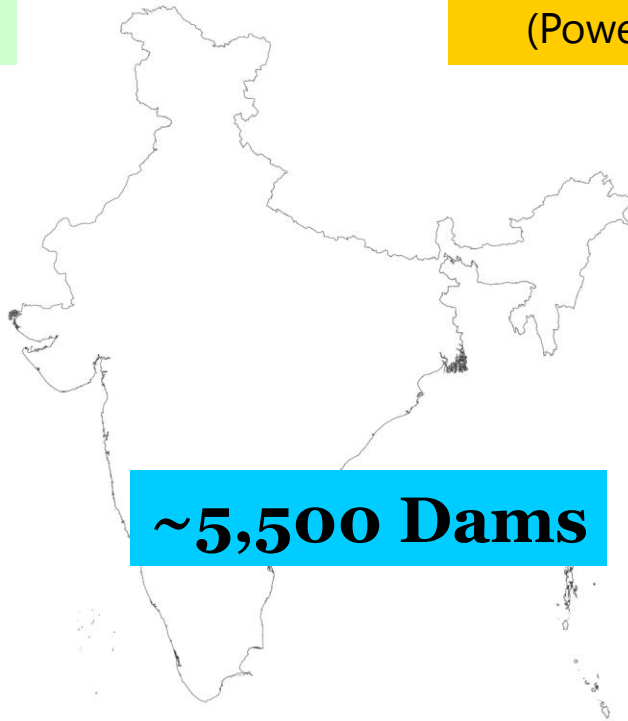
• Two

Individuals

Policy Makers
Decision Makers
Senior Engineers
Young Engineers

Bodies

Water Resources Departments
Other Departments
Autonomous Bodies
(Power Corporations, ...)



~5,500 Dams

Stakeholders

- Policy Makers

Ensure that Funds are available

Separate Fund Needed for Dam Safety

Other than that for DRIP

Chanellise Funds

Uninterrupted Flow

Annually fixed amount

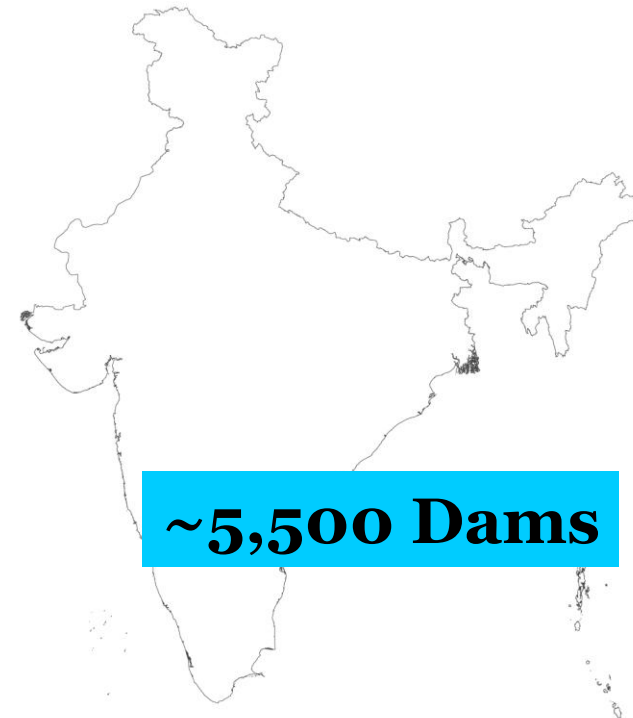
Review Role

Dam Safety Review Panels

Dam Safety Review Teams

Number

Quantitative Assessment



~5,500 Dams

Stakeholders

- Decision Makers

Caution

Dam Safety **is not just** Dam Security Budget

Change from 10% + 90%

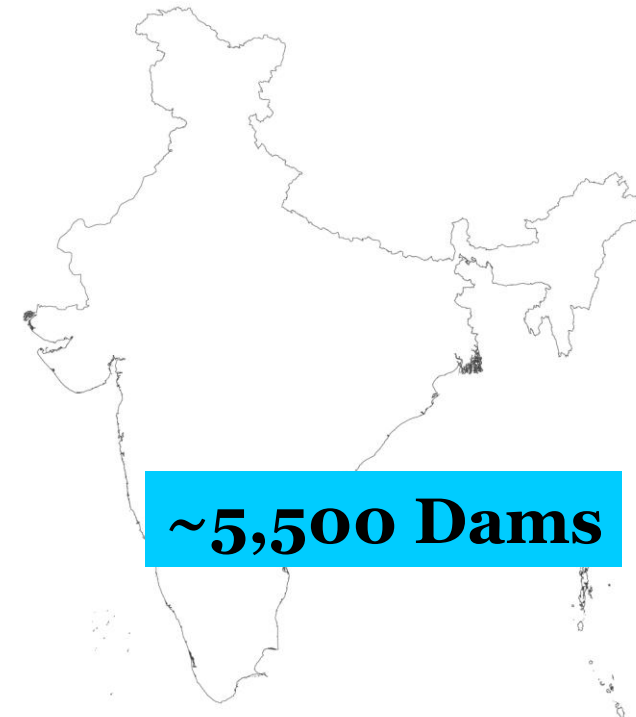
Value for loan money

World Bank, Asia Development Bank, ...

Continuity necessary

Invest in Young Engineers

Inspire them to take pride
in ensuring SAFETY OF DAMS



Stakeholders

- Decision Makers

- Special Initiatives in States with MANY DAMS

Technology Center

State of Art KNOWLEDGE and SKILL

Dam Break Analysis

Hydraulic Safety

Geotechnical & Structural Safety

EXISTING and New Dams

State of Art Laboratory

Material Assessment

Health Monitoring

Field Assessment of Dynamic Characteristics



~5,500 Dams

Stakeholders

- Decision Makers

- Technical Capacity Development

- Assess Manpower Required

- QUANTITATIVE Assessment of Dam Safety

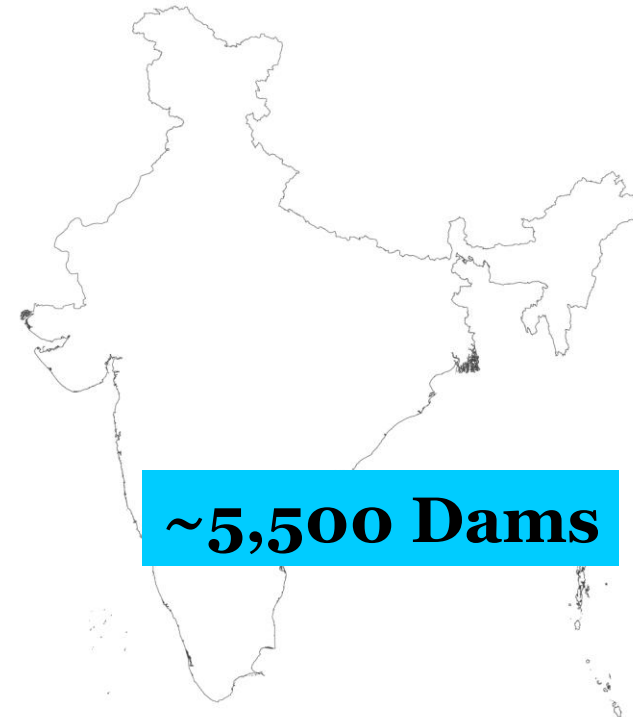
- Domain Knowledge

- Current

- Electrical Engineers :: Few

- Mechanical Engineers :: 10%

- Civil Engineers :: 90%



Stakeholders

- Decision Makers
 - Technical Capacity Development
 - Engineers

Enable

Technical Capacity Development

Technical Upgrade Degree Programs

Term of Office

At least 3 years at a Project

Mid Career

Administrative Training

Human, Financial, Social,
....

Empower

Modernize the CE Tools

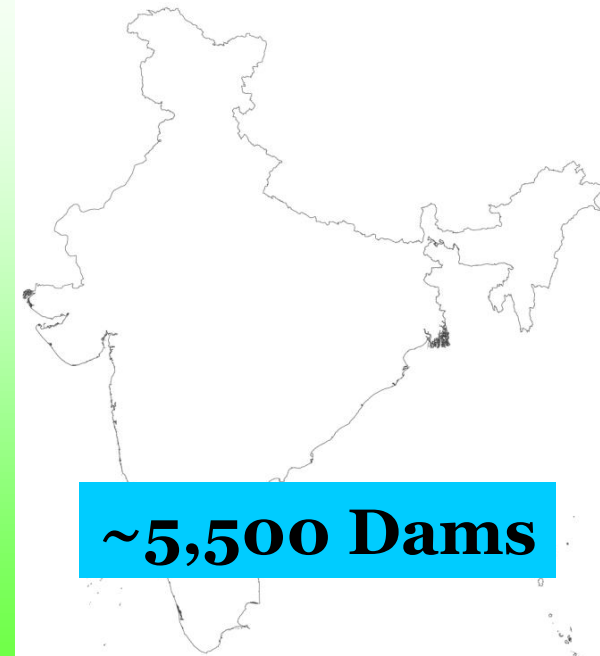
Advanced Technology

Incentivize Engineers

Deputation Allowance
Performance-based
Increments

**Differential Pay for
Engineers of
Departments and PCs**

Expect

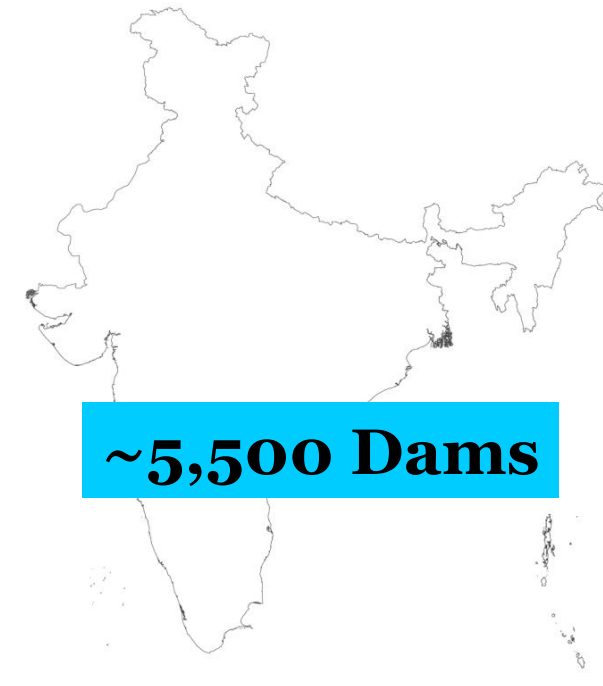


Stakeholders

- Senior Engineers

- Actions

- Plan domain activities
- Identify Active Engineers
- Train Young Engineers
- Find answers for difficult TECHNICAL questions
- Share good practices

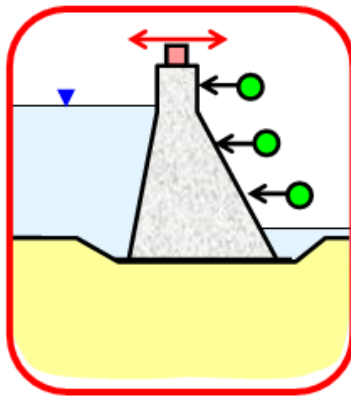


Stakeholders

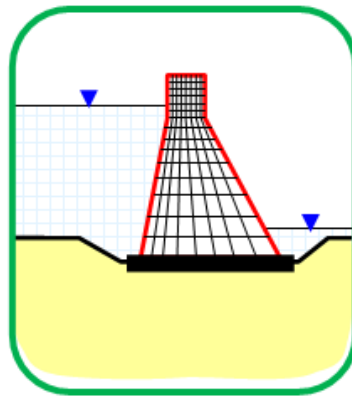
- Young Engineers

- Towards becoming Competent

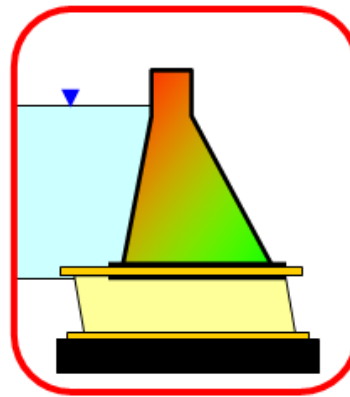
- Attitude + :: Dedicate yourself
- Skill :: Specialize in ONE area
- Knowledge :: Learn the subject deeply



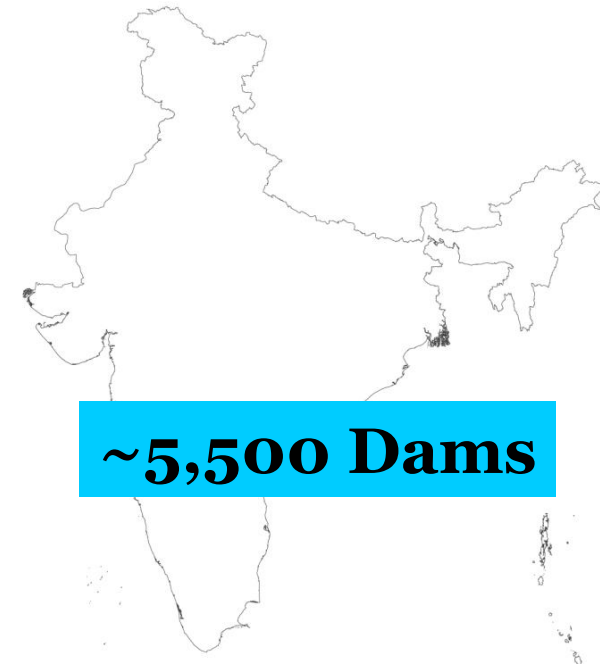
Field
Studies



Analytical
Studies

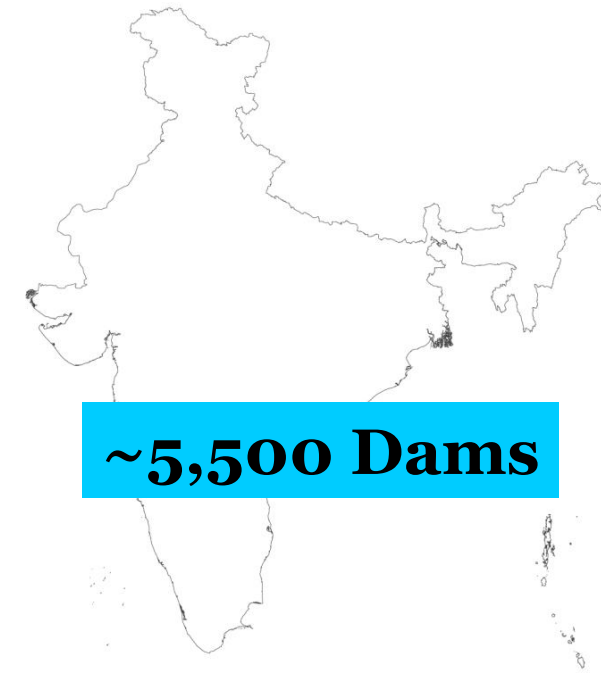


Laboratory
Studies



India Road Map...

- Specified Dams
 - ~5,500 Dams
 - Geotechnical–Structural Safety Assessment ALONE
 - 2,700 Civil Engineers needed
 - 450 Teams (of 6 each) @ 3 dams/year/team × 4 years
 - Maharashtra...!!
 - Start Today
 - Dam Safety Assessment
 - 10 Teams (= 60 Civil Engineers)
 - Training
 - 30 Teams/semester (180 Engineers) × 6 semesters (= 1,080 Civil Engineers in 3 years)
-



India Road Map...

- Geotechnical-Structural Safety Assessment
 - ONE Team of 6 Engineers

1

Senior

Clarify Big Picture
Structural Dynamics
:: 30 years
Civil Engineering

1

Lead Engineer

Ensure Progress of Work
Structural Engineering
:: 20 years
PhD preferred

2

Earthquake Engineers

Perform Structural Analysis
Structural / GT Engineering
M.Tech. (Structural Dynamics)

2

Younger Engineers

Perform Field Testing
:: Test & Measure Material Properties of Dams
B.Tech. (CE)
:: Instrumentation, Civil and GT Engineering

India Road Map...

- Three National Institutes

- Structural Safety

- 1-Semester Program

- 180 Engineers per Semester

- In 3 years (1,080 Engineers)

- 3 Courses

- Introduction to Dam Safety

- A, B, C and D; Risk Assessment

- Earthquake Analysis of Dams

- Structural Dynamics; Software

- Instrumentation of Dams

- Ambient & Forced Vibration Testing; Earthquake Monitoring

India Road Map...

- Low Hanging Fruits
 - Dam Break Analysis
 - Disaster Management
 - Emergency Action Plan
 - Hydrological Safety
 - Climate Change
 - Overtopping
 - Geotechnical and Structural Safety
 - Vulnerability
 - Leakage !!



**Risk
Assessment**

Exposure

Hazard

Vulnerability

Immediate Steps

1

- Identify typical dams
 - Concrete Gravity, Masonry, ...
 - COMPREHENSIVE dam safety assessment

2

- Identify training needs
 - Prepare Training Resource Material
 - Detail Trainees for 1 week sensitization
 - Policy Makers, Decision Makers, and Engineers
 - Finalize curriculum
 - M.Tech. and Ph.D. Programs
 - Identify Number of Dam Engineers
 - M.Tech. and Ph.D. Programs

Immediate Steps Needed

- Build Capacity of Dam Engineers
 - Sensitization
 - Short-Term Courses (1-2 week)
 - Training
 - Semester Program (4 months)
 - Earthquake Safety Assessment of Dams
 - M.Tech. Program (2 years)
 - Earthquake Safety of Dams
 - Ph.D. Program (3 years)
 - Earthquake Risk Assessment of Dams

ONLY at Established National Institutes

Immediate Steps Needed

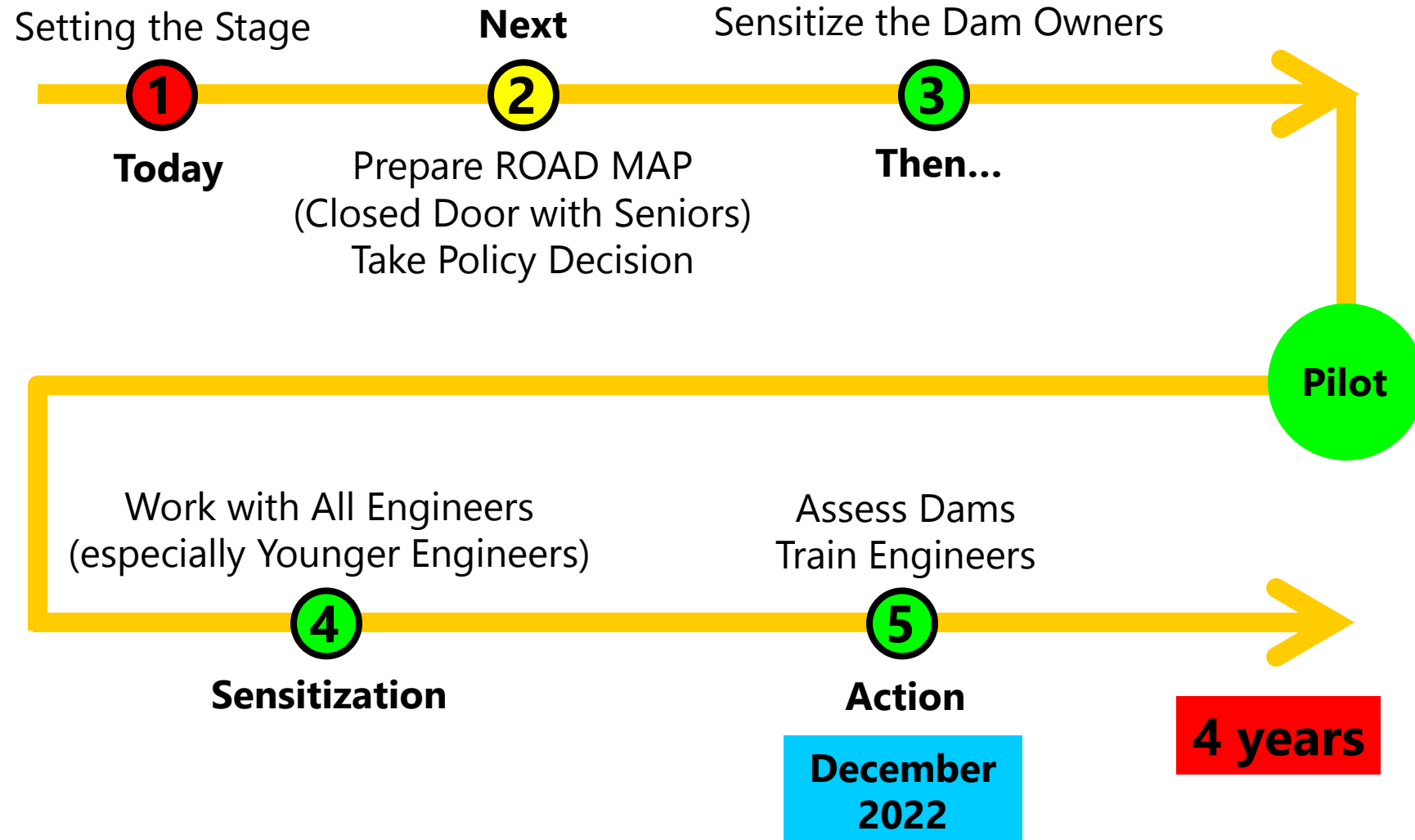
- Assess Geotechnical-Structural Safety of select dams
 - Experimental Field Assessment
 - In-situ dynamic characteristics of dams in their current conditions
 - Analytical Assessment
 - Likely response of dams by advanced nonlinear method
 - Experimental Laboratory Assessment
 - Scaled model dams by Shaking Table Tests
 - Comprehensive Risk Assessment

Immediate Steps Needed

- Update Codes dealing with Dam Safety in collaboration with BIS
 - Current
 - IS 6512: 1984 *Criteria for Design of Solid Gravity Dams*
 - IS 1893: 1984 *Criteria for Earthquake Resistant Design of Structures, Section 7: Dams and Embankments*
 - IS 4967: 1968 *Recommendations for Seismic Instrumentation for River Valley Projects*
 - Proposed
 - IS 1893 *Criteria for Eq. Resistant Design of Structures Part 1: Dams; Sec. 1 Concrete Gravity Dams*
 - IS 15988 *Eq. Safety Assessm. & Retrofitting of Structures Part 1: Dams; Sec. 1 Concrete Gravity Dams*

India Road Map...

- Strategy

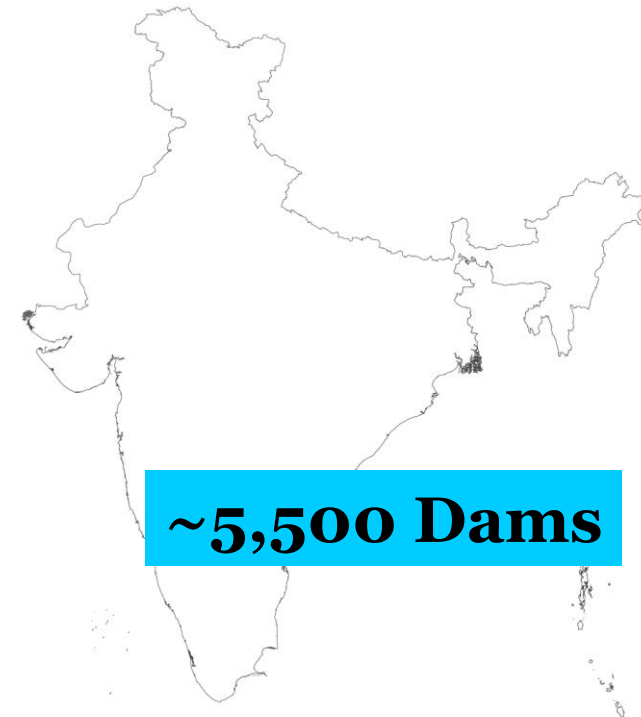


The Target

- 2021 – 2026
 - ~5,500 dams to be assessed in 4 years from today
 - ~1,350 dams per year
 - Maharashtra !!

- How to meet the target?

- Plan your WORK;
Work your Plan
- The more you sweat in peace,
the less you bleed in war



DRIP

- Get better value of the funding
 - Add
 - COMPREHENSIVE Dam Safety Assessment in Phase 2 and 3
 - Revise
 - Project Procurement Strategy for Development (PPSD)
 - Project Appraisal Document (PAD)
 - Currently SAFETY NOT ADDRESSED COMPREHENSIVELY



ing...



5 Elements of Nature

India...



5,500 Specified dams

5 Tenets

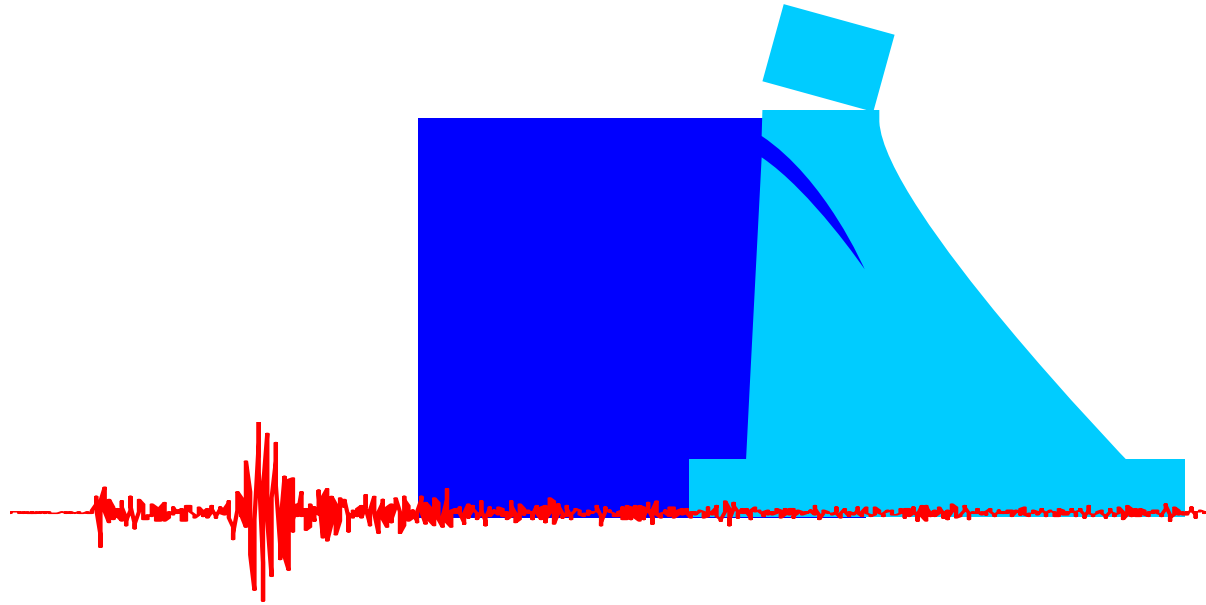
Safety

Functionality

Sustainability

Economics

Aesthetics



Dam Safety Engineering

- Art in Engineering

Safety of Dams in India



The Dream...

Grateful

- Ministry of Jal Shakti

- Shri Pankaj Kumar, Secretary
- Dr. R. K. Gupta, Chairman, Central Water Commission
- Dr. J. Chandrashekar Iyer, Central Water Commission
- Shri S. S. Bakshi, Director, Central Water Commission

- International Committee on Large Dams

- Shri D. K. Sharma, Vice-President

- Indian National Committee on Large Dams

- Shri Sunil Sharma, Secretary

Internet for Clipart





Thank you!!



Jai Hind !!



Jai Hind !!