Dam Safety in India

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Central Water Commission
Scheme of Presentation

- Overview of Dam Safety Activities in India
- Dam Rehabilitation and Improvement Project – Overview
- Lessons Learnt in DRIP Implementation
- New Initiatives for the Dam Safety-Start-up of DRIP Phase-II
Dams have played a key role in fostering rapid and sustained agricultural and rural growth and development in India.

Over the last fifty years, India has invested substantially in dams and related infrastructure.

5254 large dams have been completed and another 447 under construction (NRLD 2017). Storage capacity created by these large infrastructures is 253 BCM. Another 51 BCM storage under construction stages.

<table>
<thead>
<tr>
<th>S No</th>
<th>Country</th>
<th>No. of Dams</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>China</td>
<td>23842</td>
</tr>
<tr>
<td>2</td>
<td>United States of America</td>
<td>9261</td>
</tr>
<tr>
<td>3</td>
<td>India</td>
<td>5102</td>
</tr>
<tr>
<td>4</td>
<td>Japan</td>
<td>3112</td>
</tr>
<tr>
<td>5</td>
<td>Brazil</td>
<td>1411</td>
</tr>
<tr>
<td>6</td>
<td>Canada</td>
<td>1170</td>
</tr>
<tr>
<td>7</td>
<td>South Africa</td>
<td>1114</td>
</tr>
<tr>
<td>8</td>
<td>Spain</td>
<td>1063</td>
</tr>
<tr>
<td>9</td>
<td>Turkey</td>
<td>972</td>
</tr>
<tr>
<td>10</td>
<td>Iran</td>
<td>802</td>
</tr>
</tbody>
</table>
Risk of Dam Failure

- As per an ICOLD publication – Lessons from Dam Incidents (1973) – there have been about 200 notable failures of large dams in the world up to 1965.

- Globally about 2.2% of dams build before 1950 have failed, while the failure rate of dams built since 1951 has been less than 0.5%.

- India too has had its share of dam failures. However, the performance of Indian dams mirrors the International trends.

- The first such failure was recorded in Madhya Pradesh during 1917 when the Tigra Dam failed due to overtopping. The worst dam disaster was the failure of Machu dam (Gujarat) in 1979 in which about 2000 people have died.

- There are 36 reported failures cases so far.
Dam Failure in India

**Reported Dam failure**

- Breaching Failure due to Flooding: 44%
- Overtopping due to Inadequate Spillway Capacity: 17%
- Piping/Bad Workmanship: 14%
- Other Distress: 25%

**Year-Wise Dam Failure in India**

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of Failures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 1950</td>
<td>3</td>
</tr>
<tr>
<td>1961-1970</td>
<td>10</td>
</tr>
<tr>
<td>1971-1980</td>
<td>7</td>
</tr>
<tr>
<td>1981-1990</td>
<td>3</td>
</tr>
<tr>
<td>1991-2000</td>
<td>1</td>
</tr>
<tr>
<td>2001-2010</td>
<td>9</td>
</tr>
</tbody>
</table>
However, no definite conclusion can be drawn about the state of dam health in respective states.
Dam Failures – Contd.

- Out of 36 failures, 30 in respect of earth dams.

<table>
<thead>
<tr>
<th>Type of Dam</th>
<th>Nos. of failure</th>
<th>% Failure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Earth dams</td>
<td>30</td>
<td>83.33%</td>
</tr>
<tr>
<td>Composite dams</td>
<td>3</td>
<td>8.33%</td>
</tr>
<tr>
<td>Masonry dams</td>
<td>3</td>
<td>8.33%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>36</strong></td>
<td></td>
</tr>
</tbody>
</table>

Despite more than 83% failure share, risks associated with earth dams not to be heightened (their total proportion in India over 85%). Even if no failure recorded in case of concrete dam, it may not emphasis its safety aspects.
The most common cause of dam failures in India has been breaching – accounting for about 44% of cases – followed by overtopping that accounted for about 25% failures.

Majority of Indian dams have failed immediately after construction or at the time of first full-load, which can be clearly attributed to factors of either inadequate design or poor quality of construction.

<table>
<thead>
<tr>
<th>Age of Dam at failure</th>
<th>Number of failure</th>
<th>% Failure</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 5 years</td>
<td>16</td>
<td>44.44%</td>
</tr>
<tr>
<td>5 - 10 years</td>
<td>7</td>
<td>19.44%</td>
</tr>
<tr>
<td>10 - 15 years</td>
<td>1</td>
<td>2.77%</td>
</tr>
<tr>
<td>15 - 20 years</td>
<td>1</td>
<td>2.77%</td>
</tr>
<tr>
<td>50 - 100 years</td>
<td>6</td>
<td>16.67%</td>
</tr>
<tr>
<td>&gt; 100 years</td>
<td>2</td>
<td>5.56%</td>
</tr>
<tr>
<td>Age not defined</td>
<td>3</td>
<td>8.33%</td>
</tr>
<tr>
<td>Total</td>
<td>36</td>
<td></td>
</tr>
</tbody>
</table>
‘Dam Safety’ is important for:

- Safeguarding huge investments in infrastructure;
- Safeguarding human life, and properties of the people living downstream of the dams.

With increasing number of dams becoming older and older, the likelihood of dam failures in India is expected to be an ascending path.

Many dams have varied structural deficiencies and shortcomings in operation and monitoring facilities, while few do not meet the present design standard—both structurally and hydrologically.

Most of the States have been failing to provide sufficient budgets for maintenance and repair of the dam. Many States also lack the institutional and technical capacities for addressing dam safety issues.
Dam Safety Institutional Framework in India

- **National Committee on Dam Safety (NCDS)**
  - Constituted by Govt. of India in 1987.
  - Chaired by Chairman, CWC and is represented by all the States having significant number of large dams and other dam owning organizations.
  - Suggest ways to bring dam safety activities in line with the latest state-of-art consistent with the Indian conditions.
  - Acts as a forum for exchange of views on techniques adopted for remedial measures to relieve distress in old dams.
  - So far, 37 meetings of NCDS have been held.

- **Central Dam Safety Organization (CDSO)**
  - Central Dam Safety Organization was established in CWC, in 1979.
  - The objective of Central DSO was to:
    - Assist in identifying causes of potential distress;
    - Perform a coordinative and advisory role for the State Governments;
    - Lay down guidelines, compile technical literature, organize trainings, etc.; and create awareness in the states about dam safety.

- **State Dam Safety Organizations (SDSO)**
  - DSO/Cell established in 18 States and 5 dam owning organizations
Safety Inspection of Dams

- **Routine Periodic Inspection**
  - by trained and experienced engineers from DSO
  - at least twice a year: **pre monsoon and post monsoon**
  - examination of general health of the dam and appurtenant works
  - Preparedness of dam and hydro mechanical structures for handling expected floods

- **Comprehensive Dam Safety Evaluation**
  - Once in a 10 year
  - More comprehensive examination
  - Multi-disciplinary team for holistic view
  - May order additional field and laboratory investigations as well as numerical simulations
Safety Inspection of Dams-Contd.

Constitution of Dam Safety Review Panel (DSRP)

- One of the essential pre-requisites of DRIP was to constitute the DSRP by each State and get the dam safety inspection of their dams by the DSRP.

<table>
<thead>
<tr>
<th>State / Dam Owning Organizations having DSRPs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Andhra Pradesh</td>
</tr>
<tr>
<td>Bihar</td>
</tr>
<tr>
<td>Chhattisgarh</td>
</tr>
<tr>
<td>Karnataka</td>
</tr>
<tr>
<td>Kerala</td>
</tr>
<tr>
<td>Madhya Pradesh</td>
</tr>
<tr>
<td>Maharashtra</td>
</tr>
<tr>
<td>Odisha</td>
</tr>
</tbody>
</table>
**Objective**: to improve the safety and operational performance of selected existing dams in the territory of the participating states

**Implementing Agencies:**
- Centre Water Commission (Nodal)
- Madhya Pradesh
- Tamil Nadu
- Kerala
- Karnataka
- Odisha
- Uttarakhand
- Damodar valley Corporation

Total No. of Dams Covered = 242
Background Information of DRIP

- Key Chorological Events:
  - Negotiations with Bank: June, 2010
  - EFC Approval: May, 2011
  - Cabinet Approval: Nov, 2011
  - Signing of Agreement: Dec, 2011
  - DRIP Effectiveness: April, 2012

- Project Duration: 6 Years. Granted two years time extension (June 2020)
- Financial Outlay: 437.50 M US$ (WB share of 80%)
DRIP has three main components:

- **Project Management** of DRIP is led by the Dam Safety Rehabilitation Directorate of the Central Water Commission as CPMU.

- **Rehabilitation and Improvement** of dams and associated appurtenances, focusing on structural and non-structural measures at around 242 project sites across 7 states.

- **Institutional Strengthening**, focusing on regulatory and technical frameworks for dam safety assurance and including targeted national and international training.
DRIP IA-Wise Project Cost in INR Cr.

- TANGEDCO, 260.10
- TNWRD, 485.40
- OWRD, 147.70
- KAWRD, 276.75
- CWC, 132.00
- KSEB, 122.00
- KWRD, 158.00
- DVC, 139.41
- UJVNL, 64.10
- MPWRD, 314.54
DRIP Cost and Funding

- Project Cost:
  - Rupees: 2100 crore (US$: 437.50 M)

- Cost Component:
- Project Funding:
- WB Share (80%):
  - US$(Initial): 350 M
  - US$(Rev.): 279.3 M
  (US$M 70.7 surrendered in Feb/Mar 2014)
Workflow of DRIP dams

*Project Screening Template* is as per World Bank approved format (in line with Detailed Project Report) and includes:
- Project details
- Dam Specific details
- Health Status of dam
- Rehabilitation proposal
- ESMF compliance
- Implementation arrangement

Non Structural Measures (e.g. Inflow Forecasting system, Reservoir Operation Manual, Emergency Action Plan, Public Warning System, Public Awareness Campaign etc.)
Common Observed Problems

- Seepage boils & leakage d/s of earth dams;
- Deformity & erosion of u/s and d/s slopes, erosion of abutments and settlement & cracks along dam crests;
- Excessive seepage through masonry/conc. dams;
- Cracks and pitting in spillways and outlet gate structures, erosion of energy dissipation systems;
- Deficiencies in gates and hoisting system;
- Malfunctioning of dam monitoring instruments.
- Under-designed spillways.
Rehabilitation Progress:

- Design Flood Review completed for all dam projects to check the adequacy of Flood handling capabilities.
- Formation of Dam Safety Review Panels consisting of independent experts by each States. DSIRP inspected all the DRIP dams.
- Geophysical investigation for 5 dams.
- De-siltation study for 3 dams.
- Idukky Arch Dam – Study of *unusual dam Behavior and distress* Completed.
- Rehabilitation Works Completed for 20 dams.
# Typical Rehabilitation Works in DRIP Dams

- Pointing of upstream face of masonry dams with special UV resistant mortar to control seepage.
- Treatment of dam contraction joints for damaged seals using hydrophilic materials.
- Grouting of Masonry dams to control seepage.
- Reaming of porous drains and re-drilling of foundation drains.
- Replacement of rubber seals of the spillway and sluice gates and periodic overhauling of gate hoisting systems.
- Repairs and replacement of gates.
- Provision of automation of gates and control room structures.
- Bringing the earth dam section to design section.
- Improvement of rip-rap, chute drains, toe drains, rock toe and general drainage system for earthen dams.
- Improvement of access roads to different components of the dam project.
- Providing security system to guard dam / project area.
- Improving dam instrumentation and monitoring system of dams.
- Providing additional spillway structures / fuse plugs / flush bars to take care of increased flood.
- Raising of height of dams to cater for increased design flood.
- Repair of spillway glacis and energy dissipation arrangements.
- Survey and mapping of cracks and its remedial measures.
- Desiltation of dam reservoirs on selective basis.
- Provision of standby DG Sets, dewatering pumps.
- Provision of automation of gates and control room structures.
Institutional Strengthening

- 78 National training programmes have been conducted for over 2,700 officials.

- Four International Training on Dam Safety held at Deltares, Netherlands and USBR, USA.

- 6 technical exposure visits to Japan involving 50 participants for seismic, desiltation, and instrumentation.

- Collaboration with Japan Water Agency to develop the O&M Manual for Seismic Events.

- Organization of Three National Dam Safety conferences in Chennai (March 2015), Bengaluru (January 2016) and Roorkee (February 2017).
Institutional Strengthening

- Development of DRIP Website.
- Preparation of 16 Guidelines on different aspects of dam safety.
- QMS Documents completed.
- ISO 9001:2008 to CDSO
- Involvement of 9 Academic & Research Institutes in DRIP
What is DHARMA?

Software:
User-friendly interface designed and developed through consultation with technical experts. Distinct modules covering key dam safety considerations.

Shared Data:
Key information shared between stakeholders — individuals and organisations at Dam, State and Central level including planners, designers, contractors, suppliers.

Structured Data:
A structured, consistent approach to capture, storage and presentation of important data allows for clearer analysis and better understanding of dam safety aspects.

Web-based Software

DHARMA — Dam Health and Rehabilitation Monitoring Application — is a web-based asset management software to support the effective collection and management of asset and health data for all large dams in India.

Data Collection

Static Data:
Salient and detailed static information for each dam project including name, location, original/assemble design, purpose and project benefits, component parts.

Dynamic Data:
Regular updating of dynamic, time dependent data including current and previous stakeholders, dam health inspection results and associated rehabilitation needs/works.

Asset Management

Saved Data:
Important information (particularly design and construction drawings and health inspection reports for older dams) are saved securely in a centralised location.

Data Management

Report Generator:
Tool allowing users to generate reports in MS Word or PDF format. Standardised templates present data from software in a consistent manner with option to edit further.

Tables and Graphs:
Tool allowing users to view, customise or create tables and graphs summarising key data and metadata. Options to export to MS Excel/other software for further analysis.

Programming:
EAP and Inundation Mapping

- EAP to be prepared for each DRIP Dams
- Inundation maps for 81 dams completed
- Inundation maps for 7 further dams in various states under finalisation
- EAPs prepared using DRIP inundation mapping for 15 dams.
Lack of systematic assessment and monitoring coupled with inadequate resources is the primary cause of poor maintenance of dams and appurtenant works.

A review of the hydrology necessitated by factors like updated meteorological knowledge has concluded that some of the existing spillways cannot cater to the revised design floods.

Review of Design Flood estimates of DRIP dams have indicated that in more than 58% cases, the design floods have undergone substantial upward revisions. Such revisions underline the issue of hydrological safety of these dams.

Revision study of dam hydrology needs to be completed much in advance of any rehabilitation exercise; and this not being the case has led to delays in DRIP implementation.

Institutional Capacity building needed in design flood estimation and flood routing for most of the states.
LESSONS LEARNT

- In many of the cases, structural interventions for mitigation of enhanced flood estimates are not found viable owing to topographical constraints. In such cases, non-structural measures including modification of dam operational parameters needs to be implemented.

- Real time inflow forecasting systems are not in place even in important reservoirs. Such systems can add to dam safety measures besides improving operational efficiencies.

- Rehabilitation of old dams using the latest materials and technologies can enhance the life of a dam for many more decades.

- Dam design drawings or drawings as constructed are not available with project authorities in many cases.

- A well planned monitoring system based on data collection and evaluation using modern instrumentation is the key to early detection of defects and ageing scenarios.
LESSONS LEARNT..Contd

- Lack of institutional capacities noticed in most cases to generate adequate design drawings for proposed works.

- Dam Safety Organizations (DSO) in states are short of adequate man power and need to be strengthened.

- Training of dam engineers for inspection & monitoring, operation & maintenance, construction supervision, and emergency action planning & latest know-how, both in India and abroad, can ensure competence building in dam safety.

- Key premier Institutions brought under DRIP by facilitating acquiring state-of-the-art technologies, hardware & software programs will meet the future requirements of dam owners across the country.

- Dam Break Analysis leading to preparation of inundation maps for DRIP dams is helping in preparation of Emergency Action Plans to meet the challenges in case of catastrophe.
Prevention and mitigation of ageing dams can be achieved best through carefully thought-out designs, and implementation of well-managed operation and maintenance programs.

Siltation of reservoir is a serious issue, though in most cases the extent of siltation continues to remain unknown.

Appropriate Interventions for Sediment Management is not available in most cases. In few cases river sluices are available in dams, but they have not been operated for long periods, and are no more functional.

Desiltation of reservoir is difficult in many a cases owing to environmental concerns related to sediment disposal.

Lessons learnt from DRIP have contributed for the finalization of Central Dam Safety Bill 2016, to be passed by the Parliament.
Proposal for DRIP -II

- Pre-Requisites for participation in the DRIP-II:
  - Early Submission of proposal consisting of name of the proposed dams, their deficiency along with the cost estimates to CWC.
  - Formation of Dam Safety Review Panel by each participating States.
  - Formation of State Dam Safety Organisation in the States.
  - Immediate initiation of the review of design flood of the proposed dams. Review of Design Flood has to be carried out by the State themselves either through their department or consultancy or through academic institutes and requires the CWC’s approval.
  - Formation of a dedicated cell (Project Management Unit) in each of the participating States for day-to-day liasoning.
  - Preparation of Project Screening Templates (Rehabilitation proposals) for each proposed dam by undertaking geo-technical, geophysical investigation and under water inspection by ROV, wherever required etc.
  - Disclosure of the ESMF framework to the general stakeholders.
  - Preparation of Tender Documents, approval of the same from the competent level, and start of tendering process and award of works.
Proposal for DRIP -II

• Pre-Requisites for participation in the DRIP-II:
  • Sufficient estimates to cover all proposed rehabilitation measures – *estimates should be prepared on latest SOR to avoid large variations*.
  • Need to investigate the exact leaking dam blocks, the quantity of leakage with respect to reservoir water level – *it is essential to know levels, locations of exit and probable entry points of water in the dam body etc., for planning the appropriate rehabilitation measures. If any remedial measures were taken by the department in the past to mitigate the problem, the same should be recorded along with the outcome of rehabilitation.*
  • Need to have centralized system for procurement of goods as well as the preparation of the EAP, dam breach study, and flood forecasting and warning system so as to have uniformity in system which may result in economic maintenance in future
  • Need of expert advice (*in case DSRP does not include hydro-mechanical expert*) for major hydro-mechanical issues.
Proposal for DRIP -II

• Pre-Requisites for participation in the DRIP-II:
  • Sufficient Estimates for comprehensive rehabilitation work along with the provision for basic dam safety facilities works.
  • Sufficient provision for the dam instrumentation, trainings (both national as well as international), potential tourism sites at the dam, investigation works, preparation of Emergency action plan for each of the proposed dams, Desiltation study, bathymetric survey work, inflow forecasting of reservoir, flood warning system, if required.
  • Project funds shall not be used to increase the design storage capacity of a reservoir.
  • Rehabilitation cost of the dam – varies from dam to dam. Under DRIP, average rehabilitation cost of one dam comes as about Rs. 10.0 Crores.
## Original / Updated Project Cost (Rs. In Cr.)

<table>
<thead>
<tr>
<th>Implementing Agency</th>
<th>As Per PAD</th>
<th>Original Project Cost</th>
<th>Revised Project Cost Submitted By SPMU</th>
<th>Conti.</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>I</td>
<td>II</td>
<td>III</td>
<td>Total</td>
</tr>
<tr>
<td>MPWRD</td>
<td>315</td>
<td>293</td>
<td>6</td>
<td>16</td>
<td>315</td>
</tr>
<tr>
<td>OWRD</td>
<td>148</td>
<td>88</td>
<td>16</td>
<td>43</td>
<td>148</td>
</tr>
<tr>
<td>TNWRD</td>
<td>746</td>
<td>428</td>
<td>33</td>
<td>25</td>
<td>486</td>
</tr>
<tr>
<td>TANGEDCO</td>
<td>280</td>
<td>246</td>
<td>8</td>
<td>7</td>
<td>260</td>
</tr>
<tr>
<td>KWRD</td>
<td></td>
<td>129</td>
<td>20</td>
<td>9</td>
<td>158</td>
</tr>
<tr>
<td>KSEB</td>
<td></td>
<td>98</td>
<td>15</td>
<td>9</td>
<td>122</td>
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<tr>
<td>CWC</td>
<td>132</td>
<td></td>
<td>30</td>
<td>102</td>
<td>132</td>
</tr>
<tr>
<td>KAWRD</td>
<td>-</td>
<td>253</td>
<td>24</td>
<td>0</td>
<td>277</td>
</tr>
<tr>
<td>UJVNL</td>
<td>-</td>
<td>45</td>
<td>2</td>
<td>0</td>
<td>47</td>
</tr>
<tr>
<td>DVC</td>
<td>-</td>
<td>32</td>
<td>2</td>
<td>0</td>
<td>34</td>
</tr>
<tr>
<td>Unallocated Resource</td>
<td>480</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>121</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>2100</td>
<td>1610</td>
<td>157</td>
<td>212</td>
<td>2100</td>
</tr>
</tbody>
</table>

**Percentage:**
- Original: 86.22%
- Revised: 6.20%
- Unallocated: 6.64%
- Conti.: 0.95%
## Cost of Rehabilitation of American dams

<table>
<thead>
<tr>
<th>Size-Based Category</th>
<th>Percent of Dams in Need of Rehab</th>
<th>Cost Estimate Per Rehab Project</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Category #1 1 &lt;= 15’</td>
<td>42% = 7,635</td>
<td>$276,098/project</td>
<td>$2.273 Billion</td>
</tr>
<tr>
<td>Category #2 1 &lt;= 25’</td>
<td>44.2% = 11,900</td>
<td>$649,821/project</td>
<td>$8.13 Billion</td>
</tr>
<tr>
<td>Category #3 1 &lt;= 50’</td>
<td>43% = 13005</td>
<td>$1,685,834/project</td>
<td>$22.569 Billion</td>
</tr>
<tr>
<td>Category #4 greater than 50’</td>
<td>38% = 2,068</td>
<td>$8,851,025/project</td>
<td>$18.484 Billion</td>
</tr>
<tr>
<td>Total cost for all projects (23800 Dams) Avg. cost Rs. 14.48 Cr.</td>
<td></td>
<td></td>
<td>$51.456 Billion (344755.2 Cr)</td>
</tr>
</tbody>
</table>

Source: ASDSO 2009
Project Screening Template

- FORM-I: PROJECT DETAILS
- FORM-II: DAM SPECIFIC DETAILS
- FORM-III: HEALTH STATUS OF DAMS
- FORM-IV: REHABILITATION PROPOSALS
- FORM-V: ENVIRONMENTAL AND SOCIAL MANAGEMENT FRAMEWORK (ESMF) COMPLIANCE
- FORM-VI: IMPLEMENTATION ARRANGEMENT
- FORM-VII: ADDITIONAL INFORMATION
- PRACTICAL APPLICATION
Some of the Tools for Developing a Good Project Screening Template

- Salient features
- Hydrology reports including peak flood
- Instrumentation data
- Pre- and post-monsoon inspection reports
- Periodic inspection reports
- Incident reports
- Input from dam operators
- Mechanical-electrical reports
- Environmental impact report
Preparatory Activities

- **DRIP-1**: 242 dams, 9 IAS in & States. Preparatory phase took over 2 years.
- **DRIP-2**: 80% dams are more than 25 years old. Many of these dams are in distress and need immediate rehabilitation. 400 dams may be targeted. Approximate rehabilitation cost: Rs. 7000-8000 crores.
- Preliminary meeting at DEA held on 1 Nov 2016. States have been requested to submit the detailed proposals.
DISTRIBUTION OF LARGE DAMS IN INDIA DECADE-WISE

NO OF LARGE DAMS

TIME IN DECADES

Upto 1900
1901 to 1950
1951 to 1960
1961 to 1970
1971 to 1980
1981 to 1990
1991 to 2000
2001 & Beyond
Year of construction not available
Under Construction

68
302
235
504
1288
1303
705
655
194
447

0
200
400
600
800
1000
1200
1400
Age-wise distribution of large dams in India

- 0-50 Years: 79.70%
- 50-100 Years: 12.70%
- More Than 100 Years: 3.97%
- Age not Known: 3.63%
Type-wise distribution of large dams in India
Type-wise distribution of Large Dams in India
Machu-II Dam Failure

- Machu-II Dam is located on river Machu, 9 km u/s of Morbi town in Gujarat.
- Completed in 1972, the 24.7 m high dam has a central masonry spillway and 2.3 & 1.4 km long earthen flanks on either side.
- On Aug. 10, 1979, witnessed a flood of 14000 cumecs against designed spillway capacity of 6180. Dam overtopped and 700 & 1000m stretch of flanks washed out.
- 2000 people died in Morbi and 12700 houses were destroyed.
- Now, dam height raised by 2.7m, spillway capacity enhanced to 26650 cmecs.
Sarathi Dam, Madhya Pradesh
Durgawati Dam, Bihar
Approach Road issue at Ashok Nalla Dam of Odisha
Kuttiyadi Dam, Kerala
Maudha Dam, Uttar Pradesh
Baglihar Dam, Jammu & Kashmir
Koteshwar Dam, Uttarakhand
Dhuti Weir and Ari Dam, Madhya Pradesh
Konar Dam, Jharkhand
Chand Patha Dam, Madhya Pradesh
Temghar Dam, Maharashtra
Design Flood - Extent of Revision

- One third of dam failures are the direct result of flood exceeding the capacity of spillways.
- In India, overtopping accounts for 25% failures. Machu-II failure (1979) was due to overtopping, on account of inadequate spillway capacity.
- Checking and upgrading the DF estimates is a key technical priority in national dam safety program.
- DF revisions is also the prime requirement under Dam Rehabilitation & Improvement Project (DRIP).
- Review of DFs completed for 217 DRIP dam projects.
- For DRIP dams, there is an upward revision of over 50% for 58% of dams and an upward revision of over 100% for 36% of dams.
- For many dams, revised DF is exceeding the original estimates by substantial orders:
  - Kharadi dam (MP): 929%,
  - Sher tank (MP): 503%,
  - Manimukhanadhi Dam (TN): 384%,
  - Mangalam dam (Kerala): 525%.
### Design Flood - Extent of Revision

<table>
<thead>
<tr>
<th>Extent of Revision</th>
<th>DVC</th>
<th>UJVNL</th>
<th>Karnataka</th>
<th>Kerala</th>
<th>TN</th>
<th>OWRD</th>
<th>MPWRD</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-25%</td>
<td>3</td>
<td>23</td>
<td>22</td>
<td>7</td>
<td>4</td>
<td></td>
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<td>59</td>
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<td>25-50%</td>
<td>2</td>
<td>5</td>
<td>3</td>
<td>14</td>
<td>3</td>
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<tr>
<td>50-75%</td>
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<td>2</td>
<td>13</td>
<td>2</td>
<td></td>
<td></td>
<td>29</td>
</tr>
<tr>
<td>75-100%</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>7</td>
<td>2</td>
<td></td>
<td></td>
<td>18</td>
</tr>
<tr>
<td>&gt;100%</td>
<td>2</td>
<td>13</td>
<td>2</td>
<td>3</td>
<td>5</td>
<td></td>
<td></td>
<td>8</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>8</td>
<td>52</td>
<td>88</td>
<td>88</td>
<td>88</td>
<td>88</td>
<td>88</td>
<td>217</td>
</tr>
</tbody>
</table>

- **Total No. of Dams**: 217
**Dam Instrumentation:**

- Status of dam instrumentation in most of the dams is very poor. Hardly 4 to 5% of dams are having some meaningful and operational dam instrumentation to monitor the behavior of the dam.

- Even in cases where instrumentation measures like V-notches or plumb-lines are available, not sufficient care is being given to the data collection and achieving.

- States have very limited technical capabilities for analyzing instrumentation data for investigation and detection of dam distress.

- Seismic instruments are either not there, or if available are not functional. The dam operator urgently require seismic instrumentation networks for ensuring prompt response to earthquake events.
Chimony Dam, Kerala
Investment made in Dams and the related Infrastructures by the Central/State Govts.

- Over the past 11 five year plan periods, development of major and medium irrigation sector alone has absorbed over 3,50,418 crores of rupees.

- Some of the early plan periods taking away lion’s share (11 to 22%) perhaps constraining developing of other equally crucial sectors.

Source: Report of the Working Group’s on MMI and CAD for 12th Plan
<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Name of state</th>
<th>Status of Dam Safety Organisation /Cell / setup overseeing dam safety activities etc. of states</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Andhra Pradesh</td>
<td>Dam Safety Organisation</td>
</tr>
<tr>
<td>2</td>
<td>Bihar</td>
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<tr>
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<td>Chhattisgarh</td>
<td>Dam Safety Cell</td>
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<tr>
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</tr>
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<td>Dam Safety Directorate</td>
</tr>
<tr>
<td>7</td>
<td>Karnataka</td>
<td>Dam Safety Committee / Dam Safety Cell</td>
</tr>
<tr>
<td>8</td>
<td>Kerala</td>
<td>Dam Safety Organisation</td>
</tr>
<tr>
<td>9</td>
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<td>Dam Safety Organisation</td>
</tr>
<tr>
<td>10</td>
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<td>Dam Safety Organisation</td>
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<tr>
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<td>Dam Safety Organisation</td>
</tr>
<tr>
<td>Sl. No.</td>
<td>Name of state</td>
<td>Status of Dam Safety Organisation /Cell / setup overseeing dam safety activities etc. of states</td>
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<tr>
<td>--------</td>
<td>---------------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>12</td>
<td>Punjab</td>
<td>Dam Safety Committee</td>
</tr>
<tr>
<td>13</td>
<td>Rajasthan</td>
<td>No separate Organisation for dam safety. Director (Dam) in the Water Resources Department oversees the activities for safety of Dams.</td>
</tr>
<tr>
<td>14</td>
<td>Tamil Nadu</td>
<td>Dam Safety Directorate</td>
</tr>
<tr>
<td>15</td>
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<td>Dam Safety Organisation</td>
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<td>Dam Safety Cell</td>
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<tr>
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<tr>
<td>18</td>
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<td>Dam Safety Organisation</td>
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<tr>
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<td>BBMB</td>
<td>Dam Safety Directorate</td>
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<td>DVC</td>
<td>DSO</td>
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<td>Generation</td>
<td>Corporation Limited (MePGCL)</td>
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<td>23</td>
<td>NHPC</td>
<td>Dam Safety Cell</td>
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## Pre & Post monsoon Inspection Report - 2016

<table>
<thead>
<tr>
<th>Sr No.</th>
<th>State Name</th>
<th>No. Of Dams</th>
<th>Pre-Monsoon</th>
<th>Post-Monsoon</th>
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<tbody>
<tr>
<td></td>
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<td>Reports</td>
<td>Cat 1</td>
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<tr>
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<td>Jammu and Kashmir</td>
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<td>130</td>
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<td>0</td>
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<tr>
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<td>30</td>
<td>1</td>
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<tr>
<td></td>
<td><strong>TOTAL</strong></td>
<td><strong>1459</strong></td>
<td><strong>461</strong></td>
<td><strong>63</strong></td>
</tr>
</tbody>
</table>

*Category I - Deficiencies which may lead to failure of dam*

*Category II - Major deficiencies requiring prompt remedial measures*

*Category III - Minor deficiencies which are rectifiable during the year*