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(पहला पुनरीक्षण)

Indian Standard

INSPECTION AND MAINTENANCE OF DAMS AND
APPURTENANT STRUCTURES — GUIDELINES
(*First Revision*)

ICS 93.160

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BUREAU OF INDIAN STANDARDS
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NEW DELHI 110002

FOREWORD

This Indian Standards (First Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Dams and Reservoirs Sectional Committee had been approved by the Water Resources Division Council.

Dams have contributed to the development of the nation. However, dams may also pose a potential hazard because of catastrophic damage which can take place due to any failure of dam or accident. A probable failure of the dam means not only the loss of structure and the impounding capacity but sudden release of large quantity of water stored may also cause heavy damage to life and property in the areas in the immediate downstream vicinity of the dam.

The necessity for proper inspection and maintenance of dams and appurtenant structures is evident. The risk of dam failure may increase as much by neglect of proper and timely inspection and maintenance as by inadequacies in design and construction.

The major areas needing attention to inspection and maintenance of dams and appurtenant structures have been discussed and listed in these guidelines. These are based on knowledge gained from past experience on dams and are not necessarily exhaustive.

This standard was first published in 1979. In this revision certain provisions relating to inspection and maintenance of dams have been elaborated further.

In the preparation of this standard considerable assistance has been taken from the following documents prepared by the Central Water Commission, New Delhi:

- a) Guidelines for safety inspection of dams, and
- b) Proforma for periodical inspection of dams.

There is no ISO standard on the subject. This standard has been prepared based on indigenous data/practices prevalent in the field in India.

The composition of the committee responsible for the preparation of this standard is given at Annex A.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

INSPECTION AND MAINTENANCE OF DAMS AND APPURTENANT STRUCTURES — GUIDELINES (First Revision)

1 SCOPE

1.1 This standard covers the records required at site for reference and identifies the areas for inspection and maintenance of dams and appurtenant structures.

1.2 Separate detailed operation and maintenance manuals for each dam shall be prepared taking these guidelines into account and special features and requirements of the structure.

1.3 This standard does not cover the aspects concerning the inspection and maintenance of gates, powerhouses and barrages.

2 REFERENCES

The standards given below, contain provisions which through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below:

<i>IS No.</i>	<i>Title</i>
6922 : 1973	Criteria for safety and design of structures subject to underground blasts
8826 : 1978	Guidelines for design of large earth and rockfill dams

3 GENERAL

3.1 This standard identifies only important provisions for inspection and maintenance of dams and appurtenant structures. These provisions, which are overall and general, shall be considered together with specific instructions that may have been stipulated during design, construction or maintenance.

3.2 The dam owner shall ensure timely availability of adequate funds, as per requirement, for regular scheduled maintenance of dams and appurtenant structures.

3.3 The dam and appurtenant structures shall be under the overall charge of an officer, who has been specifically assigned inspection and maintenance responsibilities. He or his representative shall be available at the dam site particularly during flood season and shall be adequately trained and fully

conversant with the following:

- a) Standing operating procedure (SOP),
- b) Maintenance and vigilance procedure of the dam,
- c) Maintenance and operation of all control equipment,
- d) Reservoir operation schedules,
- e) Identification of signs of deficient behaviour,
- f) Reporting procedures of emergency situations, and
- g) Emergency repairs.

3.3.1 For unusual conditions like high floods, earthquakes, rockfalls, mountain slides, etc, which may affect the safety of the dam and appurtenant structures, project authorities shall make arrangements for the following actions:

- a) To issue warning to settlements inhabitants, owners of industries, plants and machineries, transportation agencies, etc, located downstream of the dam and appurtenant structures;
- b) To operate the spillway and outlets judiciously in the best interest of public safety, regardless of economic loss through loss in storage and power; and
- c) To inform appropriate authorities immediately of the unusual conditions and impending danger.

3.3.2 The officer-in-charge of inspection and operation shall act quickly in all emergencies. For this purpose the project authorities shall issue instructions in the form of actions to be taken in emergency. For situations where instructions do not exist, the officer-in-charge shall use his best judgement.

4 RECORDS REQUIRED AT SITE

Records that may be required for proper inspection and maintenance shall be available at site. These shall be properly maintained and regularly updated by including latest available information. Where no records are available, efforts shall be made to regenerate them to the extent possible. Data in respect of upstream gauging stations, flood warning system and communication channels, if installed, shall be properly maintained. Additional data such as rainfall, wave height, wind velocity, temperature, humidity, etc,

shall also be collected.

4.1 For All Dams

In case of all dams the records/data as given below shall be available at site. If no data is available (particularly in respect of very old dam), dam safety studies shall be carried out to obtain the following data to the extent possible.

4.1.1 Final detailed project report and details of modifications done during construction.

4.1.2 Geological/geotechnical data and reports on the foundation and abutment.

4.1.3 Details of special foundation and abutment treatment carried out.

4.1.4 A set of completion drawings according to which the project was constructed.

4.1.5 Details (including types) and location of instruments embedded/installed in and around the structure.

4.1.6 Detailed drawings of all service facilities like internal lighting, emergency lighting, drainage, etc.

4.1.7 Records of corrective measures, repair or treatment that have been done subsequent to completion.

4.1.8 Important inspection reports as well as reports of consultants of pre-construction, during construction and post-construction.

4.1.9 Details of design criteria followed.

4.1.10 Photographs in chronological order showing all phases of construction and subsequent maintenance with detailed description.

4.1.11 Index plan of the area in which the dam is located showing important towns, roads, rail routes and communication facilities.

4.1.12 Index plan of downstream area showing natural flood zone, corresponding to highest observed flood and spillway design flood. Serious efforts shall be made to conduct dam break analysis and prepare flood zone corresponding to this analysis. The index plan shall depict all important towns/villages and properties lying in the above mentioned flood zones. Caution boards indicting these flood zones/levels shall be displayed in downstream areas.

4.1.13 Tentative emergency action plan for possible flooding due to condition detailed in 3.3.1.

4.1.14 Contour map of dam site extending upto 200 m or 10 times the dam height, whichever is more, on both upstream and downstream, showing all features of the dam like toe lines, access roads, etc.

4.1.15 Reservoir maps showing silted basin at suitable intervals, through conventional or satellite imageries.

4.1.16 Plan of the catchment area showing rain gauge stations, and capacities of upstream storages.

4.1.17 Details of communication system, telephones, wireless, etc, directory of important key officers, flood warning procedures, etc.

4.1.18 *Flood Forecasting System*

4.1.19 Record of availability of emergency material/equipment/machines which may be required during emergency repair and maintenance.

4.1.20 Structural behaviours reports during initial filling of reservoirs and for subsequent periods on the basis of instruments data, if available.

4.1.21 Seismicity of the area on the basis of data collected from various seismic observatories located on seismic network of the project.

4.1.22 *Area Capacity Curve of Reservoir*

4.1.23 *Design/Revised Inflow Hydrograph*

4.2 For Concrete/Masonry Dams

In addition to the records/data mentioned in 4.1, the following additional records/data shall be available at site.

4.2.1 Summarized data of observations on embedded/installed instruments, including initial readings and instrument constants.

4.2.2 Summarized data on control tests carried out during construction in respect of concrete, mortar and their constituent materials, if available.

4.2.3 Details of construction history including stages of construction particularly in low blocks where considerable time has elapsed prior to resumption of work.

4.2.4 *Reports on Hydraulic Model Studies*

4.2.5 Manual of operation and maintenance of spillway gates. The operation of spillway gates shall be as per designed criteria hand model studies for energy dissipation system.

4.2.6 Discharging capacity curves of spillway for full as well as partial opening of gates.

4.2.7 Performance report of energy dissipators during normal as well as high floods upto a distance of 1 km downstream of all surplussing arrangements (at least once in two years).

4.3 For Earth/Rockfill Dams

The following additional records/data shall be

available at site, in addition to those mentioned in 4.1.

4.3.1 Stage-wise construction record of the dam showing volumes and heights achieved in each season and time rate of progress.

4.3.2 Record of special compaction done near concrete/masonry structure, abutment contacts and outlet locations, if available.

4.3.3 Summarized records of compaction, control sampling and complete laboratory and field test results on all samples on record during construction and pre-construction periods.

4.3.4 Record of relief wells, piezometers and seepage drains.

4.3.5 *Manual of Operation and Maintenance*

4.4 Arch Dams and Buttress Dams

Data similar to that listed in 4.1 and 4.2 shall be available at site. In addition, specific additional data may be decided to be collected according to inspection and maintenance requirements of the structures (Particular attention shall be paid to the behaviour of abutments and the deflection of the main structure).

5 INSPECTION

5.1 Periodical inspection of dams and appurtenant structures is necessary specially before and after monsoon season to ascertain/examine their condition and functioning. The main purposes of carrying out periodic inspection are:

- a) to ensure the adequacy of the structures to serve the purpose for which they were designed,
- b) to verify the conditions of the structures and monitor their behaviour,
- c) to investigate conditions that might cause distress to the structures, and
- d) to study the extent of deterioration based on which maintenance and repairs can be planned.

5.2 After an unusual event, a thorough inspection of the dam and its appurtenant works for detecting damage and weakening, if any, shall be made. The inspection shall be carried out in accordance with Guidelines for Safety Inspection of Dams issued by CWC.

5.2.1 After occurrence of any earthquake the dam shall be inspected as per ICOLD guidelines.

5.3 Adequate inspection shall be carried out by competent personnel to investigate the performance of the dam and appurtenant structures. All inspection

observations shall be compared with the design assumptions and prediction, previous results, results of model studies and tests and limiting values, where specified. Any conditions that might adversely affect the safety of structures shall be closely observed. These shall include conditions such as excessive settlement, deflection, seepage, uplift pore-pressure, deterioration of masonry/concrete, etc. Periodical inspection of reservoir area including reservoir rim shall also be undertaken.

5.3.1 Inspection reports on the condition of the structures shall be prepared and submitted by the Engineer-in-Charge of Inspection to the concerned higher authorities along with detailed comments. In case of large dam (*see* IS 8826), besides these regular inspection, special inspection of all the works (including the dam, the reservoir and the appurtenant works), shall be made by a committee of experts at least once in 5 yrs in accordance with the criteria for Phase I inspections laid down in the guidelines for safety inspection of dams published by CWC. The committee shall go through the record of observations concerning the behaviour of structures, the inspection reports on the condition of the structure, etc, and other relevant data and submit a report suggesting ways and means for improvements required, if any, about the safety and serviceability of the structures.

5.4 Concrete/Masonry Dams

In case of concrete/masonry dams the following aspects need particular attention.

5.4.1 Drainage systems in the foundation and the dam body shall function properly. Individual sources of seepage shall be inspected and recorded against date and corresponding reservoir level. It shall also be observed if the seepage is increasing or decreasing and if there is any significant departure from normal conditions of seepage, which may affect the safety of the dam.

5.4.2 Periodic inspection shall be made to observe any leakage, seepage cracks, spallings and algae growth on the surface of the dam and in openings like gallery and adits and record maintained.

5.4.3 Abutment shall be observed to locate any leaks, cracks or slides.

5.4.4 Scour downstream of spillway, spill/tail channel shall be observed to the extent required.

5.4.5 The spillway and outlet energy dissipating arrangements as well as their appurtenant works shall be inspected regularly for damage. Dewatering may be resorted to undertake the necessary inspection. Where dewatering is not possible, suitable underwater inspection may be done.

5.4.6 Contraction joints, formed drains and ventilation pipes shall be inspected and obstructions, if any, be removed periodically.

5.4.7 Emergency lighting system, gallery ventilation and other service facilities shall always be functional.

5.4.8 In case of instruments, arrangements shall be made for regular inspection and observation. Any unusual observations shall be reported to the concerned authorities. Non functional instruments may be replaced wherever possible.

5.4.9 Drainage holes shall be regularly inspected for choking and cleaning.

5.5 Earth/Rockfill Dams

In case of earth/rockfill dams the aspects given in 5.5.1 to 5.5.7 need particular attention.

5.5.1 If there are instruments installed in the dam, the required instrumentation observations given in 5.5.1.1 to 5.5.1.4 shall be made. Non-functional instruments may be replaced wherever possible.

5.5.1.1 Hydrostatic pressures within the foundation and the embankment shall be observed to check seepage conditions and performance of the drainage system.

5.5.1.2 Pore water pressure on the downstream shall be observed with respect to filling of the reservoir to know whether the increase is proportionate or excessive.

5.5.1.3 Settlement of various zones of the embankment and also that of foundation shall be observed for different reaches. Horizontal movement (normal as well as parallel to dam axis) of the embankment shall also be observed at specified sections.

5.5.1.4 Seepage discharge to evaluate the proper functioning of drainage system without undue increase in pore water pressures.

5.5.1.5 Observations on surface settlement points to check the behaviour of the slope of the dam.

5.5.1.6 Inspection/levelling of the bench marks in the dam and reservoir area shall be carried out at regular intervals and connected to the reference bench marks fixed in an area considered to be outside the influence of the reservoir loading.

5.5.2 Visual inspections and observations indicated in 5.5.2.1 to 5.5.2.6 shall be made.

5.5.2.1 Seepage conditions through the dam foundation and abutments shall be observed. It shall also be observed if the seepage is increasing or decreasing and if there is any significant departure from normal conditions of seepage which may result

in seepage flow, springs, bubbles, wet patches and washing out of fine materials on the dam slopes.

5.5.2.2 The area along downstream face of the dam and up to a distance of 10 H or 200 meters (where H is the maximum height of the dam from its deepest level) whichever is more beyond its toe, shall be regularly watched/inspected for occurrence of any boils.

5.5.2.3 Condition and performance of drains and relief wells including the adequacy of outfall conditions shall be observed. It shall be ensured that no structure/wells be constructed up to 10H or 200 m, whichever is more, beyond its toe.

5.5.2.4 Condition of upstream slope protection of the dam shall be observed below the minimum reservoir level in areas susceptible to damage.

5.5.2.5 Observation shall be made of the condition of the crest and slopes of the dam, specially in the zones adjacent to concrete structures, to locate any deformation, settlement, cracks, etc.

5.5.2.6 Seepage at junctions between earth dam and concrete/masonry retaining wall shall be carefully watched.

5.5.3 Upstream slope of the dam shall be carefully examined after long periods of high velocity winds and when the reservoir is being drawn down, to locate cracks, slides, settlements, damage to slope protection, etc.

5.5.4 Seepage water shall be periodically tested for chemical and physical analysis to determine if any material is being washed out.

5.5.5 The condition of outlet conduits shall be carefully observed to locate any seepage and longitudinal or transverse cracks near outlet location. It may be desirable to have continuous observations of seepage through the contacts between the hearth and rigid structures.

5.5.6 The condition of all appurtenant works embedded in the dam shall be carefully observed to locate any seepage cracks, etc. Continuous observations of all the seepage points in the appurtenant works shall be made.

5.5.7 All concrete appurtenant works shall be periodically inspected. Areas exposed to high velocity flows shall be examined more frequently.

6 MAINTENANCE

6.1 Inspection reports shall be periodically reviewed by competent authorities and necessary maintenance and repair instructions issued expeditiously. Maintenance required shall be completed before the monsoon, as far as possible.

6.2 In the case of concrete/masonry dams, steps indicated in 6.2.1 to 6.2.10 shall be taken for their maintenance.

6.2.1 Drainage system in the foundation and the dam body shall be maintained properly.

6.2.2 Leaks, cracks and spillings on the surface of the dam and in openings like gallery and adits shall be treated.

6.2.3 Leaks, cracks, slides, etc, in the abutment shall be treated.

6.2.4 Measures shall be taken to protect against harmful retrogression.

6.2.5 No blasting operation shall be permitted to be carried on or near the dam except as permitted in IS 6922.

6.2.6 Access to vital parts and adequacy of lighting facilities shall be ensured.

6.2.7 All weather accessibility of approach road to dams site shall be ensured.

6.2.8 Emergency lighting system shall be properly maintained.

6.2.9 Any debris or rock pieces collected in the energy dissipation structures/surplussing arrangement shall be removed before monsoon. Cleaning beyond these structures shall be done to the extent required. After monsoon or for periods when the spillway and outlets therein are not to be operated, the energy dissipation structures shall be examined for erosion, retrogression, normal wear and tear for undertaking repairs. Such repairs shall be undertaken expeditiously to bring the energy dissipation structure to a safe operating condition before being operated for the next monsoon floods.

6.2.10 Leaks, Cracks and spillings on the spillway piers, under sluices and outlets shall be treated.

6.3 In the case of earth/rockfill dams steps indicated in 6.3.1 to 6.3.6 shall be taken for their maintenance.

6.3.1 Sufficient quantities of suitable filter materials,

rockfill, gravel and sand shall be stored and suitably protected at strategic location of the dam for use in an emergency conditions.

6.3.2 The embankment shall be maintained to its designed section. Filling up of all subsidences at top of dam and slopes shall be done expeditiously. Rip-rap on the upstream face, if disturbed, shall be restored as a regular maintenance procedure as well as the turfing on the downstream slope.

6.3.3 No trees or other deep rooted plants shall be permitted to grow on the slopes and toe of the dam.

6.3.4 The drainage system shall be thoroughly cleaned before monsoon and shall be maintained clear of all obstructions.

6.3.5 Reservoir shall not be filled until the stage of progress of works permits it without endangering public property.

6.3.5.1 The first filling of reservoir shall be done after carefully examining the competency of the dam, adequacy of the outflow control devices etc.

6.3.6 If boils seem to occur, these shall be controlled by placing suitable filter material till such time when clear water emerges from the boil.

6.3.6.1 If boils are large and uncontrollable by adopting the procedure stated in 6.3.6, reservoir level shall be suitably lowered. Permanent remedial measures shall be undertaken at the earliest opportunity.

6.4 All steel structures shall be properly maintained.

6.5 Alternate and emergency lighting, flood warning and communication systems shall be properly maintained.

6.6 Trashracks and log booms shall be cleaned regularly and maintained.

6.7 Approach channel shall be properly maintained and cleared of all obstructions.

6.8 All important components of the dam shall be marked and painted identifying their name, location and elevation.

ANNEX A

(Foreword)

COMMITTEE COMPOSITION

Dams and Reservoirs, Sectional Committee, WRD 9

<i>Chairman</i>	<i>Representing</i>
DR B. K. MITTAL	Central Water Commission, New Delhi
<i>Members</i>	<i>Representing</i>
CHIEF ENGINEER (BHAKRA DAM)	Bhakra Beas Management Board, Chandigarh
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SHRI T. S. MURTHY (<i>Alternate</i>)	Central Water and Power Research Station, Pune
DIRECTOR	Central Water Commission, New Delhi
SHRI A. K. DHAVAN (<i>Alternate</i>)	Central Water Commission, New Delhi
SHRI R. M. KHATSURIA	Consulting Engineering Services (I) Pvt Ltd, New Delhi
SHRI P. B. DEOLALIKAR (<i>Alternate</i>)	Geological Survey of India, Lucknow
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DIRECTOR RESERVOIR, OPERATION DIRECTORATE (<i>Alternate</i>)	Indian Institute of Technology, New Delhi
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SHRI S. S. NARANG (<i>Alternate</i>)	Irrigation and Waterways Department, Government of West Bengal, Kolkata
SHRI G. K. KAISTHA	Irrigation Department, Government of Uttar Pradesh, Roorkee
SHRI R. N. SINGH (<i>Alternate</i>)	Irrigation Department, Government of Punjab, Chandigarh
CHIEF ENGINEER (MEDIUM & MINOR) & ADDL. SECRETARY	Irrigation Department, Government of Maharashtra, Nashik
SUPERINTENDING ENGINEER (CDO) (<i>Alternate</i>)	Irrigation Department, Government of Haryana, Chandigarh
HEAD OF THE CIVIL ENGINEERING DEPARTMENT	Water Resources Department, Government of Madhya Pradesh, Bhopal
CHIEF ENGINEER (I&CAD)	Jaiprakash Industries Ltd, New Delhi
SUPERINTENDING ENGINEER (DAMS) (<i>Alternate</i>)	Karnataka Power Corporation Limited, Bangalore
SHRI A. DASGUPTA	Kerala State Electricity Board, Thiruvananthapuram
SHRI H. P. CHAKRABARTI (<i>Alternate</i>)	Gammon India, Mumbai
CHIEF ENGINEER (DAM DESIGN)	National Hydroelectric Power Corporation Ltd, Faridabad
SUPERINTENDING ENGINEER DAM DESIGN CIRCLE I (<i>Alternate</i>)	North Eastern Electric Power Corporation Ltd, New Delhi
CHIEF ENGINEER (RSDD)	National Institute of Hydrology, Roorkee
DIRECTOR DAMS (RSDD) (<i>Alternate</i>)	Public Works Department, Government of Tamil Nadu, Chennai
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EXECUTIVE ENGINEER (MD-4) (<i>Alternate</i>)	Director General, BIS (<i>Ex-officio Member</i>)
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