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IS 7349 (2012): Barrages and weirs - Operation and maintenance - Guidelines [WRD 22: River Training and Diversion Works]



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भारतीय मानक  
बैरज और वियर — प्रचालन और रख-रखाव — मार्गदर्शी  
( दूसरा पुनरीक्षण )

*Indian Standard*

BARRAGES AND WEIRS — OPERATION AND  
MAINTENANCE — GUIDELINES  
( *Second Revision* )

ICS 93.160

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**BUREAU OF INDIAN STANDARDS**  
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NEW DELHI 110002

## FOREWORD

This Indian Standard (Second Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the River Training and Diversion Works Sectional Committee had been approved by the Water Resources Division Council.

Proper maintenance and operation of barrages and weirs are the prime factors to govern the life and efficacy of the structure. Experience shows that improper operation and maintenance have considerably diminished the life as much as the efficacy of the structure. It is necessary for the engineer in-charge, to be well conversant with the final drawings (both civil and manufacturer's drawings of hydro-mechanical equipments) and manual, etc. His prime duty should include the documentation of the data, design computations, modifications in the designs and final drawings, etc, as well as inspection of the structure from time-to-time.

This standard was first published in 1974 and revised in 1989. The first revision was made in view of the experience gained during the use of this standard. In the first revision requirements of operation and regulation had been fully revised, providing detailed clarifications/guidelines on many of the issues faced by the site engineers. The history of headworks had also been revised with the addition of data on gate/shutter operation adopted from time-to-time.

With the experience gained from the prototype behaviour of many barrages and weirs and the corresponding remedial measures suggested/adopted for addressing the difficulties, faced in actual operation and maintenance, it is considered necessary to revise the standard to incorporate many of the measures currently in vogue based on the latest technical advancements.

The composition of the Committee responsible for the formulation of this standard is given at Annex B.

*Indian Standard*

# BARRAGES AND WEIRS — OPERATION AND MAINTENANCE — GUIDELINES

*( Second Revision )*

## 1 SCOPE

This standard lays down guidelines for the operation and maintenance of hydro-mechanical installations and civil structures connected with the barrages and weirs.

## 2 REFERENCES

The standards listed in Annex A contain provisions, which through references 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 possibilities of applying the most recent edition of the standards indicated in Annex A.

## 3 GENERAL

Generally, the river discharges are widely fluctuating and operations/regulation of the gates have to be modified from time-to-time on the basis of river behaviour, morphological changes, etc. Barrages are not storage structures and the waterway is designed according to design flood without any moderation. As such, during the life of barrage, it is seldom that all the gates are required to be opened fully. Gate operations, particularly during low floods is a key factor for flushing of sediments and prevention or alteration of shoal formation on the upstream and downstream of the barrage.

## 4 OPERATION AND MAINTENANCE OF HYDRO-MECHANICAL INSTALLATIONS

**4.1** It should be ensured that a thorough inspection of hydro-mechanical installations/equipment is done atleast once in a year to check corrosion, loss of metal and other defects. All machinery at the works should be kept clean, tidy and in proper working order and care should be taken to ensure that it is properly handled in conformity with the manufacturer's instructions. The main hydro-mechanical items are generally the gates, hoist equipment, control system, etc. IS 7718 may also be referred for inspection, testing and maintenance of gates.

In case of remote controlled operation of gates, it has to be ensured that the operating system

(hardware and software) are fully functional in addition to mechanical controls.

### 4.2 Operation of Gates and Falling Shutters

**4.2.1** All lift gates should be operated at suitable intervals, preferably once in fortnight to clear the gate grooves/slots, flood passage and ensure free movement of moving parts of gate. In low supplies when openings are not desirable, raising of gates by 150 mm for a few minutes should suffice. If the gates have not been moved for a sufficiently long time, they should not be forcibly raised all at once but should be lifted by about 30 mm or so and left at that position for about 10 to 15 min till the silt deposited against the gates gets softened and water begins to ooze out. This is essential to avoid heavy strain on the machinery.

**4.2.2** The speed of operation of the gates should be limited to the maximum speed indicated by the manufacturer.

**4.2.3** The head regulator gates should be opened equally unless otherwise indicated in the model studies report.

**4.2.4** The operation of under sluice gates should be based on approved gate operation schedule besides model studies, if conducted, for optimum silt exclusion, hydraulic efficiency and structural safety.

**4.2.5** Sequence of operation of barrages gates/weir shutters should be decided by the engineer-in-charge depending on the prevailing factors, such as river behaviour, shoal formation, scour, etc, both on the upstream and the downstream. However, while deciding the same, recommendations/ observations of the model studies, if any, should also be kept in view.

**4.2.6** Where the considerations given in **4.2.5** are not governing, it should generally be desirable to subject barrage gates to wedge operation commencing to open from the centre and moving on either side till all the gates have been opened equally. The gates should be opened in installments not exceeding 300 mm at a time. However, suitable passage may be provided to flush out the boulders/debris, as required.

**4.2.7** The operation should be carried out in such a manner that the safety of the structure is not jeopardized at any time. It should be ensured that the permissible difference in static head on either side of the divide walls is not exceeded beyond the safe limit, which should be clearly specified.

**4.2.8** The gates provided for silt/shingle excluding devices should be closed very slowly to avoid water hammer action, and other detrimental effects.

**4.2.9** Stop-logs are multiple elements placed one above the other upstream of main gate for facilitating inspection and maintenance of main gates. They are generally operated by a gantry crane or a monorail hoist under balanced head condition. Stoplogs shall not be operated under flowing water or unbalanced condition unless these and the operating machinery is designed for such conditions.

#### **4.3 Maintenance of Gates**

**4.3.1** All cavities and angles in the gates/shutters should be kept clear of debris, driftwood, moss and silt accumulations. All drainage holes in the webs of horizontal structural members should be kept clear to drain off any accumulated water. Green stains should not be allowed to form on the steel members at the back of the gates/shutters. The gates and counter balanced boxes should hang perfectly in level and plumb. This should be checked occasionally and adjustment made as needed. In case of shutters, the chains/anchors holding them should be kept free from rust. IS 10096 (Part 1/Sec 1) and IS 7718 may also be referred for the inspection/maintenance of the gates considering the type of gates provided on the barrages/weirs.

**4.3.2** No painting is required for machined surfaces and surfaces of stainless steel, brass or bronze. These surfaces should be protected by a coating of gasoline-soluble rust preventive non-corrosive compound.

**4.3.3** Painting shall be restored by the same type/quality of paint as originally provided if it has proved satisfactory. Otherwise a suitable painting system can be evolved considering local conditions. The method of application for the paint and surface preparation shall be as per IS 14177 or any standard practices being followed by project owner with the approval of concerned competent authority.

#### **4.4 Gate Grooves and Seals**

Grooves and particularly their machined faces should be kept clean and lubricated well and all sticky deposits should be scraped off before application of lubricant.

#### **4.4.1 Seals**

Efficiency of rubber seals should be tested initially after construction and at the time of closures or isolation of different portions for repairs. The horizontality and verticality of the seal seat and wall plates should be checked with spirit level and seal faces of the rubber seal should be tested to press uniformly both by light test and by use of paper strip inserts. Seals of the gate should be checked for wear and tear as well as deterioration. These should be adjusted/replaced, as necessary. Few sets of spare seals should be kept in stock and stored for emergency in such a way that these seals do not get damaged during storage with the passage of time.

#### **4.4.2 Staunching Pipes**

Staunching pipes, where provided, should be checked for their sealing efficiency. Repairs/replacements should be carried out, if necessary.

#### **4.5 Steel Wire Ropes**

All steel wire ropes must be cleaned to remove all dust accumulation and lubricated with suitable grease at least once a year.

**4.5.1** The clamping devices should be de-clamped and re-clamped at least once in three years. The inspection and maintenance of wire ropes, wire clamps and other clamping devices should be in accordance with the provisions contained in IS 3973 and IS 10096 (Part 3).

#### **4.6 Roller Trains and Fixed Rollers**

The roller trains should be examined at least once a year. Partially jammed rollers should be cleaned, freed and greased but totally jammed rollers should be replaced. The bolts of roller guard should be checked and tightened. The sliding/fixed rollers should be extracted at the time of closure (unless necessitated otherwise due to some defects which may need immediate repairs), and cleaned and greased properly. Spare rollers should be kept in stores for ready replacement. IS 7718 may also be referred for inspection, testing and maintenance of gates.

#### **4.7 Winches/Hoist**

**4.7.1** All winches and lifting drums should be examined at least once a year to see, if all the gears and axles are clean and properly lubricated. All grease-fed bearings should be cleaned, old grease removed with kerosene oil and fresh grease applied. The alignment of shafts should be checked and coupling bolts tightened.

**4.7.2** All grease cups must be kept full of lubricants and covers tightened periodically to ensure lubricant

moving and causing an effective seal against dust getting into the bearings. For winches with ratios of 60 : 1 to 100 : 1, four men should be able to operate the hoist easily. If the working of any winch becomes hard and it requires more men to operate, it should be examined and the defect removed before it is used. Winch gear covers should have felt or rubber washers to check the entry of dust. The winches should be operated in correct direction and to ensure this, direction or operation should be correctly marked and the limits of operation indicated.

**4.7.3** In case of electrically-operated hoists, all precautions necessary to ensure safety and fault free operation of electric motors and switching devices such as checking up of insulation of all electrical wirings, motor armature windings, etc, should be taken. Mechanical upkeep of motor bearings and reducing gears should be ensured through proper inspection and lubrication. The arrangement for operation of hoists manually in addition to the operation of hoists by electric means should also be provided besides provision for isolating the one from the other. The latest technique of automatic gate lifting may also be provided, if the project is equipped for such operation.

**4.8** Wooden planking wherever provided in the decking of hoist bridge, should be checked to tighten up the loose holding down nuts and bolts and worn out planks shall be replaced. The wooden planking should receive at least two coats of creosote oil application once in two years.

**4.9** The engineer-in-charge should test all lift gates, chain and clips of falling shutters and submit a certificate to the competent authority before the advent of the monsoon to the effect that all gates/falling shutters are in good operational condition.

**4.10** All flood lighting and barrage illumination should be checked daily during flood season and once in a week during slack season.

**4.11** The road bridge bearings should be inspected, cleaned and attended for any defects once a year after the monsoon.

**4.12** Any part of the gate leaves, grooves, lifting mechanisms, etc, that may get deteriorated or damaged due to negligence or accident, should be thoroughly repaired or replaced as soon as the damages are noticed.

**4.13** The cleaning and painting of superstructures should be done once in two years.

**4.14** IS 10096 (Part 3) may also be referred for inspection/maintenance of hoists considering the type of hoist provided on the barrages/weirs before the onset of monsoon and after the flood season.

## 5 INSPECTION, MAINTENANCE AND INSTRUMENTATION OF CIVIL WORKS

**5.1** Inspection of barrages and weirs is necessary to repair all damages and to obviate the possibility of extension of damage. Such inspection should usually be carried out annually for all underwater works after monsoon by means of under water lamps and sounding rods. In addition, detailed inspection in stages should be carried out using underwater videography at suitable intervals depending upon extent of damage. Repairs can be undertaken by either depleting the pond or by isolating the damaged portion by construction of ring bunds. The requisite suitable measures for upstream floor and other floors shall be suitably planned and designed.

**5.2** The repairs as necessary as a result of inspection should be carried out well before the onset of the next monsoon. Serious defects noticed should be reported to appropriate authorities for taking remedial measures in time.

**5.3** The inspection and maintenance for the following works may be carried out:

- a) *Aprons*:
  - 1) Upstream apron and area immediately upstream of it; and
  - 2) Downstream apron and area immediately downstream of it;
- b) *Impervious floors*:
  - 1) Upstream of the gates/falling shutters; and
  - 2) Downstream of the gates/falling shutters;
- c) Piers/Abutments;
- d) Road/Rail bridges;
- e) Sediment excluding devices;
- f) Canal head regulator;
- g) Instrumentation and performance; and
- h) River training works.

### 5.3.1 *Aprons*

The sounding and probing in the area should be undertaken every year immediately after the monsoon in order to assess the scours and launching of aprons in the vicinity of structures. The non-launching portion should be carefully examined, particularly on downstream, to ensure the effectiveness of inverted filter.

### 5.3.2 *Impervious Floors*

A thorough inspection of upstream and downstream floors should be undertaken after the monsoon. The upstream floor should be inspected every year early in the fair weather season by probing and the use of



underwater lamps. A careful inspection of joints of the stone-sets should be done where such structures exists. Minor repairs can be done underwater whereas major repairs may be undertaken by isolating the area.

**5.3.2.1** The downstream basin should also be carefully inspected and the repairs carried out well in time before the onset of monsoon. In case of deep cisterns requiring expensive cleaning and dewatering, inspection of sandy reaches can be carried out by probing but in boulder reaches where this may not be possible, dewatering, cleaning and repairs may be carried out by rotation once in three years. The condition of boulder-set or granite block in the case of boulder stage river should be carefully examined, and repairs and replacements made, as found necessary. While dewatering deep downstream basins, care should be taken to ensure that the design uplift for such condition is not exceeded. This should be clearly specified in the regulation order.

### **5.3.3** *Sediment Excluding Devices*

A thorough inspection of roofs, ducts and mouth of the sediment excluders should be carried out every year in the fair weather with the help of divers and underwater lamps. Minor repairs may be carried out underwater and major repairs by local isolation.

### **5.3.4** *Canal Head Regulator*

The works should be carefully examined every year in the fair weather. The upstream floor should be examined by probing and downstream floor under dry conditions during closure or isolating the area where closure may not be possible. Visual inspection of upstream floor should also be carried out once in three to five years by isolating the area. All necessary repairs should be carried out in time.

### **5.3.5** *Instrumentation and Performance*

It is essential that every year a performance report be prepared on the basis of instrument observations. The observations can be broadly classified under the following sub-heads:

- a) Uplift pressure;
- b) Suspended sediment;
- c) Settlement;
- d) Retrogression;
- e) Aggradation upstream; and
- f) Discharge distribution and cross flow.

#### **5.3.5.1** *Uplift pressure*

The uplift pressure observation pipes (*see* IS 6532) are embedded in the weir or barrage structure, generally in piers and flank walls in such a manner as to give representative uplift, pressure along and immediately beneath the horizontal floor and at

different points along the vertical cut-off. Additional pressure pipes may be installed, if required, to determine uplift pressure at critical points in case of stratified foundations. The pipes should be numbered and a permanent record of observations should be maintained. The observed uplift pressure should be compared with the design uplift pressures with the help of a graphical plot and any needed remedial measures taken. Frequency of observation will depend upon local conditions. It may generally be enough to take observations once a month during monsoon period and more frequently during the non-monsoon period. It should be ensured that,

- a) the mouths of all pipes are kept closed by caps to obviate the chances of foreign matter findings its way into the pipes and clogging them;
- b) each pressure observation point is given a distinct number; and
- c) each pipe is frequently tested to ensure that its strainer is not choked. This can be best done with the help of an ordinary hand pump, by working it till water comes out freely.

#### **5.3.5.2** *Pressure release (drainage) pipes*

The effluent/discharge coming out of pressure release/drainage pipes, where provided in the downstream floor, should be observed for its quantity as well as quality of sediment contents. Such observations may be possible only during dry season when all the gates of the compartments are closed. This is necessary to check the efficient working of the drainage system. A correlation between head of water and discharge should be established and any large variations immediately taken notice of and suitable action taken. As presence of sediment in the effluent could lead to undermining of the foundations, immediate remedial measures should be undertaken. In extreme case, it may become necessary even to completely block the sediment discharging pipe.

#### **5.3.5.3** *Hydraulic jump profile*

Strip gauges should be painted every 10 m on the wing walls and the long divide walls to observe the hydraulic jump profile in the prototype under different hydraulic conditions. The following observations should be taken:

- a) Upstream water level;
- b) Downstream water level;
- c) Shade temperature — maximum and minimum;
- d) Temperature of the river water at a depth from the surface below which it remains approximately constant;

- e) Temperature of the sub-soil water in a few selected observation pipes;
- f) Water level in all pipes may be observed by using a bell sounder or by other suitable means;
- g) Discharge from drainage pipes; and
- h) Depth of sediment on upstream and downstream floors.

#### 5.3.5.4 *Suspended sediment*

During the monsoon season, water sample should be taken in accordance with IS 4890 simultaneously upstream and downstream of the under-sluices and in the canal below the head regulator to assess the suspended sediment therein. Such observations should be taken at least once a week (closer intervals in case of high sediment concentration) to assess the efficiency of sediment exclusion device and to decide if any change in the mode of regulation and/or other remedial measures are required.

#### 5.3.5.5 *Settlement*

Where appreciable foundation settlements are anticipated, particularly when the structure is founded partially or wholly on clay or other soft soil, surface settlement of relatively heavily loaded parts of the structure should be observed early in the fair weather every year and remedial measures undertaken, if necessary. This can be done by establishing permanent observation points of steel on the structure and doing precise levelling from permanent bench marks established sufficiently away from the influence of any structure.

#### 5.3.5.6 *Retrogression*

Retrogression of the river bed can be expected downstream of the weir/barrage. In order that the lowering of water level at any discharge condition does not exceed that provided for in the design, it is necessary to establish gauges on both banks, one immediately downstream of the work and two more, 1 000 m and 2 000 m downstream of the first and to observe them simultaneously at least once a day. Remedial measures should be undertaken as and when required to ensure the safety of the structure.

#### 5.3.5.7 *Aggradation upstream*

The river bed upstream of the barrage or weir is likely to aggrade resulting in increased afflux and reduction in freeboard provided in design. To determine the increase in the afflux, if any, gauges should be established on the upstream, one immediately upstream of the work and one each at 1 000 m and 2 000 m upstream of the first, and observed regularly. The afflux bunds may have to be

raised, if found necessary, to restore the designed freeboard.

#### 5.3.5.8 *Discharge distribution and cross-flow*

Observations should be taken to find the discharge distribution through different bays of the barrage. If there is significant cross-flow and/or difference in discharge intensities through different bays, remedial measures should be taken to check this tendency by adopting modified gate regulations, removal of shoals, etc.

#### 5.3.5.9 *Pond capacity*

Where balancing storage is also provided in the barrage, soundings in the entire pond area may be made at suitable intervals for periodic review of storage capacity.

#### 5.3.6 *River Training Works*

**5.3.6.1** A detailed river survey covering the barrage/weir and river training works upstream and downstream should be carried out every year. The survey should preferably extend about one metre above the design flood level on both the banks on upstream side. Similarly, the survey on downstream side should extend to a length up to which river bed changes occur. Sufficient number of permanent reference marks should be established on both banks to facilitate superimposition of old and new survey. The changes in the river course should be examined and remedial measures taken.

**5.3.6.2** The afflux bunds, guide bunds and spurs should be examined in the fair weather and necessary repairs to the bunds, pitching and aprons carried out and completed well before the onset of monsoon. An adequate stock of boulder/stones should be maintained close to the protection works for use in emergency.

## 6 OPERATION AND REGULATION

**6.1** Adequate regulation staff should be provided and their duties should be clearly specified. Adequate stock of stores, tools and plants required to meet emergencies should be maintained on all barrages and weirs. These should be listed in detail in the regulation orders and their availability checked periodically by the engineer-in-charge. The gauge sites (*see 6.3.2.1*) should be linked with the headworks by a reliable communication arrangement such as telephone, wireless, telegraph, etc. As a precautionary measure, the engineer-in-charge will maintain a dossier of personnel who could be deployed at project site in emergency. These personnel should be available at very short notice and capable of performing assigned tasks.

**6.2** In general, operation of the barrage gates should ensure the following features:

- a) Required pond level is maintained both during the non-monsoon flows and the falling flood periods.
- b) Non-monsoon flows remain near the under-sluice bays so that feeding of the canal(s) through the head regulator(s) is not affected.
- c) A fair uniform distribution of discharge along the width of the barrage is obtained, as far as practicable.
- d) Flow parallel to barrage axis both on the upstream and the downstream of the barrage is avoided at all times, as far as practicable.
- e) Risk of deep scour and shoal formations in the vicinity of the barrage both on the upstream and the downstream is minimized, as far as possible.
- f) If shoal formation has taken place, the gates in front of the shoal should be opened more to accentuate flushing of sediment with the forward flow wherever sufficient discharge is available. Alternatively, method of sudden and simultaneous opening of required number of gates in front of the shoal could be tried.
- g) To evolve the operation of gates to exclude maximum silt/debris deposits on the upstream side and also to minimize the entry of same in canals/channels.
- h) Hydraulic jump should not be allowed to form beyond the toe of the downstream glacis in any case.
- j) A relatively high intensity of flow is avoided in the deep scour zones, if formed.
- k) If a shoal has formed on either upstream, or downstream, or both sides of the barrage, it is washed out and kept away from the barrage, as far as practicable.
- m) Gate operation schedule should also consider constraints regarding rates of lowering/raising of ponds. It should also consider the safe rate of filling of the canals.
- n) Constant and regular supply in canals/channels even during fluctuations in discharges from power houses located on the upstream side.
- p) Approach channel should be trained so that the tendency of the river to meander near the barrage or outflanking the barrage can be arrested.

**6.3** The operation and regulation can be divided into

three distinct periods as given below:

- a) Pre-monsoon;
- b) During monsoon; and
- c) Post-monsoon.

### **6.3.1** *Pre-monsoon Operation*

It is a low flow period and normally no wastage of water should be permitted during this period. The barrage gates/falling shutters should be regulated in such a way that all the available supplies are conserved and pond level is maintained. Any excess flow over and above the requirements through the head regulator(s) should be released through under-sluice bays and silt excluder tunnels, wherever provided. The release through the head regulator of the canal should be based on the discharge tables. The discharge tables should be occasionally checked for accuracy by actual measurements in the canal.

For any flashy flood, the canal may have to be closed temporarily, if the concentration of suspended silt is in excess of the safe limit prescribed.

### **6.3.2** *Monsoon Operation*

**6.3.2.1** Gauges to indicate flood stage should be installed sufficiently (not less than 1 000 m) upstream of the barrage at suitable locations so as to ensure adequate margin of time for operation of gates at the weir/barrage site.

**6.3.2.2** During low floods, the gauges should be signalled and recorded every 3 h while in medium and high floods, these should be recorded every hour. The signaller at the headworks, on receiving the flood warning should communicate the same to the official/officer-in-charge of the headwork and other regulation points downstream and to the district officers of the neighbouring districts.

**6.3.2.3** The advisability of installation of wireless transmitting stations on headworks located on major rivers for speedy transmission of flood warning should be considered.

**6.3.2.4** In order to create most favourable conditions for sediment exclusion from the canal, still-pond regulation should be resorted to, as far as possible. However, in locations where canals cannot be closed for flushing, semi-still pond/regulation may be adopted (as in the case of power channels) as given below:

- a) *Still pond operation* — In still pond operation, all the gates of the under-sluice bays are to be kept closed so as to limit the discharge flowing into the under-sluice pocket to be equal to the canal supply. The specified or required discharge only should be drawn in the canal and the surplus river discharge should be passed through the

spillway bays or river sluice bays, if provided. As the under-sluice bays are kept closed, the flow velocity in the pocket cause the sediment to settle down and relatively clear water enters the canal. However, the pocket gets silted up in this process after some time.

At that time, the canal head regulator gates should be closed and deposited silt should be flushed out by opening the gates of the under-sluice bays. The canal supply may be stopped during this scouring operation which may take about 24 h. After the silt deposits are flushed out sufficiently, the head regulator gates should be opened and under-sluice closed. This operation is desirable where the crest of the head regulator is at a sufficiently higher level than that of the upstream floor of the under-sluice bays. This still pond operation should be continued till the river stage reaches the pond level after which the under-sluice gates should be opened to avoid overtopping.

- b) *Semi-still pond operation* — In the semi-still pond operation, the gates of the canal head regulator are not closed for flushing of silt deposit in the pocket. The gates of the under-sluice bays should be kept partially open to the minimum necessary so that the bed material in the pocket could be passed downstream. The discharge in excess of the canal requirement should be passed through the under-sluice bays and silt excluder tunnels also, wherever provided.

**6.3.2.5** Excluders, where provided, should be kept open and while doing so, the limitations imposed by the safety of the structure should be kept in view. The required intensity of discharge  $q$ , which may be sufficient to flush the deposited silt in the pocket can be calculated from the Lacey/Blench's scour equation:

$$R = 1.35 \left[ \frac{q^2}{f} \right]^{0.33}$$

where

- $R$  = scour depth that is, between the water level and the level of the pocket floor in this case, in m;  
 $q$  = intensity of discharge, in  $\text{m}^3/\text{s}/\text{m}$  width; and  
 $f$  = silt factor corresponding to the deposited material in the pocket.

The required intensity of discharge thus calculated may be generated by suitable gate openings when sufficient head is available in the pond. Under no

circumstances should the under-sluice gates be allowed to be overtopped. Silt ejectors in the canal should be operated as much as possible so that the chances of heavy siltation in the canal posing a problem of flushing due to its compaction are minimized.

**6.3.2.6** During monsoon month, it is important to keep a constant watch over the sediment entering the headworks, the portion thereof ejected by the extractor if any, and the sediment deposition taking place in the canal and to ensure that sediment deposition only to the extent that can be washed out early in the fair weather before the full demand develops, is allowed. For this, the following actions should be taken:

- a) Sediment charge observations (both suspended sediment and bed load) should be made at least once a day in low floods immediately below the head regulator, below the silt ejector, if any, and at any other sensitive point lower down the canal. The frequency of observations may be increased in medium and high floods as required;
- b) Cross-section of the canal should be taken daily at a few sensitive points to watch the extent of sediment deposition in the canal;
- c) Water surface slopes in the sensitive head reach of the canal should be kept under observation daily with the help of gauges;
- d) The ponding upstream of power stations, if any, in the canal should be restricted to the requisite extent so as to avoid harmful sediment deposition; and
- e) The canal should be closed from the headworks,
  - 1) beyond a specified sediment charge during medium/high flood and re-opened when the sediment charge drops below the specified limit. Since the silt carrying capacity of the canal would govern this specified limit, it would vary from project to project and should be estimated based on actual data/experience. In so far as the power channels are concerned, this would depend on the size of the particle carried down.
  - 2) when sediment deposition at the sensitive points has reached the maximum permissible bed level. This limit along with the sediment charge in excess of which the canal is to be kept closed, may have to be fixed for different months during the monsoon period in order to be able to meet the irrigation and power demand.

**6.3.2.7** Since cross flows and vortex formations dangerously cause deep scours both on the upstream and downstream of the barrage leading to washing away or sinking of cement concrete blocks and loose stone aprons, and damages to the nose and shanks of guide bunds, visual observations of the direction of current and vortex formation during low and medium floods should be made. After critically observing the effects of different patterns of gate operation on the same, the engineer-in-charge should judiciously select the correct pattern which would cause only minimum scour or minimum shoaling.

**6.3.2.8** The engineer-in-charge should be conversant with the shoal formations, changing network of spill channels, etc, which cause unequal distribution of flows through different bays, cross flow near the barrage floor ends, vortex formations, etc. Gate operation of barrage structure should be attempted in such a manner that the shoal formation in the vicinity of barrage structure both upstream and downstream is avoided.

**6.3.2.9** The pond level should be kept minimum required to feed the canal with the required discharge by suitably opening the gates. It should be ensured that in a high flood, all falling shutters of weirs are lowered and all gates raised clear of the water level with adequate freeboard to clear floating debris.

**6.3.2.10** The operation of barrage gates/weirs shutters should preferably be based on model studies at various flood intensities, that is, low, medium and high, as modified by observed river behaviour at site. In this connection, for major barrages it would be desirable to constitute a gate regulation committee for each barrage comprising senior engineers of the project design office and research station and engineer-in-charge of the headworks division. The Committee should hold meetings at least once during pre-monsoon, monsoon (preferably twice) and after monsoon and should review the gate operation pattern and modify, wherever necessary on the basis of the observed river cross-section on the upstream and downstream of the structure. After some years when satisfactory flow conditions are established, all the recommendations of the Committee from time-to-time should be compiled in the form of a manual so that guidance could be obtained by the gate operating personnel for future use in the project. Generally with the rise in the flood discharge, step-by step gate operation with gradual increase of opening from ends towards the centre is sometimes recommended.

**6.3.2.11** In order to keep a close watch on the river behaviour and bed configuration both upstream and downstream of the barrage, river surveys should be

conducted regularly, once before the floods and another after the floods. For major structures, powerful launches fitted with echo-sounders or any other state of art instrument is desirable to take cross-sections even during medium flood stage. The survey should be conducted over a stretch of the river close to the barrage at least up to the end of guide bank both on upstream and downstream. The bed levels should be determined at close intervals of at least 10 m. Depending upon the bed configuration, the pattern of gate regulation should be modified suitably to ensure safety and better hydraulic performance of the barrage. Canals having hydro-electric power stations should be provided with trashracks at the head regulator to check entry of floating debris. The trashracks should be kept clean, preferably by a mechanical or electrical operation device. Instances of collapse of trash racks due to lack of cleaning and excessive pressure built up have been on record. Where floating debris try to enter the irrigation canal head regulators, trash booms may be erected just upstream of the head regulators.

**6.3.2.12** The cranes for lifting weir shutters should be housed safely in the crane house when not in use.

### **6.3.3** *Post-monsoon Operation*

**6.3.3.1** Sediment charge observations and cross-section at sensitive points on the canal should be continued at less frequent intervals till satisfactory conditions have been established.

**6.3.3.2** Still/semi-still pond operation, with sediment excluders operating, depending on the surplus water availability should be continued till water becomes reasonably clear.

**6.4** When a canal is first opened, a low supply should be run for a few hours at least and the depth should gradually be increased according to the requirements. The rate of falling and lowering of the canal should be prescribed and these should not be transgressed. Silt ejector hoppers and outlet pipes may be cleaned by pressure flow or back-jetting before the canal is started for operation.

**6.5** If a study of the survey data indicates that shoal formation has occurred on the upstream and/or downstream of the barrage in spite of judicious operation of the gates, during normal and flushing operation of reservoir, the shoal should be removed by dredging by the use of suitable dredgers to the extent possible so that satisfactory flow conditions are established and also desired capacity is restored.

**6.6** Satellite imageries obtainable from the National Remote Sensing Agency may be helpful in the identifying the variations of the bank lines, flow

patterns, formation of submerged shoals, etc, in the upstream pond from year to year. Studies with satellite imageries may be made and remedial measures for improving the river behaviour and flow pattern may be taken up.

6.7 In addition, physical/morphological model study will be useful for understanding,

- a) morphological behaviour of the river;
- b) its aggradation, degradation and meandering tendency; and
- c) sediment transport with varying level, etc.

Attempt should be made to prove/improve these models on the basis of prototype observations of barrages.

## 7 HISTORY OF HEADWORKS

A continuous history of river behaviour and the overall performance of the barrage/weir, head regulators and river training works should be maintained on all major headworks. The history should also contain the details of maintenance, damage and repair carried out from time-to-time, prescribed schedule of gate operation and in case of deviation of prescribed schedule, the actual gate operation with reasons thereof, etc. Necessary drawings should be appended in the record. Pre-monsoon and post-monsoon river bed contours may be plotted, reduced in size and properly filed in serial order for comparison to understand the pattern of shoals, scours, oblique flow, etc.

## ANNEX A

(Clause 2)

### LIST OF REFERRED INDIAN STANDARDS

<i>IS No.</i>	<i>Title</i>	<i>IS No.</i>	<i>Title</i>
3973 : 1984	Code of practice for the selection, installation and maintenance of wire ropes ( <i>first revision</i> )		testing and maintenance of fixed wheel and slide gates ( <i>first revision</i> )
4890 : 1968	Methods for measurement of suspended sediment in open channels	10096	Recommendations for inspection, testing and maintenance of radial gates and rope drum hoists:
6532 : 1972	Code of practice for design, installation, observation and maintenance of uplift pressure pipes for hydraulic structures on permeable foundations	(Part 1/Sec 1) : 1983	Inspection, testing and assembly at the manufacturing stage, Section 1 Gates
7718 : 1991	Recommendations for inspection,	(Part 3) : 2002	After erection ( <i>first revision</i> )
		14177 : 1994	Guidelines for painting system for hydraulic gates and hoists

**ANNEX B***(Foreword)***COMMITTEE COMPOSITION****River Training and Diversion Works Sectional Committee, WRD 22**

<i>Organization</i>	<i>Representative(s)</i>
Central Water Commission, New Delhi	SHRI G. S. PURBA ( <b>Chairman</b> )
Bhakra Beas Management Board, Nangal Township	SUPERINTENDING ENGINEER SENIOR DESIGN ENGINEER (B&B) ( <i>Alternate</i> )
Border Roads Organization, New Delhi	SHRI A. K. DIKSHIT SHRI D. K. PURWAR ( <i>Alternate</i> )
Brahmaputra Board, Guwahati	GENERAL MANAGER CHIEF ENGINEER (P&D) ( <i>Alternate</i> )
Central Water & Power Research Station, Pune	SHRI D. N. DESHMUKH SHRI M. N. SINGH ( <i>Alternate</i> )
Central Water Commission, New Delhi	DIRECTOR (FM I) DIRECTOR (BCD) E&NE ( <i>Alternate</i> )
Consulting Engineering Services, New Delhi	SHRI P. K. CHATTERJEE DR OM PRAKASH ( <i>Alternate</i> )
Delhi College of Engineering, New Delhi	HEAD (CIVIL ENGINEERING DEPARTMENT)
Flood Control Department, Government of Assam, Guwahati	CHIEF ENGINEER (QUALITY CONTROL) ADDITIONAL CHIEF ENGINEER ( <i>Alternate</i> )
Gammon India Limited, Mumbai	SHRI M. S. BISARIA SHRI V. N. HEGGADE ( <i>Alternate</i> )
Ganga Flood Control Commission, Patna	DIRECTOR (MASTER PLANNING 2) DIRECTOR (PLANNING) ( <i>Alternate</i> )
ICT Pvt Ltd, New Delhi	SHRI P. L. DIWAN PROF S. K. MAZUMDER ( <i>Alternate</i> )
IIT, Roorkee	DR NAYAN SHARMA
Indian Institute of Technology, New Delhi	HEAD (CIVIL ENGINEERING DEPARTMENT)
Irrigation & Waterways Directorate, Govt of West Bengal, Kolkata	DIRECTOR (CDO) DR ABHIJIT SAHA ( <i>Alternate</i> )
Irrigation Department, Government of Andhra Pradesh, Hyderabad	SUPERINTENDING ENGINEER (B&C) SUPERINTENDING ENGINEER (DAMS) ( <i>Alternate</i> )
Irrigation Department, Government of Haryana, Chandigarh	CHIEF ENGINEER (DRAINAGE) DIRECTOR (CENTRAL DESIGN) ( <i>Alternate</i> )
Irrigation Department, Government of Jammu, Jammu	SHRI BODH RAJ DOGRA SHRI NATHA RAM ( <i>Alternate</i> )
Irrigation Department, Government of Punjab, Chandigarh	CHIEF ENGINEER (DRAINAGE) JOINT DIRECTOR (CENTRAL DESIGNS) ( <i>Alternate</i> )
Irrigation Department, Government of Uttarakhand, Roorkee	DIRECTOR (IRI) RESEARCH OFFICER (IRI) ( <i>Alternate</i> )
Irrigation Department, Government of Maharashtra, Nasik	SUPERINTENDING ENGINEER (GATES) SHRI R. V. JALTARE ( <i>Alternate</i> )
Kolkata Port Trust, Calcutta	SHRI BIKAS CHAUDHURI SHRI M.N RAY ( <i>Alternate</i> )

<i>Organization</i>	<i>Representative(s)</i>
Ministry of Railways (RDSO), Lucknow	DIRECTOR (B&F)/INP. ASSISTANT DESIGN ENGINEER (B&F) ( <i>Alternate</i> )
NHPC Ltd, Faridabad	SHRI A. K. JAIN SHRI MAHESH KUMAR ( <i>Alternate</i> )
Public Works Department, Chennai	EIC, WRO & CE (GI) SUPERVISING ENGINEER (DC) ( <i>Alternate</i> )
RITES, New Delhi	SHRI G. SETHURAMAN SHRI MUKESH KUMAR ( <i>Alternate</i> )
Sardar Sarovar Narmada Nigam Limited, Gandhi Nagar	SHRI VIVEK P. KAPADIA SHRI MUKESH B. JOSHI ( <i>Alternate</i> )
Tehri Hydro Development Corporation Limited, Rishikesh	SHRI G. M. PRASAD
Water Resources Department, Patna	SHRI S. JANKI RAMAN PRASAD SINHA
Water Resources Development Organization (WRDO), Bangalore	SHRI C. V. PATIL SHRI BASAVARAJA KOTI ( <i>Alternate</i> )
BIS Directorate General	SHRI J. C. ARORA, Scientist 'F' and Head (WRD) [Representing Director General ( <i>Ex-officio</i> )]

*Member Secretary*  
SHRI R. R. DASH  
Scientist 'B' (WRD), BIS





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