भारतीय मानक

उत्पलव तथा समान अधिप्रवाह संरचनाओं का निर्माण — रीति संहिता

(पहला पुनरीक्षण)

Indian Standard

CONSTRUCTION OF SPILLWAYS AND SIMILAR OVERFLOW STRUCTURES — CODE OF PRACTICE

(First Revision)

UDC 627·831·012·4 : 006·76

BUREAU OF INDIAN STANDARDS
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Price Group 7

FOREWORD

This Indian Standard (First Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Spillways Including Energy Dissipators Sectional Committee had been approved by the River Valley Division Council.

A number of multi-purpose river valley projects including dams with spillways and similar overflow structures are being taken up in the country. As such, standardization of their construction practices has acquired significance so that optimization of cost, material and time can be achieved. It is with this aim that this standard has been prepared.

For general principles of concrete and concreting, reference may be made to IS 456 : 1978 'Code of practice for plain and reinforced concrete (*third revision*)' and IS 457 : 1957 'Code of practice for general construction of plain and reinforced concrete for dams and other massive structures'. For construction of masonry, reference may be made to IS 8605 : 1977 'Code of practice for construction of masonry in dams' For design of gravity dams, reference may be made to IS 6512 : 1984 'Criteria for design of solid gravity dams (*first revision*)' and for drainage system reference may be made to IS 10135 : 1985 'Code of practice for drainage system for gravity dams, their foundations and abutments (*first revision*)'.

This standard was first published in 1984. The present revision has been prepared to incorporate the latest practices prevailing in the field. In this revision recommendations regarding concrete mix strength and aggregate size, and finishes for formed and unformed surfaces have also been modified.

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

CONSTRUCTION OF SPILLWAYS AND SIMILAR OVERFLOW STRUCTURES — CODE OF PRACTICE

(First Revision)

1 SCOPE

This standard deals with procedures for construction of concrete and masonry spillways and similar overflow structures.

2 REFERENCES

The Indian Standards listed in Annex A are necessary adjuncts to this standard.

3 GENERAL

Construction of concrete and masonry spillways and similar overflow structures may involve all or a number of the following items:

a) Diversion of river;
b) Excavation and preparation of foundation;
c) De-watering;
d) Masonry construction and/or concreting;
e) Instrumentation;
f) Installation of gates and their hoisting arrangements; and
g) Provision of bridge superstructure.

4 DIVERSION OF RIVER

When spillway is located in river channel section, the diversion arrangements for constructing spillways form part of overall dam construction and should mainly depend on the type of dam, for a spillway may be used with both rigid and non-rigid dams. The diversion arrangements to a lesser extent may also be necessary for construction of a spillway adjoining the main dam or separate from it on a saddle across a minor stream. For details of diversion reference may be made to IS 9461 : 1980, IS 9795 (Part 1) : 1981, IS 10084 (Part 1) : 1982, IS 10084 (Part 2) : 1994, IS 10788 (Part 1) : 1984 and IS 13912 : 1993.

5 EXCAVATION AND PREPARATION OF FOUNDATION

5.1 Excavation

Excavation should be carried out keeping in view the provisions given at **5.1.1** to **5.1.3**.

5.1.1 Generally a considerable length of area needs to be excavated to enable the various operations to go on continuously. Congestion in the work area should be avoided.

5.1.2 For excavation to proceed with machinery, the ground water table should be lowered sufficiently to prevent bogging down of the machinery. For details reference may be made to IS 9759 : 1981.

5.1.3 Excavation of foundation for concrete spillway and similar overflow structures should be carried out to the desired depth and concrete should be laid on sound rock. Excavation within 500 mm of the foundation grade should be done just before concrete is laid on sound rock and should not be allowed to remain exposed for long time. In case the geological exploration indicates existence of faults, shear or weak zones, necessary treatment of the foundation should be carried out before laying the concrete.

5.1.4 Blasting operation should be carried out carefully without affecting the rock mass beyond the required area of excavation and shall be restricted to minimum 500 mm above the foundation levels and at least 30 m away from any existing structure. However, in special cases the blasting may be carried out at a distance of less than 30 m from any existing structure using controlled blasting. If necessary, field tests may be carried out to decide various parameters of controlled blasting.

5.1.5 It is desirable to keep the foundation slope upwards in downstream direction.

5.2 Preparation of Foundation

Provisions given at **5.2.1** to **5.2.4** should be kept in view while preparing the foundation.

5.2.1 Immediately before placing concrete/masonry, all surface of foundations upon or against which the concrete/masonry is to be placed, should be free from standing water, mud, debris, organic deposits, and other foreign material which may prevent a tight bond between the rock and concrete/masonry. All surfaces of rock upon or against which the concrete/masonry is to be placed should, in addition to the foregoing requirements, be clean, solid and free from all objectionable coatings, sand loose, semidetached or unsound

fragments and should be sufficiently rough to ensure satisfactory bond with the concrete/masonry. The cleaning and roughening of the surface of rock should be performed by the use of high-velocity air-water jets, wet sand blasting, stiff brooms, picks or other effective means satisfactory to the inspection agency. The surfaces of foundation against which concrete/masonry is to be placed shall be kept continuously wet for at least twenty-four hours immediately prior to placing concrete/masonry so that moisture is not drawn from the freshly placed concrete. In case of foundations like soft phylites, mica, schists, etc, the time of wetting required may be appropriately reduced so that the surface does not become sticky, soft and coated with a film of argillaceous or micaceous material which would affect proper bonding of concrete/masonry with foundation.

5.2.2 *Stepping in the Foundation*

5.2.2.1 Stepping in the foundation should be avoided and a continuous foundation profile provided (*see* Fig. 1). The slope in foundation grade should not, normally, exceed 45°.

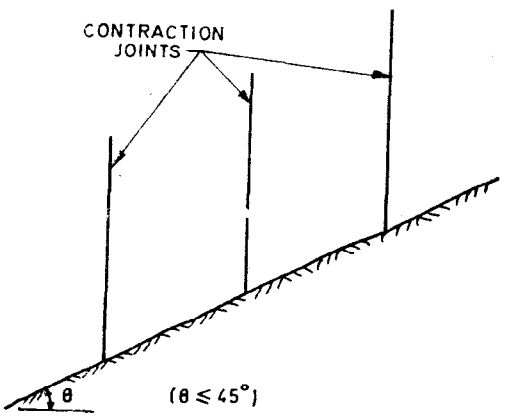
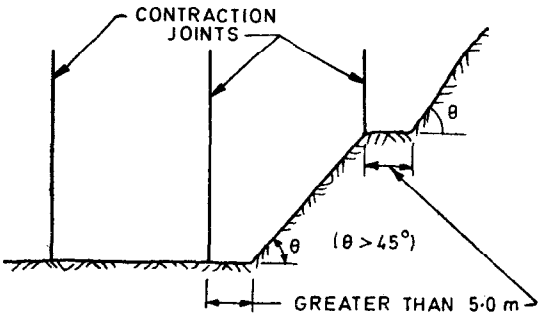


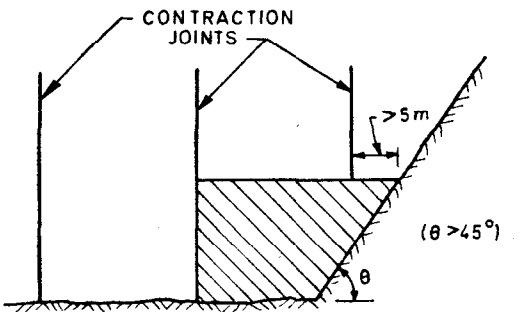
FIG. 1 A TYPICAL CONTINUOUS FOUNDATION PROFILE

5.2.2.2 In cases, where foundation grade has a slope greater than 45°, as in the case of abutments, the arrangement as shown in Fig. 2A or 2B should be adopted. If the alternative shown in Fig. 2B is followed, concreting in shaded portion should be carried out first and allowed to cool down to the temperature of the foundation. The contraction joint should then start for the higher block from the higher level.

5.2.2.3 Whenever there is a break in slope, the contraction joints should be located at the point of break in slope as shown in Fig. 3A. In cases, where location of contraction joints are fixed, arrangement as shown in Fig. 3B should be adopted.

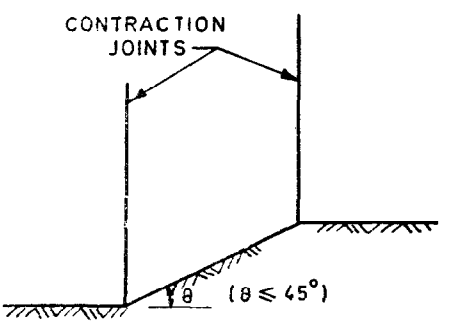


2 A

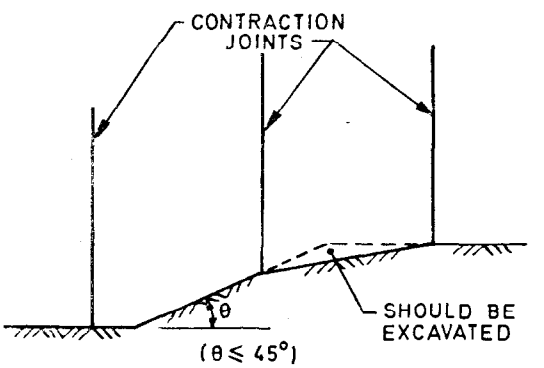


2 B

FIG. 2 LOCATION OF CONTRACTION JOINTS IN FOUNDATION GRADES WITH SLOPES OVER 45°



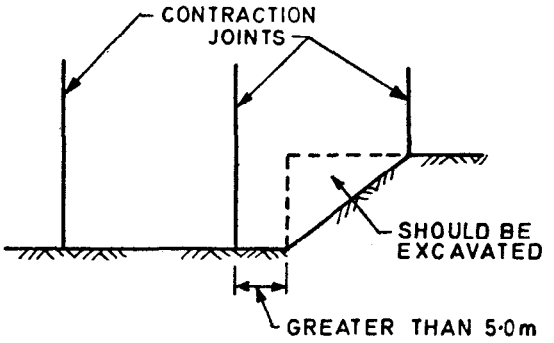
3 A



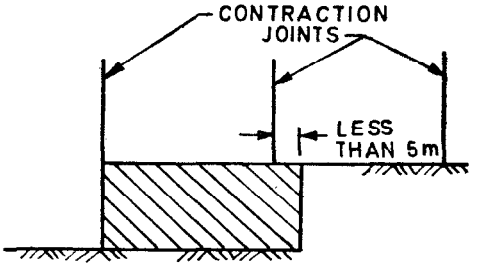
3 B

FIG. 3 LOCATION OF CONTRACTION JOINTS IN FOUNDATION GRADES HAVING BREAK IN SLOPE

5.2.2.4 If the excavated foundation rock profile is likely to be as shown in Fig. 4A and it is not possible to readjust the location of contraction joints, further excavation should be carried out, as shown, if the level portion of the bottom of slope is greater than 5 m. However, if the level portion is less than 5 m, arrangement shown in Fig. 4B may be adopted. If alternative shown in Fig. 4B is adopted, concreting in shaded portion should be carried out first and allowed to cool down to the temperature of the foundation before raising the block further. The contraction joint should then start for higher block from the higher level.



4 A



4 B

FIG. 4 TREATMENT OF FOUNDATION GRADES HAVING STEPS

5.2.2.5 When the spillway is constructed in masonry and foundation slopes are as shown in Fig. 5, concrete of about 0·6 m thickness should be provided at the junction between the rock face and masonry so as to obtain proper bond between masonry and the sandwiched concrete should be filled up simultaneously with every lift of masonry and properly vibrated. Some stone pins should be kept protruding from the side face of the masonry to have proper keying with the sandwiched concrete.

5.2.3 Whenever the foundation is sloping steeply and when shear zones, faults and other weak layers exist in the foundation, necessary treatment of the foundation should be carried out in consultation with the geologist and the designer before laying the concrete.

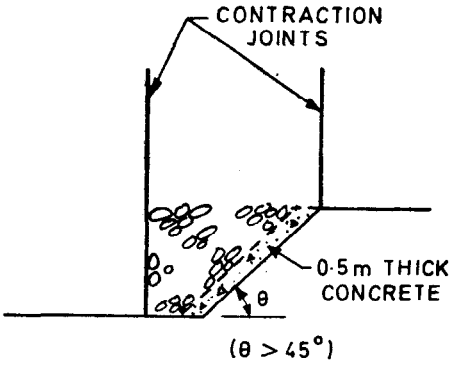


FIG. 5 TREATMENT OF FOUNDATION GRADES HAVING STEPS IN THE CASE OF MASONRY SPILLWAY

5.2.4 In hot climate, it is better to cool foundations before laying concrete. For provisions on the subject, reference may be made to IS 457 : 1957, IS 7861 (Part 1) : 1975 and IS 7861 (Part 2) : 1981.

5.3 Grouting

The principal purpose of grouting is to fill openings in a foundation and render it impervious to percolating water. It is also used to improve the strength and elastic properties of the foundation material into which it is injected. The method of grouting, in large measure, depends upon the nature of treatment to be given to foundation materials which, in turn, depends upon the geological features. For details of grouting for foundation treatment, reference may be made to IS 6066 : 1994.

6 DE-WATERING

6.1 For ease of construction it becomes essential that the work area should be dry. In practice, however, it becomes difficult to obtain a perfectly dry area. Therefore, de-watering system which ensures exclusion of sufficient water to permit the construction to proceed smoothly should be aimed at. Reference may be made to IS 9759 : 1981 for dewatering.

6.2 Concrete levelling course of a suitable thickness may be laid over the excavated surface, if required, for laying the reinforcement in a dry environment.

7 CONCRETE SPILLWAYS

7.1 Material

For proper design of concrete mixes and placing in spillway blocks, general reference may be made to IS 456 : 1978, IS 457 : 1957 and IS 9103 : 1979.

7.1.1 Pozzolanas may be used with advantage in cement concrete mix with a view to effecting economy in construction and to control alkali-aggregate reaction. The pozzolana cement concrete is considered to have less resistance against abrasive forces and cavitation. The use of such concrete should, therefore, be avoided for the top layer of crest and downstream glacis portions, where ordinary Portland cement concrete is recommended. For ordinary Portland cement, reference may be made to IS 269 : 1989 and IS 8112 : 1989. For use of pozzolanic material, reference may be made to IS 1344 : 1981, IS 1489 (Parts 1 and 2) : 1991, IS 1727 : 1967, IS 2541 : 1991 and IS 3812 : 1981.

7.1.2 The concrete mix should be designed on the requirement of strength (*see* IS 6512 : 1984) in different parts of spillway in dams and other considerations. However, the maximum size of aggregate and desirable minimum grade of concrete for different structures connected with spillways in dams are given in Table 1.

7.1.3 The concrete which comes immediately in contact with trunion girder and takes the thrust in bearing from it should be of non-shrinkage quality for a minimum thickness of 300 mm.

7.1.4 *Reinforcement*

The provision of steel reinforcement in concrete should be governed by IS 456 : 1978.

7.2 Concrete Operations and Embedments

Concreting operations should be carried out and embedments made keeping in view the provisions contained in 7.2.1 to 7.2.5. Maximum height of concreting in a single pour should not exceed 2 m, each lift in layers not exceeding 500 mm in thickness, and difference in levels of adjoining blocks should not generally exceed 10 m Concrete should be properly and effectively vibrated.

7.2.1 *Placing Concrete in Spillway*

7.2.1.1 Crest and face of the spillway forming part of the dam should have formed surface. The formed surface should have accurate alignment and evenness of surface for prevention of destructive effect of flowing water. Gradual surface irregularities (*see* Note) should not exceed 6 mm. The chute, bucket and hydraulic jump type stilling basin should have floated unformed surface. Floating should be done either by vibro-screed or metal edged screed. The concrete surface should be left undisturbed for 30 to 45 minutes until surface water disappears and there is no visible skin. Joints and edges should be finished with steel edging tools.

NOTE — Offsets and fins caused by displaced or misplaced form sheathing, lining or form sections, by loose knots in forms or by otherwise defective form lumber are considered as abrupt surface irregularities. All others are closed as gradual surface irregularities. Gradual irregularities are measured with a template consisting of a straight edge for plane surfaces or its equivalent for curved surfaces. The length of template for testing formed surfaces is generally 1·5 m.

7.2.1.2 Precautionary measures should be taken to prevent cavitation or abrasion resulting from abrupt offsets (*see* Note below **7.2.1.1**) on those surfaces of open-flow spillways that may be subject to high velocity flow. Abrupt offsets on such surfaces should not be permitted. The offset, if there is any, should be completely eliminated by grinding to the required bevels according to flow velocity as set forth in Table 2. Abrupt offsets away from the flow or parallel to the flow should only be required to meet the maximum allowable limit for the specified finish as provided in Table 3.

7.2.2 *Temperature Control*

For control of concrete cracking and development of high thermal stresses, temperature control of concrete is necessary. This may be achieved by precooling of concrete in gradients so as to obtain desirable placement temperature of concrete. The concrete, as deposited, should have a temperature of not more than the stipulated value (usually 15 to 21°C for spillway concrete in hot climate). The temperature of the concrete should be not less than 5°C in moderate weather or 10°C when the mean daily temperature is lower than 5°C. As an additional precaution when the mean daily temperature is lower than 5°C, one percent calcium chloride by mass of cement may be used to bring the concrete to a stage of greater maturity at the end of the specified period of protection. Reference may be made to IS 7861 (Part 1) : 1975 and IS 7861 (Part 2) : 1981 for further details.

7.2.3 *Sequence of Pouring*

Concrete should be poured from downstream face side towards upstream face side. The surface of each pour may be provided with upward slope of about 1 in 100 in downstream direction.

7.2.4 *Cold, Transverse and Longitudinal Joints*

7.2.4.1 Cold joint between two lifts should be avoided. This may be done by adopting the following steps:

a) Green cutting of top surface of first lift;

b) Sand blasting and cleaning of top surface of previous lift; and

c) Anchor bars may be provided, if necessary.

Table 1 Concrete Mix Strength and Aggregate Size

(*Clause* 7.1.2)

Sl No.	Structure	Maximum Size of Aggregate in mm	Desirable Minimum Concrete Grade
(1)	(2)	(3)	(4)
i)	Spillway mass concrete	150	M 15
ii)	Around opening with reinforcement	40	M 20
iii)	1·5 to 2·5 m thick on upstream face excluding crest of spillway	150	M 20
iv)	Spillway crest (minimum 1·5 m thick on surface), downstream spillway face	80	M 20
v)	Spillway bucket, stilling basin		
	a) all concrete in the top 0·6 m including baffle walls, end sills, chute blocks, etc	40	M 25
	b) all concrete below 0·6 m from top surface	80	M 20
vi)	Retaining walls of spillway		
	a) minimum 1·5 m on face	150	M 20
	b) interior	150	M 15
	c) reinforced retaining walls	80	M 20
vii)	Irregularities of foundation	40	M 20
viii)	Spillway piers and breast walls	80	M 20
ix)	Spillway bridge deck		
	a) Beams	40	M 20
	b) Deck	20	M 20
x)	Trash rack structure	40	M 20
xi)	Block outs	20	M 20

Table 2 Offset and Grinding Tolerance for High Velocity Flow

(*Clause* 7.2.1.2)

Sl No.	Velocity Range, Metres per Second	Grinding Bevel, Ratio of Height to Length
i)	10 to 25	1 to 20
ii)	25 to 35	1 to 50
iii)	Over 35	1 to 100

Table 3 Maximum Allowance of Irregularities in Surface Finish

(*Clause* 7.2.1.2)

Sl No.	Type of Irregularities	Finish (Formed Surface)[1] Maximum Permissible				Finish[2] (Unformed Surface)[3] Value in Millimetres		
		F_1	F_2	F_3	F_4	U_1	U_2	U_3
i)	Depression	25·0						
ii)	Gradual		10·0	3·0	3·0			
iii)	Abrupt		3·0	1·5	Not allowed			
iv)	All surfaces					10·0	5·0	5·0

[1]Allowance in millimetres — measured from 1·5 metre template.

[2]For classes of finish refer IS 457 : 1957.

[3]Allowance in millimetres — measured from 3 metre template.

7.2.4.2 A high quality of bond and water tightness in a horizontal construction joint is best assured when the concrete, and specially that in the upper portion of the lift, has the least slump that will permit proper working and consolidation. Wet mixes, particularly, should be avoided. Their tendency to segregate and bleed badly results in weak concrete and a heavy layer of laitance at the surface which makes clean up difficult.

7.2.4.3 The quality of the joint depends on the quality of the concrete and on the clean up to the joint surface. Footprint, protruding pieces of large aggregate or depressed keys interfere with accomplishment of good clean up. Such features also make necessary complete removal of free water difficult, which, if not accomplished, may prevent good bond even though the surface is otherwise properly cleaned. Proper use of vibrator usually leaves the surface suitably even.

7.2.4.4 *Surface of construction and contraction joints*

The surface of construction joint should be clean, rough and damp when covered with fresh concrete. Cleaning should consist of the removal of all laitance, loose or defective concrete, coatings, sand, sealing compound, if used, and other foreign materials. Cleaning should be accomplished by wet sand blasting, followed by thorough washing. The joints in mass concrete, and where practicable in other concrete, should be cleaned and washed immediately before concrete in the next lift is placed. Where it is not practicable to clean the joints after forms are set, the joints should be wet sand blasted and washed at the last opportunity prior to setting the forms and the joints should be washed thoroughly with air-water jets immediately prior to placement of the adjoining concrete. The method to dispose of waste water used in curing and washing of concrete surfaces should be such that the waste water does not stain, discolour, or affect the exposed surfaces of the structures. All embedded pipes, recesses, or openings used for disposing of waste water should, after they have served their purpose, be filled completely with concrete mixed in the proportions specified. All pools of water should be removed from the surfaces of construction joints before the new concrete is placed. The surfaces of all contraction joints should be cleaned thoroughly of accretions of concrete or other foreign material by scraping, chipping or other satisfactory means. All concrete surfaces of contraction joints should be pointed with two coats of coal tar pitch.

7.2.4.5 *Placing of anchors in concrete*

Anchor bolts, structural shapes, plates and bearings required in connection with the installation of gates, gate hoists, operating machinery and other apparatus should be placed in concrete as shown on the drawings or as found necessary. Wherever practicable, anchors should be installed before the concrete is placed and, except as otherwise provided, drilling for installation of anchors in concrete should not be permitted. Where the installation of anchors prior to placing the concrete is not practicable, satisfactory formed openings should be provided and the anchors should be grouted into the openings at some later time. Anchor bolts for machinery may be placed in approved pipe sleeves to facilitate installation of machinery and the sleeves should be completely filled with grout after the locations of the bolts are finally determined. In order to avoid cracking of face concrete, the bonded anchors should be insulated to a minimum of 500 mm length from the trunion.

7.2.4.6 *Placing of anchors in rock*

Wherever necessary, holes should be drilled into the rock to receive bars for anchoring concrete walls, spillway buckets, stilling basins and ground mats to the rock. The diameter of anchor bar holes should be not less than 1·5 times the diameter or greatest transverse dimension of the anchor bar specified for that hole. Anchor bars should be cleaned thoroughly before being placed. The holes should be cleaned thoroughly, kept flagged until placing the bars and should be filled completely and compactly with grout or mortar. All water should be removed from the hole when the anchor grout is placed. The anchor bar should be forced into place before the grout or mortar has taken its initial set and where practicable, should be vibrated or tapped until entire surface of the embedded portions of the bars is in intimate contact with the grout. Anchor bars should be placed in advance of concrete operation to allow the grout to set. Special care should be taken to prevent movement of the bars after they have been set.

7.2.4.7 *Embedment of pipes*

Metal pipes required in connection with drilling of grout holes and drainage holes from the gallery should be placed in the concrete. For details reference may be made to IS 10135 : 1985.

7.2.4.8 *Chipping and roughening of concrete surface*

At places, as directed by the inspection agency, concrete surface upon or against which additional concrete is to be placed should be chipped and roughened to a depth of not more than 25 mm of the surfaces. The roughening should be performed by chipping or other satisfactory methods and in such a manner as not to loosen, crack, or shatter any part of the concrete beyond the roughened surface. After being roughened, the surface of the concrete should be cleaned thoroughly of all loose fragments, dirt, lime and other objectionable materials and should be sound, hard and in such condition as to assure good mechanical bond

between old and new concrete. Concrete which is not hard, dense and durable, should be removed to the depth required to secure a satisfactory surface.

7.2.4.9 To stop seepage of water through transverse joints double seals are generally used. For seals at contraction joints reference may be made to IS 4461 : 1979 and IS 12200 : 1987.

7.2.5 The following should be kept in view:

a) It is desirable to have surface slope of 1 in 100 rising from upstream face to downstream face for better shearing stability.

b) Formed construction joints should be avoided wherever practicable as they result in planes of weakness susceptible to the formation of cracks and to the passage of water unless effective water stops are provided.

c) The joints should be provided with chamfers at the upstream and downstream face to avoid cracking of concrete due to thermal expansion when stress concentration may occur at the edges. The size of such chamfer may be kept as 25 × 25 mm or 40 × 40 mm. The chamfer may be reduced on the downstream face of overflow sections since the joint lies centrally in each bay and bigger recess may give undesirable flow conditions.

7.2.6 *Concreting Around Openings*

7.2.6.1 For concreting around openings like galleries, sluices and block-outs it should be ensured that the centering, formwork and permanent steel lining where provided are properly erected in place and are in proper line and level before placement of concrete. Reinforcement, where necessary, should be accurately placed and secured in position before placement of concrete.

7.2.6.2 If concrete is placed monolithically around openings having vertical dimensions greater than 0·6 m, or if concrete in decks, floor slabs, beams, girders or other similar parts of structures is placed monolithically with supporting concrete, following instructions should be strictly observed:

a) Placing of concrete should be delayed by not less than one hour nor more than three hours at the top of openings and at the bottom of fillets under decks, floor slabs, beams, girders or other similar parts of structures when fillets are specified and at the bottom of such structural members when fillets are not specified, but in no case should the placing be delayed so long that the vibrating unit will not of its own weight readily penetrate the concrete placed before the delay. When consolidating concrete placed after the delay, the vibrating unit should penetrate and revibrate the concrete placed before the delay.

b) The last 0·6 metre or more of concrete placed immediately before the delay should be placed with as low a slump as practicable and should be thoroughly compacted.

c) The surface of concrete where delays are made should be clean and free from loose and foreign material when concrete placing is started after the delay.

d) Concrete placed over openings and in decks, floors, beams, girders and other similar parts of structures should be placed with as low a slump as practicable and special care should be exercised to effect thorough consolidation of concrete.

7.2.6.3 The concrete should be worked into the corners and angles of the forms and around the reinforcement, instruments and other embedded items, without permitting segregation. While placing concrete it should be ensured that the reinforcement, instruments and other embedded parts are not displaced. Care should be taken in placing concrete around the forms and permanent steel lining to avoid damage to them. The concrete should not be dumped directly from buckets on them.

7.2.7 *Batching, Mixing and Placement of Concrete*

7.2.7.1 The batching and mixing plant should be able to accurately determine and control the prescribed amount of various ingredients of the concrete by separate weighting. For other details reference may be made to IS 457 : 1957.

7.2.7.2 The batching and mixing plant should be so designed as to ensure uniform distribution of all ingredients throughout the mass at the end of the mixing period.

7.2.7.3 The concrete should be conveyed from the batching and mixing plant to the forms as rapidly as practicable by the methods which will prevent separation or loss of ingredients.

7.2.7.4 The concrete should be placed in its final location within 30 minutes after mixing. Placing of concrete should be done preferably with bottom dump buckets with arrangements for positive regulation of the amount and the rate of placement of concrete.

7.2.8 *Compaction of Concrete*

7.2.8.1 The concrete should be compacted to obtain the maximum practicable density uniformly over the whole mass. Vibrators of proper design should be used for the purpose and the intensity and duration of vibration should be sufficient to produce satisfactory compaction. The vibrators should be checked periodically. Vibrators having vibrator head 100 mm or more in diameter should be operated at least 6 000 rev/min when immersed in concrete. Vibrators having vibrator head less than 100 mm in diameter should be operated at

least 7 000 rev/min when immersed in the concrete.

7.2.8.2 Systematic spacing of the points of vibration should be established to ensure that no portions of the concrete are missed. The entire depth of a new layer of concrete should be vibrated and the vibrator should penetrate several centimetres into the layer below to ensure thorough union of layers. Excessive vibration causing segregation and laitance or that tending to bring excessive amount of water to the surface should be avoided. In no case should the vibrators be used to transport concrete inside the forms. Care should be taken to avoid contact of the vibrators with the surface of the forms or displacement of the reinforcement, instrument or embedded parts.

7.2.9 *Finishes*

Recommended finishes for formed and unformed surfaces are given in Table 4.

Table 4 Finishes for Formed and Unformed Surfaces

Sl No.	Formed/Unformed Surfaces	Type of Finish[1)]
(1)	(2)	(3)
i)	Upstream face of concrete dam below MDDL and surfaces upon or against which fill material or concrete is to be placed.	F_1
ii)	Galleries and adits; retaining walls, bridges not prominently exposed to public inspection and surfaces not permanently concealed by fill materials or concrete or not required to receive finishes F_1, F_3 and F_4.	F_2
iii)	Structures permanently exposed to public view, that is parapets, spillway piers, interior and exterior walls of hoist elevator towers and other decorative features.	F_3
iv)	Spillway crest, spillway face, spray walls, part of intake for canal, penstocks, outlets for canal structures and river sluice conduits and all surfaces for which accurate alignment and evenness of surface are important from the stand point of eliminating destructive effects of water action.	F_4
v)	Road surfaces/other surfaces that will be covered by fill material/ concreted (screeded finish).	U_1
vi)	Floors of spillway outlet works and stilling basin, floors of gallery and exposed face of spillway bridges.	U_2
vii)	Top of parapets, stair treads, gallery floors and spillway buckets/hydraulic jump type stilling basin.	U_3

NOTE — When waterflow velocities on unformed concrete surface of outlet works, spillways, etc, are calculated to exceed 15 m/s, further limitations on U_2 and/or U_3 finishes should be considered for the allowable irregularities to prevent cavitation.

[1)]For types of finish, reference may be made to IS 457 : 1957.

7.2.10 *Tolerances*

All concrete structures should be constructed to exact lines, grades and dimensions established. However, inadvertent variations from the established lines, grades and dimensions should be permitted to the extent set forth in Annex B.

7.2.11 Proper quality control should be ensured in accordance with IS 457 : 1957.

7.3 The concrete placement may be done by any of the following methods:

a) Trestle and crane system;
b) Cableways;
c) Multi-trestle system;
d) Concrete pump;
e) Truck mixers, dump trucks; or
f) Belt conveyors.

8 MASONRY SPILLWAYS

8.1 General

In masonry dams, it is a general practice to provide concrete lining on the crest as well as the glacis. For details of construction of masonry, reference may be made to IS 8605 : 1977.

8.2 Concrete Lining

It is important to ensure proper bonding of the lining with the underlying masonry and to provide smooth surface finish conforming to design profile. The concrete should be homogeneous and well compacted by vibrators. The lining should be provided with concrete of grade M 20.

8.2.1 *Lining on Upstream Face*

The lining should be provided from an elevation where tension starts developing and is taken up to the crest. The thickness of lining should be designed on the basis of tension developed with a minimum of 1·0 m, with thickness increasing towards crest. Anchor bars of 25 mm diameter at 1·5 m centre to centre both ways should be provided, embedded 1·5 m into the mosonry. Reinforcement in lining should be provided in accordance with design requirements. A typical section of spillways showing these details is given in Fig. 6.

8.2.2 *Measures of Seepage Control Through Upstream Masonry Face*

8.2.2.1 In order to achieve adequate imperviousness and thereby to reduce the seepage of water through the upstream face of masonry spillway, seepage control arrangement should be provided. Several such preventive measures are described

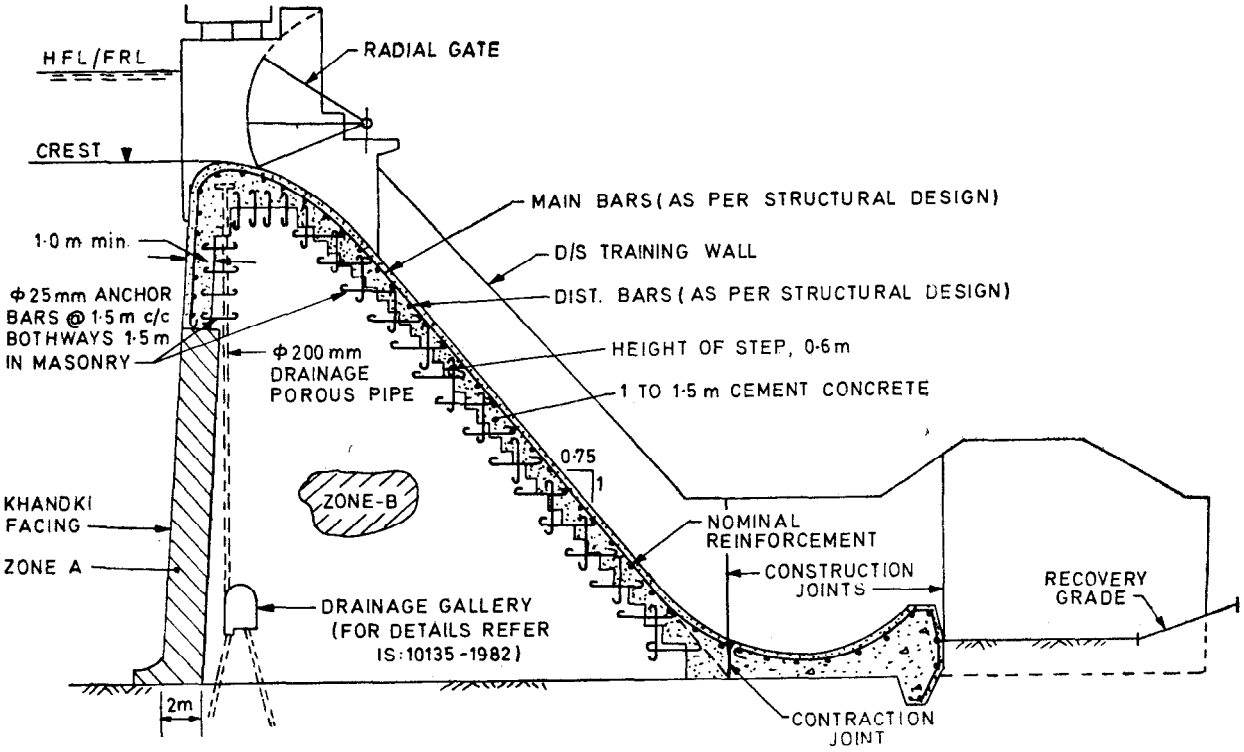
below, of which a suitable alternative may be adopted:

a) *Coursed rubble masonry (Khandki facing upstream) with adjacent rich mortar zone* — The upstream masonry in about 2 to 3 m thickness should be constructed in rich cement mortar (1 cement : 3 sand) with coursed rubble (khandki) facing upstream (*see* Fig. 7). A khandki is a selected stone 600 to 900 mm long, 400 to 500 mm wide and 200 to 300 mm high. Its face to be exposed upstream is properly dressed on the surface and the periphery is also dressed evenly to a depth of 50 to 70 mm inside from the surface. The dressed periphery facilitates provision of uniform and tight mortar joints. The rest of the masonry beyond the rich zone should be constructed according to the proportion and workmanship specified.

b) *Upstream concrete facing* — A concrete membrane on the upstream face replacing khandki as in (a) backed with rich masonry may be provided. The concrete membrane should be properly bonded to the dam masonry by means of keys and anchor bars to prevent separation of concrete from the masonry either due to shrinkage of concrete or due to build-up of hydrostatic pressure at the interface. The concrete membrane may be either thin, about 1·5 to 2 m, with surface temperature reinforcement (*see* Fig. 8) or thick, about 3 m, without temperature reinforcement (*see* Fig. 9).

c) *Sandwich concrete membrane* — A sandwich concrete membrane between the upstream face stone masonry and the hearting (or core) masonry may be provided as shown in Fig. 10 to act as an intercepting curtain. The thickness of the concrete membrane should be about 1·5 m. It should be constructed simultaneously with the lifts of the upstream and downstream masonry work. Suitable keys in concrete and dowel bars between concrete and masonry should be provided as shown in Fig. 10 to have monolithic action of the concrete membrane and the masonry. No temperature reinforcement is necessary as the membrane is not exposed.

d) *Prepacked sandwich concrete* — A membrane of prepacked sandwich concrete may be used as shown in Fig. 11. In this method the space to be concreted is prepacked with well graded coarse aggregate and then sand cement mortar is pumped into it from bottom up by means of perforated pipes already laid in the aggregates.



NOTES

1 *ZONE A* : Masonry in rich cement mortar proportion 1 : 3.

2 *ZONE B* : Masonry in lean cement mortar proportion 1 : 5.

3 For details of drainage arrangement, refer IS 10135 : 1985.

FIG. 6 TYPICAL CROSS-SECTION OF SPILLWAY

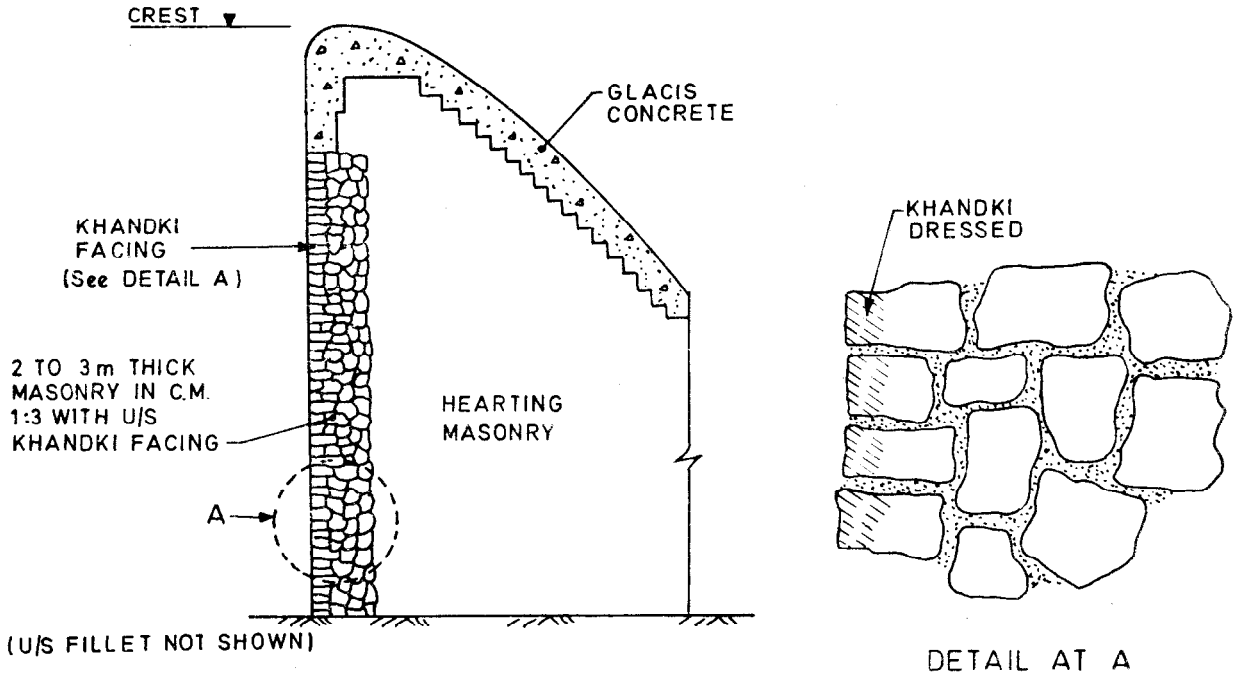


FIG. 7 KHANDKI FACING WITH RICH MASONRY ZONE ON UPSTREAM

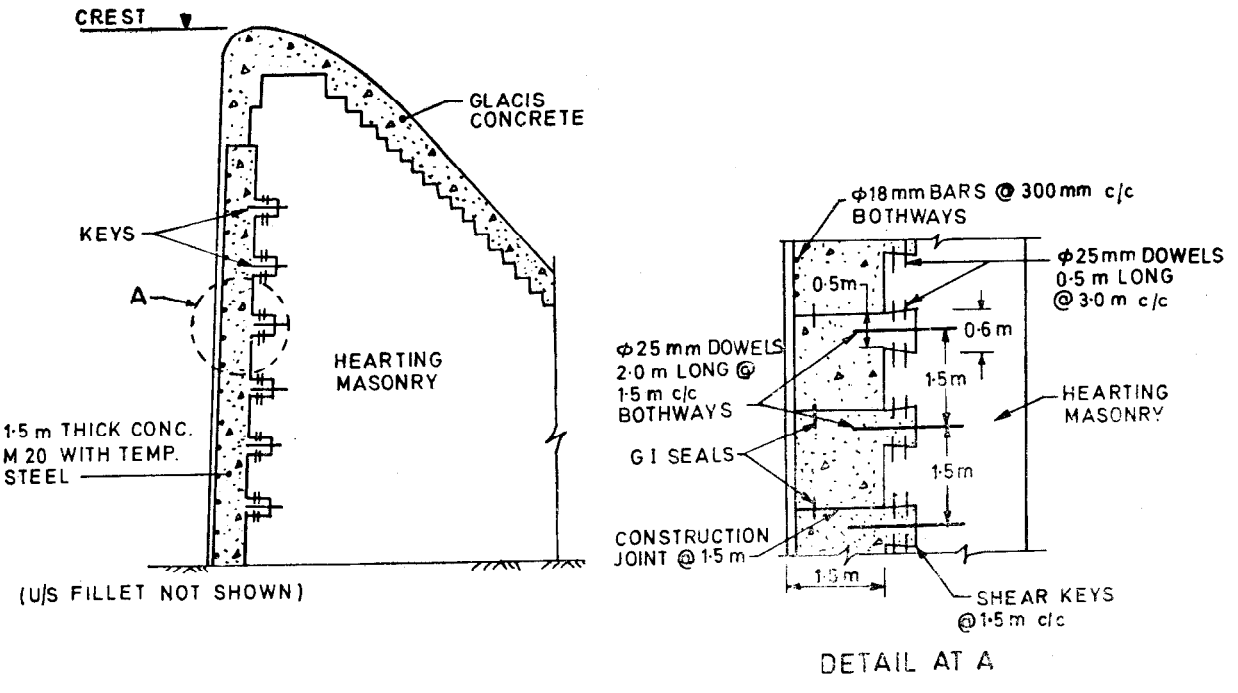


FIG. 8 THIN CONCRETE MEMBRANE WITH REINFORCEMENT ON UPSTREAM FACE

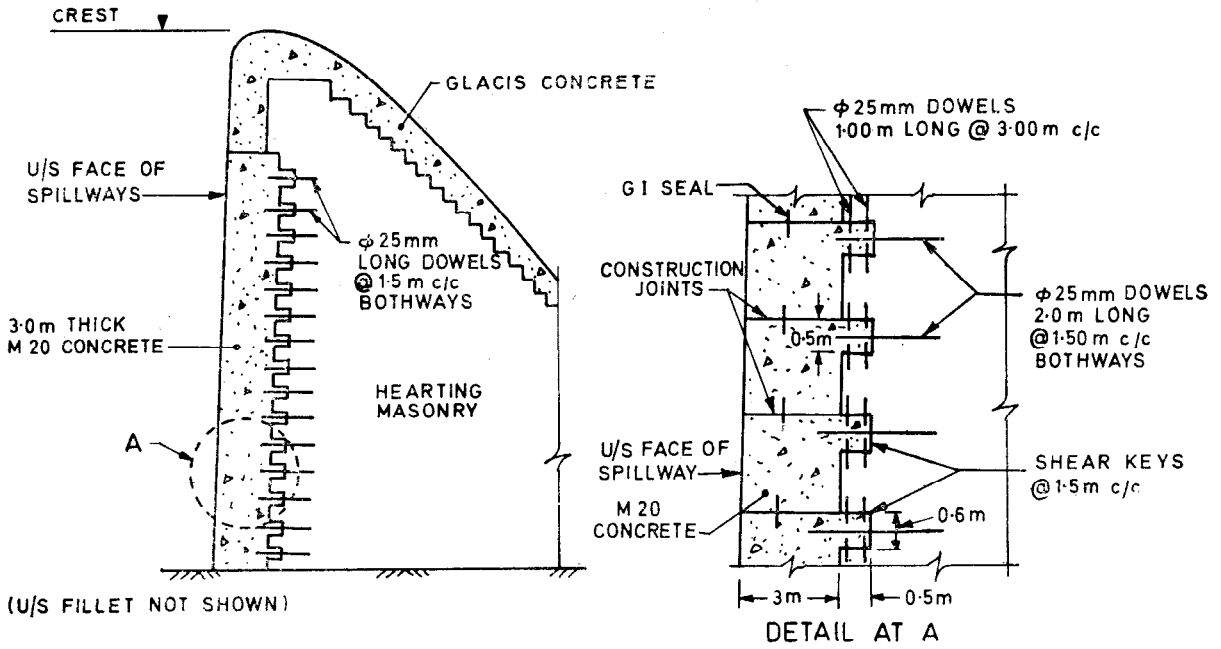


FIG. 9 THICK CONCRETE MEMBRANE ON UPSTREAM FACE

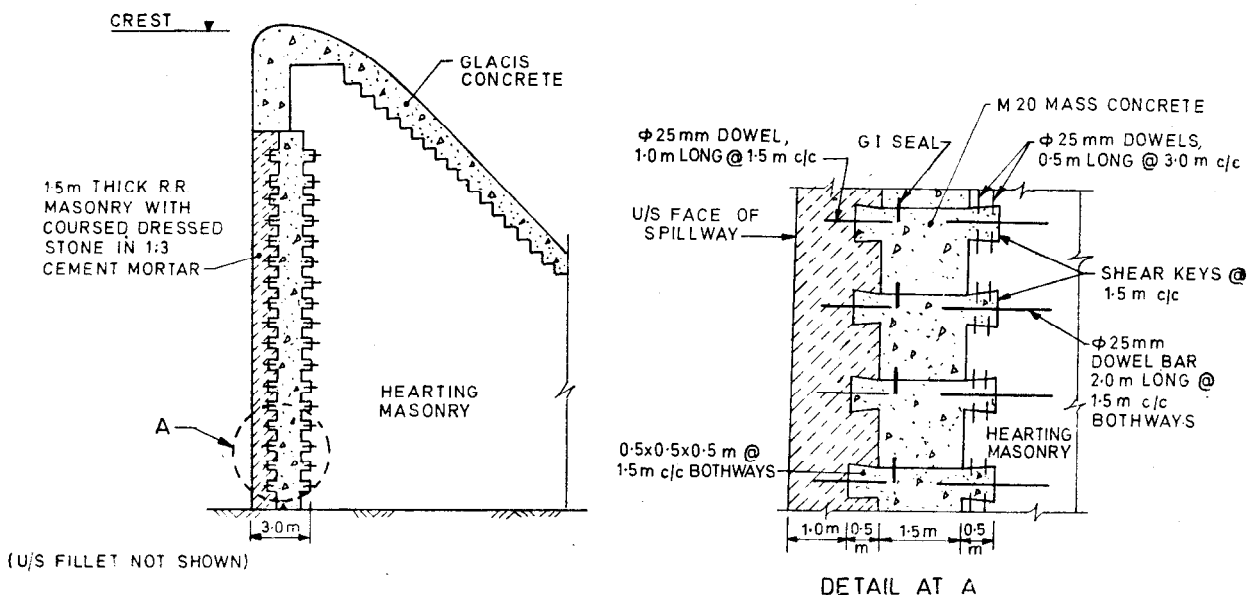


FIG. 10 SANDWICH CONCRETE MEMBRANE ON UPSTREAM FACE

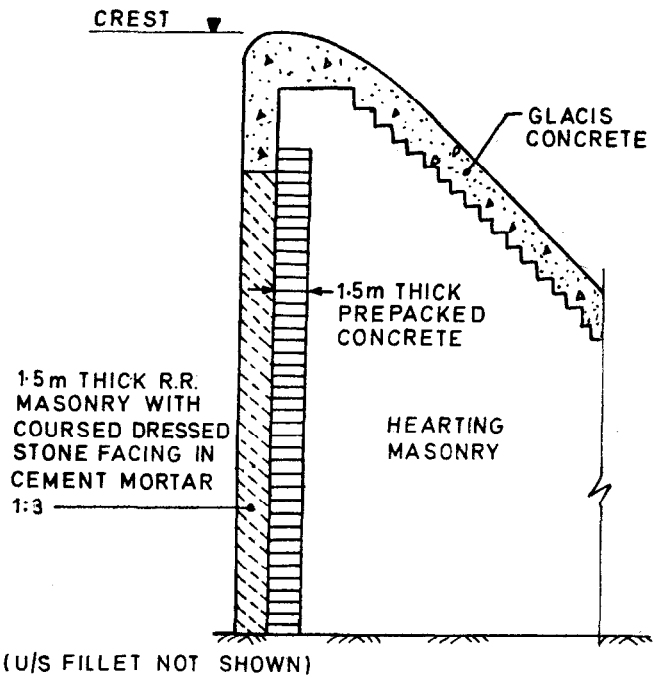


FIG. 11 PREPACKED SANDWICH CONCRETE MEMBRANE ON UPSTREAM FACE

8.2.2.2 Guniting with rich cement mortar may be resorted to for reducing the seepage from the upstream face (*see* IS 13645 : 1993). This technique should, however, be considered more as a remedial measure rather than a preventive measure for seepage control.

8.2.3 *Lining on Crest and Downstream Glacis*

Lining of uniform thickness is provided on the downstream glacis between the tangent points for crest and tangent points for bucket. Lining of a thickness of 1·5 m for major dams and 1·0 m for medium dams is normally provided. Masonry in contact with the lining should be constructed in steps of about 0·6 m. Anchor bars of 25 mm diameter should be provided at 1·5 m centre to centre both ways and embedded 1·5 m into masonry. These bars are provided horizontally as well as vertically for achieving bond between the masonry and concrete. Typical details are shown in Fig. 6.

9 DRAINAGE HOLES

Drainage holes should be provided in accordance with the provisions contained in IS 10135 : 1985.

10 INSTRUMENTATION

It is very important that proper instruments are installed and monitored in the structure to keep a watch on its structural and hydraulic behaviour. Such information is of immense help in taking precautionary corrective measures well ahead of any possible failure. For details of installation and observation of instruments reference may be made to IS 4967 : 1968, IS 6524 : 1972, IS 7436 (Part 2) : 1976, IS 8282 (Part 1) : 1976, IS 10334 : 1982 and IS 10434 (Part 1) : 1982.

11 INSTALLATION OF GATES AND HOISTING ARRANGEMENTS

An appropriate arrangement of gates and hoists should be provided. Reference may be made to IS 4623 : 1984, IS 10096 (Part 1/Sec 1) : 1983, IS 4622 : 1992, IS 5620 : 1985, IS 9349 : 1986 and IS 7718 : 1991.

ANNEX A
(*Clause* 2)

LIST OF REFERRED INDIAN STANDARDS

IS No.	*Title*
269 : 1989	Specification for 33 grade ordinary Portland cement (*fourth revision*)
456 : 1978	Code of practice for plain and reinforced concrete (*third revision*)
457 : 1957	Code of practice for general construction of plain and reinforced concrete for dams and other massive structures
1344 : 1981	Specification for calcined clay pozzolana (*second revision*)
1489 (Part 1) : 1991	Specification for Portland pozzolana cement : Part 1 Fly ash based (*third revision*)
1489 (Part 2) : 1991	Specification for Portland pozzolana cement : Part 2 Calcined clay based (*third revision*)
1727 : 1967	Methods of tests for pozzolanic materials (*first revision*)
2541 : 1991	Code of practice for preparation and use of lime concrete (*second revision*)
3812 : 1981	Specification for fly ash for use as pozzolana and admixture (*first revision*)
4461 : 1979	Code of practice for joints in surface hydro-electric power stations (*first revision*)
4622 : 1992	Recommendations for structural design of fixed wheel gates (*second revision*)
4623 : 1984	Recommendations for structural design of radial gates (*second revision*)
4967 : 1968	Recommendations for seismic instrumentation for river valley projects
5620 : 1985	Recommendations for structural design criteria for low head slide gates (*second revision*)
6066 : 1994	Recommendations for pressure grouting of rock foundations in river valley projects (*second revision*)
6512 : 1984	Criteria for design of solid gravity dams (*first revision*)
6524 : 1972	Code of practice for installation and observation of instruments for temperature measurement inside dams, resistance type thermometers
7436 (Part 2) : 1976	Guide for types of measurements for structures in river valley projects and criteria for choice and location of measuring instruments : Part 2 Concrete and masonry dams
7718 : 1991	Recommendations for inspection, testing and maintenance of fixed wheel and slide gates (*first revision*)
7861 (Part 1) : 1975	Code of practice for extreme weather concreting : Part 1 Recommended practice for hot weather concreting
7861 (Part 2) : 1981	Code of practice for extreme weather concreting : Part 2 Recommended practice for cold weather concreting
8112 : 1989	Specification for 43 grade ordinary Portland cement (*first revision*)
8282 (Part 1) : 1976	Code of practice for installation, maintenance and observation of pore pressure measuring devices in concrete and masonry dams : Part 1 Electrical resistance type cell
8605 : 1977	Code of practice for construction of masonry in dams
9103 : 1979	Specification for admixtures of concrete
9349 : 1986	Recommendations for structural design of medium and high head slide gates (*first revision*)
9461 : 1980	Guidelines for data required for design of temporary river diversion works
9759 : 1981	Guidelines for de-watering during construction

IS No.	*Title*
9795 (Part 1) : 1981	Guidelines for the choice of the type of diversion works : Part 1 Coffer dams
10084 (Part 1) : 1982	Criteria for design of diversion works : Part 1 Coffer dams
10084 (Part 2) : 1994	Design of diversion works — Criteria : Part 2 Diversion channels and open cut or conduit in the body of dam
10096 (Part 1/Sec 1) : 1983	Recommendations for inspection, testing and maintenance of radial gates and their hoists : Part 1 Inspection, testing and assembly at the manufacturing stage, Section 1 Gates
10135 : 1985	Code of practice for drainage system for gravity dams, their foundations and abutments (*first revision*)
10334 : 1982	Code of practice for selection, splicing, installation and providing protection to the open ends of cables used for connecting resistance type measuring devices in concrete and masonry dams
10434 (Part 1) : 1982	Guidelines for installation, maintenance and observation of deformation measuring devices in concrete and masonry dams : Part 1 Resistance type jointmeters
10788 (Part 1) : 1984	Code of practice for construction of diversion works : Part 1 Cellular coffer dams
12200 : 1987	Code of practice for provision of water stops at transverse contraction joints in masonry and concrete dams
13645 : 1993	Guniting the upstream of masonry dams — Guidelines
13912 : 1993	Closure of diversion channel and open cut or conduit in the body of dam — Code of practice

ANNEX B

(*Clause* 7.2.10)

CONSTRUCTION TOLERANCES FOR MASS CONCRETE STRUCTURES

B-1 MASS CONCRETE STRUCTURES

B-1.1	All structures:		
	a) Variation of the constructed linear outline from established position in plan	In 6 metres In 12 metres	12 mm 20 mm
	b) Variation of dimensions to individual structure features from established positions	In 24 metres or more In buried construction twice the values specified above	32 mm
B-1.2	a) Variation from the plumb, from the specified batter or from the curved surfaces of all structures including the lines and surfaces of columns, walls, piers, buttresses, arch sections, vertical joint grooves, and visible arrises	In 3 metres In 6 metres In 12 metres or more In buried construction twice the values specified above For water tight joints *see* **B-1.5**	12 mm 20 mm 30 mm
	b) Variation from the level or from the grades in slabs, beams, soffits, lintels, sills, horizontal joint grooves, and visible arrises	In 3 metres In 6 metres In buried construction twice the values specified above	6 mm 12 mm
B-1.3	a) Variation in cross-sectional dimensions of columns, beams, buttresses, piers, and similar members		− 6 mm + 12 mm

b) Variation in thickness of slabs, walls, arch sections and similar members		− 6 mm + 10 mm
B-1.4 Footing for columns, piers, walls, buttresses and similar members		
a) Variation of dimensions in plan		− 12 mm + 50 mm
b) Misplacement or eccentricity		2 percent of footing width in the direction of misplacement but not more than 50 mm
c) Reduction in thickness		5 percent of specified thickness
B-1.5 Variation from the plumb and levels for sidewalls and sills for gates and similar watertight joints		Not greater than a rate of 3 mm in 3 metres
B-1.6 Variation in the sizes and locations of sleeves, floor openings and wall of openings		6 mm
B-1.7 Variation in steps		
a) In a flight of stairs		Rise 3 mm Tread 6 mm
b) In consecutive steps		Rise 1·5 mm Tread 2 mm

B-2 REINFORCED CONCRETE CONSTRUCTION

B-2.1 Variation from the plumb		
a) In the lines and surfaces of columns, piers, walls and in arrises	In 3 metres In 6 metres In 12 metres or more	6 mm 10 mm 20 mm
b) For exposed corner columns, control-joint grooves and other conspicuous lines	In any bay or 6 metres In 12 metres or more	6 mm 12 mm
B-2.2 Variation from the level or from the grades:		
a) In floors, ceilings, beam soffits and in arrises	In 3 metres In any bay or 6 metres maximum In 12 metres or more	6 mm 10 mm 20 mm
b) For exposed lintels, sills, parapets, horizontal grooves and other conspicuous lines	In any bay or 6 metres maximum In 12 metres or more	6 mm 12 mm
B-2.3 Variation of the linear building lines from established position in plan and related position of columns, walls and partitions	In any bay or 6 metres maximum In 12 metres or more	12 mm 25 mm
B-2.4 Variations in the sizes and locations in sleeves, floor openings and wall openings		6 mm
B-2.5 Variation in cross-sectional dimensions of columns and beams and in the thickness of slabs and walls		− 6 mm + 12 mm
B-2.6 Footings		
a) Variation of dimensions in plan		− 12 mm + 50 mm

b) Misplacement or eccentricity	2 percent of the footing width in the direction of misplacement but not more than 50 mm	
B-3 CONDUITS		
B-3.1 Departure from established alignment or from established grade	High-velocity conduits	12 mm
B-3.2 Variation in thickness at any point		
Conduits	— 2 percent or 6 mm whichever is greater	
Conduits	+ 5 percent or 12 mm whichever is greater	
B-3.3 Variation from inside dimensions conduits	1/2 percent	

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