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Indian Standard

CODE OF PRACTICE FOR DRAINAGE SYSTEM FOR GRAVITY DAMS, THEIR FOUNDATIONS AND ABUTMENTS

(First Revision)

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(First Revision)

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Indian Standard

CODE OF PRACTICE FOR DRAINAGE SYSTEM FOR GRAVITY DAMS, THEIR FOUNDATIONS AND ABUTMENTS

(First Revision)

0. FOREWORD

0.1 This Indian Standard (First Revision) was adopted by the Indian Standards Institution on 20 November 1985, after the draft finalized by Dams (Overflow and Non-overflow) Sectional Committee had been approved by the Civil Engineering Division Council.

0.2 A dam constructed across any stream disturbs the natural drainage — surface and sub-surface. The seepage water inside the body and foundations of the dam should be disposed of to enhance the safety factor of the structure. Hence, a well planned drainage system is essential.

0.3 During operation of the dam, a watch should be kept on the prevailing uplift pressures so as to assess the adequacy or otherwise of the drainage provided.

0.4 It is necessary to observe and study the quantum of seepage from various sources individually as well as collectively with respect to data on rainfall, reservoir level, etc, and to take remedial measures in case of abrupt departures from the normal.

0.5 This standard was first published in 1982. Many technical comments were received since then. The present revision is being issued to take care of these comments. Important modifications incorporated in this revision include:

a) Provision of water seal to prevent entry of air in drainage holes for minimizing formation of calcium carbonate and thereby reducing choking of drainage holes; and

b) Addition of criteria to determine the necessity of providing a drainage gallery.

1. SCOPE

1.1 This code prescribes general requirements and methods of drainage in and around a gravity dam, its foundations and abutments. It does not cover drainage requirements for energy dissipation devices, chutes and training walls. It may be supplemented by specific requirements to suit the site conditions.

2. CLASSIFICATION

2.1 Drainage is the safe disposal of surface and seepage water in the abutment, foundation and the body of the dam. The drainage is thus classified into the following four categories:

a) Surface drainage,

b) Sub-surface drainage,

c) Internal drainage of the dam, and

d) Foundation drainage.

Although foundation drainage forms a part of the sub-surface drainage, yet for the purpose of this standard, it has been covered under a separate sub-head due to its importance.

3. REQUIREMENTS AND METHODS OF DRAINAGE

3.1 Surface Drainage — All open surfaces in the vicinity of the dam shall be provided with adequate drainage. For this purpose open surface channels shall be so designed and laid as to drain off the area effectively and carry away the surface run-off into the reservoir upstream of the dam or into the river downstream of the dam. The service roads and other approach roads leading to dam shall have proper camber and longitudinal slopes for catch water drains. The water from these catch drains shall be collected at suitable intervals depending on topography, rainfall, etc, and led away into the natural drains away from the dam. The roadway, the ducts for electric cable, the crane rail recesses and any other recesses provided at the top of the dam shall be drained through pipes of at least 100 mm diameter.

3.2 Sub-surface Drainage — This shall be provided for the following purposes, if necessary:

a) Protection of slopes, and

b) Drainage of abutments.

3.2.1 *Protection of Slopes* — In some river valley projects, the hill slopes in the vicinity of abutments need to be protected against likely slips. This shall be done by either providing a combination of concrete cladding/shotcreting and drainage holes or any other suitable

arrangement or by providing drainage holes only. Provision of non-return valves, which allow water to flow towards the reservoir area or hill slopes in the vicinity of abutment only, shall be made in the drainage holes.

3.2.2 *Drainage of Abutments* — The drainage gallery may be extended into the abutment rock, together with provision of cross tunnels, as drainage tunnels, if necessary, for ensuring the stability of abutment blocks or the abutment.

3.3 Internal Drainage of Dam — Internal drainage of a gravity dam usually comprises porous concrete drains/formed drains at the contraction joints and in the body of the dam.

3.3.1 Vertical drains at contraction joints shall be provided to intercept the seepage water through the joint and such seepage water shall ultimately be let out into the drainage gallery system. For water stops to be provided reference may be made to 'Indian Standard code of practice for water stops at transverse contraction joints in masonry and concrete dams' (*under preparation*).

3.3.2 The internal drainage of concrete/masonry dam shall be provided with 200 mm dia vertical drains or uniformly inclined (till they meet the gallery) at 3 m centre to centre. For masonry dams these shall be of precast porous concrete while for concrete dams these shall be formed drains. These shall convey the seepage water through the body of the masonry/concrete dam to drainage gallery system. Suitable water seal to prevent entry of air may be provided at the discharge end of the drainage pipe in the gallery. For masonry dams, the drains shall be of porous concrete blocks while for concrete dams, they shall be formed drains.

3.3.3 A typical detail of porous concrete drain is shown in Fig. 1. The porous concrete drain shall conform to the following requirements:

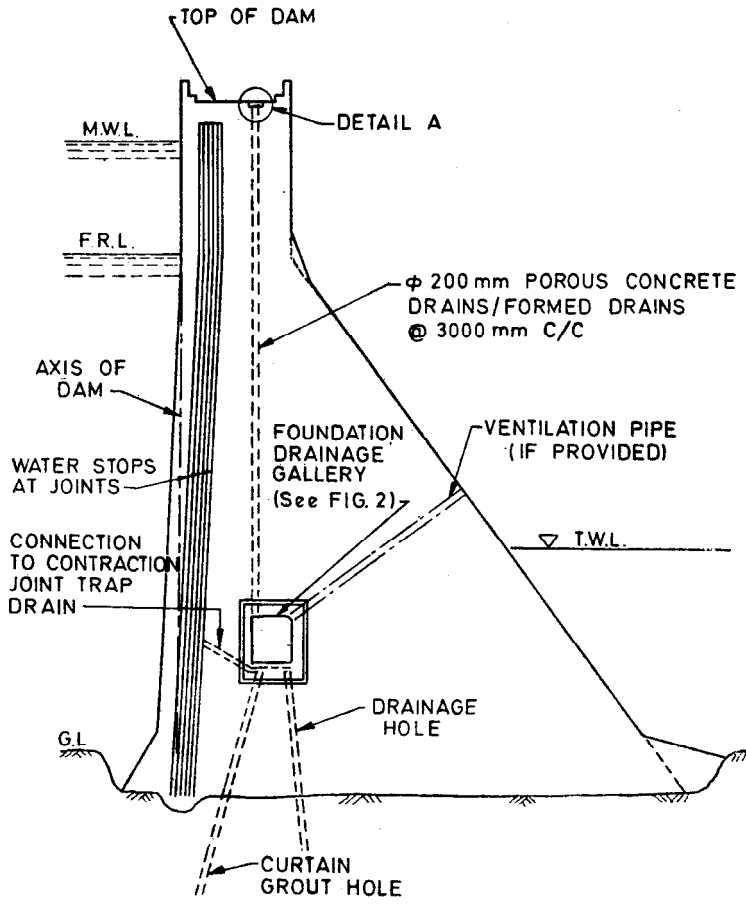
a) The drain shall consist of precast porous concrete blocks of size 400 × 400 × 200 mm with a circular hole of 200 mm dia in the middle;

b) The porous concrete shall be of 1 : 5 proportion by mass, that is, one part of cement to 5 parts of 20 to 5 mm size aggregate (conforming to IS : 383-1970*); and

c) When tested for permeability with 200 mm thick slab of this concrete under a head 100 mm, the discharge shall not be less than 30 litres/min/m^2.

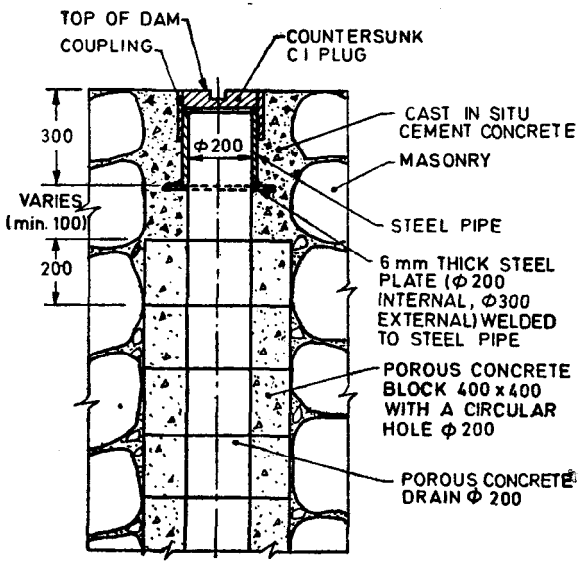
3.3.4 Formed drains for concrete dams are formed during construction of dam by use of suitable forms.

*Coarse and fine aggregates from natural sources for concrete (*second revision*).



1A

FIG. 1 POROUS CONCRETE DRAIN/FORMED DRAIN (*Continued*)



All dimensions in millimetres.

FIG. 1 POROUS CONCRETE DRAIN/FORMED DRAIN

3.4 Foundation Drainage Gallery — The main aim of a foundation drainage gallery is to collect seepage water from foundation and the body of the dam. Besides, it provides space for drilling and grouting the foundations and inspection of dam structure.

3.4.1 The upstream face of the gallery shall be located at a minimum distance of 5 percent of the maximum reservoir head or 3 m from the upstream face, whichever is more. A supplementary drainage gallery is sometimes provided towards the toe. For layout and size of gallery, reference may be made to 'Indian Standard Code of practice for galleries and other openings in dams: Part 1 General requirements' (*under preparation*).

3.4.2 Various galleries in the dam and tunnels in the abutments receive water from drainage holes, joint drains, formed drains/porous concrete drains, seepage, grouting operations, washing and cleaning, fire-fighting, spring leaks, etc. This water should be drained away under gravity with a slope not flatter than 1 in 1 000. The water collected in the galleries/tunnels below the general downstream level shall be led into one or two sumps provided and pumped out.

3.4.3 Gallery shall invariably be provided in the body of the dam where height of the structure above normal foundation level is more than 10 m (measured up to crest level in the case of overflow portion of the dam). For dams with heights below 10 m, the designer should consider the provision of gallery keeping in view factors like foundation condition and height of water retained.

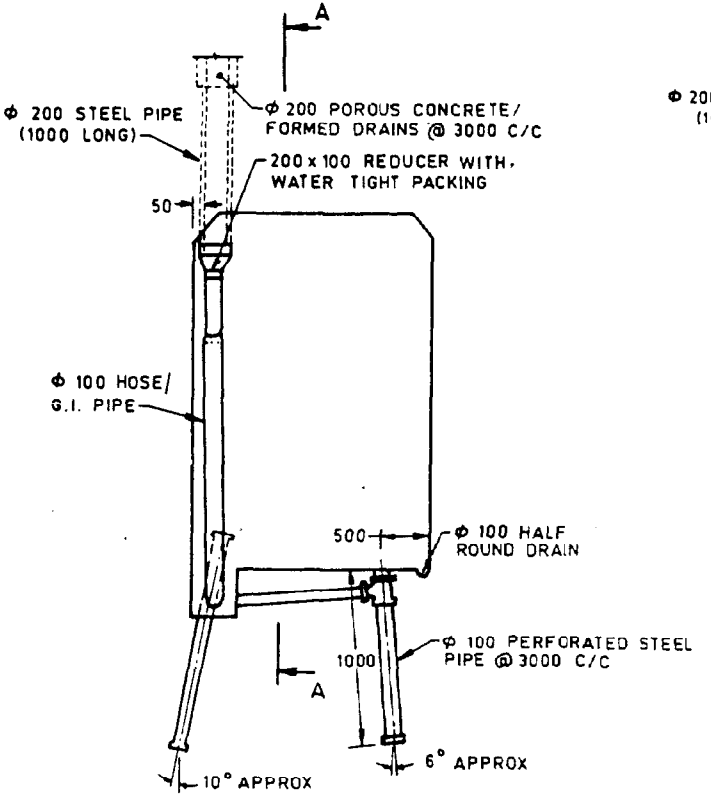
3.5 Foundation Drainage — Foundation drainage provides a means to relieve the uplift under the dam foundations. This drainage is accomplished by a line of holes drilled from the foundation gallery into the foundation rock. The size, spacing and depth of these holes are assumed on the basis of physical characteristics of the foundation rock, foundation condition and depth of storage of the reservoir. The diameter of the hole is generally *NX* drill which is 75 mm. The spacing of the hole may be kept as 6 m centre to centre. The depth of the holes may be kept between 20 and 40 percent of the maximum reservoir depth and between 30 and 75 percent of the curtain grouting depth for preliminary design. The actual spacing and depth may be determined on the basis of geological conditions. These should be further reviewed and holes provided at closer intervals or further deepened on the basis of actual observations after the reservoir is filled. To facilitate this, additional nipples/pipes shall be embedded in the gallery concrete. The drainage holes of 75 mm diameter are drilled through 100 mm diameter pipe embedded in the masonry/concrete portion. When drainage holes are drilled through soft foundations for the drainage of shear zones, faults, etc, a perforated pipe should be placed in the drainage holes and the space between walls of hole and this pipe should be filled with pea gravel. This arrangement would avoid caving-in of walls and the holes could be got washed, if required.

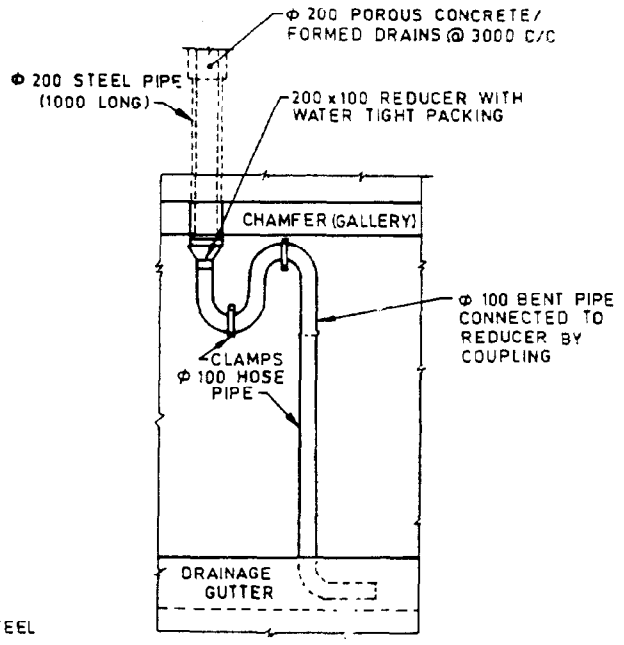
3.5.1 Drainage holes should be drilled after all foundation grouting has been completed within a minimum horizontal distance of 15 m. The drainage holes shall be drilled, through the drainage, gallery, through previously installed metal pipe extending down to the foundation rock. Additional drainage holes or curtain grouting shall be provided, if uplift pressures higher than designed values are observed. After drilling, the pipes shall be plugged at top and seepage water from the hole shall be taken off at a T-joint and let to the gutter of gallery (*see* Fig. 2).

3.5.2 Besides the foundation drainage gallery, the drainage holes shall be drilled through tunnels in the foundation and abutments. Spacing and depth of the holes shall depend on the geology.

3.5.3 Where cross galleries, additional foundation galleries and drifts are introduced, necessary drainage arrangements should also be considered and provided.

3.5.4 The seepage water from drainage holes should be monitored from consideration of quantity, contents of fines and chemicals and remedial action taken, if warranted.





VIEW AA
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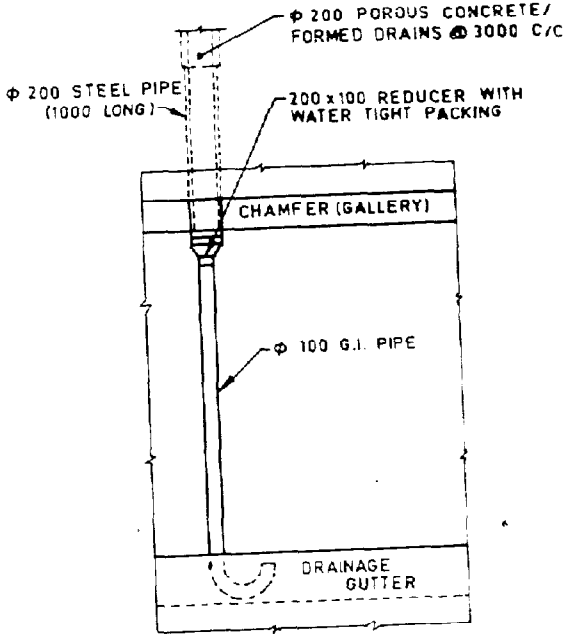

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WATER SEAL DETAILS

All dimensions in millimetres.

2A Foundation Drainage Gallery (in Rock)

FIG. 2 FOUNDATION DRAINAGE GALLERY (*Continued*)

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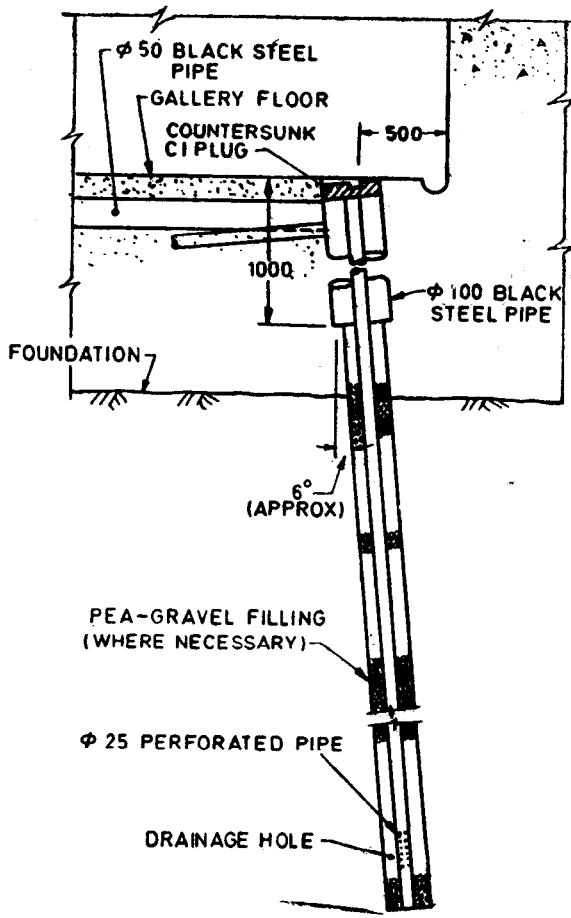

2B Foundation Drainage Pipe (in Soft Foundation)

All dimensions in millimetres.

FIG. 2 FOUNDATION DRAINAGE GALLERY

(*Continued from page* 2)

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