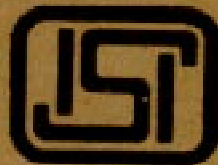


Indian Standard

CODE OF PRACTICE FOR
CONSTRUCTION OF MASONRY IN DAMS

(Second Reprint JUNE 1986)

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Indian Standard

CODE OF PRACTICE FOR CONSTRUCTION OF MASONRY IN DAMS

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Indian Standard

CODE OF PRACTICE FOR CONSTRUCTION OF MASONRY IN DAMS

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 16 October 1977, after the draft finalized by the Dam Sections (Non-Overflow) Sectional Committee had been approved by the Civil Engineering Division Council.

0.2 Stone masonry for dams, if properly constructed, satisfies the requirements of strength and durability and at the same time, being labour oriented, is particularly suitable for Indian conditions and was extensively used in the past. Its use for modern structures is increasing steadily. Need was, therefore, felt to publish a code of practice to serve as a useful guide to engineers and their technical assistants-in-charge of such works.

0.3 A trend is developing in the construction of masonry in dams wherein small needle vibrators are used to vibrate the masonry. Specific recommendations on this practice will be made after sufficient data becomes available on their use.

0.4 In the preparation of this standard, valuable assistance has been derived from the specifications for various masonry dams in the country.

0.5 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the results of a test or analysis, shall be rounded off in accordance with IS : 2-1960*. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

1. SCOPE

1.1 This code covers requirements regarding quality of material and general construction practices for stone masonry used in dams and other massive structures and aims at control of masonry work with a view to ensuring strength, durability, impermeability and uniformity.

1.2 This code requires to be supplemented by special instructions, if any, for each job.

*Rules for rounding off numerical values (*revised*).

2. TERMINOLOGY

2.0 For the purpose of this code, the following definitions shall apply.

2.1 **Aggregate, Fine** — Natural sand or sand prepared from crushed stone, gravel or such other inert materials.

2.2 **Cement Mortar** — A mixture of Portland cement, fine aggregate and water and any admixture approved by engineer-in-charge.

2.3 **Laitance** — An extremely fine film of material of little hardness which may form on the surface of freshly laid stone masonry.

2.4 **Transverse Joints** — Vertical transverse joints provided in the dam for convenience of construction and design considerations.

2.5 **Quoins** — Dressed stones used for the corners.

2.6 **One-line Dressing** — Finishing given to the stone face with no portion of it projecting more than 10 mm from the straight edge laid along the face of the stone.

3. MATERIALS

3.1 **Cement** — Portland cement, Portland slag cement, Portland pozzolana cement and supersulphated cement used for plain and reinforced concrete work and stone masonry work in dams and other massive structures shall comply with the requirements of IS:269-1976*, IS:455-1976†, IS:1489-1976‡ and IS:6909-1973§ respectively. Special cements may also be specified for use in dam masonry.

3.2 **Admixture** — Admixture including pozzolanas, air entraining agents, wetting agents, etc, shall be used only under specific authorization and wherever so permitted, the proportions and methods of use shall be specified by the engineer-in-charge.

3.2.1 Materials permitted as admixtures shall have established merit for improving any specific quality of the mortar without causing deleterious effects.

3.3 **Sand** — The sand shall conform to IS:2116-1965||.

3.4 Stone

3.4.1 *Stone for Masonry* — The stones for masonry shall be hard, dense, durable, tough, sound and clean. They should be free from decay.

*Specification for ordinary and low heat Portland cement (*third revision*).

†Specification for Portland slag cement (*third revision*).

‡Specification for Portland-pozzolana cement (*second revision*).

§Specification for supersulphated cement.

||Specification for sand for masonry mortars.

weathered faces, soft seams, adhering coatings, sand holes, veins, flaws, cracks, stains and other defects and shall have, as far as possible, uniform colour and texture. Stones not uniform in colour, texture and/or with stains may be permitted after proper tests. The size of stones shall normally vary from 0.05 to 0.01 m³. The stone shall be taken from quarries approved from geological and engineering considerations. No stone shall weigh less than 25 kg. The stone used in the hearting shall be roughly cubical in shape. No stone weighing between 75 kg and 150 kg shall be less than 225 mm in any direction and no stone weighing between 25 kg and 75 kg shall be less than 150 mm in any direction.

3.4.1.1 Spalls with the minimum dimension of 200 mm to 100 mm shall be used to wedge into thick mortar spaces. They shall not normally exceed 10 percent of the volume of stone masonry.

3.4.2 Stone for Coursed Face Work — The height of the stone for face work shall be uniform and is recommended to be 300 mm including mortar joint. The length and depth of the face stone shall not be less than the height of the stone. At least 50 percent of the stones shall have length more than twice the height of the stone. At least one third of the remaining stones shall be bond stones projecting not less than $2\frac{1}{2}$ times the height into the masonry. The remaining shall be header stones with depth not less than $1\frac{1}{2}$ times the height of the stone. The stones shall be hammer dressed on face and one line chisel dressed on bed, top and sides for a minimum depth of 75 mm up to which the stones shall be true and rectangular. Beyond 75 mm depth, the stones may be tapered but the tail end of the stones shall have at least half the area of the faces. Bushing on the faces of the stones shall not project more than 40 mm.

3.4.2.1 Header stones — The header stones shall not be less than 300 mm in length and one and a half times the height in depth.

3.4.2.2 Stretcher stones — The stretcher stones shall not be less than 600 mm in length and not less than its height in depth.

3.4.2.3 Bond stones — The bond stones shall not be less than 300 mm in length and two and a half times its height in depth.

3.4.2.4 Quoins — Quoin stones shall be of the same height as the face stones, but shall be true and rectangular on two faces with one line dressing for 75 mm depth in beds and sides. The stones shall be at least 300 mm long on one face and 450 mm on the other face.

3.4.3 Stone for Uncoursed Face Work — Stones for uncoursed face work shall be selected stones meeting the requirements of stones for coursed face work (see 3.4.2) except that the stones shall be hammer dressed. The stones shall be nearly rectangular.

3.4.4 Tests — Samples of stone from new quarries shall be tested for compressive strength in accordance with IS : 1121 (Part I)-1974*. The compressive strength testing shall be conducted with the load parallel to the bedding plane and also perpendicular to the bedding plane. The stone samples shall also be tested for water absorption in accordance with IS : 1124-1974† and for soundness in accordance with IS : 1126-1974‡ to ensure suitability of stones for masonry.

3.5 Water — Water used for mixing mortar, grout and also for washing the stone and curing masonry shall conform to the requirements of IS : 456-1964§.

3.6 Cement Mortar.

3.6.1 The cement mortar shall consist of cement, sand and other approved admixtures, as required, each complying with its respective specifications in accordance with 3.1 to 3.3, mixed in the proportions as may be defined. The proportions of materials entering into the mortar shall be based on laboratory studies. The moisture content of the sand and its gradation, as available for use, shall be taken into account in proportioning the mix. Pozzolanic material may also be mixed, if directed, in proportions fixed by the engineer-in-charge. If directed, suitable air entraining agent may be used to improve the quality and workability of the mortar. The exact proportions of air-entrainment shall be determined by actual tests.

3.6.2 All materials forming the mortar should be measured by mass except for water which may be by mass or by equivalent volume. Periodical calibration of the measuring instruments shall be carried out. Where weigh-batching is not possible, due consideration to bulgage of sand and its water content shall be given.

3.6.3 The mortar shall be mixed in a mixer. Mixers should not be loaded in excess of 10 percent more than the manufacturer's rated capacity. The following general principles shall be followed:

- a) The mixing time for each type of mixer shall be reckoned after all materials except the full amount of water are in the mixer. The thoroughness of mixing and adequacy of mixing time so as to give a uniform mortar shall be tested at the start of the job and at such intervals as may be considered necessary. The uniformity of

*Method of test for determination of strength properties of natural building stones: Part I Compressive strength.

†Method of test for determination of water absorption, apparent specific gravity and porosity of natural building stones (*first revision*).

‡Method of test for determination of durability of natural building stones (*first revision*).

§Code of practice for plain and reinforced concrete (*second revision*).

mortar is a reliable indication of the thoroughness of mixing and adequacy of mixing time. Retempering requiring the addition of water to preserve the required consistency shall be avoided. The minimum mixing time generally specified is as follows:

Capacity of Mixer (m ³)	Time of Mixing (min)
1.50 or less	1½
2.50	2
3.00	2½
4.00	2¾
4.50	3

For any one mix, the variation in the air-free unit weights shall not exceed the following:

For one batch	35 kg/m ³
Average of 3 batches	25 kg/m ³
Average of 20 batches	20 kg/m ³
Average of 90 batches	15 kg/m ³

- b) Use of the same mixer for different mortar mixes consecutively shall be avoided. Also, the first mortar batch at the start of the day's work shall be made richer by addition of extra cement over and above that required for the mix.
- c) The compressive strength of cement mortar used shall be as specified for the particular job. The strength of one sample shall be taken as the average of at least three test specimens taken from single batch of mortar. If the individual specimen result differs by more than ± 15 percent of the average of 3 specimens, the average of the remaining two specimens shall be worked out or the test may be repeated. If the individual test results of two specimens of mortar do not come within ± 15 percent of the average and where repeat tests are not possible, the whole set of results shall be rejected from analysis. Over a given period of time, not more than 10 percent of specimens tested shall have a compressive strength less than 80 percent of the required strength and the average of all tests shall equal or exceed the required strength. The exact proportions for the cement, sand and water for the mortars shall be fixed after conducting tests for compressive strength.
- d) The frequency of sampling of mortar separately for each mix proportion shall be as follows:
- i) Up to 100 m³ of masonry work per day, one sample per shift per mixer; and
 - ii) For every additional 100 m³ masonry work per day, one sample per shift per mixer.

3.6.4 Testing of mortar shall be done in accordance with IS : 2250-1965*. In special cases, where specimens of different sizes are used such as 15 cm × 30 cm cylinder/15 cm cube, necessary correlation shall be established and such tests may be adopted for quality control. Tests on mortar shall be regularly conducted and shall comprise compressive, tensile and permeability tests.

4. PREPARATION OF FOUNDATION

4.1 Masonry in Contact with Foundation — After completion of rough excavation of foundation, scaling and trimming for the final removal of all slabby or drummy rock or any loosened mass shall be done by chiselling, picking, barring and wedging. Any weathered or decomposed rock remaining should be removed, the doubtful areas cleaned out to sufficient depth and back-filled with concrete or masonry in richer mortar. If foundation conditions permit, consolidation grouting may be carried out before laying masonry. In case steps are required to be provided in the foundation of any individual block, stepping should not exceed 5 m with a maximum difference in elevation of 10 m.

4.1.1 Immediately prior to placing masonry, the foundation shall be moistened and coated by brush with a thick cement slurry (1 cement : about 2/3 water by volume). This shall be done within a few minutes before building masonry. The slurry shall be spread only on a small area of about 1 m² at a time and mortar spread immediately thereafter. A layer of rich mortar 50 to 75 mm thick, shall be spread over the slurry and worked into all irregularities of the rock surface, by trowels, bars or brushes. The composition of this mortar shall be the same as used in the masonry work. The first course of stones shall be carefully pressed into the mortar so as to force the mortar around the corners. The layer of mortar shall be made thicker, if required, to suit stones of sizes larger than 0.06 m³.

4.1.2 Water from any springs or leakage through the coffer dams shall be kept out of the foundation area and from masonry till the latter has set.

4.2 Masonry in Contact with Masonry — Surface of masonry shall be treated as follows before laying fresh masonry over it. Loose stones, if any, shall be removed. Mortar joints shall be scraped with iron rods and the exposed faces of stone shall be wire brushed. The surface shall be cleaned with air-water jet. The water collected in the depressions of masonry shall be removed by sponge or cloth.

4.3 Masonry in Contact with Old Masonry — Surface of old masonry which has been exposed for a long time, that is, more than 28 days, shall

*Code of practice for preparation and use of masonry mortars.

be treated as follows. Loose stones, if any, shall be removed. Old mortar joints shall be scraped to a depth of 15 mm or wet sand blasted and washed with air-water jet. Immediately prior to placing of masonry, the old masonry surface shall be treated in the same way as for foundation masonry described in 4.1.1.

5. MASONRY

5.1 General — The structure shall be built true to line, plumb or curved or as directed in a workman like manner, suitable aids like templates, scaffolding, etc, shall be used. The joints shall be the minimum possible and spalls shall be used to minimize mortar requirements in thick joints. Masonry shall be kept wet for at least 21 days after being built and at no time and on no account shall be allowed to be dry in this period. If stones, once kept, in position are to be adjusted they shall be lifted clear and reset; they shall not be moved one over the other. Walkways are necessary to ensure that the green masonry is not disturbed before it sets.

5.1.1 The maximum height of masonry allowed to be constructed at a time shall be 0.6 m in one or more layers. No fresh masonry shall be laid within 24 h over the masonry previously laid.

5.1.2 In the same block (monolith) the difference in level of masonry layers should normally be not more than 1.5 m.

5.1.3 The stones shall be free from dirt and surface-dry before being placed. The quarried stones shall be thoroughly cleaned and watered before they are brought to the block for placement.

5.1.4 The following rules shall be observed to ensure efficient construction:

- a) Do not place mortar which bleeds excessively;
- b) Keep the surface continuously moist;
- c) Clean the old masonry surface, prior to starting masonry on it, by wet sand blasting or chiselling and washing;
- d) Thoroughly and effectively broom into the old surface a layer of mortar and build the masonry course on it immediately; and
- e) Masonry work should invariably be done during day light hours.

5.2 Classification — The masonry in dam is classified as under:

- a) *Face work*
 - i) *Upstream* — The upstream face work in spillway, non-spillway and power dam sections consists of face stones hammer-dressed on face and one line chisel dressed on bed, top and sides for 75 mm from the front face built with the course normal to the face batter. This work can also be constructed in uncoursed rubble masonry.

- ii) *Downstream* — The downstream face work in the non-overflow and power dam sections consists of stones hammer-dressed on face, sides and bed for 75 mm with the course normal to the face batter. This work can also be constructed in uncoursed rubble masonry.

- b) *Random Rubble Masonry* — The hearting is of random rubble work.

5.2.1 The mortar to be used for each class and location of masonry shall conform to the particular specifications for that class of mortar and the specifications for the materials used therein (see 3.6).

5.3 Face Work — The face work shall be of selected stones and dressed as described in 3.4.2. The work shall be in parallel courses of uniform thickness. In each course, stones shall be built in header and stretcher fashion and joints shall break in courses above and below by at least half the height of the course. In case of uncoursed rubble masonry the header stones shall be placed at about 1 m centre-to-centre. The joints in face work shall not be thicker than 15 mm for single-line chisel-dressed stones or 20 mm for hammer dressed stones.

5.3.1 Bond stones in each course shall be so provided that every sixth stone or third header stone is a bond stone. In case of uncoursed facework the bond stones shall be placed at about 2.5 m centre-to-centre. The bond stones shall be staggered and marked for identification. The face masonry shall preferably be constructed simultaneously with the hearting masonry.

5.3.2 The facework shall be struck neatly and smoothed off with a trowel before the mortar takes the final set.

5.3.3 Where face work is of uncoursed rubble masonry, guniting is recommended.

5.3.4 Pointing

5.3.4.1 Mix of mortar — All pointing shall be done with cement sand mortar 1 : 3 or richer mix. The sand to be used shall be fine, passing through 600-micron IS Sieve (see IS : 460-1962*) and conforming in all other respects to IS : 2116-1965†.

5.3.4.2 Raking joints — The joints in masonry to be pointed shall be raked square for a minimum depth of two times the thickness of the joint within 24 h of laying of masonry. In special circumstances, this period may be relaxed to 48 h. The refilling and pointing shall be done within three days of raking of the joints so as to ensure good adhesion between the two mortars.

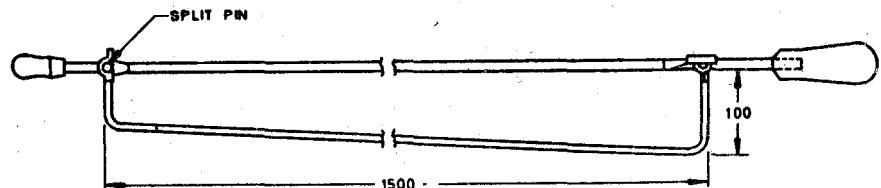
*Specification for test sieves (revised).

†Specification for sand for masonry mortars.

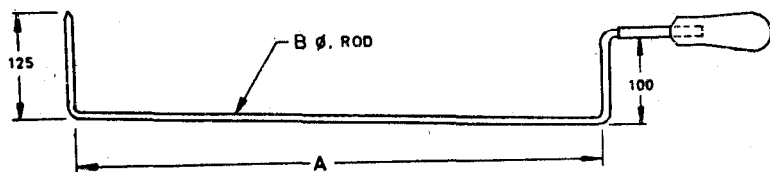
5.3.4.3 Cleaning joints — Before pointing, the joints shall be thoroughly cleaned of any dirt or loosely adhering mortar, washed out properly and thoroughly wetted.

5.3.4.4 Filling joints — The joints shall then be filled with cement mortar which shall be rammed and caulked into the joints. The pointing mix shall neither be too dry nor too wet. The mortar shall have just enough water so that it can be moulded into a ball by a slight pressure of hand but will not give out free water when so pressed and will leave the hands damp. Pointing shall be carried out as rapidly as possible and not touched again after the mortar has once set.

5.3.4.5 Nyala pointing — The lines shall be pressed on the joints and the joints shall be neatly rubbed smooth with Nyala (see Fig. 1) as soon as the mortar has begun to set. The extra mortar on edges shall be carefully scraped off to give a neat appearance.



FOR HORIZONTAL JOINTS



	A	B ϕ
For Horizontal Joints	600	10
For Vertical Joints	100	3

All dimensions in millimetres.

FIG. 1 TYPES OF NYALAS

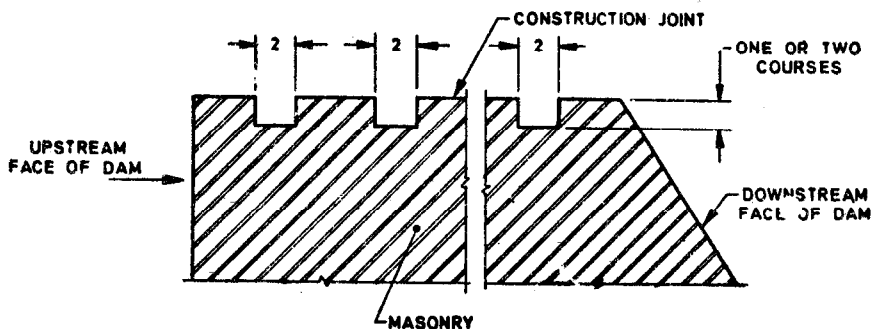
5.3.4.6 Final finish to joints — The joints shall be neat, defined, regular and of a uniform width. The joints may be filled either flush or raised as required. The surfaces pointed should be kept wet for 21 days after pointing is completed.

5.4 Random Rubble Masonry

5.4.1 Stones received from the quarry shall be used without any dressing except knocking off weak corners. They shall be set in the work on their flat beds breaking joints. No joint shall be thicker than 35 mm.

5.4.2 Following precautions shall be taken:

- a) Place the stone on its natural bed;
- b) Avoid under-pinning after a stone is laid;
- c) Avoid inserting spalls in space between stones, before it is filled up with mortar;
- d) Avoid inserting flat side of the spalls in joints, have all spalls driven end-wise;
- e) Keep the surface as rough as possible to secure bond;
- f) Before inserting spalls, shake the mortar well and vibrate the stone by hammer to facilitate excess mortar to come out;
- g) Wire brush the masonry surface clean between 20 and 24 h after it is laid;
- h) Distribute work so that fresh layers of masonry are started every alternate day; and
- j) In case of long stoppage of work suitable depressions should be left to a depth of one or two courses for proper keying and effective bondage with the new masonry. An illustration is shown in Fig. 2.



All dimensions in metres.

FIG. 2 DETAILS OF CONSTRUCTION JOINT

5.5 Truncated Construction — Truncation of masonry section should be avoided. However, if it is unavoidable, the following precautions shall be taken:

- a) The truncated section should satisfy the design criteria adopted for full section for that particular stage of construction;
- b) Truncated faces shall be constructed in steps embedding enough dowel bars to ensure proper bond between old and new masonry;
- c) The later construction on the truncated section shall be started after giving treatment to the truncated face in the same way as for masonry in contact with old masonry described in 4.3;
- d) In case concrete is used for constructing truncated section, shear keys shall be provided in both horizontal and vertical faces of the truncated section; and
- e) The joint between old concrete and masonry constructed later shall be grouted after raising the masonry to sufficient height.

5.6 Mortar Intake — With good workmanship the quantity of mortar used in masonry dam should normally be less than 45 percent.

5.7 Protection — The fresh masonry shall be protected against vibrations or any other movement which might injure it before it has reached its final set. Stones shall not be allowed to be dumped over the masonry which has not taken its final set. Mortars and fresh masonry shall be protected from rains.

5.8 Curing — Arrangements shall be made to protect the fresh masonry against rapid drying and to cure the masonry. The masonry shall be cured after 4 to 12 h of construction and water shall be gently sprayed so as to avoid damage. All exposed surfaces of masonry shall be kept continuously moist for a minimum period of 21 days.

5.9 Test — Permeability tests on masonry shall be carried out in accordance with 'Draft Indian Standard Code of practice for permeability test of masonry (during and after construction) (*under preparation*).' The impermeability to be aimed at shall be a water loss of not more than 0.5 l/min per square metre and 2.5 l/min per square metre of hole in the upstream impervious masonry portion and in the rest of the downstream portions respectively, when tested at a pressure equal to 1.75 times the expected maximum water head at that elevation. As water loss tests cannot be done at such high pressures when the masonry blocks are low and are under construction, it is suggested that the permeability tests could be carried out at a convenient pressure which would not cause disturbance to the masonry. Then, assuming a linear variation of water loss with respect to pressure applied, the loss that would result for the ultimate water pressure could be interpreted. If the test results indicate water loss greater than specified values, remedial measures in the form of additional drilling and grouting should be done and confirmatory tests carried out.