IRC:40-2002

STANDARD SPECIFICATIONS AND CODE OF PRACTICE FOR ROAD BRIDGES

SECTION-IV

(BRICK, STONE AND CEMENT CONCRETE BLOCK MASONRY)
(SECOND REVISION)

THE INDIAN ROADS CONGRESS

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Section IV

BRICK, STONE AND CEMENT CONCRETE BLOCK MASONRY

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BRICK, STONE AND CEMENT CONCRETE BLOCK MASONRY

INTRODUCTION

The Masonry Bridges Committee (B-8) was entrusted with the task of updating/reviewing the provisions contained in IRC:40-1995 "Standard Specifications and Code of Practice for Road Bridges, Section-IV (Brick, Stone and Cement Concrete Block Masonry)". The Committee prepared the draft for revision and discussed the same in detail during a number of meetings and finalised it in the meeting held on 20th February, 1999. The personnel of the Committee are given below:

S.R. Tambe .... Convenor
J.T. Nashikkar .... Member-Secretary

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Mahesh Tondon

The draft as finalised by Masonry Bridges Committee (B-8) was discussed by the Bridges Specifications and Standards (BSS) Committee in its meeting held on 7th December, 1999, which authorised the Convenor, B-8 Committee to modify the document and send the same to the Convenor, BSS Committee to finalise the document. Accordingly, the Convenor, BSS Committee approved the modified document on the 18th October, 2000 and later by the Executive Committee in its meeting held on the 29th December 2000, and Council of IRC during their meeting held on 13th May, 2001.

400. SCOPE

The Code deals with the structural use of brick, stone and cement concrete block masonry in road bridges, including the materials to be used, maximum permissible stresses and method of design and construction. This Code does not apply to brick work done during freezing weather. However, for work done during freezing weather special precautions as outlined in ***Annexure*** may be taken.

401. DEFINITIONS

401.1. Abutment

The end support of the superstructure of a bridge, which retains the earth behind it fully or partly.

401.2. Ashlar Masonry

A masonry made of squared building stones cut more or less true on all faces adjacent to those of other stones, so as to permit very thin mortar joint.

401.3. Bond

Arrangement of bricks/stones in successive courses to tie the masonry together both longitudinally and transversely, i.e., to ensure stability and greatest amount of lap. The lap shall not be less than half the height of the course, (Fig. 1).

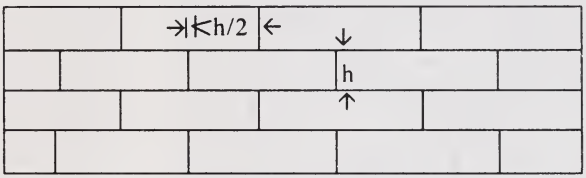

Fig. 1. Lap of Vertical Joint in Adjacent Course

401.4. Bond Stone

Bond stones are selected long stones used to hold a wall together transversely.

401.5. Coursed Rubble Masonry (First Sort)

In this type of masonry, face stones are dressed and all the stones are laid in the courses which are of equal height unless otherwise specified. The height of stone is equal to the height of the course (Fig. 2). For details MORT&H Specifications may be referred to.

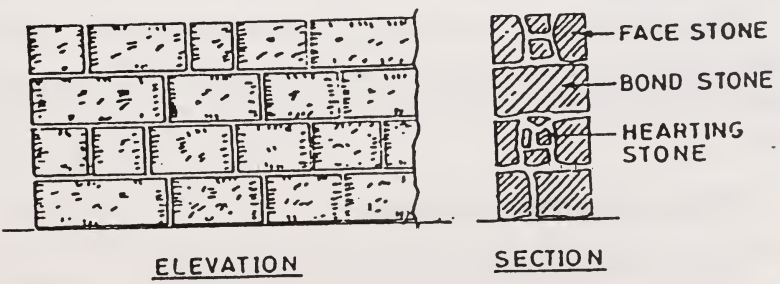

Fig. 2. Coursed Rubble Stone Masonry (First Sort)

401.6. Coursed Rubble Masonry (Second Sort)

In this type of masonry, a course shall be of uniform height throughout. In any course, all the stones may not be of height equal to that of the course but not more than two stones are used to constitute a course at any place (Fig. 3).

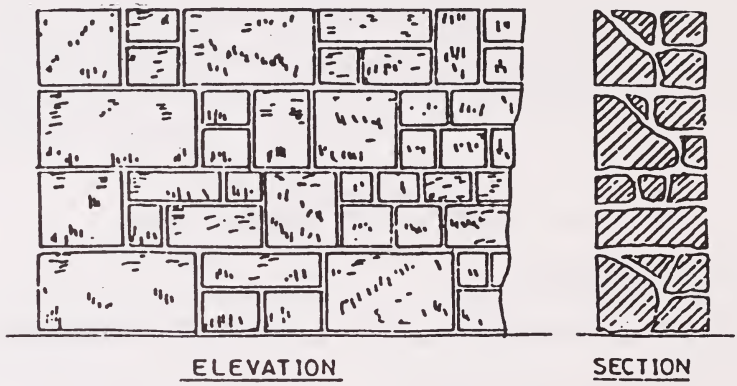

Fig. 3. Coursed Rubble Stone Masonry (Second Sort)

401.7. Cushion

The material placed over the arch and its thickness is measured from the top of crown to top of the road surface.

401.8. Effective Height

The dimension of the height of pier or abutment, etc. to be assumed for calculating the slenderness ratio. (Reference may be made to Note mentioned below Table 13 in IRC:21 Clause 306.1.2.)

401.9. Extrados or Back

This is the external curve of an arch (Fig. 4).

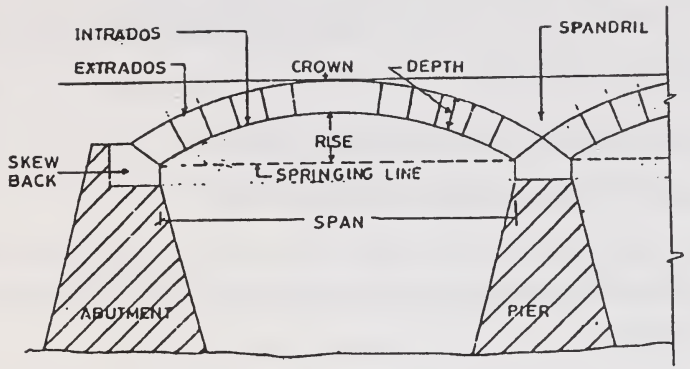

Fig. 4. Parts of an Arch

401.10. Face Stone

Stone used in the face of masonry.

401.11. Footings

The projected courses below the base of a pier, or an abutment meant to distribute the load on the founding strarta.

401.12. Gauge

Gauging means chipping or rubbing bricks or stones to form a uniform size or shape.

401.13. Hardening Time

The time in which masonry will gain 80 per cent ultimate strength.

401.14. Header Stone

A block/stone laid with its length (Dimension perpendicular to face) across the wall. The length shall not be less than twice the height of the course.

401.15. Hearting Stone

The hearting stones are the stones used for interior filling of a wall.

401.16. Intrados

This is inner curve of the arch (Fig. 4).

401.17. Intermediate Abutment Pier

Pier designed for one span off condition of an arch bridge. Generally abutment piers are heavier piers and are provided after 3 to 5 spans.

401.18. Joggle Joint

This refers to a joint where grooves are provided on one stone to fit to a corresponding projection in the adjacent stone (Fig. 5).

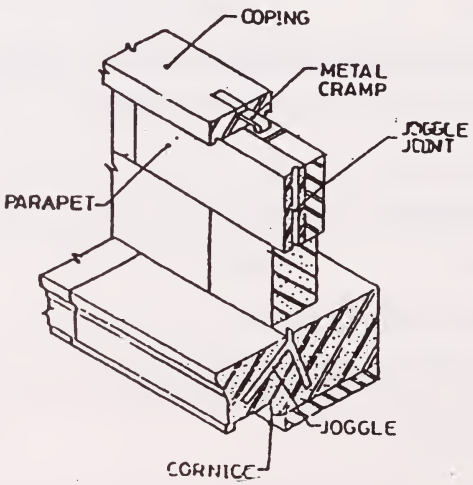

Fig. 5. Joggle Joint

401.19. Major Bridge

A bridge whose length between river side face to face of abutments is more than 60 metres.

401.20. Masonry

An assemblage of bricks, cement concrete blocks or natural stones dressed or undressed bonded together with mortar.

401.21. Pier

Intermediate support for the superstructure of bridge.

401.22. Plum Stone/Pin Headers

These are selected oblong stones embedded vertically in the interior of masonry to form a bond between successive courses. Their length shall be twice the thickness of each course of masonry.

401.23. Quoin Stone

A quoin is the external angle of wall. Quoin stone is a specially selected and neatly dressed stone for forming such angle.

401.24. Random Rubble Masonry

This is a masonry constructed out of stone as they come from the quarry. It is generally not constructed in regular courses.

401.25. Rebated or Lapped Joint

In this type of joint, rebates are provided in adjacent stones which lap over each other and prevent movement of stone (Fig. 6).

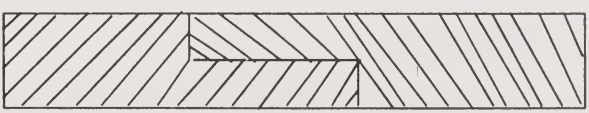

Fig. 6. Rebated or Lapped Joint Sectional Elevation

401.26. Retaining Wall

A wall designed to resist the pressure of earth filling or backfill.

401.27. Return Wall

A wall adjacent to abutment, designed and built parallel to centre line of road to retain the embankment and built up to the road levels.

401.28. Spalls

These are chips or stones used for packing up and filling the interstices in the stone masonry.

401.29. Spandril

The space formed between the extrados and the horizontal line drawn tangent to crown (Fig. 4).

401.30. Squint Brick/Stone

Brick/stones used for forming an acute or obtuse corner in brick/ stone masonry.

401.31. Toe Wall

A wall built at the end of the slope of earthen embankment to prevent slipping of earth and or pitching on embankment.

401.32. Wing Wall

A wall designed to retain backfill adjacent to abutment with its top upto road level and sloping down to bed level or above. (An angle of splay with the abutment is generally 30 to 45 degrees,

45 degrees-splayed walls are most common, splayed wing walls are some times curved.)

402. MATERIALS

The mentioned materials used in construction should comply with the relevant provisions and clauses of appropriate codes of practices.

402.1. Cement

The cement to be used shall conform to the relevant specifications as given in Table 1.

TABLE 1

	Type	In accordance with
(a)	33 Grade ordinary portland cement	IS:269-1989
(b)	43 Grade ordinary portland cement	IS:8112-1989
(c)	Portland slag cement	IS:455-1989
(d)	Portland pozzolana cement (fly ash based)	IS:1489(Part-I)-1991
(e)	Portland pozzolana cement (calcined clay based)	IS:1489(Part-II)-1991
(f)	Sulphate resisting portland cement	IS:12330-1988

Note: Reference to 53 grade ordinary portland cement conforming to IS:12269-1987 is not made in the above Table since this type of cement shall ordinarily not be used in masonry work owing to higher heat of hydration associated with its use. Grade 43 ordinary portland cement may be used with adequate precautions. Use of sulphate resistant cement may be warranted where the masonry structure is likely to be affected by presence of excessive sulphates in the surrounding soil/water.

402.2. Lime

Lime may be used as a part of composite mortar. Lime to be used shall conform to specifications of type Class-A and B of IS:712.

402.3. Bricks

The bricks to be used shall conform to the IS:1077 specifications for common burnt clay bricks except that the minimum compressive strength shall be not less than 7 MPa when tested as per IS:3495. The size of bricks shall be according to the local practice with tolerance of ± 5 per cent in dimensions.

402.4. Stone

The stone used shall conform to the relevant specifications of IS:1597 (Part-I)- Code of Practice for Construction of Stone Masonry, Part-I- Rubble Stone Masonry.

402.5. Blocks

402.5.1. Solid concrete blocks made of cement and suitable aggregates shall conform to relevant provisions of IS:2185 Part-I in respect of dimension, mix, manufacturing, curing, drying and physical requirements. The minimum compressive strength of solid concrete blocks when tested as per IS:2185 Part-I shall not be less than 10.5 Mpa.

402.5.2. Hollow, lightweight concrete blocks, etc. shall not be used.

402.6. Sand/Stone Dust/Marble Dust

Sand/stone dust/marble dust, etc., shall consist of hard, durable

clean particles of natural sand, crushed gravel, crushed marble or suitable combination of natural sand and crushed gravel. This shall not contain dust lumps, soft or flaky particles, mica and other deleterious materials in such quantities as would reduce the strength or durability of mortar.

Fine aggregates shall conform to IS:383 in general and sand to IS:2116 in particular.

402.7. Water

Water shall be clean and the percentage of deleterious materials in it shall not be more than permissible limit. In this regard provisions of IRC:21 shall be followed. Potable water can be considered fit for use.

402.8. Storage

All materials shall be stored so as to prevent their deterioration and intrusion of foreign matter and preserve their quality and suitability for the work. Any material, which has deteriorated or has been damaged or is otherwise considered unsuitable by the Engineer, shall not be used on the work.

402.8.1. Cement: Cement shall be stored on a cement storage platforms 0.6 to 1.0 m high above the ground in perfectly dry moisture free sheds and shall not be stacked more than 8 (eight) bag high. Wherever bulk storage containers are used, their capacity should be sufficient to cater to the requirements of site and should be cleaned at least once in every 3 to 4 months. Cement more than 3 to 4 months old shall invariably be tested to ascertain that it satisfies the acceptability requirements.

402.8.2. Lime: Lime shall be stored in weatherproof sheds. Lime, which has been damaged by rain, moisture or air slaking, shall not be used. If the lime is supplied as hydrated lime, it shall be stored in the same manner as cement and period of storage shall not be more than one month.

402.8.3. Bricks: Bricks shall not be dumped at site. They shall be stacked in regular tiers as they are unloaded to minimise breakage and defacement. The supply of bricks shall be so arranged that as far as possible requirement of bricks for a period of two days at least, is met with at the site at any given time. Bricks selected for use in different situations shall be stacked separately.

402.8.4. Fine aggregate: Fine aggregates, viz., sand, stone dust, marble dust, etc. shall be stored in such a way as to prevent admixture of foreign materials. It should be stored such that wind, etc. may not affect its purity.

403. DESIGN CONSIDERATIONS

403.1. General Features

The general dimensions and features shall be in accordance with the provisions given in the IRC:5 "Standard Specifications and Code of Practice for Road Bridges, Section I-General Features of Design". Masonry bridges may be restricted to where individual spans do not exceed 15 m or the height of masonry above foundations does not exceed 10 m.

403.2. Loading

Loads and forces to be considered in the design shall be in

accordance with the IRC:6 "Standard Specifications and Code of Practice for Road Bridges, Section II-Loads and Stresses". Permissible overstresses shall be governed in accordance with Clause 403.8.

403.3. Load Dispersion

403.3.1. Footings: The dispersion of load through the masonry shall be considered at 45 degrees to the vertical.

403.3.2. Over arches: For arch bridges, the load shall be taken as dispersed at an angle of 45 degrees to the vertical through the road surface and the filling material upto the level of extrados of the arch. Filling material in cushion shall be with minimum 12 per cent C.B.R. and good drainage property. Care must be taken to modify the intensity of the distributed load on narrow bridges or where load may travel close to the edge of the bridge. The cushion above the crown shall not be less than 500 mm. In respect of submersible bridges, the cushion shall be of P.C.C. and the minimum thickness shall be 300 mm. The dispersion of load through such concrete cushion shall be taken at an angle of 45 degrees.

403.4. Permissible Compressive Stress Under Direct Compression

403.4.1. The permissible compressive stress depends upon the crushing strength of the structural units, viz., bricks, blocks or stones, the grade of mortar used and it shall be related to the values as given in Table 2.

TABLE 2

Mortar mix (parts) by volume			Hardening days after completion of work	Permissible compressive stresses in Masonry for various crushing strengths of block/brick/stone in MPa.					
				Crushing strength of block/brick/stone unit in Mpa:					
Cement	Lime	Sand	Days	7	10.5	14	21	28	35 or more
1	-	3	7	0.7	1.1	1.3	1.7	2.1	2.5
1	-	4	14	0.6	0.9	1.1	1.5	1.9	2.2
1	-	5	14	0.6	0.9	1.0	1.4	1.7	2.0
* 1	0.5	4.5	14	0.7	1.1	1.3	1.7	2.1	—

* Gauged/composite/mortar

Note: (1) Linear interpolation is permissible for units whose crushing strength is intermediate between those given in the Table.

(2) For masonry in well foundations, cement sand mortar shall not be leaner than 1:3.

403.4.2. For arch rings, the permissible stress shall be in accordance with those given in Table 2 subject to a maximum of 1.6 MPa, except for arch rings in Ashlar stone masonry the maximum stress upto 2.5 MPa may be allowed.

403.4.3. For coursed rubble and ashlar masonry, the stress values given in Table 2 shall hold good.

403.4.4. For random rubble masonry conforming to IS:1597 (Part-I), the permissible stresses given in Table 2 shall be 67 per cent of the values. Random rubble masonry shall be used only in construction of return and toe wall upto 5.0 m height only.

403.5. Permissible Tensile Stress

The permissible tensile stress in brick, block or stone masonry shall be in accordance with the values given in Table 3.

TABLE 3

Sr. No.	Type of Masonry	Allowable flexural tensile stress in MPa					
	Ratio	Cement	Sand	Ratio	Cement	Lime	Sand
		1:3	1:4	1:5	1.0:0.5:4.5		
1.	Brick	0.14	0.10	0.07	0.12		
2.	Block	0.10	0.07	0.05	0.10		
3.	Stone	0.10	0.07	0.05	0.10		

403.6. Permissible Shear Stress

The permissible shear stresses in brick/stone masonry shall be taken as the greater of the two values specified in (i) and (ii) below but shall not exceed 0.2 MPa.

(i) Same as values of allowable tensile stresses given in Table 3.
(ii) One third of compressive stresses produced by dead load only at the level under consideration.

Note : The above values will be reduced by 20 per cent in the design of substructure of arch bridges..

403.7. Combination of Loads and Forces

Combination of loads and forces shall be as per IRC:6.

403.8. Permissible Overstress

403.8.1. When components are subjected to eccentric loading and or lateral forces maximum stresses resulting from combination of stresses due to axial loading, eccentric loading and due to lateral

forces may exceed the stresses given in Table 2 upto 25 per cent provided that such excesses are only due to eccentricity of loading and/or due to lateral forces excluding seismic forces.

403.8.2. For combination of loads and forces including seismic force, the resulting compressive stresses may exceed the stresses given in Table 2 upto 50 per cent.

Note: Clause 403.8.1 and Clause 403.8.2 will not be applicable at the same time. In seismic conditions, tensile stress given in Table 3 may be increased by 20 per cent.

403.9. It is necessary to check the stability of the structure under every phase of construction and also during service. The factor of safety to be ensured under the worst combination of loads, shall be as given in Clause 7.6.3.4 of IRC:78.

403.10. Sliding and Overturning

While checking the stability against sliding, co-efficient of friction between interfaces of masonry, shall be taken as 0.6 unless specified otherwise.

403.11. Pier, Abutment, Return and Wing Walls

403.11.1. Thickness: The thickness of pier/abutment return/ wing walls shall be sufficient to ensure that in any section stresses due to the worst combination of loads and moments, for which the structure is designed, are within the permissible limits prescribed.

403.11.2. Top Width

403.11.2.1. The minimum width at the top of piers and abutments for slab and girder bridges just below the caps are given in Table 4 for guidance.

TABLE 4

Span in m.	<=3	>3<=6	>6<=12	>12<=15
Top width of piers with simply supported span (mm) and Top width of all abutments (mm)	500	1000	1200	1600
Top width of pier with continuous span (mm)	500	750	1000	1300

403.11.2.2. In case of arch bridges, the top width of abutments and piers shall be adequate to accommodate skewbacks and to resist the stresses imposed under the most unfavourable conditions of loading.

403.11.2.3. The top width of wing walls and returns shall not be less than 450 mm.

403.11.3. For multiple span arch bridges, abutment piers shall be provided after every third to fifth span. Each pier of an arch bridge need not then be designed for one span off condition.

403.11.4. The ratio of the height of pier or abutment to its base width shall not be more than six.

403.11.5. When piers and abutments in masonry are constructed in rivers with velocity more than 4.5 m/sec. and carrying highly abrasive particles, following special precautions shall be taken:

(i) providing extra section thickness of 100 mm over and above the design thickness as sacrificial thickness upto 0.5 m above the H.F.L.

(ii) provision of course height of 250 mm minimum in case of stone masonry, and

(iii) use of bricks with crushing strength of 10 MPa minimum in case of brick masonry.

403.11.6. Weep holes: Adequate number of weep holes at spacing not exceeding 2 metres in horizontal and 1 metre in vertical direction suitably staggered should be provided to prevent any accumulation of water and building upto the hydrostatic pressure behind the abutment, returns and wing walls. The lowest row of weep holes shall be provided 150 mm above low water level or lowest ground level whichever is higher. Weep holes shall be provided with 100 mm dia AC pipes for structures in masonry. Circular weep holes shall be extended through the full width of masonry with slope of one vertical to 20 horizontal towards draining face. To ensure proper functioning of weep holes, properly designed filter layer must be placed behind the wall.

The pattern of the weep holes shall be predetermined to ensure its aesthetical appearance.

403.11.7. The wing wall at its end away from the abutment shall have minimum 600 mm height. This 600 mm height wall at the end will further extend 600 mm in a direction parallel to traffic direction.

403.12. Caps

The thickness and reinforcement for pier and abutment caps shall be in accordance with IRC:78.

403.13. Masonry Arch Bridges

In Seismic Zones-IV and V, masonry arch bridges having span more than 6 metres, shall not be constructed.

403.14. Parapet Wall

Height of parapet shall be as per provisions contained in IRC:5. The mortar used shall be cement sand mortar in 1:3 proportion conforming to Clause 404. For submersible bridges, instead of parapet walls pipe railing of collapsible or removable type shall be provided. In such cases, the kerbing shall be discontinuous for better drainage and least obstruction to flow of water.

403.15. Coping

Architectural coping shall be provided over the top of wing/ return/parapet walls. The minimum thickness of stone/concrete coping over stone masonry shall be 150 mm. For concrete coping, vertical joint at spacing of not more than 1.5 m shall be provided.

In case of stone masonry, the mortar used shall be cement sand mortar in 1:3 proportion prepared conforming to Clause 404.

403.16. Foundation Block

403.16.1. In case of soil base, concrete foundation block of minimum thickness of 300 mm shall be laid under the masonry. Its proportion shall not be leaner than M-15.

However, in case of rockbase, a levelling layer of concrete with minimum average thickness of 150 mm and of M-10 grade may be provided.

403.16.2. In case of reinforced concrete footing, the relevant provisions of Clause 307 of IRC:21 shall be satisfied.

404. PLANNING CONSTRUCTION AND WORKMANSHIP

404.1. Necessary Information

404.1.1. For efficient planning, design and execution of works, detailed information with regard to the following shall be furnished to those responsible for such works:

(a) Layout plan showing the orientation of the structure.
(b) Dimension details of the structure with details of sections and levels of foundation/ground levels, clear height from floor/ground level to soffit, size and span, etc.
(c) Type of stone/brick/block and class of masonry, types of bond and final finish for the masonry, the mix of the mortar to be used, etc., details of structural features, moulding and other special work.
(d) Location and other details of embedments, like, water pipes, electrical pipes, weep holes and junction, etc.

404.1.2. Mortar

404.1.2.1. The mortar shall be mixed in the approved proportions. The mix shall be clean and free from materials, like, soil/acid/alkali/organic matter or deleterious substances.

404.1.2.2. Proportioning and mixing mortar: All mortar shall be mixed by following the proportions specified. All the mortar shall be mixed with minimum amount of water to get maximum density with adequate workability. The mixing shall be done intimately in a mechanical mixer. Hand mixing can be resorted to so long as uniform density of the mix and its strength are assured but shall only be allowed for very small and isolated works, like, CD works. Hand mixing operation shall be carried out on a clean watertight platform where it is first mixed dry and after obtaining a uniform colour, water shall be added. The mortar shall then be mixed for not less than two minutes.

For cement mortar gauged with lime, lime and sand shall be ground into mortar. Immediately before use, the specified proportion of cement shall be added to a small quantity of the mortar and intimately mixed for obtaining uniform distribution of cement.

404.1.2.3. The use of retempered mortar shall not be permitted. Mortar shall be mixed in such quantity as required for immediate use. The mix, which has developed initial set, shall not be used. Initial set of mortar made with ordinary portland cement shall normally be considered to take place in 30 minutes after mixing. In case, the mortar has stiffened during initial setting time because of evaporation of water, the same can be retempered by adding water as frequently as needed to restore the requisite consistency but this retempering shall not be permitted after 30 minutes of mixing. If at any site, use of admixtures to mortar is found necessary, they shall be tested for suitability before use.

The cement mortar gauged with lime shall be used within half an hour of mixing cement.

404.1.2.4. Test of mortar: Necessary tests to determine compressive strength of the mortar, its consistency and water resistivity shall be carried out in accordance with IS:2250. For compressive strength tests, the frequency of testing shall be 1 cube for every 2 cubicmetre of mortar prepared subject to a minimum of 3 cubes for a day's work.

It may be borne in mind that, in addition to compressive strength of mortar, its resistance against shear and also its adhesion or bond with masonry unit are factors which affect the strength of the mortar and of the masonry. The performance of mortar in this respect will depend not only upon the bond developed in initial stages of hardening of mortar but also on extent to which bond

is maintained in course of time where mortar is subject to effects of temperature variation and moisture movement. The factors governing strength of bond are elaborated in IS:2250-1965.

404.2. Brick Masonry

404.2.1. Brick masonry, in general, shall conform to the requirements of IS:2212 "Code of Practice for Brick Work".

404.2.2. Wetting of bricks: All bricks immediately before being laid, shall be thoroughly wetted in tank so as to have sufficient moisture to effect a proper bond between the brick and mortar. Minimum period of soaking prior to use shall be 1 hour. Soaked brick shall be removed from the tank sufficiently in advance so that they are skin dry at the time of actual laying. Two tanks shall be provided one to soak the bricks and other to stack the wetted bricks to remove the excess water and make bricks surface dry.

404.2.3. All brickwork shall be laid in English Bond, even and true to line, plumb, level and all joints as specified. The bricks to be used on the face and at all angles forming the junction of any two walls shall be whole bricks of uniform size and rectangular faces (Fig. 7).

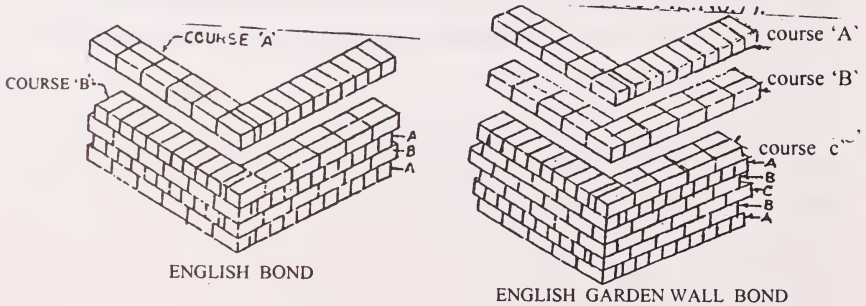

Fig. 7. English Bonds in Brick Masonry

404.2.4. Mortar beds and other joints: All bricks shall be laid with frog up, if any, on a full bed of mortar. When laying brick shall be slightly pressed so that the mortar gets into all the hollow space of bricks to ensure proper adhesion. All head and side joints shall be completely filled by applying sufficient mortar to bricks already in place and on brick to be placed and the joint shall not be more than 10 mm thick. All joints shall be properly flushed and packed with mortar so that no hollow spaces are left. All joints on exposed faces shall be tooled to give concave finish. No brickbats or cut bricks shall be used except where absolutely required for obtaining the dimensions of the different courses, specified bond and for the desired shape. The brickwork shall be built in uniform layers. Corners and other advanced work shall be raked back. Brickwork shall be done true to plumb or in a specified batter. During construction, the height of brickwork shall be restricted to 1 metre at a time above the general construction level to avoid settlement and improper jointing. Steel tee or a straight edge and plumb bob shall be used for constant checking during progress of the work.

404.2.5. Pointing: Pointing shall be carried out by using cement sand mortar not leaner than 1:3. The mortar shall be filled and pressed into the raked out joints before giving the required finish. The superfluous mortar shall then be taken off from the edges of the lines and the surface of the masonry shall be cleaned of all mortar. It shall conform to provisions of IS:2212. Raised pointing which projects beyond the face of stone, brick or block is likely to get damaged due to floods or carbonation process and hence should be avoided.

404.2.6. Plastering

404.2.6.1. Plastering may be done only where it is essential. Sacrificial plastering, which means an additional layer of plastering, may be done only in selected parts of the structures over fast flowing rivers or in severe aggressive environment.

404.2.6.2. Plastering shall be started from top and worked downwards. All putlog holes shall be properly filled in advance of the plastering as the scaffolding is taken down. Wooden screeds 75 mm wide and of the thickness of the plaster shall be fixed vertically 2.5 to 4.0 m apart to act as gauges and guides in applying the plaster. Prior to laying plaster, the surface of the wall should be wetted. The mortar shall be laid on the wall between the screeds using the mason's wooden float and pressing the mortar so that the raked joints are properly filled. The plaster shall then be finished off with a wooden straight edge reaching across the screeds. The straight edge shall be worked on the screeds with a small upward and sideways motion 50 mm or 75 mm at a time. Finally the surface shall be finished off with mason's wooden float. Metal floats shall not be used. When recommencing the plastering beyond the work suspended earlier, the edges of the old plaster shall be scrapped clean and wetted before plaster is applied to the adjacent areas. No portion of the surface shall be left out initially to be patched up later on. Plaster shall be finished to a true and plumb surface and to the proper degree of smoothness as required by the Engineer. The average thickness of the plaster shall not be less than the specified thickness. The minimum thickness over any portion of the surface shall not be less than the specified thickness by more than 3 mm. Any cracks which appear in the surface and all portions which sound hollow when tapped or are found to be soft or

otherwise defective shall be cut out in rectangle shape and redone as directed by the Engineer.

404.2.7. Curing

404.2.7.1. Green work shall be protected from rain by suitable covering. Masonry work in cement mortar shall be kept constantly moist on all the faces for a period of seven days. The top of masonry shall be left flooded with water at the end of the days work. Curing shall be done carefully so as not to disturb or wash out green mortar. In case of composite mortar, curing should commence two days after laying of masonry and shall continue for seven days.

404.2.7.2. Curing in hot weather has to be done for all finished or partly completed work by covering and wetting in such manner as will prevent rapid drying of the work.

404.2.7.3. Curing of finishes shall be started as soon as mortar of pointing/plastering has hardened sufficiently so as not to be damaged when watered. It shall be kept wet for a period of at least seven days.

404.2.7.4. During the period of curing, masonry work and plastering shall be suitably protected from all damages. At the close of the day's work or for any other period of cessation of work, watering and curing shall have to be maintained. Should the mortar perish, i.e., become dry, white or powdery through neglect of curing, work shall be pulled down and rebuilt. If any stain appears during watering, the same should be removed from the surface.

404.2.8. Laying masonry in foundation: Before laying bricks in foundation over foundation block, the top surface should

be thoroughly hacked, swept clean, wetted and then a layer of mortar not less than 12 mm thick shall be spread to make the surface on which bricks will be laid. Immediately thereafter, the first course of bricks shall be laid.

404.2.9. Where future extension is contemplated, arrangement suitable for developing bond between old and new masonry shall be made at the out set.

404.2.10. Joining old and new work: When fresh masonry is to join with masonry that is partially or entirely set, the exposed joining surface of the set masonry shall be cleaned, roughened and wetted so as to effect the best possible bond with the new work. All loose bricks and mortar or other materials shall be removed. In the case of vertical or inclined joints, it shall be further ensured so that proper bonds between the old and new masonry is obtained by interlocking the bricks. Any portion of brick work that has been completed shall remain undisturbed until thoroughly set.

404.2.11. In case of sharp corner, specially in skew bridge, a flat face of 100 mm shall be provided so as to have proper and bonded laying of bricks.

404.2.12. Finishing of work: All brick work shall be finished in a workman-like manner with thickness of joints and manner of striking or tooling indicated as above or as shown in the drawing or described in the specifications.

404.2.13. For a surface which is to be subsequently plastered or pointed, the joints shall be squarely raked out to a depth of 15 mm while the mortar is still green. The raked joints shall be well brushed to remove dust and loose particles and the surface shall be

thoroughly washed with water, cleaned, and wetted. The mortar for finishing shall be prepared as per Clause 404.1.2.

404.2.14. Condition of equipment: All equipment used for mixing or transporting mortar and bricks shall be cleaned and free from set mortar, dirt or other injurious foreign substances.

404.3. Stone masonry

404.3.1. Stone masonry in general, shall conform to the requirements of IS:1597 (Part-I) for Rubble Stone Masonry, (Part-II) for Ashlar Masonry and IS:1129 for Dressing of Natural Building Stone.

404.3.2. Type of masonry: For bridge works, generally, coursed rubble stone masonry (first sort) shall be used. For facing work, Ashlar masonry may be used if required. Random rubble stone masonry shall not be allowed in bridges except where allowed as per Clause 403.4.4.

404.3.3. Size of stones: The size of stones shall be as per IS:1597 (Part-I).

404.3.4. Laying

404.3.4.1. The masonry work shall be laid to lines, levels, curves and shapes as shown in the plan. The height in each course shall be kept same and every stone shall be fine tooled on all bed joints and faces full and true. The exposed faces shall be gauged, cut grooved, rebated and sunk or plain moulded as the case may be. The faces of each stone shall be left rough as the stone comes from quarry except where sacrificial layer is to be provided or plastering is done due to aggressive environment.

404.3.4.2. Stones shall be sufficiently wetted before laying to prevent absorption of water from mortar.

404.3.4.3. Stratified stones must be laid on their natural beds. All bed joints shall be normal to the pressure upon them.

404.3.4.4. Stones in the hearting shall be laid on their broadest face, which gives better opportunity to fill the space between stones. Hearting stones shall consist of rubble stones not less than 150 mm in any direction, carefully laid, hammered down with a wooden mallet into position and solidly bedded in mortar. Plum stones shall be provided at about 900 mm centre to centre to ensure proper bond between successive courses.

404.3.4.5. The courses of the masonry shall ordinarily be predetermined. They shall generally be of the same height. Where there is to be variation in the height of courses, larger courses should be placed at lower level, with height of courses decreasing gradually towards the top of the wall. The height of a course shall not be less than 160 mm. The practice of placing dry mortar on the course and pouring water on it to fill up gaps between stones is not allowed for cement mortar since it segregates. Mortar may be fluid mixed thoroughly and then poured in the joints. No dry or hollow space shall be left anywhere in the masonry and each stone shall have all the embedded faces completely covered with mortar.

404.3.4.6. In tapered walls, the beds of the stones and the planes of courses should be at right angles to the batter. In case of bridge piers having batters in both sides, the courses shall be horizontal.

404.3.4.7. The bed, which is to receive the stone, shall be cleaned, wetted and covered with a layer of fresh mortar. All stones

shall be laid full in mortar both in bed and vertical joints and settled carefully in place with a wooden mallet immediately on placement and solidly embedded in mortar before it has set. Clean chips and spalls shall be wedged into the mortar joints and beds wherever necessary to avoid thick beds or joints of mortar. No hollow space shall be left anywhere in the masonry and each stone shall have all the embedded faces completely covered with the mortar. The quantity of mortar consumed per cubic metre of stone masonry shall be 0.25 to 0.30 cubic metre. For masonry works over rock, a levelling course of cement concrete M-15 grade and having minimum average thickness 150 mm shall be laid over rock and then stone masonry work shall be laid. The quantity of mortar consumed per cubic meters of various type of masonry are generally as below:

(a)	Ashlar masonry	– 0.08 cum to 0.18 cum
(b)	Coursed rubble masonry	– 0.25 cum to 0.35 cum
(c)	Random rubble masonry	– 0.25 cum to 0.35 cum

404.3.4.8. Face works and hearting shall be brought up evenly but the top of each course shall not be levelled up by the use of flat chips.

404.3.4.9. For sharp corners, especially in skew bridges, through stone shall be used in order to avoid spalling of corners.

404.3.4.10. In case any stone already set in mortar is disturbed or the joints broken, the stone shall be taken out without disturbing the adjoining stones and joints, the mortar and stones thoroughly cleaned from the joints and the stone reset in fresh mortar. Attempt must never be made to slide one stone over another already laid fresh.

404.3.4.11. Shaping and dressing shall be done before the stone is laid in the work. No dressing and hammering which will loosen

the masonry will be permitted after it is, once placed. It is, therefore, advised that all-necessary chases for joggles, dowels and cramps should be formed before hand.

404.3.4.12. Through bond stones shall be provided in masonry upto 600 mm thickness. In case of masonry above 600 mm thickness, a set of two or more bond stones overlapping each other atleast by 150 mm shall be provided in a line from face to back.

404.3.4.13. In case of skew bridges and for cut and ease water, the acute angle at the corners shall not be less than 45 degrees. In case the smaller angle cannot be avoided then a flat face of 100 mm be provided.

404.3.4.14. While carrying out masonry work, templates prepared to the correct shape and approved by competent authority shall be used to ensure correct batter as well as correct shape of masonry specially cut and ease water end. The finished work shall be checked at every stage by the competent authority to ensure that it has the correct shape and batter as required by design.

404.3.5. Bond

404.3.5.1. Sufficient transverse bonds shall be provided by the use of bond stones extended from the front to the back of the wall and in case of thick wall from out side to the interior and vice versa. In the later case, bond stones shall overlap each other in their arrangement. Such overlap shall not be less than 150 mm. Minimum length of each bond stone shall be 450 mm. Bond stone or a set of bond stones shall be provided at 1.5 m to 1.8 m apart clear in every course and staggered in layer.

404.3.5.2. In case, long headers are not available, precast headers of M-15 concrete shall be used. Cast in-situ headers are not permitted.

404.3.5.3. (a) Stone shall break joint on the face for at least half the height of the course and the bond shall be carefully maintained throughout.

(b) At junctions of wall, the stones at each alternate course shall be carried into each of the respective walls so as to unite the work thoroughly.

(c) The practice of building two thin faces tied with occasional through stones and filling-up the middle with small stuff or even dry packing must be strictly prohibited.

(d) All quoins at the angles of the opening shall be made from selected stones. These shall be carefully shaped and laid alternately as long and short quoins.

404.3.5.4. All vertical joints shall be truly vertical and staggered as far as possible. Distance between the nearer vertical joints of upper layer and lower layer shall not be less than half the height of the course.

404.3.5.5. All connected masonry in a structure shall be carried up nearly at one uniform level throughout but when breaks are unavoidable, the masonry shall be racked in sufficiently long steps for facilitating joining of old and new work the stepping of racking shall be around 45 degrees with horizontal.

404.3.7. Pointing: Pointing shall be same as given in Clause 404.2.5. The thickness of joints shall not be less than 3 mm for Ashlar masonry. The maximum thickness of joints in different

works shall be as follows:

Coursed rubble	20 mm
Block work	12 mm
Ashlar masonry	6 mm

404.3.8. Curing: Curing of stone masonry shall be done as given in Clause 404.2.7.

404.4. Concrete Block Masonry

404.4.1. Only solid concrete blocks of normal weight conforming to IS:2185 Part-I, with minimum compressive strength of 10.5 MPa shall be used for bridge works.

404.4.2. Sizes of blocks: The thickness of concrete block shall not be less than 200 mm and the width shall also be not less than 200 mm. The density of concrete block shall not be less than 2.2 M ton/cum.

404.4.3. Laying

404.4.3.1. The bed, which is to receive the block, shall be cleaned wetted and covered with a layer of fresh mortar. The masonry work shall be laid to lines, levels, curves and shapes as shown in the plan. In battered sections, the beds of blocks and the plane of courses shall be horizontal. Face blocks for such sections shall be manufactured specially for the purpose.

404.4.3.2. The block shall be soaked in water for at least 15 minutes before laying to prevent absorption of water from mortar.

404.4.3.3. The concrete block masonry shall be constructed generally like fine tooled Ashlar masonry.

Each block must be fitted into its place dry in order that discrepancy of figure may be discovered and corrected before it is finally laid in mortar and settled in bed. The block shall be laid full in thin mortar, the bed and side joints being not more than 15 mm in thickness. Each

block shall be struck with a wooden mallet when laid in place in mortar to bring it to solid bearing as to bed and joints. All visible edges shall be quite free from chippings.

The courses shall be horizontal and side joints vertical throughout unless otherwise indicated in plans. Joints shall be struck.

For bond, face blocks shall be laid header and stretcher alternately unless otherwise ordered by the Engineer, the header being arranged to come as nearly as possible in the middle of stretchers below. The blocks in the courses above and below shall break joints for about half the height of the course and bond shall be carefully maintained throughout section.

404.4.4. While carrying out masonry work, templates prepared to the correct shape and approved by competent authority shall be used to ensure correct batter as well as correct shape of masonry specially cut and ease water end. The finished work shall be checked at every stage by the competent authority to ensure that it has the correct shape and batter as required by design.

404.4.4.1. In case of skew bridges and for cut and ease water, the acute angle at the corners shall not be less than 45 degrees. In case, the smaller angle cannot be avoided then a flat face of 100 mm be provided.

404.4.5. Curing for block masonry shall be done as given in Clause 404.2.7.

404.5. Arches

404.5.1. A full-scale shape of arch be laid on a levelled platform near the construction site and size of each stone and mortar thickness be marked. Then the stones be cut or blocks made accordingly. In the outer rings of the arch the alternate stone shall

have long length and short length as shown in the Fig. 8. Remaining stones/blocks in the inner part of the arch as far possible may have uniform length. The number of courses and the size of the voussoirs shall be shown on the plans. The plan should indicate the order in which voussoirs shall be placed. Voussoirs shall be full size throughout and shall have bond not less than their thickness. Beds shall be properly adjusted to bring them to radial planes. Radial joints shall be in planes parallel to the transverse axis of the arch. The intrados face shall be dressed sufficiently to permit the bricks, stones or block to rest properly upon the centering. The bricks/stones/blocks of the spandrel wall at their junctions with the extrados of the arch shall be cut to fit in the curvature of the arch (Fig. 8).

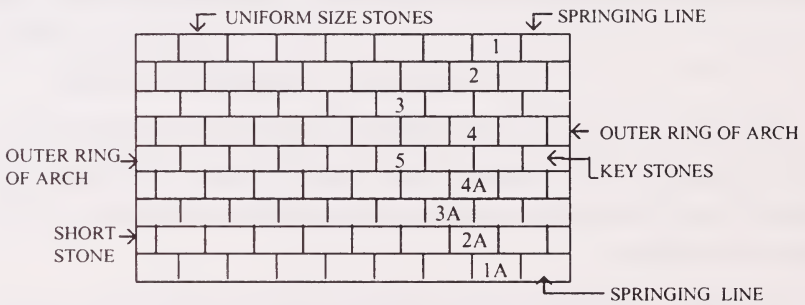

Fig. 8. Schematic Plan showing arrangement of Stones/Block in Arch Construction

Note: Number indicate the order of placing the rows of voussoirs.

404.5.2. The work shall be carried out symmetrically about the crown, units being laid in full mortar beds and the joints grouted where necessary. Pinning by the use of spalls or such material of any description shall not be permitted. Each stone must first be

fitted dry, in order that any inaccuracy may be discovered and corrected by stone cutter before it is finally laid into mortar and settled in its bed.

While carrying out haunch filling and cushioning (and also while removing these during repairs) care shall be taken to ensure stability of arch and also to avoid unsymmetrical loading on the substructure and arch. Cross camber shall be provided in the top surface of concrete of haunch filling and corresponding drain holes in the face wall to facilitate easy drainage of seepage water.

404.5.3. Scaffolding: The scaffolding in general shall be sound and strong and shall be able to withstand all loads likely to come upon it. The holes left in masonry work for supporting the scaffolding shall be filled and made good.

404.5.4. Centering

404.5.4.1. The successful completion of an arch largely depends on the design, construction and stripping of the centering. Therefore, considerable thought should be given to the method used in supporting an arch ring. For design considerations, the IRC:87 may be consulted.

Note : Centering for special condition shall be designed by experienced Engineer who has the requisite theoretical and practical knowledge in this field.

404.5.4.2. The number of full sets of centering required depend upon the number of arch spans. For two or three spans, two or three sets may be used. For five or more spans, three or more sets

may be used depending on the location of the abutment pier. For wide bridges, it may sometimes be more economical to build the centering for half width of the bridge and move sideways for the other half. However, reference may be made to IRC:87 "Guidelines for the Design and Erection of Falsework for Road Bridges".

404.5.5. Stripping

404.5.5.1. Wedges should be struck in pairs from the crown outwards to the springing line loosening them gradually without shock to the arch ring. About half the wedges can be removed in seven days and used in the adjoining arch. Centering should not be struck under 2 to 4 weeks, 3 weeks being the usual time for arches under 30 m span. Arches with higher ratio of rise to span can be stripped earlier than those with lower ratio. All braces except those that may be required for supporting scaffolding plank can be removed. For high arches, stripping should commence at the top taking down tier by tier.

404.5.5.2. In multiple span arch bridges, centering must not struck and stripped before the adjoining arch is built. Sometimes it is required that one or two arches may be kept undisturbed between the arch last built and the arch being stripped off.

404.5.5.3. Striking of centering: Centering shall not be struck until the masonry has sufficiently hardened to maintain its own weight and the haunch portions are filled to half the rise in circular arches and 1/3 rise in segmental arches. Where it is intended to reuse the formwork, it shall be cleaned and made good to the satisfaction of the Engineer.

405. EXPANSION GAP

405.1. In case of long walls, an expansion gap of 40 mm shall be provided for every 30 m length of wall. The gap should be filled with premoulded bituminous sheet or any suitable flexible material.

405.2. Where foundations of abutments and returns walls are at different levels, a gap of at least 40 mm in width must be left to separate them.

406. FLOOR PROTECTION WORKS

For floor protection works, IRC:89 may be referred to.

Annexure
(Ref. Clause 400)

SPECIAL PRECAUTIONS FOR CONSTRUCTION OF MASONRY DURING FREEZING WEATHER

1. Storage

Masonry materials should be stored and protected at the job site to prevent damage from wet, cold or freezing weather. Bagged materials and masonry units should be stored elevated to prevent migration of moisture from the ground and covered to protect the sides and tops. Consideration should be given to the method of stock piling sand to permit heating of the materials, if required.

2. Forms and Shoring

Provide substantial and tight forms to prevent leakage of mortar or grout. Brace or shore forms to maintain position and shape. Do not remove forms or shoring until masonry has hardened sufficiently to carry its own weight and any other temporary loads that may be placed on it during construction.

3. Surface Conditions

Ice or snow that has formed on the masonry bed shall be thawed by application of heat. Apply heat carefully until top surface is dry to the touch. Any section of completed masonry work that is deemed frozen and damaged shall be removed before continuing construction of that section.

4. Condition of Masonry Units

(i) Use only dry masonry units except as permitted below. Wet or frozen masonry units shall not be laid. No wetting of concrete masonry units will be permitted.

(ii) For brick masonry units used in cold weather construction, initial rates of absorption may range to a maximum of 35 mg. When sprinkling is required to achieve proper absorption rates, heated water shall be used. Water shall be above 20 degrees C when temperature of units is above freezing point and above 55 degrees C when temperature of units is below freezing point.

5. Construction Requirements

Work day temperature	Temperature for construction requirement		Protection Requirement	Protection of completed work
	Sand or Water	Sand and Water		
0 degree C to + 4 degrees C	4 degrees C — to 50 degrees C		--	During construction the masonry shall be protected from rain or snow for 24 hours by covering it with weather-resistive membrane.
- 4 degrees C to 0 degree C	--	4 degrees C to 50 degrees C	Maintain mortar temperature above freezing point.	Masonry shall be completely covered with a weather resistive membrane for 24 hours.
-7 degrees C to -4 degrees C	--	4 degrees C to 50 degrees C	Maintain mortar temperature above freezing	Masonry shall be completely covered

Work day temperature	Temperature for construction requirement		Protection Requirement	Protection of completed work
	Sand or Water	Sand and Water		
			point. Provide source of heat on both sides of wall. Employ wind brake if wind speed >25 kmph.	with insulating blankets and protected for 24 hours.
-7 degrees C and below	4 degrees C to 50 degrees C		Enclosure and auxiliary heat shall be employed to maintain temperature above freezing point. Temperature of unit shall not be less than -7 degrees C.	Masonry temperature shall be maintained above freezing point for 24 hours by enclosure and supplementary heat, such as, electric heating blankets, infrared heat lamps or other approved methods.