

SECTION 15
CONCRETE BLOCK AND MASONRY CONSTRUCTION

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SECTION 15

CONCRETE BLOCK AND MASONRY CONSTRUCTION

1501

SCOPE

- (a) All masonry construction shall conform to the provisions of this Section and other applicable Sections of this Code. The principal reference Codes and Standards are CUBIC Part 2 Section 4 - Structural Requirements - Block Masonry, and ACI 530-92 - Building Code Requirements for Masonry Structures.
- (b) In all cases masonry shall be of adequate thickness, strength and proportions to support all superimposed loads within the allowable working stresses prescribed.
- (c) All masonry materials are required to meet the specifications as outlined in 1502. If the Director has reason to doubt that the materials meet the applicable specifications he may require tests on the materials.
- (d) Masonry units may be re-used when clean, whole and conforming to the other requirements of this Section, except that the allowable working stresses shall be fifty (50) percent of those permitted for new masonry units.
- (e) Masonry units to be reused as structural units in areas subject to the action of the weather or soil shall not be permitted unless representative samples are tested for compliance with the applicable requirements of Section 1502.
- (f) The wall thickness and other specified dimensions are nominal dimensions. The actual masonry or wall dimensions may vary from the nominal dimensions by not more than one-half (1/2) inch.
- (g) Where masonry units are used as veneer, weepholes shall be provided at four (4) feet on centers by omitting mortar in the vertical joints at the bottom course of the veneer or at the lintels in multi-storey buildings. A shield or insect barrier shall be provided having openings or louvers one-sixteenth (1/16) inch or less which drains and dries the inner cavity but will retain poured insulation.
- (h) All brick masonry units, except hollow clay and shale brick, shall be laid with full head and bed joints and all interior vertical joints that are designed to receive mortar shall be filled. The average thickness of head and bed joints shall not exceed one-half (1/2) inch.

1502.1 General

- (a) Quality. The quality of materials assembled into masonry and the method and manner of their assembly shall conform to the requirements of 1502.
- (b) Other material of masonry, other than set forth herein, which is incombustible and otherwise sufficiently embodies the characteristics and satisfies the requirements of one of the materials herein may be specified by the designer of the building, but the use of such material shall be subject to the approval of the Director.

1502.2 Brick

The structural use of brick shall be avoided except where special provision can be made for reinforcement and/or for composite behaviour with other members of materials such as steel or reinforced concrete.

- (a) General. Bricks shall include masonry units up to 4-1/4" thick, 4-1/4" wide and 8-3/4" long not less than 75 percent solid.
- (b) Tests. Tests shall be made in accordance with BS 1257, or other standard approved by the Director.
- (c) Quality. Bricks shall conform to the relevant British or American Standard.

1502.3 Hollow and Solid Concrete Masonry Units

- (a) Hollow concrete masonry units shall be of a quality at least equal to that required by "Specifications for Hollow Load-Bearing Concrete Masonry Units, ASTM C90", or "Specifications for Solid Load-Bearing Concrete Masonry Units, ASTM C145", when used for bearing walls or piers or when in contact with the ground or exposed to the weather, or equal to "Specifications for Hollow Non-Load-Bearing Concrete Masonry Units" ASTM C129 when used for non-load bearing purposes and not exposed to the weather.
- (b) Structural concrete filler-block or floor tile when included in strength calculations in ribbed floor construction shall have webs and shells not less than one inch thick, unless otherwise designed, and shall develop an average compressive strength on the net area not less than that of the rib concrete.
- (c) Concrete in-fill shall be in accordance with Table 15-3 (A) or with CUBiC Table 2.405.1.

1502.4 Mortar and Grout Materials, Proportions and Workability.

- (a) Mortar and its ingredients shall be of a quality at least equal to that required by "Standard Specifications for Mortar for Units Masonry", ASTM C270, or "Standard Specifications for Mortar and Grout for Reinforced Masonry", ASTM C476 or the relevant British standard.
- (b) Masonry cement shall be of a quality at least equal to that required by "Masonry Cement, ASTM C91".
- (c) The type of mortar used for any specific job shall be as required in Table 15-2.
- (d) Grout for non-reinforced and reinforced masonry shall conform to "Standard Specifications for Mortar and Grout for Reinforced Masonry", ASTM C476.
- (e) Where mortar type is determined in accordance with Table 15-1 the volume of aggregate in mortar shall be not less than two and one-fourth (2-1/4) times but not more than three times the volume of cementitious material. When mortar type is determined by proportions, the aggregate ratio shall comply with Table 15-3.

1503 WORKING STRESSES

1503.1 General Requirements

- (a) In determining the stresses in masonry, the effects of all loads and conditions of loading and the influence of all forces affecting the design and strength of the several parts shall be taken into account.
- (b) The thickness of masonry walls shall be sufficient at all points to withstand all vertical and horizontal loads as specified in Section 12.
- (c) Stresses shall be calculated on actual rather than nominal dimensions.
- (d) The maximum allowable stresses in masonry shall not exceed those set out in this Section, unless it can be determined by accepted engineering analysis that the design meets all safety requirements.

1503.2 Working Stresses in Un-reinforced Masonry

Except as may be permitted by the Director on the basis of a rational engineering design, the compressive stresses in un-reinforced masonry shall not exceed the values given in Table 15-4.

1503.3 Higher Working Stresses

Higher stresses than herein specified may be used, but only if it is clearly established to the satisfaction of the Director, by tests, or other approved evidence, that material of a higher grade or a superior workmanship than is generally provided in accepted practice will be employed under approved inspection. Higher stresses, however, shall not be used unless approval is given by the Director in writing.

1503.4 Allowable Stresses in Composite Walls

In composite walls or other structural members composed of different kinds or grade of masonry units or mortars, the maximum stress shall not exceed the allowable stress for the weakest of the units and mortars of which the wall or member is composed.

1503.5 Allowable Stresses in Plain Concrete

Unless designed in accordance with the provisions of Section 16, structural members of plain concrete shall be proportioned for allowable stresses not to exceed twenty-five (25) percent for compression and three (3) percent for tension in extreme fiber in flexure of the compressive strength of the concrete. When the ratio of height to thickness exceeds ten (10), the percentages for compression stress shall be reduced proportionately to eighteen percent for a ratio of height to the thickness of 20.

1503.6 Shear

The shear in unit masonry shall not exceed one tenth the allowable compressive stress.

1503.7 Tension

Un-reinforced unit masonry shall be assumed to have no value in resisting tension.

1503.8 Concentrated Loads

Walls of hollow masonry units shall not directly support concentrated loads. Such loads shall be carried by concrete padstones or capping beams.

1504 CONSTRUCTION DETAILS

1504.1 General

- (a) Masonry walls of hollow or solid units or plain concrete shall be constructed as specified in Part 2 Section 2.400 of CUBiC, or in accordance with alternative rational design and detailing based on the fundamental principles of structural engineering.

- (b) Reinforced concrete shall comply with the requirements of Section 16 of this Code.
- (c) Part 2 Section 2.445 of CUBiC is applicable for the construction of single or two storey buildings to resist seismic and hurricane loads.

1504.2

Walls

- (a) Load-bearing walls of unit masonry shall have a minimum thickness of 6" except as otherwise approved by the Director on the basis of engineering calculations showing that the wall can resist adequately the calculated vertical and horizontal forces.
- (b) No roof or other members shall be so placed that they will develop direct horizontal thrust on walls unless such walls are specifically designed to withstand such thrust.
- (c) The maximum area of wall panels of 6" or 8" thick unit masonry, as measured between the concrete members which frame the panel such as the beams and its columns, shall not exceed 256 sq.ft. unless otherwise approved by the Director on the basis of engineering calculations provided by the design engineer.
- (d) For resistance to seismic and lateral forces, walls of hollow concrete block shall be designed in accordance with CUBiC Part 2, Section 4 - Structural Design Requirements Block Masonry, or in accordance with any other Code approved by the Director.
- (e) Wall reinforcement shall be as required by Seismic Performance Category C for buildings in seismic zones with peak accelerations of 0.2g to 0.3g. Police stations and buildings housing emergency medical facilities and other buildings as required by the Director shall be designed in accordance with Seismic Performance Category D. (See CUBiC 2.424).
- (f) A check shall be made to establish if the minimum reinforcement in block walls is adequate for walls under wind or earthquake loads.

1504.3

Stiffener columns

- (a) Concrete stiffener columns shall be required in walls of unit masonry as follows:
 - (i) The maximum area of wall panels of 6" or 8" thick concrete block as measured between the concrete members which frame the panels, such as the beams and stiffener columns shall be 256 square feet.

- (ii) At intervals not exceeding 20' 0" between columns.
 - (iii) At corners and junctions of load bearing walls, unless the walls are properly bonded into one another and no opening occurs within 1' 4" of the nearest wall face at the corner.
 - (iv) At the end of load bearing walls
 - (v) Notwithstanding the above, concrete stiffener columns shall also be required adjacent to any wall opening if the omission of the columns would result in stresses in the block work greater than that permitted under 1503.4 at the ends of free standing walls
- (b) Structurally designed columns may be substituted for the stiffener columns herein required. When interior cross-walls are properly bonded into the external wall these may be assumed to act as ties to the columns, provided no openings occur in either the exterior walls or the interior cross walls within 1' 4" of the nearest wall face.
- Note:** A corner or junction shall be considered to be properly bonded if all holes in all hollow blocks forming the junction are filled with concrete as per CUBiC Part 2 Section 4 Table 2.405.1, and reinforced with No 4 bars. Concreting of the cavities shall be in accordance with CUBiC 2.409.17.
- (c) Stiffener columns shall not be less than 12" in width unless otherwise approved by the Director. Stiffener columns having an unbraced height exceeding 15' 0" shall be not less in thickness than the wall and not less than 9". The column shall be designed to resist applicable lateral loads based on rational analysis. The unbraced height shall be taken at the point of positive lateral support.
 - (d) Stiffener columns shall be reinforced in accordance with Part 2 Section 4 of CUBiC (2.413) and with not less than 0.010 times the gross cross-sectional area of the concrete, nor less than four 1/2" diameter bars, with 1/4" diameter links spaced at 12 " centres generally and in accordance with 2.413.8 of CUBiC. Vertical reinforcing shall be tied to the footing and splices shall be lapped 30 bar diameters. The cover to the reinforcement (including links) shall be not less than 1".
 - (e) The concrete stiffener columns set forth herein are a minimum to limit masonry panel areas and provide an integrated frame-work for masonry. The spacing of concrete columns for skeleton frame construction may exceed the spacing herein set forth provided the masonry panels have an area of less than

256 sq.ft, and the structural system is designed to transmit horizontal wind loads to the columns.

- (f) Concrete stiffener columns designed to limit masonry panel areas may be offset at tie beams or other horizontal members to avoid openings, but the maximum spacing shall not be exceeded.
- (g) Concrete stiffener columns in load-bearing walls shall normally be poured only after the masonry units are in place. Where masonry walls in skeleton frame construction are laid up after the frame has been erected they shall be properly tied to the frame with vertical bars at 16" centres and horizontal bars at 24" centres. Where structural steel members are fire-protected with masonry units the panel walls shall be bonded into such units.
- (h) For small masonry buildings the requirements set forth in CUBiC Part 2 Section 4 or those set forth in the Building Guidelines apply.

1504.4

Tie Beams or Belt Courses

- (a) Tie beams of reinforced concrete shall be placed in all walls of unit masonry, at each floor or roof level and at such intermediate levels as may be required to limit the vertical heights of the masonry units to 12' 0". For external walls of 6" concrete block the vertical height shall be no greater than 9' 0".
- (b) A tie beam shall be not less in dimension than required for the conditions of loading nor less than the following minimums: the width of a tie beam shall be not less than the width of the wall supporting it; the depth of such a beam shall be not less than 8".
- (c) The tie beam shall be continuous. Continuity of the reinforcing in straight runs shall be provided by lapping splices not less than 30 diameters for deformed bars. Continuity shall be ensured at corners by providing positive anchorage to the main reinforcement. Continuity at columns shall be provided by continuing horizontal reinforcing through columns or by bending horizontal reinforcing in the columns a distance of 30 diameters.
- (d) Changes in level of tie beams shall be made at columns.
- (e) A tie beam may follow the rake of a gable or shed end.
- (f) The concrete in tie beams shall be bonded to the masonry units immediately below and shall not be separated therefrom by wood, felt, or any other material which may prevent bond.

1504.5 Parapet Walls

Masonry parapet walls shall be reinforced with minimum stiffener columns as previously specified and shall be coped with a concrete beam not less than 24 sq.in. in cross-section, reinforced with two 3/8" diameter reinforcing bars.

A parapet wall exceeding 5' 0" in height above a tie beam or other point of lateral support shall be specifically designed to resist horizontal wind and other loads.

1504.6 Piers

- (a) In any section of a load-bearing masonry wall where openings are arranged to leave a load-bearing section of wall less than 16" wide, such section shall be of steel or reinforced concrete.
- (b) Isolated masonry piers shall be so constructed that the height of any such pier shall not exceed ten times the least dimension.

1504.7 Brick and Stone Walls

Load bearing walls of brick and stone shall be laterally supported by stiffener columns and tie beams, or the equivalent thereof, as detailed in 1504 and shall meet these additional requirements:

- (1) In all brick walls at least every sixth course on both sides of the wall shall be a header course or there shall be at least one full header in every 72 sq.in of each wall surface. In walls more than 12" thick, the inner joints of header courses shall be covered with another header course which shall break joints with the course below.
- (2) Rubble stone walls shall be 4" thicker than is required for solid brick or concrete walls of the same respective heights but no part shall be less than 16" thick.

1504.8 Partitions

- (a) The requirements specified herein shall apply to non load bearing partitions, other than fire walls, of unit masonry construction.
- (b) The lateral distance between vertical supports of non load bearing interior partitions of unit masonry shall not exceed 36 times the actual thickness of the partition, excluding plaster, and the height shall not exceed the length.
- (c) A partition which does not extend to full storey height shall be capped with a concrete beam at least 4" high and of width at least equal to the width of the partition. The beam shall be

reinforced with a single 3/8" diameter bar to which all vertical reinforcing bars shall be anchored.

1504.9 Decorative Masonry Screens

Decorative grills or screens constructed of masonry laid with cells through the wall shall be non load bearing, and shall have units so bonded and reinforced as to resist all over-turning moments.

1505 CHANGE IN WALL THICKNESS

Except for permissible chases and recesses, walls shall not vary in thickness between their lateral supports. Where cavity walls or walls of hollow masonry units are decreased in thickness, a course of solid masonry not less than four (4) inches in thickness shall be interposed between the wall below and the thinner wall above, or the hollow units in the top course of the thicker wall shall be filled solidly with concrete (of 1:3:6 mix) or with Type S mortar or grout in accordance with ASTM 476C.

1506 CHASES

Chases in masonry walls shall be in accordance with 2.409.24 to 2.409.26 of CUBiC.

1507 SUPPORTED STRUCTURAL MEMBERS

When combustible structural members frame into walls of thickness not greater than twelve (12) inches, they shall project not more than four (4) inches into the wall and shall be so spaced that the distance between embedded ends is not less than four (4) inches. The space above, below and between such members shall be filled solidly with mortar, grout, concrete, or equivalent fire-resistive material to a depth of not less than four (4) inches on all sides of the members.

1508 SUPPORT ON WOOD

- a) Masonry shall not be supported on combustible construction, except that prefabricated partitions weighing not more than thirty (30) pounds per square foot, properly strapped or reinforced and provided with proper nailing devices for attachment, may be supported on combustible construction, provided the supporting construction has been designed to carry such loads.
- b) Concrete decks for roofs or floors may be supported on timber columns provided such decks and their supporting members have been designed in accordance with accepted engineering

practices and that special provision is made to provide resistance to wind and earthquake forces.

- c) When exposed to the weather the wood supporting members shall be of approved wood of natural decay resistance and pressure treated against termites and shall be separated from the concrete by the use of a membrane covering.

1509

ARCHES AND LINTELS

The masonry above openings shall be supported by well buttressed arches or lintels of non combustible materials which shall bear on the wall at each end for not less than four (4) inches. In addition, the bearing area shall be sufficient to prevent a concentration of compressive stresses greater than those allowed in Table 15-4.

1510

CONSTRUCTION PRECAUTIONS

- a) Except when carried independently by girders at each floor, a masonry wall shall not be built up more than twenty-five (25) feet in height in advance of other walls of the building. Walls shall be adequately braced during erection.
- b) Masonry walls in locations where they may be exposed to high winds during erection shall not be built higher than ten (10) times their thickness unless adequately braced or until provision is made for the prompt installation of permanent bracing at the floor or roof level immediately above the story under construction.
- c) Back fill shall not be placed against foundations walls until they have been braced to withstand the horizontal pressure.

1511

GROUTED AND FILLED MASONRY

Grouted and filled masonry blocks is a form of construction made with clay, or concrete units in which the interior vertical spaces are filled with grout. The interior vertical spaces shall consist of continuous cavity space between unobstructed vertical cells of hollow units. Grouted masonry shall conform to all requirements this Code.

1512

MORTAR AND GROUT

- (a) Mortar shall conform to "Specification for Mortar for Unit Masonry ASTM C270". Grout shall conform to the applicable requirements of "Specifications for Mortar and Grout for Reinforced Masonry - ASTM C476," or shall be Type M or Type S mortar to which sufficient water has been added to

produce pouring consistency. Mortar and grout for reinforced masonry shall be in accordance with ASTM C476.

- (b) Where the minimum continuous clear opening of a grout space exceeds six (6) inches, it may be filled and treated as unreinforced monolithic concrete. Masonry shall be laid in mortar of the types specified in Tables 15-2 and 15-3.

Table 15-1

Minimum Compressive Strength of Mortar

Type	Minimum Compressive Strength at 28 days (psi)
M	2,500
S	1,800
N	750
O	350

Note: Average of three 2 inch cubes of laboratory prepared mixed mortar, in accordance with ASTM C270. "Standard Specifications for Mortar for Unit Masonry".

Table 15-2

Types of Mortar Required

Type of Masonry	Type of mortar permitted
Foundations: (below grade masonry)	
Footings	M or S
Walls of Solid Units	M, S or N
Walls of Hollow Units	M or S
Hollow Walls	M or S
Masonry: Other Than Foundation Masonry	
Piers of Solid Masonry	M, S or N
Piers of Hollow Units	M or S
Walls of Solid Masonry	M, S, N or O
Walls of Hollow Masonry	M, S, or N
Hollow Walls and Cavity Walls	
(a) Design Wind Pressure Exceeds 20 psf.	M or S
(b) Design Wind Pressure 20 psf or less	M, S or N
Glass Block Masonry	M, S or N
Non-Load Bearing Partition	M, S, N, O
Fire Brick	Refractory air setting mortar
Masonry Other Than Above	M, S or N

Note: Type S mortar is to be preferred whenever Type M mortar is not required in order to meet the structural requirements.

Table 15-3**Mortar Proportions by Volume**

Minimum Compressive Strength of concrete block on Gross Cross Sectional Area. (psi)	Mortar Mix (Cement:lime:sand)	Minimum Compressive Strength of mortar (psi)
1,500	1:0-1/2:3	2,500
1,000	1:0-1/2:4	1,800
*700	1:0-1/2:4	750

Note:

- (a) The compressive strengths used have been converted from SI units. Tables 2.403.1 and 2.404.1 of Part 2 Section 4 of CUBiC should be read for the compressive strengths based on test results.
- *(b) This grade of concrete blocks to be used for non-loadbearing walls only.
- (c) For the purpose of these specifications, the weight of one (1) cubic foot of the respective materials used shall be considered to be as follows:

Portland Cement	94 pounds
Hydrated Lime	40 pounds
Sand	80 pounds of dry sand

Table 15-3 (A)**Properties of In-fill Concrete**

Minimum Compressive Strength on 6" cubes at 28 days	Concrete Mix for Cavity In-fill (cement: sand: coarse aggregate)	Minimum Compressive Strength of Concrete Block
2,300	1:3:6	1,000
3,300	1:2:4	1,800

Note: Aggregate size should not be greater than 3/4". See CUBiC Part 2 Section 4.

Table 15-4

Allowable Compressive Stresses for Empirical Design of Masonry*

Construction: Compressive Strength of Unit, gross area, (psi)	Allowable compressive stresses gross cross section area (psi)	
	Type M or S Mortar	Type N Mortar
Solid masonry of brick and other solid units of clay or shale, sand lime or concrete brick		
8,000 or greater	350	300
4,500	225	200
2,500	160	140
1,500	115	100
Grouted solid masonry of clay or shale, sand lime or concrete		
4,500 or greater	225	200
2,500	160	140
1,500	115	100
Masonry of solid concrete masonry units		
3,000 or greater	225	200
2,000	160	140
1,200	115	100
Masonry of hollow load bearing units		
2,000 or greater	140	120
1,500	115	100
1,000	75	70
700	60	55
Piers of hollow units, cellular spaces filled as in Section 15.	95	90
Hollow walls (non-composite masonry bonded)		
Solid units		
2,500 or greater	160	140
1,500	115	100
Hollow units	75	70

* Masonry Structures Building Code (ACI 530-92/ASCE 5-92/TMS 402-92)

Notes: Linear interpolation for determining allowable stresses for masonry units having compressive strengths which are intermediate between those given in the Table.

The allowable shear and tension working stresses are given in Table A102-2 of Part 2 Section 4 Appendix 1 of CUBiC.

Table 15-5

**Specified Compressive Strength of Masonry
Based on Specifying the Compressive Strength of Masonry Units***

Compressive Strength of Concrete Masonry Units (psi)	Specified Compressive Strength of Masonry	
	Type M or S Mortar	Type N Mortar
4,800 or more	3,000	2,800
3,750	2,500	2,350
2,800	2,000	1,850
1,900	1,500	1,350
1,250	1,000	950

*See ACI 530-92 Masonry Structures Building Code