MASONRY WALL TYPES

Masonry is the most enduring of all building materials, as exemplified by the oldest and most revered architecture from around the world. The exceptional structural integrity and durability of traditional masonry walls are derived from the inherent properties of the materials, and from the robustness and built-in redundancies of these assemblies. Modern masonry walls have evolved to apply these historical benefits to meet the challenges of today's building designs.

Masonry walls provide high-performance enclosures, which fulfill support, control and finish functions. Masonry loadbearing, infill and partition walls are physical barriers that provide privacy, security, and fire and sound separation. When they are part of the building envelope, masonry walls also act as a durable support for barrier and cladding elements, and of course may be utilized to provide the cladding as well.

Selecting a particular masonry wall assembly from the many available for a particular project can be influenced by many factors. This "wall selection guide", along with other sections of this manual, is intended to outline technical and performance-related masonry design considerations to assist designers and prospective building owners with their decision making.

For the purposes of this publication, masonry walls are divided into two types of assemblies. These are single wythe **structural walls** and multi-layered **rainscreen veneer walls**. Historic masonry walls are examples of structural walls where the characteristics of the assembly result primarily from the massive nature of the construction. The modern version of these walls employs reinforced, single wythe concrete block or structural clay units to provide the structure and much of the environmental separation. See *Section 1.2* for further detailed information.

Definitions:

- Wythe: A continuous vertical section of a masonry wall, one unit in thickness.

- Single wythe wall: A wall composed of a single unit of masonry in thickness (a one brick or block thick wall).

- Structural backing: the masonry or other system of structural members to which masonry veneer is tied. It is designed to withstand lateral loads (i.e. wind and earthquake loads).

- Veneer: A non-loadbearing masonry facing attached to and supported by the structural backing.

- Rainscreen wall: an exterior wall assembly that contains a drainage cavity between the structural backing and the cladding.

- Cavity wall: A construction of masonry units laid up with a cavity between the wythes. The wythes are tied together with metal ties or bonding units and are relied on to act together in resisting lateral loads.

In this publication, the **rainscreen veneer walls** category includes wall systems that use an exterior masonry wythe as a cladding, where an air space separates the cladding from an airtight and insulated inner wall, regardless of whether masonry materials are used in the structural back-up wall. Masonry cladding options include brick, block and stone veneers, supported by back ups such as concrete block, cast-in-place concrete or stud-frame systems.

While rainscreen veneer walls are thin and light compared to most **structural walls**, the reputation for fitness-to-purpose associated with brick and stone-clad walls today derives in part from the robustness of masonry, even in single wythe veneer applications. See *Section 1.3* for further detailed information

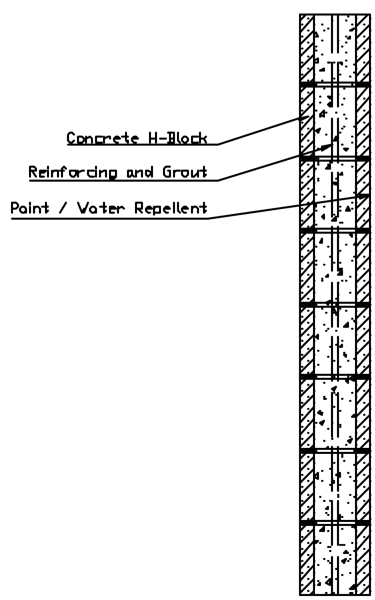
STRUCTURAL WALLS

What is a loadbearing wall?

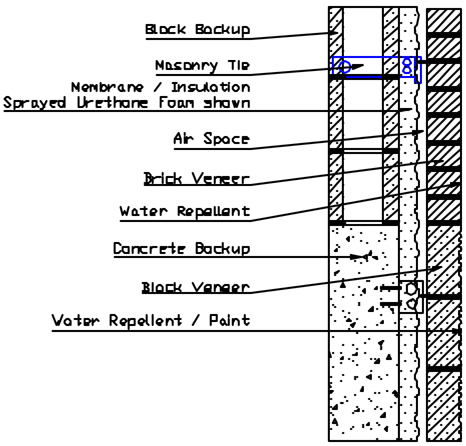
- These walls resist dead and live vertical loads.

Structural walls were historically composed of several wythes, or layers of stone, clay or concrete masonry units. Multi-wythe clay brick or terra cotta walls constructed in the early part of this century are examples of this type of construction. Single wythe concrete block walls, reinforced for seismic and wind loads, are contemporary examples of structural walls.

Single wythe masonry walls rely significantly on the capacity of masonry to perform building envelope barrier functions to resist environmental influences, such as wetting, drying, freezing and thermal expansion. The choice of appropriate materials for units and mortar, careful workmanship to achieve full and dense mortar joints, and the application of surface water repellants or paints are important factors in the satisfactory performance of these walls. Block or brick structural walls provide an efficient combination of structural durability, good building envelope serviceability, attractive appearance, fire and sound resistance, and low construction and maintenance costs. (*See Section 1.2 for further detailed information)*



RAINSCREEN VENEER WALLS



In some applications and exposure conditions, the need for better control over rain penetration led to the incorporation of an air space or cavity in traditional walls to form a capillary break between two wythes of brick. This type of two-stage wall can be referred to as a **rainscreen wall** when the air space behind the outermost element is drained and ventilated to the exterior and an effective air barrier is included on the back up assembly. These walls generally rely on the properties of a series of specific materials or components, such as thermal insulation to slow heat transfer, and air and vapour barriers to control movement of interior air, wind and water vapour.

In masonry walls, this scientific approach to enclosure design has replaced the reliance on the inherent robustness and massiveness of masonry, resulting in lighter and more complex walls. In these walls, masonry is often used only as a veneer separated from the inner wall elements by an air space. The inner wall becomes a convenient location for structural components, fenestration and thermal insulation, as well as air and vapour tight assemblies and interior finishes. Unlike new versions of the rainscreen approach with other materials, masonry rainscreen veneer wall design and construction has a successful track record for over half a century, and can be relied upon to provide high levels of performance and durability, even where moisture sensitive back-up materials are used. The highest available performance level is achieved where the back-up wall assemblies are also constructed of masonry.

The multiple layers of materials and components of these walls act in concert to obtain a successful building enclosure. Where outward air leakage is important to occupancy conditions or where the building will be exposed to severe weather, the designer should consider the advantages of masonry rainscreen veneer walls. *(See section 1.3 for further detailed information)*

The majority of residential buildings in the world are built of masonry - although often to a low level of construction quality. For this reason, photo coverage of earthquake damage from distant villages frequently features piles of bricks or stones that were once homes. While these structures bear little resemblance to our modern reinforced masonry systems, they do illustrate the need for proper structural design.

The seismic experience with masonry in California has shown that modern engineered masonry has generally provided a high level of performance. While this is reassuring for our local region, their experience with old unreinforced masonry structures highlights the need for close attention to our own stock of similar buildings.

LIMIT STATES DESIGN

Modern masonry design is similar to limit states design methods for other materials, particularly concrete. *CSA S304-04* Design of Masonry Structures is referenced by the 2005 National Building Code and the 2006 B.C. Building Code.

The following three factors in *CSA S304.1* differentiate masonry design from reinforced concrete design:

- f'_m

f'_m is the masonry compressive design strength. It is less than the masonry unit strength due to the effects of mortar bedding and interaction of the mortar and masonry unit. f'_m is usually determined from the unit strength, as shown below in Table 1.2.1-1. For some projects, such as those utilizing large amounts of high strength units, the alternative method of testing masonry assemblies (prisms) is occasionally used.

- Φ_m

The Φ_m resistance (safety) factor for masonry was increased from 0.55 to 0.60 in the 2004 edition.

- E_m

The elastic modulus for masonry may be taken as E_m=850 f'_m (not greater than 20,000 MPa), or may be determined from testing. *CSA S304.1* also provides methods for determining effective moments of inertia for deflection calculations

Value of f'_m for concrete block masonry		
	Specified compressive strength normal to the bed joint, **f'_m**, for concrete block masonry, MPa	
Specified compressive strength of unit, MPa (average net area) *	Type S mortar	
	Hollow	Solid or grouted
>40	22	17
30	17.5	13.5
20	13	10
15	**9.8**	**7.5**
10	6.5	5

*Linear interpolation is permitted.

Notes: - For grouted walls the area of grout may be ignored and the "Hollow" f'_m value used with the face-shell bedded area. This will be advantageous for larger spacings of grouted cells.
- Alternatively, for partially grouted walls a weighted value between the "Hollow" and the "Solid or Grouted" may be used,
based on the percentage of grouted cores.
- Type N mortar is seldom, if ever, used in structural masonry.

Note that CSA S304.1 now clearly provides for the use of the higher "Hollow" value for **f'_m** if the grout area is ignored.

REINFORCEMENT

Care should be taken to disperse the rebar throughout the wall, and to avoid congestion in vertical cores. The most common rebar size in reinforced masonry is 15M, followed by 20M. 25M's are occasionally used, but are difficult to handle and require long laps. Vertical bars are typically placed as one layer in the centre of the wall. Horizontal rebar is placed in bondbeam courses, often in pairs that act to centre the vertical steel. Horizontal joint reinforcing is fabricated in ladders of two 3.8mm

(9 ga) galvanized wires and embedded in horizontal mortar bed joints at a spacing of 400 or 600mm.

MINIMUM SEISMIC REINFORCEMENT

CSA S304.1 (Clause 10.15.2) specifies minimum seismic reinforcement for loadbearing and non-loadbearing walls for a project with a specific seismic hazard index [$IEF_aS_a(0.2)$]. For most cases, the required reinforcement areas must be oriented a minimum of 1/3 in either direction. The larger amount of reinforcement will usually be used vertically.

Vertical steel spacing must not exceed 6(t+10) mm or 1200 mm, whichever is less. The maximum spacing of horizontal reinforcement is:

- 400 mm where only joint reinforcement is used
- 1200 mm where only bond beams are used
- 2400 mm for bond beams, and 400 mm for joint reinforcement where both are used

In many cases, it will be found that this minimum seismic steel will also be adequate for flexural, shear or axial load resistance.

SHI*	**Area Required**	**Typical Spec 200mm Wall**
Loadbearing SHI ≥ 0.35	Total 0.002 A_g 2/3 = 0.00133 1/3 = 0.00067	Vertical: 15M @ 800mm (0.00132) Horizontal: 2-15M @ 2400mm + Joint reinforcing @ 400mm (0.00117)
Non-loadbearing SHI ≥ 0.75	Total 0.001 2/3 = 0.00067 1/3 = 0.00033	Vertical: 15M @ 1200mm (0.00088) Horizontal: 1-15M @ 2400mm + Joint reinforcing @ 400mm (0.00073)

* SHI = Seismic Hazard Index $IEF_aS_a(0.2)$

See reinforcement ratio table on page 5. See Guide Structural Notes in Section 3.3 for typical reinforcement for other wall thicknesses.

In addition to flexural, shear and minimum seismic steel, vertical reinforcing is required at each side of openings over 1200mm long, at each side of control joints, and at corners, ends and intersections of walls. *CSA S304.1-04* (Clause 4.6.1) allows unreinforced masonry partitions if they are less than 200 kg/m^2 in mass and 3 m in height, <u>but only</u> for seismic hazard indices < 0.75.

SEISMIC DESIGN FOR DUCTILE SHEAR WALLS

The minimum seismic requirements described above for "Conventional" reinforced masonry will be all that is required for the vast majority of masonry buildings. However, the *B.C. Building Code 2006* (Table 4.1.8.9) and *CSA S304.1-04* (Clause 10.16) contain additional provisions for a range of ductile shear wall categories beyond the conventional seismic requirements They are based on the concept of ductility through inelastic behavior in a "plastic hinge" zone at the base of a cantilever shear wall. These detailing and design provisions ensure that the shear capacity exceeds the flexural capacity that is providing the ductile mechanism. They provide values of either 1.5 or 2.0 for R_d, the "ductility related force reduction factor," used in determining design loads.
The shear wall categories and their maximum building heights for the two higher seismic hazard indices from BCBC Table 4.1.8.9 are shown below:

			Maximum Height	
		R_d	.35-.75	>.75
1.	Conventional	1.5	30 m	15 m
2.	Limited Ductility	1.5	40 m	30 m
3.	Moderately Ductile	2.0	60 m	40 m
4.	Moderately Duct. Squat	2.0	n/a	n/a

For the cases beyond the Conventional ductility walls there are additional requirements for grouting, and reinforcing spacing and detailing. There are also and limits on h/t, compressive strains, and shear resistance. For typical masonry walls designed in the Squat category with $h_w / l_w < 1$, there is an h/(t+10) limit, and requirements for uniform loading and reinforcement ratios.

An R_d of 2.0 for all materials is now required for post-disaster buildings. This can be provided by structural masonry by meeting the requirements of Clause 10.16. The requirements for typical squat masonry walls such as those used for fire halls are contained in Clause 10.16.6.

Large differences in the ductility of framing systems in orthogonal directions should be avoided.

DESIGN AIDS

There are two masonry design textbooks based on S304.1-04 that are available from the Masonry Institute of B. C.

Masonry Design for Engineers and Architects
(M. Hatzinikolas, Y. Korany)
with CD of Design Standard CSA S304.1-04 ($115.0)

Masonry Structures – Behavior and Design
Canadian Edition
(Robert G. Drysdale, Ahmad A. Hamid)
CSA S304.1-04 included in print ($150)

Masonry Design Software is also in development.

Structural Design

Wall Reinforcement Ratio, $\rho_g = A_s/A_g$

Wire or Bar Size	Spacing S (mm)	Wall Thickness (mm)			
		b=140	b=190	b=240	b=290
2 - 9 ga.	@ 1200	0.00013	0.00010	0.00008	0.00006
	800	0.00020	0.00015	0.00012	0.00010
	600	0.00027	0.00020	0.00015	0.00013
	400	0.00040	0.00029	0.00023	0.00019
	200	0.00080	0.00059	0.00046	0.00038
2 - 8 ga.	@ 1200	0.00016	0.00012	0.00009	0.00008
	800	0.00024	0.00018	0.00014	0.00011
	600	0.00032	0.00023	0.00018	0.00015
	400	0.00048	0.00035	0.00028	0.00023
	200	0.00095	0.00070	0.00055	0.00046
#10	@ 1200	0.00060	0.00044	0.00035	0.00029
	800	0.00089	0.00066	0.00052	0.00043
	600	0.00119	0.00088	0.00069	0.00057
	400	0.00179	0.00132	0.00104	0.00086
	200	0.00357	0.00263	0.00208	0.00172
#15	@ 1200	0.00119	0.00088	0.00069	0.00057
	800	0.00179	0.00132	0.00104	0.00086
	600	0.00238	0.00175	0.00139	0.00115
	400	0.00357	0.00263	0.00208	0.00172
	200	0.00714	0.00526	0.00417	0.00345
#20	@ 1200	0.00179	0.00132	0.00104	0.00086
	800	0.00268	0.00197	0.00156	0.00129
	600	0.00357	0.00263	0.00208	0.00172
	400	0.00536	0.00395	0.00313	0.00259
	200	0.01071	0.00789	0.00625	0.00517
#25	@ 1200	0.00298	0.00219	0.00174	0.00144
	800	0.00446	0.00329	0.00260	0.00216
	600	0.00595	0.00439	0.00347	0.00287
	400	0.00893	0.00658	0.00521	0.00431
	200	0.01786	0.01316	0.01042	0.00862
#30	@ 1200	0.00417	0.00307	0.00243	0.00201
	800	0.00625	0.00461	0.00365	0.00302
	600	0.00833	0.00614	0.00486	0.00402
	400	0.01250	0.00921	0.00729	0.00603
	200	0.02500	0.01842	0.01458	0.01207

This table provides wall reinforcement ratios for various rebar spacings and block sizes.

PHYSICAL PROPERTIES OFCONCRETE BLOCK WALLS

Table A-1 **Properties of Concrete Masonry Walls (per metre or foot length)**
Revised

Grouted Cells / metre		0.00	0.83	1.00	1.25	1.67	2.50	5.00
Cell/dowel Spacing (mm)		*none*	1200	1000	800	600	400	200
Nominal Size		***150*** mm			*6* inch			
A_e	$(mm^2 \times 10^3)$	**52.0**	**66.7**	**69.6**	**74.0**	**81.3**	**96.0**	**140.0**
	(in^2)	*24.6*	*31.5*	*32.9*	*35.0*	*38.4*	*45.4*	*66.2*
I_x	$(mm^4 \times 10^6)$	**172**	**181**	**183**	**186**	**191**	**201**	**229**
	(in^4)	*126*	*133*	*134*	*136*	*140*	*147*	*168*
S_x	$(mm^3 \times 10^6)$	**2.46**	**2.59**	**2.62**	**2.66**	**2.73**	**2.87**	**3.27**
	(in^3)	*45.8*	*48.2*	*48.7*	*49.5*	*50.7*	*53.3*	*60.8*
Weight	(kN/m^2)	**1.90**	**2.09**	**2.13**	**2.19**	**2.29**	**2.49**	**3.08**
	(psf)	*39.6*	*43.7*	*44.6*	*45.8*	*47.9*	*52.0*	*64.3*
Nominal Size		***200*** mm			*8* inch			
A_e	$(mm^2 \times 10^3)$	**75.4**	**94.5**	**98.3**	**104.0**	**113.6**	**132.7**	**190.0**
	(in^2)	*35.6*	*44.6*	*46.5*	*49.2*	*53.7*	*62.7*	*89.8*
I_x	$(mm^4 \times 10^6)$	**442**	**464**	**468**	**475**	**485**	**507**	**572**
	(in^4)	*324*	*340*	*343*	*347*	*355*	*371*	*419*
S_x	$(mm^3 \times 10^6)$	**4.66**	**4.88**	**4.93**	**5.00**	**5.11**	**5.34**	**6.02**
	(in^3)	*86.7*	*90.9*	*91.7*	*93.0*	*95.0*	*99.3*	*112.0*
Weight	(kN/m^2)	**2.46**	**2.75**	**2.81**	**2.89**	**3.03**	**3.32**	**4.18**
	(psf)	*51.4*	*57.4*	*58.6*	*60.4*	*63.4*	*69.4*	*87.3*
Nominal Size		***250*** mm			*10* inch			
A_e	$(mm^2 \times 10^3)$	**81.7**	**108.1**	**113.4**	**121.3**	**134.5**	**160.9**	**240.0**
	(in^2)	*38.6*	*51.1*	*53.6*	*57.3*	*63.5*	*76.0*	*113.4*
I_x	$(mm^4 \times 10^6)$	**816**	**872**	**883**	**900**	**928**	**984**	**1152**
	(in^4)	*598*	*638*	*647*	*659*	*679*	*721*	*844*
S_x	$(mm^3 \times 10^6)$	**6.80**	**7.27**	**7.36**	**7.50**	**7.73**	**8.20**	**9.60**
	(in^3)	*126.5*	*135.2*	*136.9*	*139.5*	*143.8*	*152.5*	*178.6*
Weight	(kN/m^2)	**2.97**	**3.35**	**3.43**	**3.55**	**3.74**	**4.12**	**5.28**
	(psf)	*62.0*	*70.0*	*71.7*	*74.1*	*78.1*	*86.1*	*110.3*
Nominal Size		***300*** mm			*12* inch			
A_e	$(mm^2 \times 10^3)$	**88.3**	**121.9**	**128.6**	**138.7**	**155.5**	**189.2**	**290.0**
	(in^2)	*41.7*	*57.6*	*60.8*	*65.5*	*73.5*	*89.4*	*137.0*
I_x	$(mm^4 \times 10^6)$	**1341**	**1456**	**1479**	**1514**	**1571**	**1687**	**2032**
	(in^4)	*982*	*1066*	*1083*	*1108*	*1150*	*1235*	*1488*
S_x	$(mm^3 \times 10^6)$	**9.25**	**10.04**	**10.20**	**10.44**	**10.83**	**11.63**	**14.01**
	(in^3)	*172.1*	*186.8*	*189.7*	*194.1*	*201.5*	*216.3*	*260.6*
Weight	(kN/m^2)	**3.53**	**4.00**	**4.10**	**4.24**	**4.48**	**4.95**	**6.38**
	(psf)	*73.7*	*83.6*	*85.6*	*88.6*	*93.6*	*103.5*	*133.3*

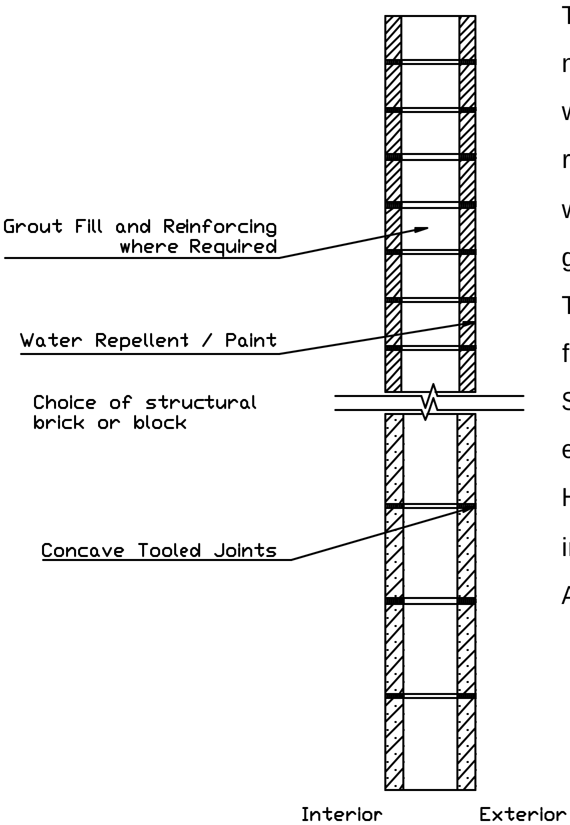
Note: Assume Bond Beams at 2.4 m (8 ft) O.C. Rev Dec/02
Table based on Metric blocks and modules (190 mm high units)
Assumed Weight 22 kN/m3 140.4 pcf

Adapted from “Engineered Masonry Design”; Glanville, Hatzinikolas, Ben-Omran

As discussed in *Section 1.1*, masonry walls are of two types: **structural walls** and **rainscreen veneer walls**. Single wythe concrete block or clay brick walls are the most common structural masonry walls: four such single wythe wall systems are discussed below. Each type offers different performance potential in terms of climatic factors, fire, thermal, sound and seismic resistance; and construction and maintenance costs. Furthermore, each wall system will have inherent aesthetic characteristics. Additional treatments or finishes may be added to each of these wall systems to develop them further.

Although masonry units do not have high thermal resistance, their high mass provides a beneficial moderating influence on interior temperatures. This "Mass Effect" provides better dynamic thermal performance than a lightweight wall of the same R-value, and can reduce heating and cooling loads – see Section 2.6.3 for further information.

SYSTEM 1: UNINSULATED STRUCTURAL WALL



The use of hollow masonry provides an economical wall system with a masonry finish on both sides. A wide range of finishes can be achieved with different textures and colours of brick and block. Suitable reinforcing for seismic and structural strength can be placed within the wall. Recent engineering advances permit these walls to be built to greater heights with less reinforcing.

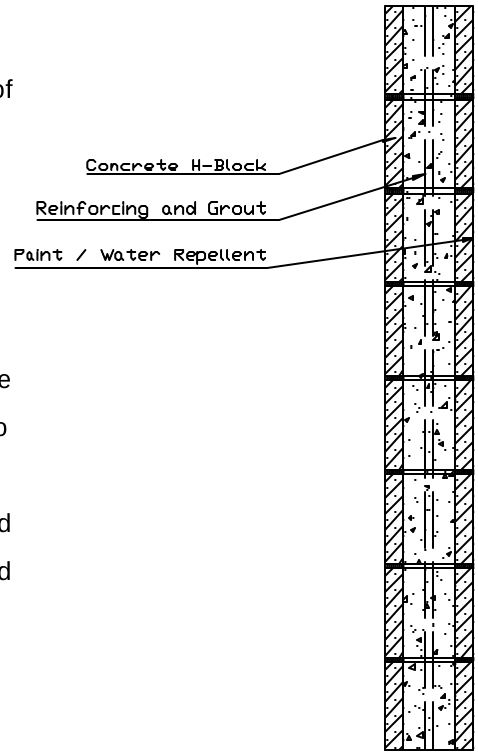
The weather resistance of this system relies on good workmanship for full head joints, a concave joint profile and exterior wall coatings. (See S*ection 1.6.2* - Sealing Masonry for further information.) Thermal efficiency is adequate for building types with low heating requirements. Hollow cores may be filled with foam or loose fill insulation for a slightly improved thermal performance.

Advantages:

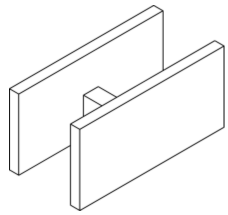
- Economical Wall / Structure
- Masonry finish on both sides
- Accepts reinforcing

Structural Wall Types

SYSTEM 2: FULLY GROUTED – H-Block wall



This system uses the H-Block, a special unit which allows the pouring of a continuous concrete core in the wall.



The absence of end webs facilitates the laying of the block around reinforcing steel and minimizes head joint leakage potential.

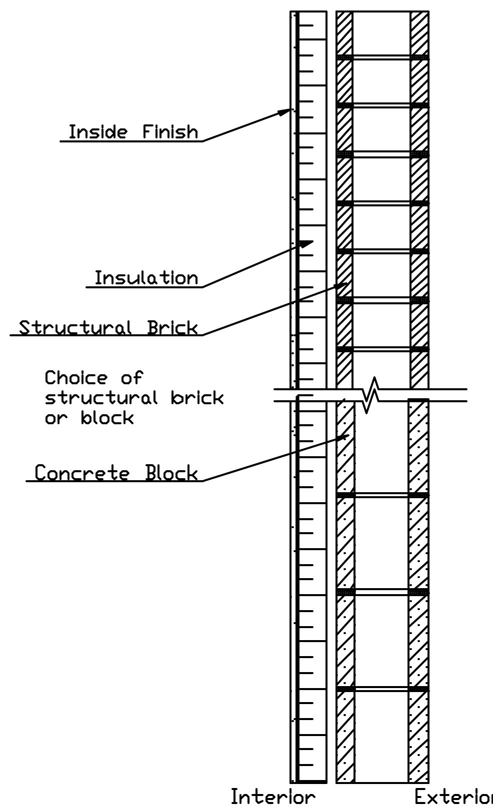
The finished wall has a high degree of structural strength and can be used both above and below grade as an economical alternative to formed-in-place concrete walls.

Solid filled masonry walls contribute to dryer mass walls and improved building performance. Appropriate coatings for water resistance should still be used on surfaces below grade or exposed to weather.

Advantages:

- Monolithic wall that accommodates heavy reinforcing.
- Improved water resistance

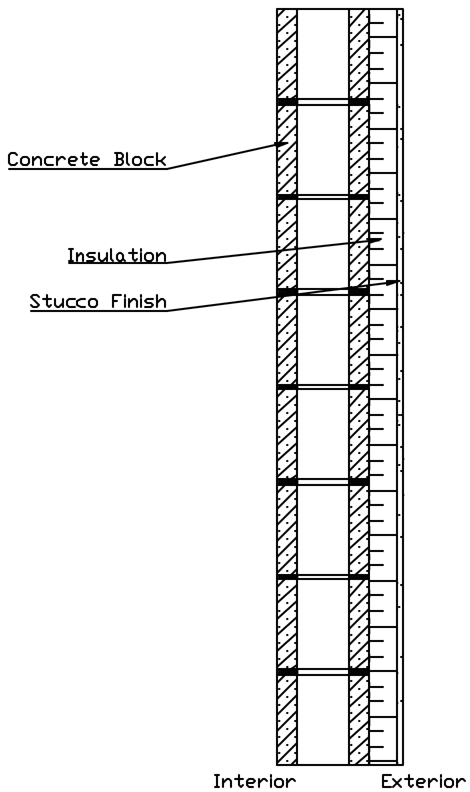
SYSTEM 3: INTERIOR INSULATION



The placing of insulation on the interior of the wall substantially increases the thermal resistance of the standard masonry wall. This system can include air and vapour barriers as well as interior finish options. Interior insulation places the dewpoint between the insulation and the masonry. If this is a concern, proper moisture management steps need to be taken. One method is to step the insulation away from the masonry, creating a cavity with drainage and drying potential. The other is to use sprayed urethane foam as insulation - an effective barrier against moisture. *Refer to details Section 1.2.4 for more information.*

Advantages:

- Durable exterior
- Improved thermal performance



SYSTEM 4: EXTERIOR INSULATION

The application of insulation to the exterior of the wall combined with the mass of the masonry on the interior provides for high thermal efficiency as well as good rain resistance depending on the exterior finish applied.

Advantages:

- Improved thermal performance from insulation and exposed interior mass
- Improved water resistance

This Cost Guide was prepared by the B.C. Chapter of the Canadian Masonry Contractors Association.
Installed wall costs include **labour and materials**.
Variations to the basic walls are given as additions or deductions from a base cost, to arrive at a total for various options. These total costs are based on typical commercial walls in the Vancouver area with few openings, piers, off-sets or corners. See note at bottom of this page.
Although costs are given in both sq.m. and sq.ft. - only metric block are generally available.
These costs reflect the Vancouver market – areas requiring shipping of materials may see slightly higher prices.

STRUCTURAL BLOCK & BRICK MASONRY

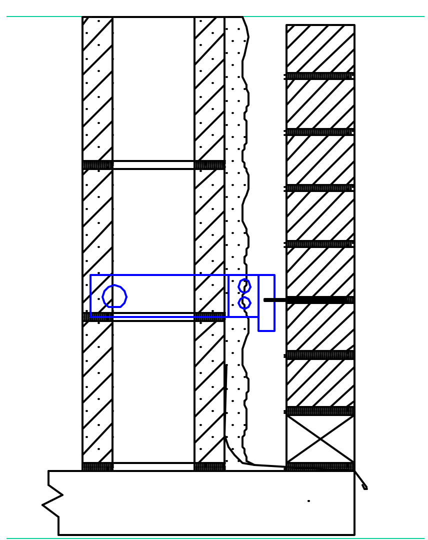
8m high, grouted vertically @ 800mm, bond beams @ 2400mm			$ / sq.m	$ / sq.ft
CONCRETE BLOCK				
Baseline:	190mm(20cm) smooth grey, 15MPa		**110 - 130**	**10 - 12** *
Width	90mm	deduct	(7)	(0.65)
	115mm	deduct	(10)	(1.00)
	140mm	deduct	(10)	(1.00)
	190mm		-Baseline Above–	
	240mm	add	21	2.00
	290mm	add	32	3.00
Height	90mm (1/2 high)	add	54	5.00
Strength	20 MPa	add	2	0.20
	30 MPa	add	3	0.30
Fire Rated - ULC		add	2	0.20
Finish	Scored	add	13	1.25
	Split Face	add	16	1.50
	Split Rib	add	22	2.00
	Split Ledge	add	27	2.50
	Ground Face	Add	43	4.00
Colour	Standard (block & mortar)	add	21	2.00
	Premium (block & mortar)	add	32	3.00
CLAY BRICK:				
Baseline:	190x90x290 or 390 mm		**225 - 260**	**21 - 24** *
Width	140mm	deduct	(10)	(1.00)
EXTERIOR TREATMENT				
Clear water repellent		add	8	0.80
Anti-graffiti repellent		add	17	1.60
Elastomeric Paint Coating		add	17	1.60
REINFORCEMENT & GROUTING				
Including grout, joint reinforcing, placing of rebar				
Baseline	25% (vertical @ 800mm), 20cm width			
	33% (@600mm)	add	5	0.50
	50% (@400mm)	add	10	1.00
	Solid Grouted	add	18	1.70
	Solid Grouted H-block	add	22	2.00

* Due to market volatility, these cost figures should be used for general comparisons only.
C.M.C.A. members can provide budget costs or quotations for specific projects based on actual plans, specifications, site conditions, location and construction season.

During the 1960's and 1970's, the Division of Building Research of the National Research Council of Canada (NRC) published important technical literature about the design and function of walls, windows and roofs. Fundamental concepts described in this literature have been referred to as "the principles of enclosure design". Among these concepts is the familiar “rainscreen” principle that can explain the consistently successful performance of masonry rainscreen veneer walls.

An ordinary interior partition must be a physical barrier providing privacy, sound separation and some degree of security as well as meeting certain aesthetic requirements. An exterior wall must do all of this, plus prevent rain and air leakage, control vapour migration, control heat and radiant energy transfer, and resist certain physical loads.

A masonry wall with even modest control over air and vapour movement and minimal thermal insulation can provide all of these enclosure requirements throughout a very long service-life. Masonry-clad walls generally include an air space behind the cladding that is drained and ventilated to the exterior. Examples of walls with a brick or stone rainscreen veneer have successfully incorporated all of the of aspects rainscreen enclosures for most of the twentieth century.



AIR BARRIERS

A fundamental element of any wall is a structural barrier to air movement. Uncontrolled air movement can result in loss of interior environmental control, rain entry and damaging condensation of moisture from interior air. An air barrier for a building must be sufficiently airtight to adequately contain the interior environment and to separate inside from outside.

Achieving a buildable and airtight barrier throughout the walls, windows and roofs of buildings is often one of the most difficult tasks for designers and builders. In many instances, the difference between a well performing building enclosure and a disaster, is the attention given to this one objective. Durability of the air barrier, in turn, depends on the functioning of all other components of the assembly. In masonry rainscreens, the air barrier is typically a membrane, trowel-on or sprayed foam system applied to the cavity side of the back-up wall.

Air pressure across the envelope due to wind, operation of mechanical ventilation equipment and stack effect can induce substantial physical loads. Of these, wind will likely exert the largest force. Although maximum wind gusts may only last a few seconds and occur once in a decade, these loads must not damage the air barrier. The various air barrier components of the building envelope must have sufficient structural integrity, or be structurally supported, to transfer loads to the structure of the building without damage or excessive deflection. Concrete block back-up walls easily provide such structural support with minimal deflection.

Air leakage across the enclosure must be prevented to control rain entry, maintain interior comfort and to avoid condensation-related moisture problems. If air tightness at the interior side of thermal insulation is insufficient to contain the interior environment and prevent outward interior air movement across thermal insulation, interior air may contact cold surfaces in the enclosure. This type of air movement can be referred to as exfiltration and is known to be an important cause of moisture-related damage to the enclosures of buildings. This is less of a concern with masonry claddings than with other, less moisture tolerant materials.

INSULATION

A layer of thermal insulation is normally required to obtain control over the temperature of the interior environment and to protect the enclosure from the affects of the weather. Considered only as thermal separation between inside and out, insulation could be placed at any convenient plane in the wall. However, insulation should be placed so as to protect critical components and assemblies from the temperature changes that occur in the exterior environment.

Placement of thermal insulation in the correct location with respect to the airtight assemblies is important for proper enclosure functioning. The building structure, the wall structure and the air barrier, should be as thermally isolated as possible from the exterior. In a masonry rainscreen, placing insulation over the membrane on the back-up wall inside the cavity airspace meets these requirements.

VAPOUR BARRIERS

Outward diffusion of water vapour can be another source of condensation-related wetness although not likely to be as significant as air leakage. Movement of water vapour into building enclosure assemblies by diffusion can occur when interior air has a significantly higher moisture content than outside air. Water vapour will follow the "concentration gradient", generally from inside to out, and may result in condensation on cold surfaces. A vapour barrier is incorporated into the enclosure assembly to control diffusion-related moisture movement.

A vapour barrier should be located at the warm side of the enclosure and may be associated or combined with the air barrier. Although the location of a vapour barrier may be similar to that of an air barrier, the functioning and degree of wetting of these enclosure components are not the same. Obtaining adequate control over diffusion of water vapour is generally achieved by the incorporation of a suitable material. Adequate control over air movement is a significant design and construction problem requiring care and attention throughout the building envelope.

CLADDING

Masonry cladding can function as a rain screen when it is separated from an airtight and properly insulated enclosure by an air space that is open to the exterior. The air space provides a capillary gap, reducing contact of wet cladding with other enclosure elements. It also allows for drainage and ventilation drying of moisture which may be present behind the cladding. This air space reduces air pressure on the cladding by permitting wind to pressurize the air space. This type of air pressure moderation can reduce the force of wind that might otherwise push water through openings in the cladding. The air space can also accommodate tolerances in the position of the back-up system.

The outermost enclosure elements and assemblies will be subjected to extremes of temperature, wetting and drying and should be free to move in response. The movement joints associated with a rain screen cladding can accommodate thermal movement or other changes in in-service conditions. The horizontal movement joints in masonry at shelf angles need not be sealed if they are otherwise protected from wind-driven rain – such as with edge flashings. Otherwise, they are sealed like vertical joints with caulking. See *Section 2.4.2* for details.

The rain screen principle and the other considerations of enclosure design developed by NRC many years ago explain the consistently high performance of masonry-clad walls.

Section 1.1 of this manual noted that the oldest and most enduring buildings in the world are constructed of masonry. The serviceability of these masonry walls is attributed to the inherent robustness of masonry materials. That section reviewed the different kind of masonry walls, while the design of rainscreen veneer walls was described in *Section 1.3.1.* The different combinations of veneer claddings and back-up walls are discussed below.

MASONRY RAIN SCREEN WALLS

The four 'D's of successful wall design:

Deflection: Limit wall exposure to rain with overhangs and flashings.

Drainage: Any moisture that makes it into the wall is redirected outside.

Drying: Features that speed the drying of wet materials.

Durability: Use only materials that are tolerant of moisture.

Brick, block or stone may be used as the outermost element for the walls of buildings. Used in this way, a single wythe of masonry is the wall cladding and is often referred to as a "veneer". Masonry rainscreen walls include an air space behind the veneer that is drained and ventilated to the exterior.

The cavity in a masonry wall provides:

- drainage and drying
- a capillary break (gap) between cladding and back-up
- pressure moderation of wind driven rain
- for tolerances in the back-up wall location
- a good location for some or all of the wall insulation

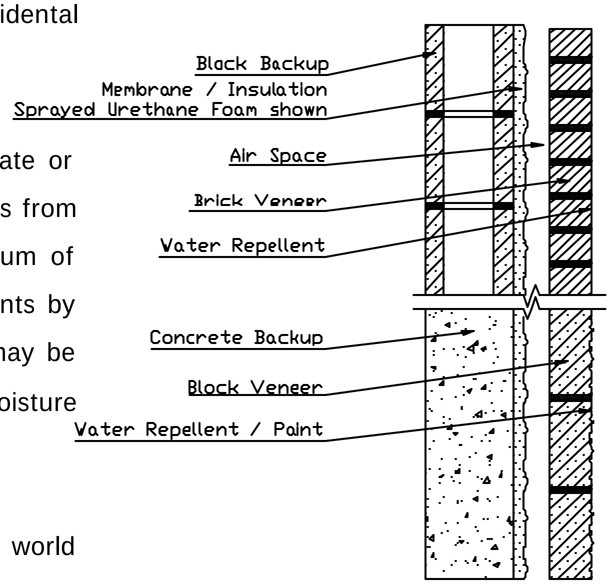
To maximize the performance of these functions, the cavity should be kept reasonably clear of mortar droppings. Inward of the air space are the structural, airtight and thermally insulated components of rain screen walls discussed in S*ections 1.1 and 1.3.1.* Wall assemblies inward of the airspace of masonry-clad walls are referred to as the "back-up", and may be of several types as described below. The masonry veneer is usually about 100mm thick with its weight supported vertically by the foundation, or by steel shelf angles at each floor for higher buildings. For lateral wind and earthquake loads, the veneer is connected to the back-up by corrosion resistant steel ties at a designed spacing. A wide range of wall assemblies with a masonry veneer have successfully

See *Section 2.6* for a description of stainless steel versus hot-dipped galvanized ties. See S*ection 2.5* for a review of flashing materials.

incorporated all of the aspects of rain screen enclosures for most of the twentieth century.

MASONRY OR CONCRETE BACK-UP

A masonry veneer with masonry back-up can provide the most durable contemporary rain screen wall available. A concrete block or poured-in-place concrete back-up wall can accommodate higher levels of incidental wetness than a wood or steel stud back-up.



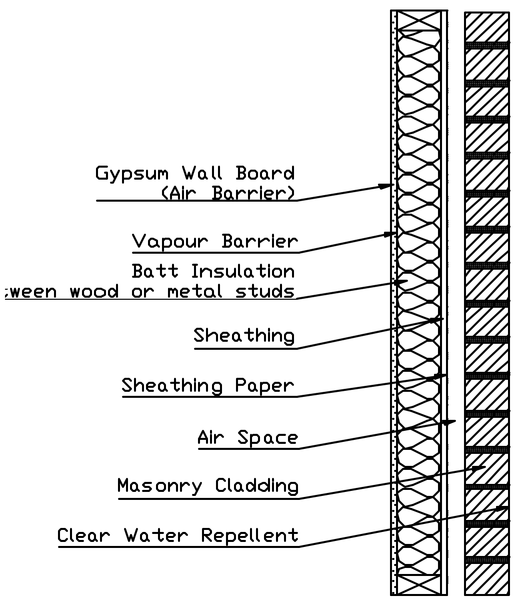
Buildings with a masonry back-up in a mild climate with moderate or controlled interior air conditions, may derive adequate airtightness from an uncoated concrete block back-up and require only a minimum of thermal insulation. Occasional wetting of masonry wall components by rain or condensation of moisture from outward air movement may be well within the tolerable capacity of the relatively massive and moisture resistant wall assembly.

The often exceptional performance of the oldest buildings in the world suggests that the durability of masonry can be a positive factor in building design and construction.

Where more air tightness is required to contain humid interior environments, particularly in cold climates, increased air tightness and thermal insulation may be advisable. Increased air-tightness can be obtained as needed by applying paint or coatings on the exterior of a concrete block back-up, or by applying sprayed urethane foam insulation. An air barrier membrane at critical junctions between a concrete block or poured-in-place concrete back-up wall and other enclosure components and assemblies can provide the necessary air seals.

More demanding interior or exterior environments may require higher levels of air-tightness or weather resistance of the building enclosure. It may be necessary or convenient to use a continuous membrane over all back-up surfaces to extend continuous waterproofing and air-tightness over all structural or structurally supported elements of the building envelope.

STUD BACK-UP - INSULATED STUD SPACE



Wood frame and steel stud infill walls with insulation within the stud space are familiar wall assemblies in a wide range of building types. The brick veneer/wood stud back-up wall is very commonly used for single family and low-rise residential construction in North America (see *Section 1.4*). Steel stud infill walls are often used in concrete structural frame buildings. Both of these materials are less moisture resistant than block or concrete back-ups, and must be carefully designed and constructed.

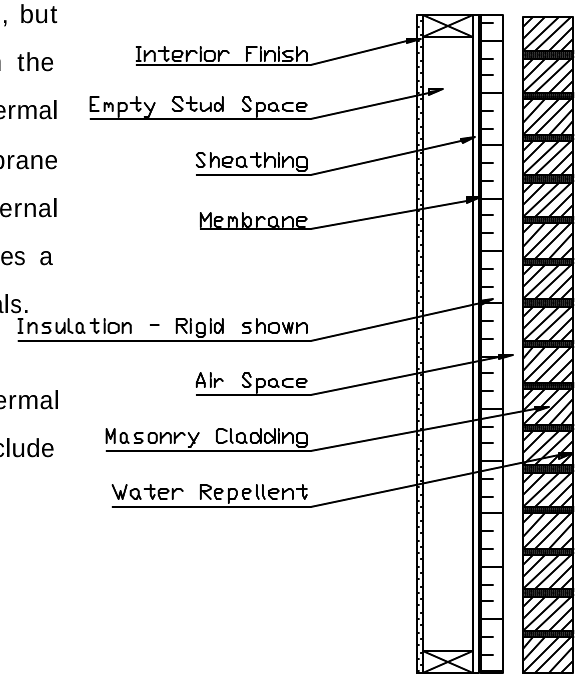
Because these systems employ insulation only in the space between the studs, thermal bridging must be considered, particularly for steel studs in colder climates. The effective combined R-value can be greatly reduced, and cold spots can cause condensation problems.

The principles of enclosure design (reviewed in *Section 1.3.1*) require air-tightness at the interior side of the insulation. Interior wall finishes should be rendered airtight where batt insulation fills stud spaces. The use of sealants or membranes may accomplish this objective while the continuity and strength of interior finishes becomes a design and construction consideration. This approach, which is often referred to as the airtight drywall (ADA) approach, influences detailing and product selection at junctions and joints of interior finishes with all other building envelope components.

This approach can be advantageous for masonry-clad, concrete frame buildings with steel stud infill. With some ingenuity, it can also be useful in wood frame construction. An interior air barrier approach is generally not recommended for buildings using a structural steel frame.

STUD BACK-UP - INSULATED CAVITY

This approach also uses wood or steel stud back-up wall materials, but incorporates some or all of the insulation in the cavity between the outside of the stud wall and the masonry cladding. This reduces thermal bridging and is compatible with the simpler air barrier membrane approach on the exterior of the stud back-up wall. An external membrane is simple to install over the sheathing and also provides a higher level of moisture protection to the wood or steel stud materials.



The cavity insulation can reduce condensation concerns for both thermal bridging and the external membrane. This system should not include vapour-tight interior finishes.

The additional wall thickness required for cavity insulation, the airspace and the masonry veneer may be offset by Floor Space Ratio relief under local jurisdiction bylaws.

This Cost Guide was prepared by the B.C. Chapter of the Canadian Masonry Contractors Association.
Installed wall costs include **labour and materials**.
Variations to the basic walls are given as additions or deductions from a base cost, to arrive at a total for various options. These total costs are based on typical commercial walls in the Vancouver area with few openings, piers, off-sets or corners. See note at bottom of this page.
Although costs are given in both sq.m. and sq.ft. - only metric block are generally available.
These costs reflect the Vancouver market – areas requiring shipping of materials may see slightly higher prices.

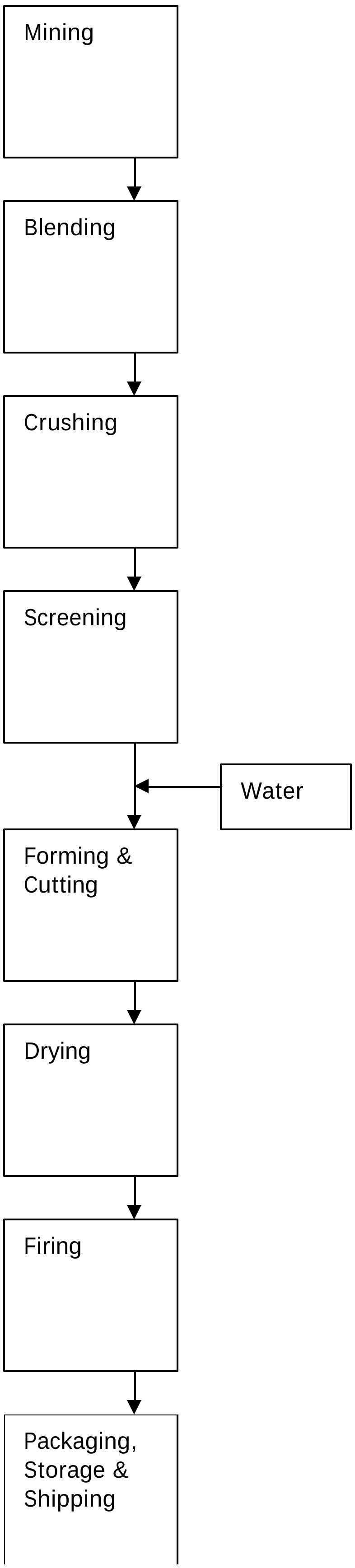
RAINSCREEN VENEER MASONRY

8m high, brick ties @ 600 x800mm, flashing, weep holes, grey mortar

					$ / sq.m	$ / sq.ft.
CLAY BRICK						
		Size (see *Section 2.1.3* of the Technical Manual for more on brick modules)				
Baseline:	2 1/4 Modular	90 x 57 x 190 mm				
or:	2 1/2 Standard	90 x 63 x 190 mm			**215 - 270**	**20 - 25** *
	Norman	90 x 63 x 290 mm				
	Econ, Saxon	90 x 90 x 290 mm				
	Giant	90 x 90 x 390 mm				
Detailing						
	Coloured mortar			add	3	0.30
	Soldier course (per metre or foot)			add	17	1.60
	Rowlock course (per metre of foot)			add	25	2.30
CONCRETE BLOCK						
Full Height		90 x 190 x 390 mm				
	Baseline:	Smooth Grey			**110 - 130**	**10 - 12** *
	Finish:	Scored		add	10	0.90
		Split Face		add	11	1.00
		Split Rib		add	19	1.75
		Split Ledge		add	24	2.25
		Ground Face		add	40	4.00
	Colour:	Standard (block & mortar)		add	18	1.70
		Premium (block & mortar)		add	24	2.20
1/2 High		90 x 90 x 390 mm				
	Baseline:	Smooth grey			**160 - 190**	**15 - 18** *
		Split Face		add	15	1.50
		Colour	Standard	add	25	2.30
			Premium	add	33	3.00
EXTERIOR TREATMENTS						
Clear Water Repellent				add	8	0.80
Anti-graffiti Repellent				add	17	1.60
Elastomeric Paint Coating				add	17	1.60
SYSTEM ITEMS						
Closer Tie Spacing		- 600 x 600 or 400 x 800		add	3	0.30
		- 400 x 600		add	5	0.60
Stainless Steel Ties		- 600 x 800		add	2	0.25
Moisture/Air Barrier & Insulation - varies				add	20 - 30	2 - 3
HIGH RISE						
10m - 20m				add	10-20%	
20m - 50m				add	15-25%	

Deductions of **10% - 15%** are possible with larger units. These vary with layout modularity, details and project specifics

* Due to market volatility, these cost figures should be used for general comparisons only.
C.M.C.A. members can provide budget costs or quotations for specific projects based on actual plans, specifications, site conditions, location and construction season.



The term brick as used today denotes a rectangular masonry unit formed in a plastic state from clay or shale and burned in a kiln. If brick is made from materials other than clay or shale, the name of the material from which the unit is manufactured is included, such as concrete brick.

The composition of the raw materials used and the manufacturing process affect the properties of clay masonry products. Basically, the important properties of brick are colour, texture, size variation, absorption, compressive strength and durability.

Generally, the harder a brick is, the longer lasting and more water resistant it is. Brick used in construction must endure heat, cold, wetting, drying, surface impact, ultra violet light and chemical exposure. The qualities of brick have been proven through centuries of use.

MANUFACTURING PROCESS

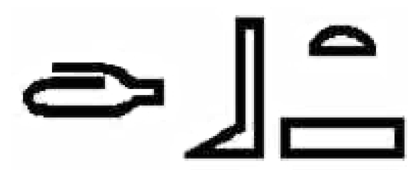
Brick is formed in two principle ways: the extruded method or the pressed brick method. The most common is the extruded process, which produces brick with a smooth or wire cut surface texture. Additional surface deformations and treatments can be added after extrusion. The pressed brick process produces a very accurately formed brick, with a smooth texture. Brick colours are primarily a product of the raw clay mixture and the firing procedure. Modern brick plants employ long tunnel kilns, in which kiln cars of “green brick” are continuously fed through drying, firing and cooling zones. Energy is conserved by recycling heat from the cooling zone to the drying zone.

PRODUCTS

Both Clay Face Brick and Structural Units are covered by CSA A82-06.
A standard face brick (cored brick) is defined as a brick that is at least 75% solid. Hollow structural units have a net cross-sectional area of 40% to 75%.
The minimum width of a brick unit is 75 mm.

GRADE

There are two grades of clay masonry units: Exterior (EG), and Interior (IG). EG units are required for all exterior applications in Canada, where a high degree of resistance to frost action and weathering is desired and where a brick unit may be exposed to frost action when permeated with water. IG units do not have to meet as high a resistance to frost action, and may only be used for interior applications. In practice, only EG units are usually inventoried by brick producers.



Egyptian hieroglyph (c. 3100 BC)
“Brick” – literally “block of clay”

TYPES

There are three types of face or hollow brick in CSA A82-06: Types S, X and A.

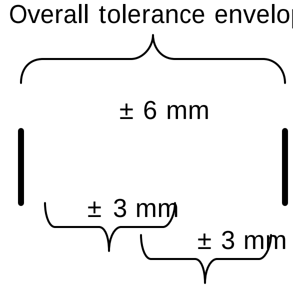
Type S bricks are for general use in exposed exterior and interior masonry walls and partitions, where normal variations in size are permitted. This is by far the most commonly used and specified brick type, and provides the basis for acceptance if no other type is specified.

Typical Base Specification:

Clay Face Brick and Hollow Brick:
to CSA A82-06, Grade EG, Type S

The dimensional tolerances for Type S units have been tightened in the 2006 edition, by requiring closer tolerances on units supplied for a specific project. In effect, this makes the tolerances at least as tight as the previous Type X dimensional restrictions. For example, the Type S tolerance on the 190 mm length of a standard brick used to be ± 6 mm for Type S, and ± 4 mm for Type X. For Type S, it is now ± 6 mm overall, but only ± 3 mm within a project job lot sample.

Overall tolerance envelope



Possible project tolerance envelopes within overall

Type X brick are for special use in exposed exterior and interior masonry walls and partitions where a higher degree of mechanical perfection and smaller permissible variation in size are required.

Type A brick are manufactured and selected to produce characteristic architectural effects resulting from non-uniformity in size, colour and texture of individual units.

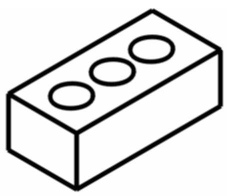
“Other than chips, the surfaces that will be exposed in place shall also be free of cracks or other imperfections detracting from the appearance of the brick when viewed from a distance of 4.5 m for Type X and **6.1m (20ft)** for Types S and A”

VENEER UNITS

Notes:

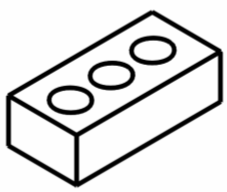
- *All sizes shown as* ***Width x Height x Length.*** *Other sizes may be available from some manufacturers.*
- *Many special shapes are also available. See your masonry manufacturer for more information.*
- *Thickness of mortar joints between units can be adjusted slightly by the mason to fit required length/height dimensions.*

Size	**Metric (mm)**	**Imperial (in)**



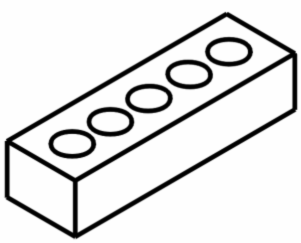
STANDARD

Actual size	90 x 64 x 190	3½ x 2½ x 7½
Nominal size	100 x 75 x 200	4 x 3 x 8
Coursing	4c = 300 mm	4c = 12 in
# of units	66.7 per m^2	6.0 per ft^2



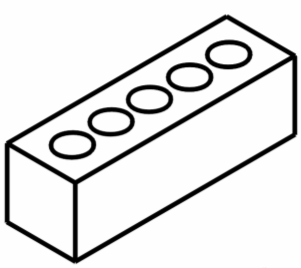
MODULAR

Actual size	90 x 57 x 190	$3^{5}/_{8}$ x 2¼ x $7^{5}/_{8}$
Nominal size	100 x 67 x 200	4 x $2^{2}/_{3}$ x 8
Coursing	3c = 200 mm	3c = 8 in
# of units	75 per m^2	6.75 per ft^2



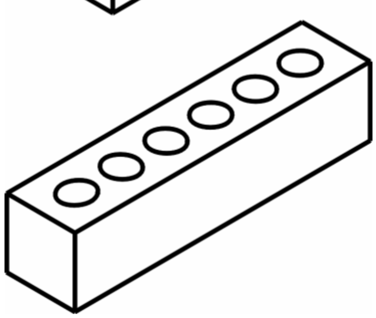
NORMAN

Actual size	90 x 64 x 290	3½ x 2½ x 11½
Nominal size	100 x 75 x 300	4 x 3 x 12
Coursing	4c = 300 mm	4c = 12 in
# of units	44.5 per m^2	4.0 per ft^2



ECON / SAXON

Actual size	90 x 90 x 290	3½ x 3½ x 11½
Nominal size	100 x 100 x 300	4 x 4 x 12
Coursing	2c = 200 mm	2c = 8 in
# of units	33.3 per m^2	3.0 per ft^2



GIANT

Actual size	90 x 90 x 390	3½ x 3½ x 15½
Nominal size	100 x 100 x 400	4 x 4 x 16
Coursing	2c = 200 mm	2c = 8 in
# of units	25 per m^2	2.25 per ft^2

Sizes and Shapes

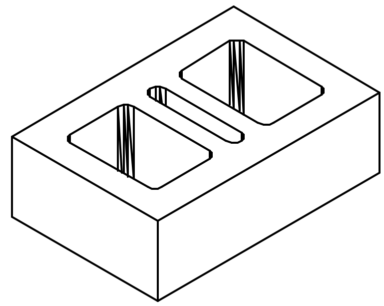
STRUCTURAL UNITS

See *Section 1.2.1* for information on structural design

Metric (mm)	**Imperial (in)**

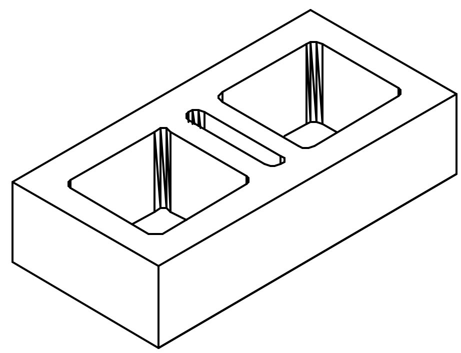
300 (12”) STRUCTURAL

90 x 90 x 290	3½ x 3½ x 11½
140 x 90 x 290	5½ x 3½ x 11½
190 x 90 x 290	7½ x 3½ x 11½
(Nominal 100x300)	(Nominal 4x12)



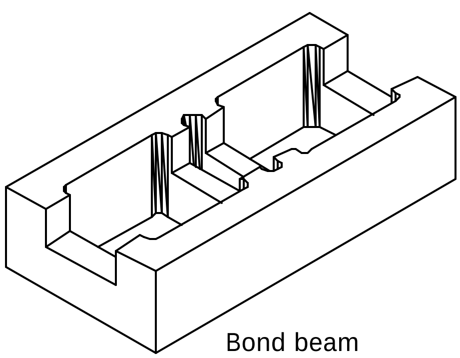
400 (16”) STRUCTURAL

90 x 90 x 390	3½ x 3½ x 15½
140 x 90 x 340	3½ x 3½ x 15½
190 x 90 x 390	3½ x 3½ x 15½
(Nominal 100x400)	(Nominal 4x16)

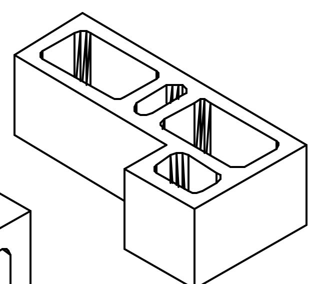


SAMPLE SHAPES

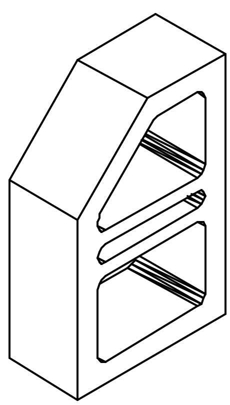
See manufacturer for full range of shapes available.



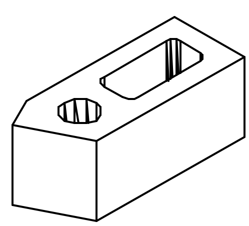
Bond beam



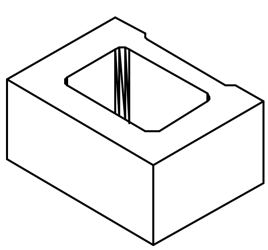
L-Corner



45° Cant



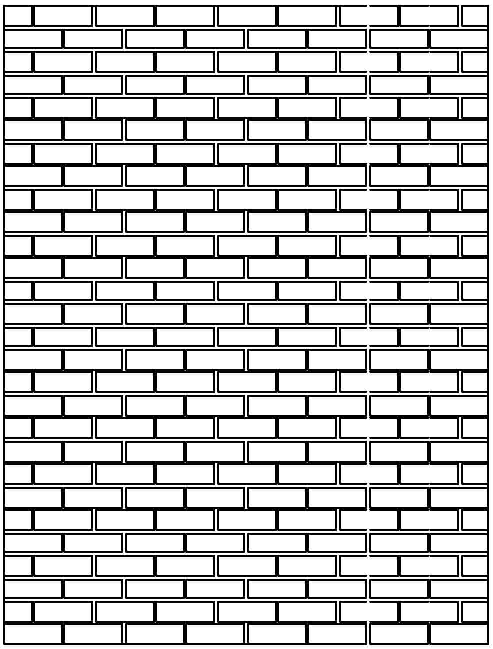
Squint

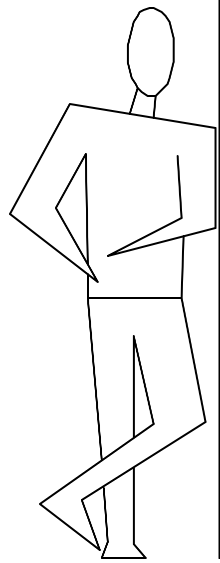


Half

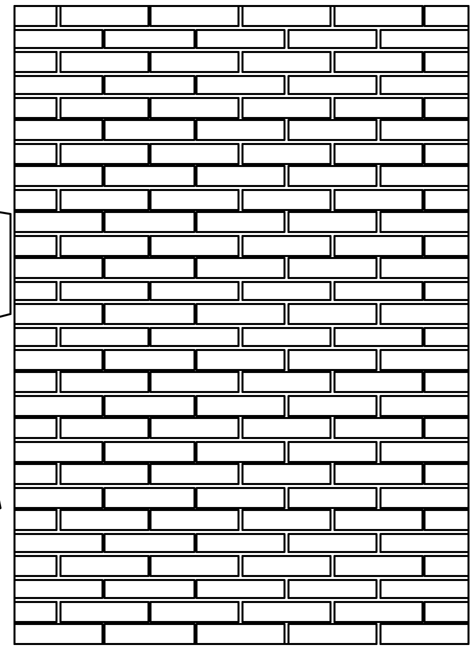
Examples of walls in running bond (half bond) using face brick of differing sizes.

Standard Brick

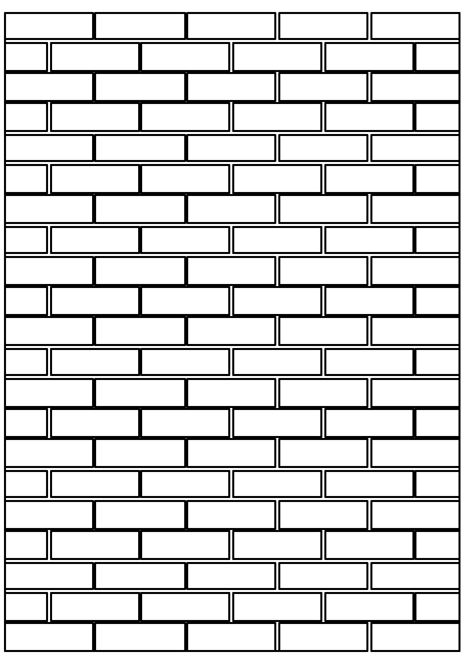


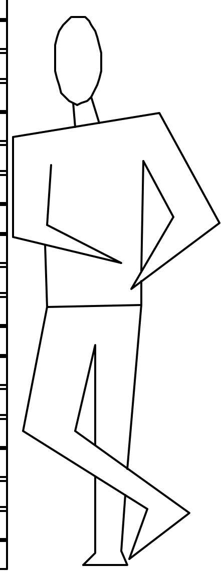


Norman Brick

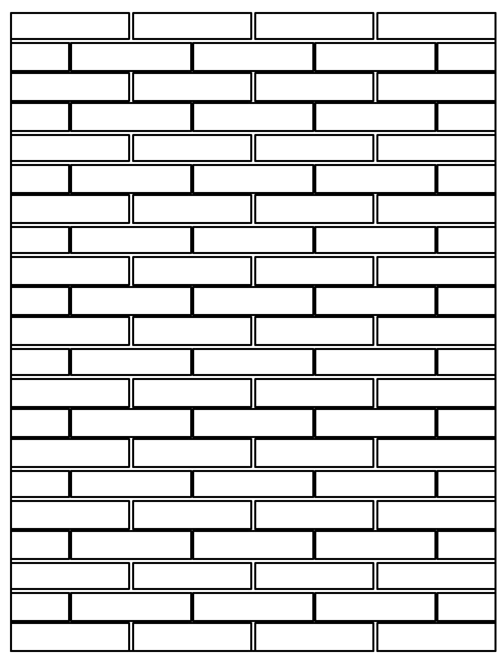


Econ/Saxon Brick





Giant Brick



ADVANTAGES OF MODULAR LAYOUT

Where possible, it is desirable to lay out the brickwork according to the module of the brick being used - both in length and in height. Proper layout will minimize the cutting of bricks, thereby reducing costs. A good layout will also improve appearance by avoiding small cut pieces, mitres, and uneven bonds. It also allows for uniformity in the mortar joints, avoiding unusually large or small joints. In sufficiently large panels, the mason can adjust joint thicknesses to suit required panel heights and widths. (See also *Section 2.1.4 – Layout Considerations*)

For all brick laid in 1/2 bond the module is determined as follows:

Horizontal module = 1/2 (brick length + joint)
Vertical module = brick height + joint

CONSIDERATIONS WHEN CHOOSING A BRICK SIZE

The larger the brick size the more economical the cost of the wall.

Unit	Cost Factor
Standard	1.00
Modular	+ 5 to 10%
Norman, Econ/Saxon, Giant	- 10 to 15%

As a general rule – the larger the brick size the more economical the cost of the wall (see *Section 1.3.3 - Cost Guide*). The key to realizing these savings is proper layout both at the design and construction phases.

The choice of unit size impacts more than just the module and cost:

- With **soldier courses** (usually found above windows or as accent banding) where the unit is laid vertically, the soldier course doesn't always bond with the horizontal units.
- **Corners** may require special units (either cut on site or specially manufactured) to maintain 1/2 bond.

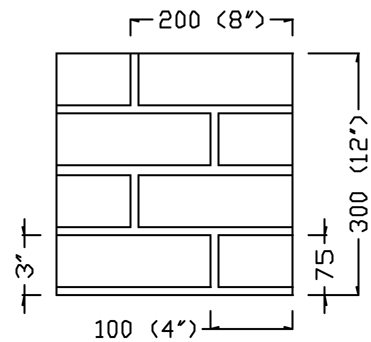
Special units such as L-corners and 214mm soldier units should be clearly identified in the specifications and masonry details.

Other brick sizes than those shown below may be available, check with local brick manufacturers.

STANDARD BRICK

Cost Factor = 1.00
(Base)

Metric "Standard" brick and Imperial "Standard" brick are identical in size. "Standard" brick are the same size whether specified as metric or imperial since these sizes fall safely within manufacturing tolerances. The difference in the module is entirely reflected in the size of the mortar joint.



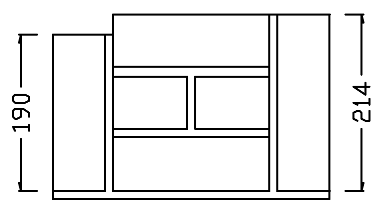
Standard bricks are the same size whether specified as metric or imperial

Horizontal	**Module:**	**100mm (4")**
	Brick:	188mm (7 1/2")
	Joint:	12mm (1/2")
Vertical	**Module:**	**75mm (3")**
	Coursing	4c=300mm (12")
	Brick:	63mm (2 1/2")
	Joint:	12mm (1/2")

With "Standard" brick:

Soldiers: "Standard" brick used in soldier courses do not have the same height as 3 courses of brick. A special, longer 214mm (8 1/2") brick can be used successfully to match regular coursing.

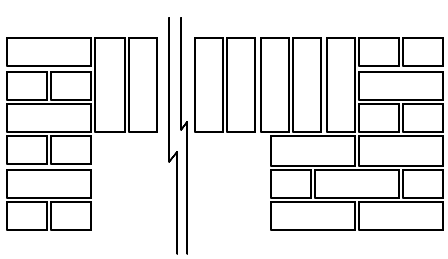
Bond: 1/2 bond is maintained around corners

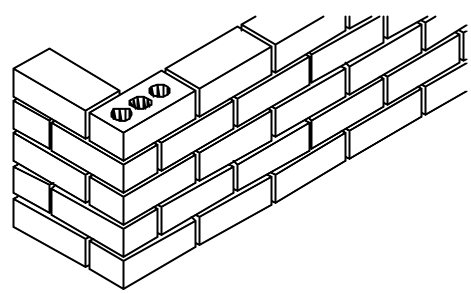


"Standard" soldiers will not line up with horizontal courses (left). When needed, special 214mm units can be used (right).

If a soldier course is used above an opening, remember the following points:

- Jams can be cut to suit to accept lintel angles
- A 214mm unit can be used to course out vertically
- A soldier course can be carried around the whole building to eliminate this coursing problem. A banding or horizontal effect will result.
- A soldier lintel looks better if it is extended beyond the jam. It will then appear to "bear" on the surrounding masonry.





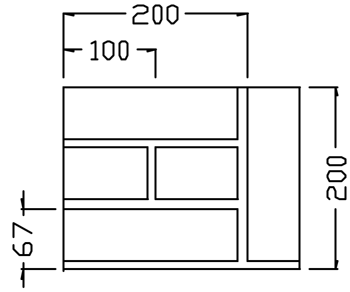
1/2 bond

MODULAR BRICK

Cost Factor
+ 5 to 10%
$

"Modular" brick are designed so that 3 vertical courses equal 200mm or 8 inches. This permits using the brick vertically as a soldier course lining up with 3 horizontal courses.

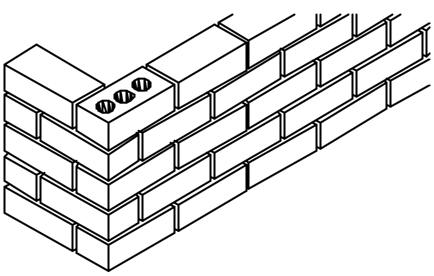
"Modular" brick walls are generally slightly less economical than "Standard" brick walls because of the smaller unit size. However, they can be more economical if there are a lot of details where their modularity is advantageous (soldier courses, basketweave, etc.)



- A "Modular" brick courses evenly as a soldier.

Metric	**Horizontal**	**Module:**	**100mm**
		Brick:	190mm
		Joint:	10mm
	Vertical	**Module:**	**67mm**
		Coursing	3c=200mm
		Brick:	57mm
		Joint:	10mm

Imperial	**Horizontal**	**Module:**	**4"**
		Brick:	7-5/8"
		Joint:	3/8"
	Vertical	**Module:**	**2-2/3"**
		Coursing:	3c=8"
		Brick:	2 ¼"
		Joint:	3/8"+



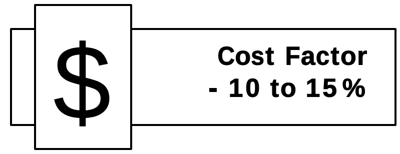
1/2 bond

With "Modular" brick:

Soldiers: "Modular" brick courses evenly as a soldier

Bond: 1/2 bond is maintained around corners

NORMAN BRICK

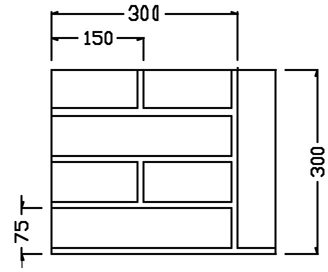


"Norman" brick are usually the same height as a "Standard" brick, but 100mm (4") longer giving a more horizontal look to a wall as well as reducing overall wall cost.

<u>The cost factor shows the decrease of the in-the-wall cost due to the larger size of this unit, assuming the wall is laid out to the appropriate module.</u>

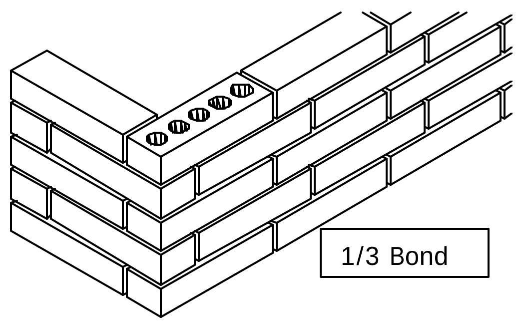
Normans can be laid in either 1/2 bond or 1/3 bond. In 1/2 bond special L-corner units are recommended to maintain bond around corners without cutting small pieces. Soldiers are modular, one equals 4 brick courses.

1/2 bond can also be accomplished using alternating 240mm (9-1/2") closer bricks at corners and wall ends but this alters the module and can result in additional cutting in other locations.



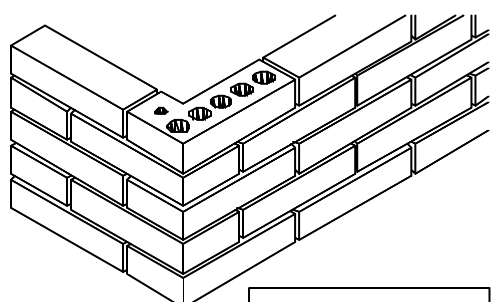
Imperial similar

Metric	**Horizontal**	**Module:**	**150mm**
		Brick:	288mm
		Joint:	12mm
	Vertical	**Module:**	**75mm**
		Coursing	4c=300mm
		Brick:	63mm
		Joint:	12mm



1/3 Bond

Imperial	**Horizontal**	**Module:**	**6"**
		Brick:	11 1/2"
		Joint:	1/2"
	Vertical	**Module:**	**3"**
		Coursing:	4c=12"
		Brick:	2 1/2"
		Joint:	1/2"



1/2 bond using an L-Corner unit

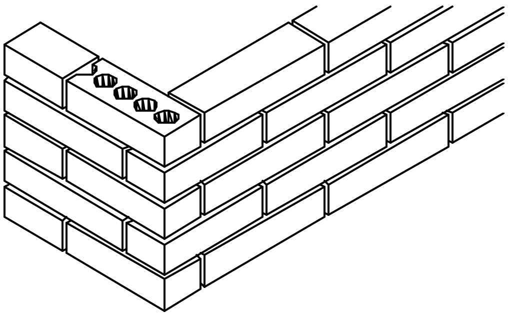
Notes:

- Horizontal module changes from 100 (4") for "Standards" to 150 (6") for "Normans"
- The length of imperial and metric "Normans" are **not** equal.
- A 2 1/2" height "Norman" is commonly used in BC.
- 2 1/4" height "Normans" are available, but at a higher in-the-wall cost.

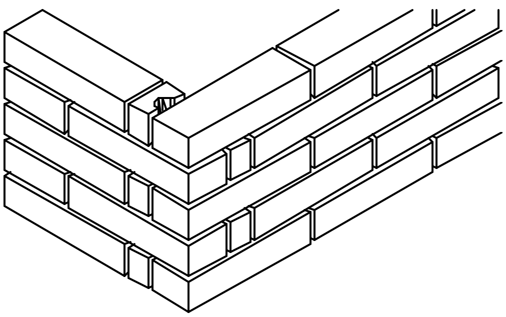
With “Norman” bricks:

Bond: 1/3 bond is the natural bond around corners. Special units can be used to achieve 1/2 bond.

Soldiers: Match the height of 4 courses.



1/2 bond using
a Closer unit



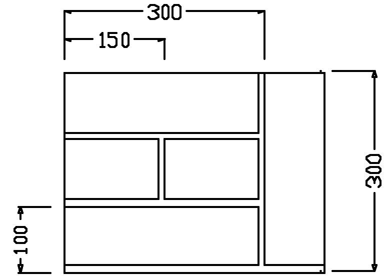
1/2 bond using a Bat

Brick Modules

$ **Cost Factor**
- 10 to 15%

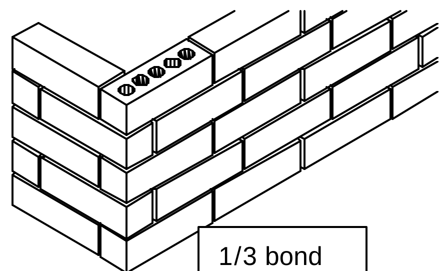
ECON / SAXON BRICK

("Econ" and "Saxon" are proprietary names for this size of unit in BC.)



- Units used as soldiers course out evenly.

These units are economical alternatives to "Standard" brick.
"Econ" or "Saxon" brick have the same height to length ratio as "Standard" brick (1:3) and therefore have a similar appearance. These units can be laid in either 1/2 bond or 1/3 bond. In 1/2 bond special L-corner units are recommended to maintain bond around corners without cutting small pieces. If laid in 1/2 bond, L-corner or 9 1/2" (240mm) closer units are generally used. If the job is laid out to a 150mm module this can be an economical alternative to "Standard" brick because only half as many units are laid. Soldiers are modular, one equals 3 brick courses.

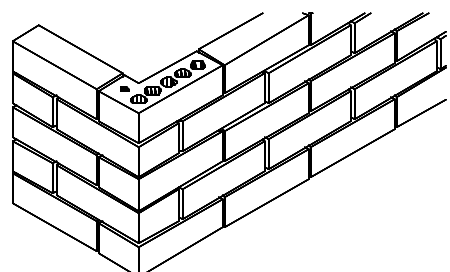


1/3 bond

Metric	**Horizontal**	**Module:**	**150mm**
		Brick:	290mm
		Joint:	10mm
	Vertical	**Module:**	**100mm**
		Coursing	2c=200mm
		Brick:	90mm
		Joint:	10mm

Imperial	**Horizontal**	**Module:**	**6"**
		Brick:	11 1/2"
		Joint:	1/2"
	Vertical	**Module:**	**4"**
		Coursing:	2c=8"
		Brick:	3 1/2"
		Joint:	1/2"

Note: Imperial and metric lengths are not equal



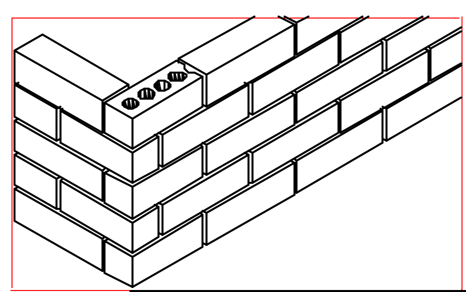
1/2 bond using L-corners

With "Econ" or "Saxon" bricks:

Bond: 1/3 bond is the natural bond around corners. An L-corner or closer can be used to maintain 1/2 bond around corners

Soldiers: Match the height of 3 courses

Note: Closers alter the module. Using them may result in forcing cuts elsewhere.



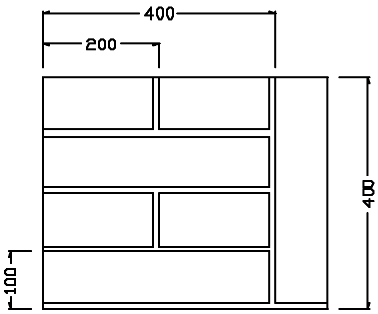
1/2 bond using Closer units

GIANT BRICK

("Giant Brick" is a proprietary name for this size of unit in BC.)

$ **Cost Factor**
- 10 to 15%

Giants, like Normans, have a 1:4 height to length ratio. They are generally laid in 1/2 bond but can also be laid in 1/4 bond. Corners in 1/2 bond require cut pieces (Bats).

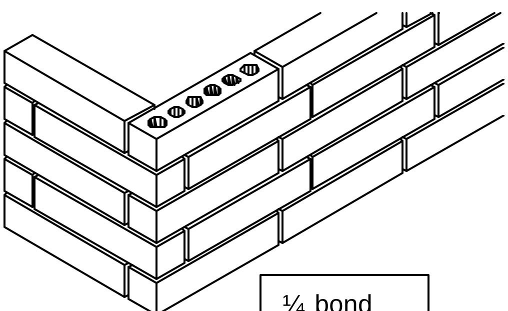


Imperial similar

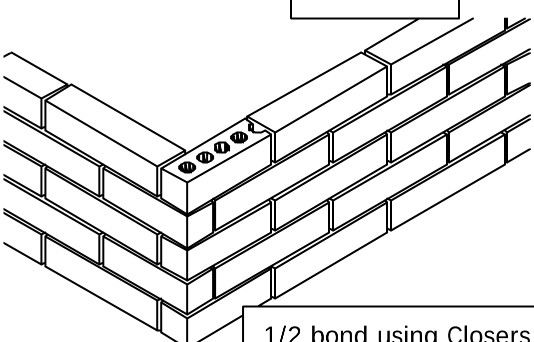
Metric	**Horizontal**	**Module:**	**200mm**
		Brick:	390mm
		Joint:	10mm
	Vertical	**Module:**	**100mm**
		Coursing	2c=200mm
		Brick:	90mm
		Joint:	10mm

Imperial	**Horizontal**	**Module:**	**8"**
		Brick:	15 1/2"
		Joint:	1/2"
	Vertical	**Module:**	**4"**
		Coursing:	2c=8"
		Brick:	3 1/2"
		Joint:	1/2"

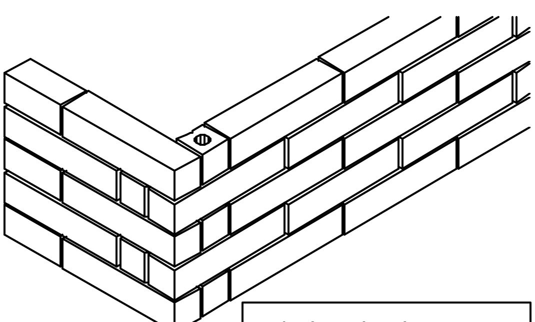
Note: Imperial and Metric lengths are not equal.



¼ bond



1/2 bond using Closers



1/2 bond using Bats

With "Giant" bricks:

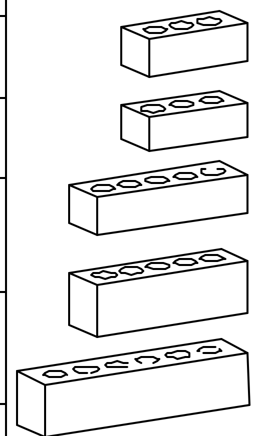
Bond: 1/4 bond is the natural bond around corners. Brick Closers or Bats (cut pieces) are used to maintain 1/2 bond around corners

Soldiers: Match the height of 4 courses. Half units are often used to match the height of two courses (200mm).

BRICK MODULE SUMMARY TABLES

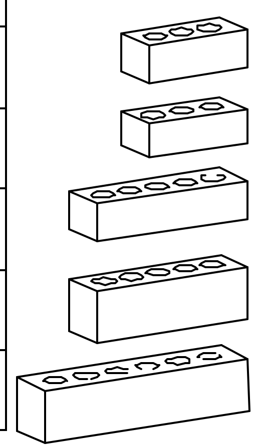
For metric bricks:

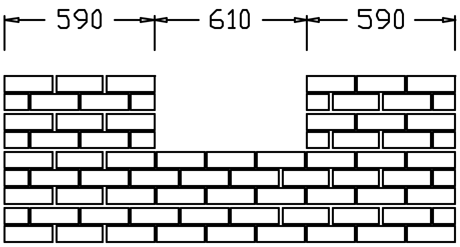
Brick	Module (l x h)	Cost Factor	Natural Bond	1/2 Bond Corners	Soldiers
Standard	100x75	1.00	1/2 bond	Natural	Special 214mm unit matches 3 courses
Modular	100x67	+ 5 to 10%	1/2 bond	Natural	3 courses
Norman	150x75	- 10 to 15%	1/3 bond	L-corner: 140mm return Closer: 240mm	4 courses
Econ / Saxon	150x100	- 10 to 15%	1/3 bond	L-corner: 140mm return Closer: 240mm	3 courses
Giant	200x100	- 10 to 15%	1/4 bond	Closer: 290mm Bat: 90mm	4 courses (2 for half units)



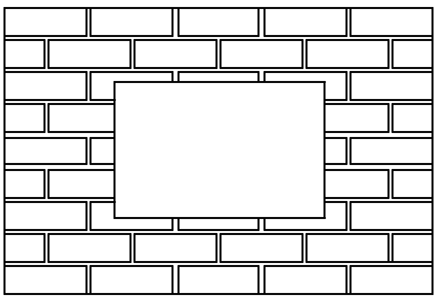
For imperial bricks:

Brick	Module (l x h)	Cost Factor	Natural Bond	1/2 Bond Corners	Soldiers
Standard	4”x3”	1.00	1/2 bond	Natural	Special 8 1/2” unit matches 3 courses
Modular	4“x2 2/3“	+ 5 to 10%	1/2 bond	Natural	3 courses
Norman	6”x3”	- 10 to 15%	1/3 bond	L-corner: 5 1/2” return Closer: 9 ½“	4 courses
Econ / Saxon	6”x4”	- 10 to 15%	1/3 bond	L-corner: 5 1/2” return Closer: 9 ½“	3 courses
Giant	8”x4”	- 10 to 15%	1/4 bond	Closer: 11 1/2" Bat: 3 1/2"	4 courses (2 for half units)





Modular Layout



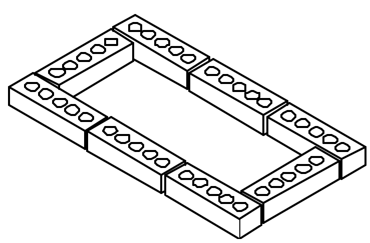
What not to do: this opening requires 16 cuts

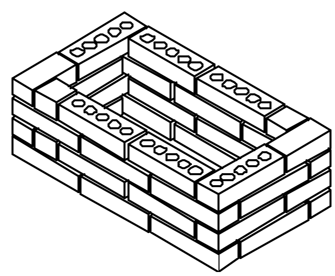
COLUMNS, PIERS and OPENINGS

For the horizontal layout of short panels of brick (i.e. columns or panels between windows) and small openings, the dimensions should correspond closely to the module of the unit used. This is a particular benefit when there are many similar short panels or openings. For longer walls, the mason can adjust mortar joints to get back to the brick module.

The horizontal dimension of a brick **panel** should be divisible by the module minus 1 mortar joint. (eg. A panel or column 3 Standard bricks wide would only have 2 joints and therefore be 590mm not 600mm. Conversely an **opening** in a brick panel 3 bricks wide would have to account for an extra joint (3 bricks + 4 joints) and be 610mm.

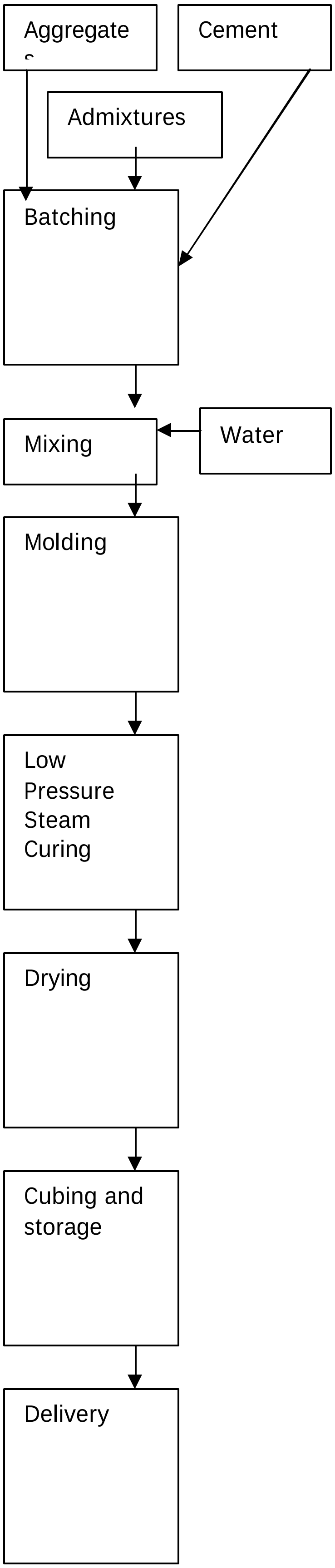
When using over-size brick (Normans, Econs, etc.) consider not just the 1st course but also the 2nd. Often what seems to lay out to the module on one course requires cuts on the second.





The vertical layout is generally less critical because of the frequency and adjustability of the mortar joints, but care should be taken to stay as close to the brick module as possible. This is especially critical when laying out openings and short rises under windows.

Keeping these points in mind will avoid unnecessary cutting and enhance the appearance of your brick project.



Most specification writers, architects, engineers and builders, commonly refer to concrete masonry units as CMU's or concrete block.

The units are formed in a block machine, which uses vibration and pressure to form the blocks from a relatively dry mix with a low water/cement ratio. The basic ingredients are Portland cement, graded aggregates and water; although lightweight aggregates, plasticizers, pozzolans, colouring pigments and water repellants may also be used. After forming, the units are given an accelerated cure in low-pressure steam kilns and are available for use within 48 hours of manufacture.

Concrete masonry provides a cost effective answer to a variety of essential building needs, including: structure, fire separation, architectural finish, thermal mass, sound control, and low maintenance.

The properties of concrete block can provide a total system to address this broad range of building requirements.

The most common unit manufactured today is the 190x190x390mm unit (200x200x400mm nominal with a 10mm joint). It is manufactured with two cores to accommodate vertical reinforcement and to provide a balanced, lighter weight unit for the mason. A wide variety of architectural profiles, textures and colours are available to offer the designer a broad range of surface treatment options. See Section 2.2.4.

PRODUCTS

Concrete masonry units are designed and specified as follows:

Concrete block CSA A165.1-04

Concrete brick CSA A165.2-04

Sample Spec: Concrete masonry units: To CSA A165.1-04

Classification H/15/A/M

Where
H = Hollow
15 = compressive strength in MPa
A = density over 2000 kg/m^3, max. absorption of 175 kg/m^3.
M = moisture controlled - cured, dried, wrapped

You can specify different physical properties for the block according to the following table:

	Solid Content	
H	Hollow (net area is less than 75% of gross area)	
S	Solid	
	Compressive Strength in MPa	
15	15 MPa, standard inventory.	
20	Higher strengths available to order at slight premium.	
25	(See *section 1.2.3 - Cost Guide*)	
30		
35		
	Oven dry density	**Maximum water absorption**
A	**(kg/m^3)**	**(kg/m^3)**
B	Over 2000	175
C	1800-2000	200
D	1700-1800	225
N	Less than 1700	300
	No limits	No limits
	Linear Shrinkage (%)	**Moisture Content (% total absorption)**
M	0.045	45
O	No Limits	No Limits

(See *section 3.1 – Masonry Standards Commentary* for more information)

STANDARD WEIGHT / SEMI-LIGHTWEIGHT / LIGHTWEIGHT

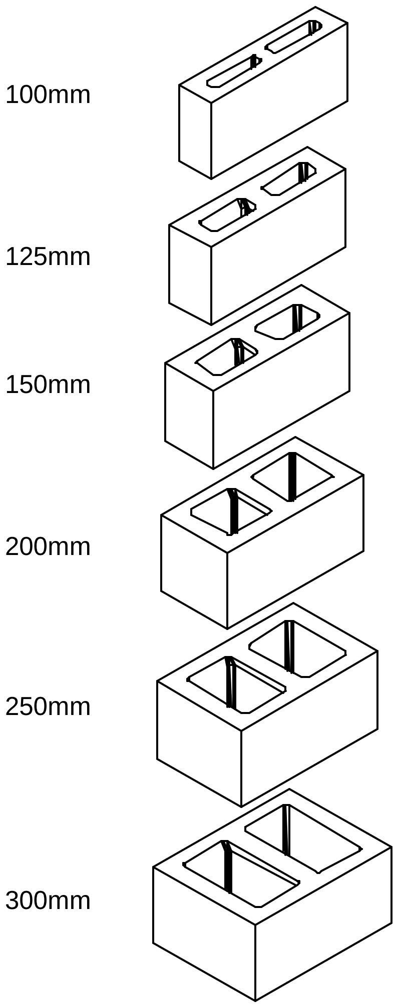
Concrete masonry units are made with either standard weight or lightweight aggregates, or a combination of the two.

A loadbearing concrete block of 200x200x400mm nominal size will weigh approximately 18kg when made with standard weight aggregates, and 15kg when made with semi-lightweight aggregate. In British Columbia, structural units are usually standard weight, which typically consist of 100% sand and gravel aggregates, with a density of 2200kg/m^3.

Semi-lightweight (medium weight) units are typically made up with 50% sand and 50% pumice aggregate, with a density of approximately 1800kg/m^3. Full Lightweight units are primarily pumice aggregate with a density of 1300kg/m^3 and are usually used for interior 4-hour fire-rated walls.

(See *section 2.7.1 – Fire Ratings* for more information)

SIZES



Concrete masonry units are made in various sizes and shapes to fit different construction needs. (See *Section 3.1 – Masonry Standards Commentary* for additional information) Typical shapes include stretcher; double end; half unit; bond beam; half-high unit; H-block unit; multi block unit (See over). Each size and shape is also available in various profiles and surface treatments.

Concrete unit sizes are usually referred to by their nominal dimensions. Thus, a unit known as 200x200x400mm will actually measure 190x190x390mm. When it is laid in a wall with 10mm joints, this unit will occupy a space 400mm long and 200mm high.

Horizontal	**Module:**	**200mm**
	Block:	390mm
	Joint:	10mm
Vertical	**Module:**	**200mm**
	Coursing:	1c = 200mm
	Block:	190mm
	Joint:	10mm

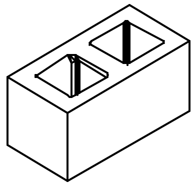
<u>The 125mm unit</u> (actually 115mm wide) is the narrowest block capable of:

- being reinforced for seismic zones
- 1 hour fire-rating hollow
- 2 hour fire-rating grouted solid
- STC of 46 (STC 50 when grouted solid)

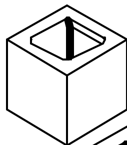
It is useful as either a partition or exterior back-up to claddings.

SHAPES

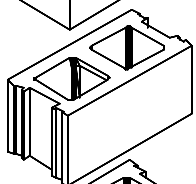
Double-ender



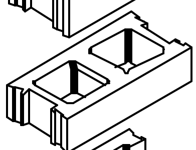
Half



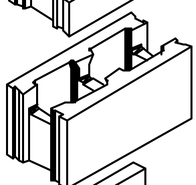
Stretcher



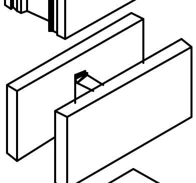
Half-high



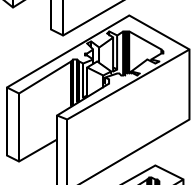
Bond-beam



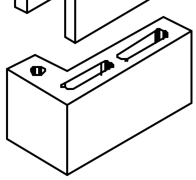
H-Block



Multi-block



L-corner (100mm)



The H-Block unit offers special structural advantages:

- Easily accepts heavy reinforcing
- Creates a nearly monolithic slab of concrete when grouted solid (*See Structural Wall Types Section 1.2.2 p.2*)

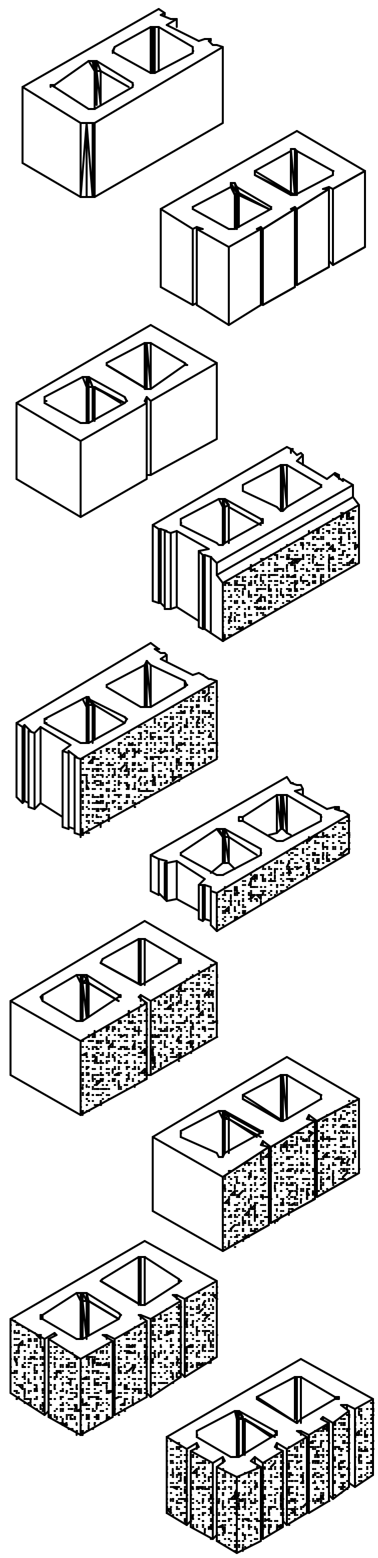
Available in all architectural finishes

PROFILES & TEXTURES

Groundface Units

Units are now produced with a ground, polished stone appearance. They are available in all sizes and colours.

See manufacturer's product information and samples for details



Bullnose

Triple-score return

Single-score

Split ledge

Split face

Half-high split

Two-rib split

Three-rib split

Four-rib split return

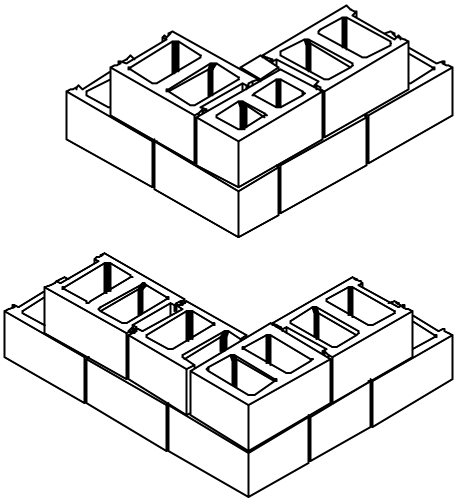
Six-rib split return

Modular Layout

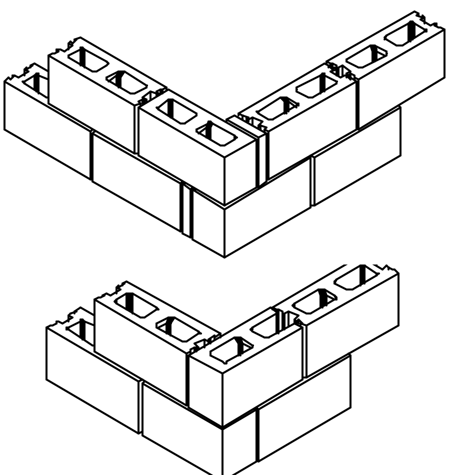
Work to a 200mm module where possible to avoid cutting and retain alignment of vertical cores for rebar.

Openings should be placed at a modular distance from corners or other openings (distance between them in whole multiples of module (200mm))

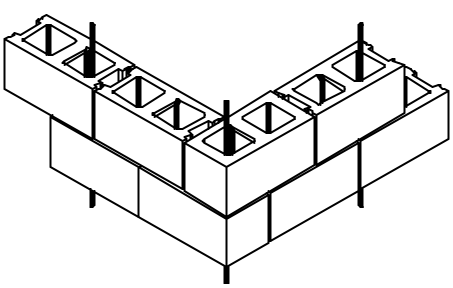
The mason will make corners work. On the left are examples of structural wall corners in different block sizes.



300mm block corners



150mm block corners



Dowel layout

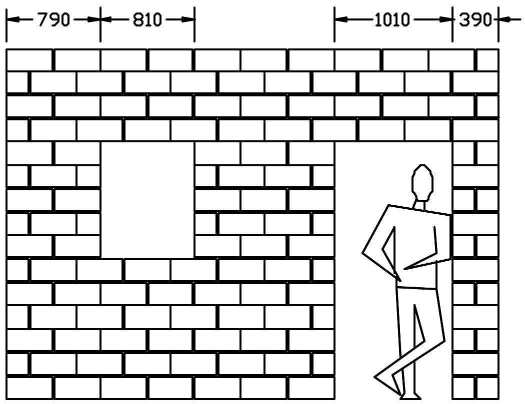
STRUCTURAL LAYOUT

Structural masonry is typically reinforced (our seismic zones make the use of reinforcing steel mandatory). Dowels are placed in the footing before any masonry units are laid. This requires careful planning so as to avoid “missing the cores”. Luckily, block core location is easy to predict.

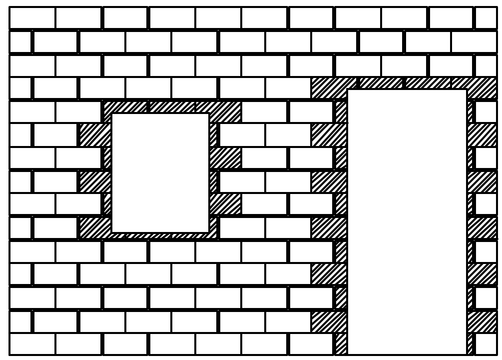
- First dowel is placed 100mm from corner
- All other dowels are usually spaced at multiples of 200mm apart (Typically 800mm) based on engineering requirements

LAYOUT EXAMPLES

Proper layout will minimize costs by reducing time of construction, maximizing the strength of the material and reducing waste.



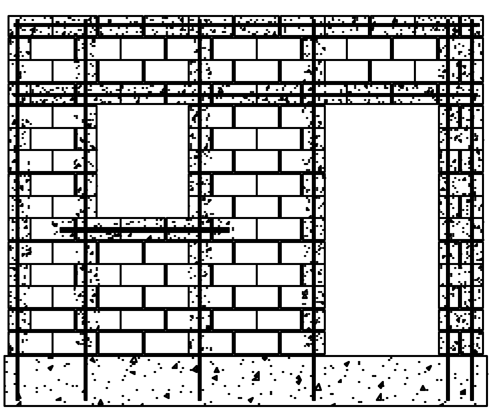
Proper layout with no cut units.



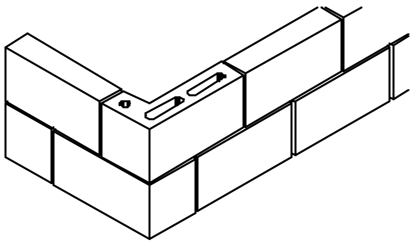
Many cut units reduce productivity and increase waste.

Notice how the window is 20mm (thickness of two joints) wider than the pier on the left. The pier loses a joint, while the opening “gains” one

Reinforcement creates a grid of steel and grout within the concrete block wall. Modular design ensures the steel can be placed and grouted properly to meet design requirements.



VENEER LAYOUT

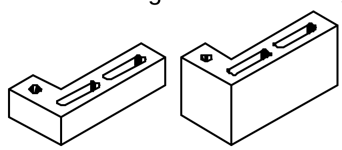


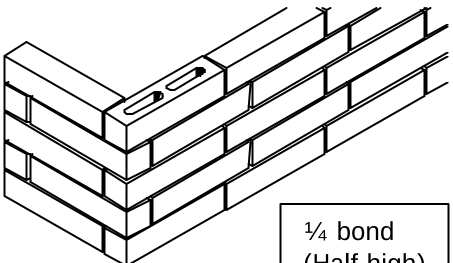
Corner of "Full high" with return L-corner

Veneer units are available in both "Half high" (100mm vertical module) and "Full high" (200mm vertical module)

Walls built with veneer units may keep the same appearance as structural walls by using special L-corner return units.

100mm high 200mm high



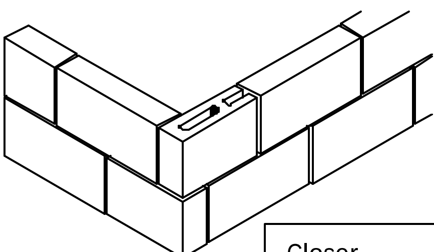


¼ bond (Half high)

"Half high" units

These units have a 1:4 height to length ratio. They are generally laid in 1/2 bond to match any surrounding structural masonry, but can also be laid in 1/4 bond. Corners in 1/2 bond require cut pieces (Bats) or special L-corner pieces.

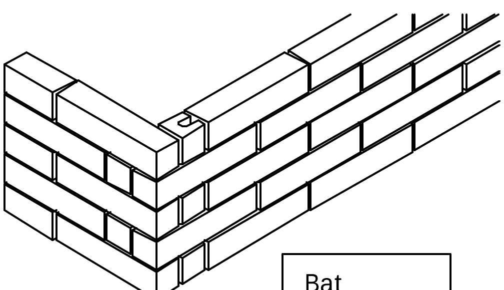
Metric	**Horizontal**	**Module:**	**200mm**
		Block:	390mm
		Joint:	10mm
	Vertical	**Module:**	**100mm**
		Coursing	1c=100mm
		Block:	90mm
		Joint:	10mm



Closer (Full high)

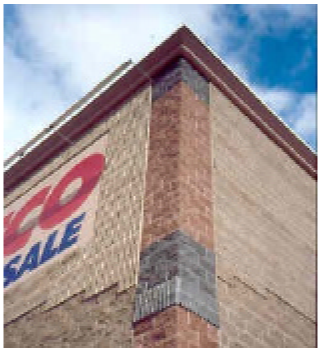
"Full high" units

Metric	**Horizontal**	**Module:**	**200mm**
		Block:	390mm
		Joint:	10mm
	Vertical	**Module:**	**200mm**
		Coursing	1c=200mm
		Block:	190mm
		Joint:	10mm

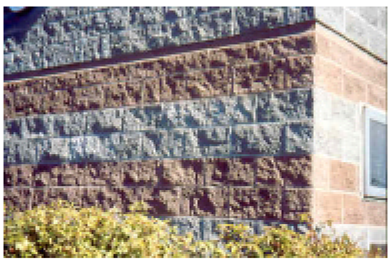


Bat (Half high)

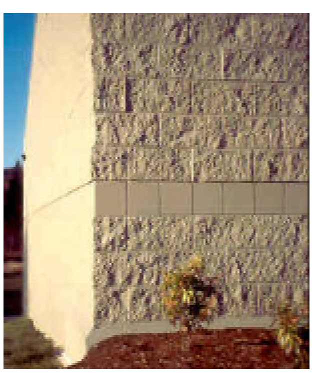
Architectual Coloured Concrete Block Walls



Multiple Coloured splitface and 6-rib



Combination of coloured split ledge and natural splitface



Painted splitface with smooth

Textures and Profiles:

Architectural Concrete Blocks allow the designer to combine colour, texture and profile to provide a limitless range of building appearance options. They are available for both structural and veneer applications. Architectural structural units offer economic and environmental benefits from their efficient combination of structure and finish.

Smooth and "Splitface" textures can be used separately, or in combination to create a wide variety of wall detailing possibilities. The Splitface effect is produced by splitting two units apart with hydraulic blades after curing during production process.

Ribbed and Ledge profiles allow the designer to play with light and shadow, both vertically and horizontally, to achieve unique design effects which change with the direction of the sun through-out the day. They are produced by combining custom moulds with the splitface technique described above.

Colour Options:

Colour can be provided the by either surface coatings or integrally coloured units.

Surface Coatings:

Colour in concrete block walls can be provided by surface treatments such as paint and tinted water repellants. Quality elastomeric paints are available in a multitude of colours, which can be used to create a wide variety of architectural patterns and details. They offer excellent weather resistance in wet climates. Tinted water repellants provide an alternative colour approach, with slightly less effect on surface texture.

Integral Colour:

Integrally coloured units are produced with oxide additives blended into the concrete block mix during the manufacturing process. A range of earth tone colours is readily available – contact local suppliers for colour samples. Coloured mortars are usually used with coloured block to solidify the colour impact, and to simplify cleaning after construction. These units are usually produced on a custom order basis, with only a few weeks lead-time.

The application of a clear water repellant to integrally coloured block walls after they are completed and cleaned is recommended in wet climates such as coastal BC. This maximizes weather resistance and helps to keep the walls cleaner over time. Some block manufacturers also offer proprietary integral water repellant systems to further improve weather resistance.

Caution for Coloured Smooth Block:

Due to the nature of the manufacturing process, integrally coloured block walls in a standard, smooth texture generally display a wider colour range than the consistent colour provided by splitface texture units. This can be observed by viewing typical smooth grey coloured walls, or the backside of a splitface structural wall.

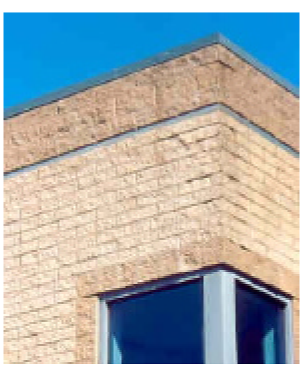
This wider range can occur because the “slick” on the smooth exterior surface of the block has a high cement and colour content, which is affected by small changes in moisture content, temperature and curing during manufacture. This is not the case for a splitface surface, because the splitting process exposes the consistent interior of the block mix.

Smooth block walls may also be more difficult to clean because cleaning materials and processes can have more affect on the smooth surface than would occur with a splitface texture. (see Section 1.6 of the MIBC Technical Manual for further discussion on cleaning masonry)

For these reasons, the specification of integrally coloured smooth units is not recommended for large wall elements, without a review of these concerns by the designer with the block manufacturer. The surface coatings discussed above provide simple alternatives.

Painted smooth for school corridor
(Kid Proof !)

Coloured splitface.
Note colour range in smooth



Multiple colours of full and half-high splitface with smooth band

Hydraulic splitter creating splitface unts.

Combination of coloured splitface with natural smooth units framing the windows and half-high smooth in vertical recess.

INTRODUCTION

The principal purpose of mortar is to adhesively bind together the individual masonry units. It also provides protection against the penetration of air and water through the joints in a masonry assembly. Mortar also bonds the non-masonry elements of an assembly such as joint reinforcement and ties. It also compensates for minor dimensional variations in the masonry units, and provides coursing adjustment to meet required dimensions. Finally, mortar joints contribute to the architectural quality of the masonry assembly both through colour and shadow.

Mortars are supplied to the job site in three ways:

- Site mixed – the mortar is prepared on site by the mason.
- Pre-mixed wet – the mortar is commercially prepared off-site and shipped in tubs ready to use. A retarder is added to the mixture to ensure the mortar in tubs does not set up before being placed in the wall.
- Pre-mixed dry – the mortar is commercially prepared off-site. Water is added to the mix by the mason on site.

The supply of mortar is not typically specified but rather determined by the mason based on site conditions.

BOND – MORTAR'S MOST IMPORTANT PROPERTY

Mortar mixes include ingredients that give it strength (i.e. cement) and those that promote workability and good bond with the masonry units. Good workability and water retentivity are essential for maximum bond. A mortar that has a high cement content will be stronger, but may produce less bond. Conversely, a mortar with moderate cement content will not be as strong, but will have better bond strength.

- Mortar bonds masonry units together. Good bond strength will significantly contribute to a masonry wall's integrity and weather resistance.
- The compressive strength of mortar has only a small effect on the strength of the wall, but gives it durability.

A good balance of strength and bond is required. This leads to both good seismic performance and weather resistance.

Site inspection of mortar is generally not a significant concern for designers, because the bricklayer and the specifier are both looking for workable, well-proportioned mixes that ensure installation efficiency for the mason and long term performance for the designer.

MORTAR COLOUR

From 8-22% of the wall area is taken up with mortar (depending on the unit size), therefore the colour of the mortar can significantly alter the appearance of the wall. Natural gray mortar is the most common and generally the best choice for brick and gray block. It sets off the brick colour nicely and is the most economical. In general, if a brick mortar colour is used it matches the brick in a lighter tone. Coloured mortars are usually specified for coloured block to solidify the colour impact and to simplify cleaning after construction.

SPECIFYING MORTAR

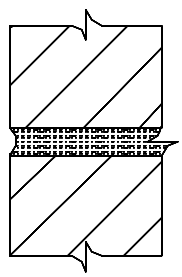
CSA A179-04 *Mortar and Grout for Unit Masonry* covers raw materials, mortar types, mixing process and mortar specifications. Mortar types within CSA A179-04 are designated by letters “S” or “N”: Type S is typically used for both structural and veneer masonry, while Type N can also be used for veneer masonry construction. Mortar specification can be made either through the Proportion or Property method. The Proportion method is used for site-mixed mortar and is based on respective volumes of sand and cementitious materials. The Property method is based upon compressive strength tests of mortar cubes, and is typically used for pre-mixed mortar. (Also see *Section 3.1 – Masonry Standards Commentary*)

Typical spec: *Mortar to: CSA A179-04*
Type S, mortar for structural and veneer masonry
Proportion specification shall apply to field mixed mortar;
Property specification shall apply to mortar manufactured off-site.

Ancient Egyptian mortars were made from burned gypsum and sand while later development in mortar technology utilized a combination of lime and sand. These mortars developed their strength slowly (through a process of carbonation). Since about 1900, Portland Cement has been incorporated into mortar to provide more rapid strength development. Modern mortar is composed of cement and lime or masonry/mortar cements, masonry sand, water, and possibly some admixtures.

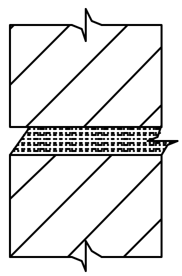
JOINT PROFILES

The mortar joint profile has an impact on water resistance. It also has a significant effect on appearance. Ranked by their effectiveness (highest to lowest) to resist penetration of water, common joint types are:



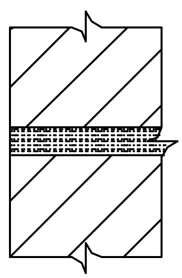
1. Concave Joint

Concave tooling of the mortar joint compacts the mortar properly against the units. A dense, smooth surface is formed that sheds water effectively. This type of joint is very effective in resisting rain penetration and therefore is recommended for use in walls exposed to wind driven rain.



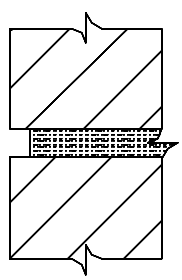
2. Weathered Joint

Although less effective than the concave tooled joint, the weathered or weather joint can be acceptable as a water resistant mortar joint as it is somewhat compacted and sheds the rain.



3. Flush Joint

The trowelling of a flush joint forms an uncompacted joint with a possible hairline crack where the mortar is pulled away from the unit. Flush joints cannot be recommended as being rain resistant mortar joints and should only be used on walls that are to receive additional finishes.



4. Raked Joint

The raked joint may or may not be compacted and it provides a ledge where rain water will settle and possibly enter the wall. It is therefore not recommended as a rain resistant mortar joint and should not be used on walls exposed to weather.

Note: Because raked joints do not weather well, the use of scored block (which require the use of a raked joint) is not recommended for exposed walls.

Grout, or “block-fill” as it is sometimes referred to, is specified to *CSA A179-04*.

TYPES OF GROUT

Coarse Grout, the most commonly used type of grout, has a maximum aggregate size of 12 mm (1/2”). The slump should be between 200 and 250mm (8”-10”). This is much higher than typical ready mix concrete, but is very necessary to properly fill the cores of masonry units and flow around reinforcement or other elements within the wall.

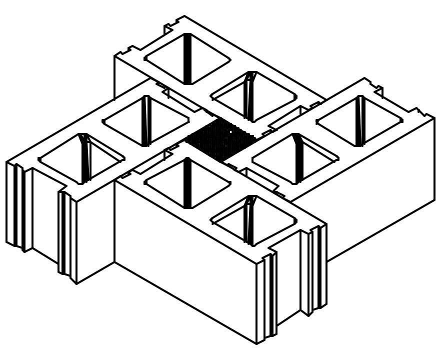
Fine Grout uses coarse sand for aggregate and would only be used in small core units such as reinforced brick. Fine grout is required to flow through small openings so a grout slump of over 250mm is recommended.

Grout is usually supplied in ready-mix trucks, with quality control data available from the supplier. Field test cylinders may also be taken.

GROUT STRENGTH

Typical test results for the same grout mix:
Pinwheel test: 18 to 25 MPa
Cylinder test: 13 MPa

Grout strength specification is a topic requiring clarification. Because grout must flow for substantial distances through small core openings, it must be placed at a very high slump of 200 to 250 mm. After placing, the water required to increase the slump is then absorbed into the units to provide a concrete mix with a normal water content - and higher final strength. Grout tested using standard non-absorptive plastic or metal cylinders still contains the extra water, and develops correspondingly lower strength results.



“Pinwheel” used to test grout

The “Pinwheel” test simulates the absorption conditions the grout would experience in the wall, but is awkward to use on site and is seldom used.

CSA A179 recognizes this difference in sample preparation by calling for only a 12.5 MPa grout strength when cylinders are used. The actual strength in the wall will be much higher, typically over 20 MPa which exceeds the 15 MPa strength of standard concrete blocks. This grout strength is compatible with the design strengths contained in *CSA S304.1.*

However, Structural Notes and specs have typically called for 20 or 25 MPa grout tested by cylinders. In reality, a 20 MPa grout may be preferred for pumping reasons anyway. If Structural Notes do not recognize the 12.5 MPa strength minimum, then a project cylinder test result below a 20 or 25 MPa specified strength should not treated as a cause for concern. A 25 MPa high slump grout designed for cylinder testing may actually be 40 MPa in the wall. This is a waste of money (extra cement) and may be a less satisfactory product (compatibility and shrinkage). (Also *see Section 3.3 – Guide Structural Notes*)

Sample spec: Grout to CSA A179-04
Minimum compressive strength 12.5 MPa
at 28 days by cylinder test under the property specification
Maximum aggregate size 12 mm diameter
Grout slump 200 to 250 mm

CLEANOUT / INSPECTION HOLES

Unit cores that are to be grouted should be free of excessive mortar protrusions and mortar droppings at the base. Clean-out/inspection holes at the base of the reinforced cores will facilitate the removal of excessive mortar droppings, and confirm that grout has reached the bottom of the core. Clause 8.2.3.2.2 of CSA A371-04 Masonry Construction allows the requirement for clean-out/inspection holes to be waived by the designer when the contractor has demonstrated acceptable performance or where the walls are not structurally critical. In some cases the designer will require the initial walls to have clean-outs pending demonstrated performance, and then waive cleanouts for the remaining walls.

GROUTING

Grout Lift: that portion of a total grout pour placed in one pass of the grout filling process.

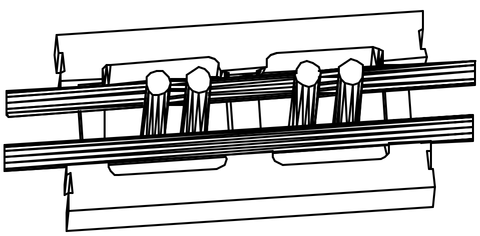
Grout Pour: the total height of grout placed in a wall during a grouting operation. A grout pour consists of one or more grout lifts.

While grouting, care must be taken to completely fill the reinforced cores and to ensure that all bars, bolts and anchors are fully embedded.

Grout is typically pumped in 2.4m (8') pours from bondbeam to bondbeam. The maximum pour height in CSA A371-04 is 4.5 m, but this would only be practical for H-block or 250 or 300 mm units. For a grout pour of 3 m or more, the grout must be placed in lifts of 2 m or less.

(For more detail, see *Section 3.3 - Guide Structural Notes*)

REINFORCEMENT



2 bars vertically and 2 bars horizontally in a 20cm wall are almost impossible to grout, particularly at splices where steel is doubled.

See Section 1.2.1 for minimum reinforcement requirements.

The core size of the masonry units will dictate the size and number of bars that can be effectively grouted. Typically, reinforced masonry makes use of 15M or 20M bars. Units 125, 150 and 200mm wide should not contain more than one vertical bar per core. Units 125 and 150mm wide should be restricted to one horizontal bar per course in bondbeams. (See also *Section 3.3 - Guide Structural Notes*)

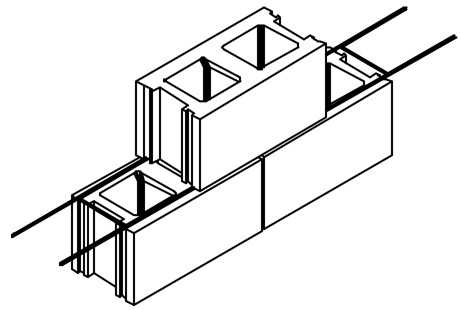
NOTE: At splices, the number of bars per core is doubled – increasing congestion.

Maximum number of bars	100 mm	125 mm	150 mm	200 mm	250 mm	300 mm
Vertical bars per core	N/A	1	1	1	2	2
Horizontal bars per course (lintel, bondbeam)	N/A	1	1	2 *	2 *	2 *

***** 2 bars in bond beam can help to center vertical steel

Reminder: for every bar specified, there are two at splices.

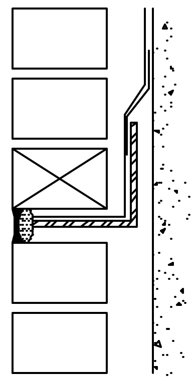
JOINT REINFORCEMENT



Joint reinforcement is used in addition to horizontal steel bars when bondbeams are spaced at more than 1200 mm. It is a ladder of 9 gauge (3.7 mm) wire installed in the mortar joint, which positions a wire in the centre of each block faceshell. It is spaced at a maximum of 600mm, 400 mm for stack pattern, and at 400 mm in seismic zones. Joint reinforcement resists wall cracking and can contribute to the horizontal steel area in the wall.

THROUGH-WALL FLASHINGS

Flashings channel moisture which may penetrate the exterior wythe to the outside. Weepholes located at the base of each wall, or at any horizontal interruption of the cavity, allow this moisture to escape.

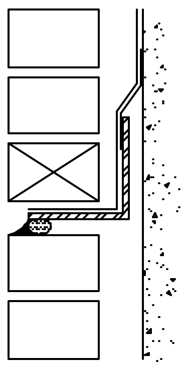


Caulked Brick-to-Brick

Location of through-wall flashing

Through-wall flashing is required:

- At base course of masonry veneer walls.
- Directly above lintels over openings for windows, doors, etc.
- At intermediate shelf angle locations in multi story buildings.
- Under masonry sills, copings, etc.
- Over mechanical penetrations
- At vertical returns where dampness may come in contact with sensitive materials.

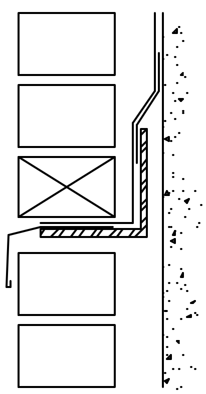


Caulked Brick-to-Toe of shelf angle

Through-wall flashing materials

Considerations when selecting materials:

- Toughness of material to resist puncture, tearing and other damage during construction and service.
- Durability to resist corrosion or deterioration over the life of the building.
- Material should be easily formed to desired shapes and sizes and made waterproof.
- Should be resistant to staining the adjacent masonry and other building materials.
- Material should be easy to seal, lap and form.



With drip-edge

Flashing materials:

- Peel & stick (flashing grade) or torch-on modified bituminous membranes (supported across any large cavity)
- EPDM
- Prefinished sheet metal (painted galvanized steel)
- Stainless Steel sheet metal
- Fastening devices should be corrosion-resistant and compatible with the materials used (potential galvanic action between metals should be addressed)
- Primers and adhesives (according to manufacturers' recommendations)

Installation

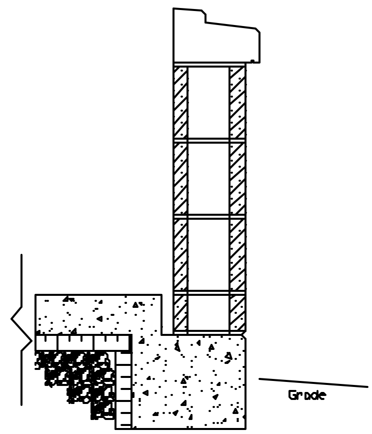
Through-wall flashing should be installed on a smooth surface and care must be taken to ensure drainage to the exterior. Overlaps, joints and primers should be to manufacturer's recommendations. Metal flashing joints must allow movement due to expansion / contraction.

Note:
Manufacturer recommendations should be followed for material compatibility, surface preparation, priming requirements, overlaps and terminations.

The flashing should return up the substrate at least 150mm behind the sheathing paper or air/vapour barrier membranes. End dams should be installed at each end of the flashing runs to stop moisture from finding a way around the flashing.

Weepholes must be installed in the first course above flashing at intervals not exceeding 800mm. A drop to grade of at least 100mm is recommended, more if landscaping will be used at the base of the wall.

Note: a "flashing effect" can be obtained for structural walls without the addition of a flashing by shaping a concrete ledge in such a way as to direct any moisture out through weepholes.



Natural flashing effect by using a base ledge detail.

CAP FLASHINGS

Cap flashings protect the top of masonry walls from rain by:

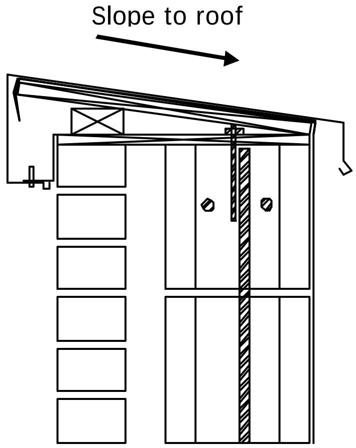
- acting as a barrier against moisture
- covering the top of the wall sufficiently to stop wind-driven rain from working its way up under the flashing
- eliminating stains caused by dirt-laden runoff

Cap flashings typically consist of two parts: The protective cap and the membrane.

Cap flashing materials

Considerations when selecting materials:

- Toughness of material to resist puncture, tearing and other damage during construction and service.
- Durability to resist corrosion or deterioration over the life of the building.
- Should be resistant to staining the adjacent masonry and other building materials.



Membrane wraps the assembly from above the veneer to the roof.

Protective cap materials:

- Prefinished sheet metal (painted galvanized steel)
- Fastening devices should be corrosion-resistant and compatible with the materials used (potential galvanic action between metals should be addressed)

Membrane materials:

- Peel & stick (metal roof underlay grade) or torch-on modified bituminous membranes
- EPDM
- Primers and adhesives (according to manufacturers' recommendations)
- Other roofing materials (consult the Roofing Contractors Association of BC)

Installation

Note:
Manufacturer recommendations should be followed for material compatibility, surface preparation, priming requirements, overlaps and terminations.

Membrane installation:

- Flashing should be installed on a smooth surface.
- Overlaps and joints should be to manufacturer's recommendations.

Protective cap installation:

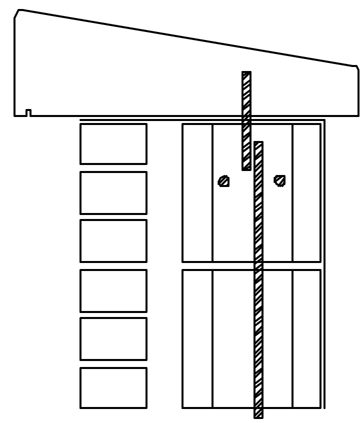
- Metal flashing joints must allow movement due to expansion / contraction.
- The flashing should cover at least 75mm of the top face of the masonry wall to protect from wind-driven rain.
- The top surface of the flashing should **slope to roof** so as to eliminate drip stains on the face of the wall.

COPINGS

Copings protect the top of masonry walls from rain by acting as a barrier against moisture. Copings can be more effective if they project from the front face of the wall to form a drip edge.

Copings are underlain by a membrane or metal flashing

Coping materials



Membrane wraps from top of veneer to roof.
Dowel passes through membrane and penetration must be sealed.

Coping materials:

- Stone
- Brick
- Concrete

Membrane materials:

- Peel & stick (flashing grade) or torch-on modified bituminous membranes
- EPDM
- Roofing membranes (consult the Roofing Contractors Association of BC)
- Primers and adhesives (according to manufacturers' recommendations)

Installation

Membrane installation:

Flashing should be installed on a smooth surface.

Overlaps should be to manufacturer's recommendations.

Coping installation:

Copings are anchored through the membrane to the wall. All membrane penetrations must be properly sealed.

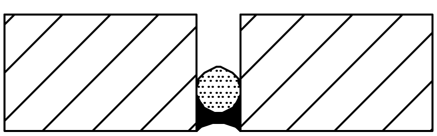
Note:
Manufacturer recommendations should be followed for material compatibility, surface preparation, priming requirements, overlaps and terminations.

DESIGN CONSIDERATIONS

It is the responsibility of the designer to provide the location and type of vertical and horizontal movement joints required in masonry walls. The requirements for movement joints should be based on the following considerations:

1. Thermal expansion and contraction of masonry.
2. Moisture shrinkage and expansion of masonry units.
3. Creep and shrinkage of concrete structural elements.
4. Deflection of supporting structures, particularly structural steel.
5. Drying shrinkage of wood frame.
6. Earthquake movements

The *National Building Code of Canada* and CSA masonry standards do not specify the spacing of movement joints, so they are to be determined by the designer based on calculations, past experience and industry recommendations. Although there is much material written on this subject, the literature is often confusing due to the multitude of masonry construction types. The designer must give careful consideration to the type of material, the wall system and the structural frame before selecting the movement joint spacing.



Movement joints should be left clear of mortar, and properly sealed with caulking over a backer rod.

MASONRY UNIT PROPERTIES

Clay brick typically expands after production, due to the re-entry of moisture into clay after it has been fired in the kiln. However, much of this expansion will have taken place while it is inventoried and shipped, and before it is installed. In addition, there will be some shrinkage in the mortar joints between the units, with the result that there will be minimal net expansion from this process. Clay brick will undergo moisture cycle movement from regular wetting and drying due to the weather. Thermal expansion and contraction will occur, and the coefficient of expansion is horizontally 0.5-0.6 mm per metre per 100°C and vertically 0.7-0.9 mm per metre per 100°C

Concrete block undergoes a non-reversible shrinkage due to carbonization and the loss of moisture that occurs with time in a cement-based product. In addition to the non-reversible shrinkage, concrete block also undergoes moisture cycle movements with wetting and drying as well as thermal expansion or contraction. The coefficient of thermal expansion of block is 0.8-1.0 mm per metre per 100°C.

Glass Block has a considerably higher coefficient of expansion than traditional masonry, steel or concrete. Manufacturers' literature should thus be consulted for maximum panel size, reinforcing and expansion joint detailing.
(For more information on movement refer to *Table 1, CSA S304.1*)

REINFORCED STRUCTURAL WALLS vs. VENEERS

Horizontal reinforcing, either in the mortar joints or grouted into bond beams, can be used to increase the tensile resistance as a means of crack control in structural walls. The use of reinforcement thus permits a larger spacing of vertical movement joints.

Movement joint spacing for veneer depends to some degree on the rigidity of the support system. Structural steel typically will have larger deflections than concrete frame buildings. Veneers on taller buildings also require horizontal movement joints formed by gaps under shelf angles to accommodate vertical movement.

Possible Joint Locations:

- Wall openings
- At given spacings in a continuous wall
- Changes in wall height
- Foundation or support structure joints
- Changes in support conditions (foundation vs. framing)
- Proximity to wall corners or intersections
- Changes in wall thickness

VERTICAL MOVEMENT JOINT LOCATIONS

When selecting vertical movement joint locations, the primary consideration should be the location of large openings where stress concentrations can be expected to occur. Other considerations include: changes in wall height, changes in wall thickness, corners, offsets and wall intersections. The aspect ratios of walls will also at times influence the maximum joint spacing. Thermal stresses, differential movements, foundation settlements or structural deflections should all be taken into account before deciding on joint locations.

Corners of openings are often good joint locations, with symmetrical layouts sometimes considered for aesthetics. Movement joints should be shown on elevation drawings, or determined with the masonry contractor at a pre-construction meeting.

Typical Maximum Vertical Control Joint Spacings

Wall Type	Material	Movement joint spacing
Veneer	Clay	7m – 10m
	Concrete	5m – 7m
Reinforced masonry	Clay	15m
	Concrete	15m

HORIZONTAL MOVEMENT JOINT LOCATIONS

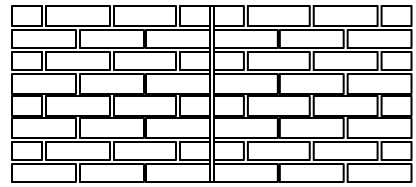
Horizontal movement joints are formed by, and located at, shelf angles. While lintel angles provide support over openings, shelf angles within the wall are primarily for movement control, not vertical support. It can be efficient to locate shelf angles so that they coincide with lintel angles in the wall elevation. Horizontal movement joints are usually specified once the building height reaches three or four stories. They are typically spaced at each floor level, but could be located at greater spacings depending on the back-up system and expected movements. There is no maximum spacing specified in engineered masonry design.

VERTICAL MOVEMENT JOINTS

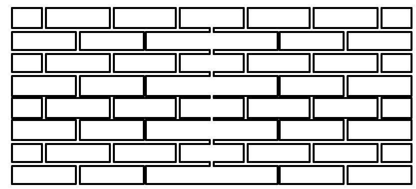
Vertical movement joints span masonry panels vertically (both structural and veneer). They allow for movement of the masonry along the length of the panel.

To construct a vertical joint, half units are used every other course (in running bond). In order to hide the joint, a caulking colour that approximates **the units** should be specified. Vertical banding details can also hide these joints.

If a vertical movement joint is placed above an opening, the arching effect of the masonry will be eliminated. This will affect the design of the lintel over the opening.



Caulk does not match



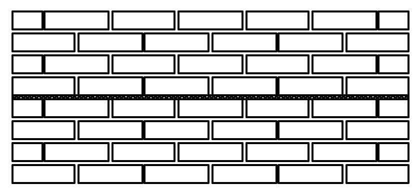
Caulk matches brick

HORIZONTAL MOVEMENT JOINTS

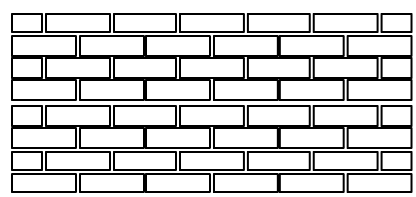
Horizontal movement joints span tall masonry veneer panels horizontally. They allow for movement of the masonry over the height of the panel.

Horizontal joints are formed by the gaps below shelf angles.

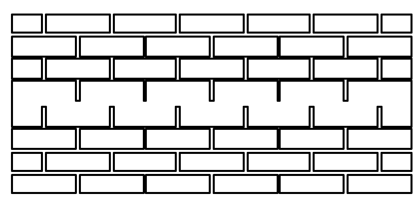
Since the thickness of a horizontal joint at shelf angles is larger than normal, it is important to minimize its impact. Joints are hidden by using caulking that approximates **the mortar** in colour and by incorporating them into horizontal banding designs.



Caulk does not match



Caulk matches mortar



Caulk matches brick

Ties must be labeled:

Tie packaging or pieces must be labeled, including corrosion protection type

aDRI Values in B.C.:

Abbotsford	4.13*
Cranbrook	0.73
Kamloops	0.61
Port Alberni	2.94*
Prince George	1.15
Prince Rupert	9.37*
Vancouver	3.72*
Victoria	3.33*

* Locations with values above 2.75 require stainless steel ties for walls over 13 m.

GENERAL

Brick tie requirements are outlined in *CSA A370-04 Connectors for Masonry*. The older kinds of ties, such as strip ties and Z ties as are seldom used in modern commercial construction, can not be used in higher seismic zones, and are now referred to as "Prescriptive Ties". The newer, 2-piece, adjustable, engineered ties that are now in common use are now simply referred to as "Ties". *CSA A370-04* contains strict design requirements for strength, deflection and free play. Ties are designed to resist the lateral wind and seismic loads provided for specific locations by the *B.C. Building Code (BCBC)*. Factored Tie Capacities are normally provided by test data from the manufacturers.

Corrosion resistance is a key requirement for ties which are required to secure masonry claddings over their long expected life. The section below updates the corrosion requirements first introduced in the 1994 standard, which included the use of stainless steel ties in higher masonry walls in regions of the country which experience high wind-driven rain conditions.

STAINLESS STEEL TIES

The 2006 BCBC references the 2004 edition of *CSA A370, "Connectors for Masonry"*. The standard requires stainless steel ties for masonry over **13 m** high (formerly "buildings" over 11 m) for areas subject to high wind-driven rain such as coastal B.C. Hot dipped galvanized coatings are acceptable corrosion protection for walls 13 m or lower in coastal B.C., and for all wall heights in the drier areas of B.C. The standard provides rain data for locations across Canada in Annex E, in terms of Annual Driving Rain Indices (aDRI).

To take full advantage of the very long service life offered by masonry veneers, stainless steel ties may also be specified for lower walls on institutional or monumental buildings. It may also be simpler to specify stainless steel ties for the lower walls of buildings using them on higher levels of the structure. In any case, the impact on total wall cost is relatively minor. Stainless steel ties are readily available, and have been used on many projects on the west coast for over a decade.

TIE DESIGN for SEISMIC LOADS

Earthquake lateral loads on brick ties are determined by the formula for elements and components of buildings and their connections from the BCBC (clause 4.1.8.17):

$$V_p = 0.3\ F_a\ S_a(0.2)\ I_E\ S_p\ W_p$$

Where: V_p = lateral force

F_a = acceleration based site factor (soil type)

$S_a(0.2)$ = spectral response acceleration (seismic factor)

I_E = building importance factor:
1.0; except 1.3 for schools,etc.;1.5 for post-disaster

$S_p = C_p\ A_r\ A_x\ /\ R_p$ $(0.7 < Sp < 4.0)$

C_p = component factor: 1.0 for ties

A_r = component force amplification factor: 1.0 for ties

A_x = height factor: 3.0, worst case at top of wall for ties

R_p = component response modification factor:
1.5 for ties, 1.0 for fasteners

W_p = weight of component: take as 1.8 kN/m^2

$S_p = (1.0)(1.0)(3.0)\ /\ 1.5 = 2.0$ $(0.7 < Sp < 4.0)$

This new formula in the 2006 BCBC may result in lower lateral seismic loads that the previous code version (V_p=v.I.S_p.W_p , with S_p=5).

This may result in wind loads governing in more cases.

Where $I_E\ F_a\ S_a(0.2) < 0.35$, these requirements do not apply for masonry veneer connections for buildings, other than post-disaster buildings.

The latest generation of strong, 2-piece adjustable ties can provide the opportunity for spacings up to the maximum allowable of 600 mm vertically and/or 820 mm (32”) horizontally. For metric block and metric stud spacings, the effective horizontal maximum is 800 mm.

BRICK TIE DESIGN EXAMPLE

The structural design example below is based upon the requirements of the 2006 BCBC; *CSA S304.1-04 Design of Masonry Structures*; and

CSA A370-04 Connectors for Masonry.

The process begins with the calculation of seismic and wind loads for a typical 2-storey school in Vancouver. The seismic case is assumed to govern for this example.

For this example, we try a tie with a factored resistance (design strength) of 1.1 kN. The allowable spacing of the ties may be affected by whether the back-up wall is concrete block or steel stud. The spacing for the non-flexible block wall is directly obtained by dividing the tie strength by the applied load in kN/m^2, which results in an area in this case of 0.83 m^2
(8.9 sq. ft.) per tie. However, the maximum spacing for any tie system to metric block is limited to a maximum of 600 mm by 800 mm (.48 m^2) (5.2 sq.ft.), so this spacing is specified. (actual horizontal spacing maximum is 820 mm to accommodate studs at 24 in.)

Staggered ties allowed:

A370-04 now allows ties to be placed in a staggered pattern.
This may be more efficient, and ensure that all studs are loaded for wood and metal backups.
There must be a top row tie at every stud line.

For the flexible steel stud back-up, additional requirements are applied to account for the less rigid support condition. For this case, a smaller wall area per tie of .42 m^2 (4.5 sq. ft.) is calculated, and the spacing options are based on stud space increments. The selection of a higher capacity tie may put both back-up systems into the maximum spacing condition.

PROJECT:

Vancouver, 2 storey school, on soft rock
Brick veneer on both concrete block, and steel stud back-up: stud spacing @ 400 mm, stud height 2.8 m.

1. LATERAL LOADS

- Wind Load: The Factored Wind Load calculation as determined for other components at the most severe location on the building may govern for veneer ties, compared to the seismic example below.

- Seismic Load: $V_p = 0.3 F_a S_a(0.2) I_E S_p W_p$

  $F_a = 1.0$; $S_a(0.2) = 0.94$; $I_E = 1.3$; $W_p = 1.8 \text{ kN/m}^2$

  $S_p = C_p A_r A_x / R_p = (1.0)(1.0)(3.0) / 1.5 = 2.0$

$V_p = 0.3(1.0)(0.94)(1.3)(2.0)(1.8)$

$= 1.32 \text{ kN/m}^2$

2. TIE SPACING (Assume Seismic governs for this example)

Examine spacing for a tie with a <u>factored</u> resistance of 1.1 kN (from manufacturers' test data literature)

> Note:
> CSA A370-04 requires a minimum unfactored tie strength of 1.0 kN.

- Concrete Block Back-up (non-flexible)

  Area $= 1.1 \text{ kN} / 1.32 \text{ kN/m}^2 = 0.83 \text{ m}^2$ / tie

  - Therefore space at the maximum 600 mm vertically by 800 mm horizontally. Area = 0.48 m^2
  - Could also consider lower capacity tie.

- Steel Stud Back-up (flexible)

  - Double tributary area load for flexible back-up:

    Area $= 1.1 \text{ kN} / (1.32 \text{ kN/m}^2 \times \mathbf{2}) = 0..42 \text{ m}^2$ / tie

  - Check 40% of stud load:

    (40%)(0.4m)(2.8m)(1.32) = 0.59 kN / tie

    0.59 < 1.1 kN tie capacity - OK

  Spacing options:

  1. Maximum vertical spacing of 600 mm by the stud spacing of 400 mm horizontally. Area = 0.24 m^2 (= 0.42 OK)

  2. Horizontally at double stud spacing of 800 mm (staggered) by a vertical spacing of 450 mm. Area = 0.36 m^2 (= 0.42)
     (Based on vertical brick module fitting 450 mm.)

  3. Could also consider a higher capacity tie.

> **Spacing at Openings and Tops & Bottoms of walls:**
> - Openings: not more than 300mm from edge at maximum 600 mm spacing.
> - Top: not more than 300mm to top row, at every stud, even if staggered.
> - Bottom: not more than

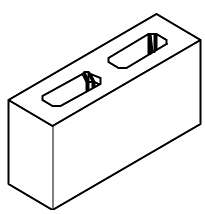
FIRE ENDURANCE

The fire resistance ratings of masonry walls are determined by heat transmission measured by temperature rise on the cold side. A masonry wall will not let flames or smoke through even after the temperature of the wall on the cold side has risen above required levels. Few walls fail due to load during the fire test, during cooling under the fire hose, or during the double load test that follows. Fire endurance can be calculated as a function of the aggregate type used in the block and the equivalent solid thickness of the wall.
Fire-rated walls made of gypsum wallboard are not required to endure the same fire-hose test.

115mm BLOCK
Narrowest block offering:

- 1 hour fire rating (hollow)
- 2 hour fire rating (grouted solid)
- ability to accept reinforcement

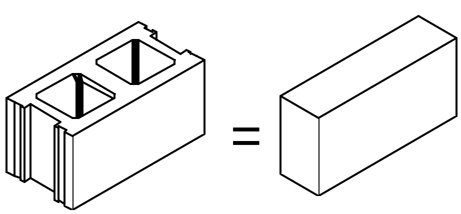
Partition walls made of these blocks also offer excellent:
- Security
- Sound control
- Fire resistance



The fire rating of a masonry wall can be evaluated in two ways. The "Equivalent Thickness" method is outlined in detail in *Appendix D* of the B.C. *Building Code*. The material equivalent thickness required to achieve various ratings are listed in *Table D-2.1.1*.
The second recognized method is to employ the higher fire ratings provided by the *Underwriters Laboratories of Canada (ULC)*. The U.L.C ratings apply only to specific block shipments from certified suppliers.

EQUIVALENT THICKNESS

Equivalent thickness is the solid thickness that would be obtained if the same amount of concrete contained in a hollow unit were re-cast without core holes.



Calculating Estimated Fire Resistance Example: A 200 mm hollow masonry wall is constructed of Type N or S concrete units reported to be 56% solid. What is the estimated fire resistance of the wall? Equivalent Thickness = 56% x 190mm = 106 mm which gives a 1.5 hour fire rating.

Minimum required equivalent thicknesses for masonry and concrete (mm) From table D-2.1.1 of the Building Code							
Hours	**0.5**	**0.75**	**1**	**1.5**	**2**	**3**	**4**
Solid Brick (>80%)	63	76	90	108	128	152	178
Cored Brick (<80%)	50	60	72	86	102	122	142
Concrete Block (Std. Weight)	44	59	73	95	113	142	167

Fire ratings for walls of hollow concrete masonry units in hours

Block Thickness (Actual)	Percent Solid	Equivalent Thickness	Standard Weight Concrete **Types N / S**		Semi-light weight concrete **Types N / S**		Light weight concrete **Type $L_2$20S**	
			N.B.C.[1]	U.L.C.[2]	N.B.C.[1]	U.L.C.[2]	N.B.C.[1]	U.L.C.[2]
mm	**%**	**mm**	**hrs.**	**hrs.**	**hrs.**	**hrs.**	**hrs.**	**hrs.**
90	73	66	3/4	-	3/4	-	1	-
115	63	73	1	-	-	-	-	-
140	58	81	1	-	1	-	1 1/2	-
190	56	106	1 1/2	2	1 1/2	2	2	4
240	53	127	2	3	2	3	3	4
290	51	144	3	3	3	3	4	4

[1] National Building Code of Canada (N.B.C. 1995 Table D-2.1.1.)
Hollow concrete units made with type N/S concrete
must have a net area comprehensive strength of 15 MPa 28 days.
[2] Underwriters Laboratories of Canada
Available in British Columbia from some manufacturers.

Example 1:

A four-hour firewall is required for 200mm nominal wall thickness.

A four-hour fire rating may be achieved by using a U.L.C. rated lightweight block, or by filling a 190 mm wide block with concrete grout (see BC*BC Section D-2*)

Example 2:

A two-hour firewall is needed.

Using the table, a 190mm unit is rated by the NBC to have a 1.5-hour fire rating, but with a U.L.C. certificate, that same block can be certified for two hours.

There are other options available to achieve the two-hour rating:

- Use a 115mm or larger block grouted solid
- Use a 240mm or larger block
- Use a lightweight 190mm or larger block

The transmission of sound through rigid partitions is accomplished principally by the forced vibration of the wall; that is, the entire rigid wall is forced into vibration by the impact of the sound waves against it. The vibrating thus becomes a secondary source of sound and radiates a certain amount of sound to the space on the opposite side. It is therefore to be expected that the noise insulation value of a wall will depend primarily upon the mass or inertia of the wall, the stiffness of the wall, and the internal damping of the wall. The ideal noise insulator is a "limp-heavy" wall. When one side is sealed with paint, plaster, or gypsum board, the concrete masonry wall fits this description precisely.

STC			100	125	150	200	250	300
		Nominal	100	125	150	200	250	300
		Actual	90	115	140	190	240	290
hollow	Standard Weight		46	47	48	50	52	54
solid filled	Standard Weight		-	50	52	56	58	60

Sound Transmission

Sound transmission The higher the transmission loss of a wall, the better it functions as a barrier to the passage of sound. Sound Transmission Class, STC, is a means of rating sound reduction by a single number.

To determine the effectiveness of wall construction as a means of sound isolation, a two room test method is employed. In ASTM E-90-75 a steady sound is generated and measured on one side of a wall, and the sound which passes through is measured in an adjacent room.

Reliability

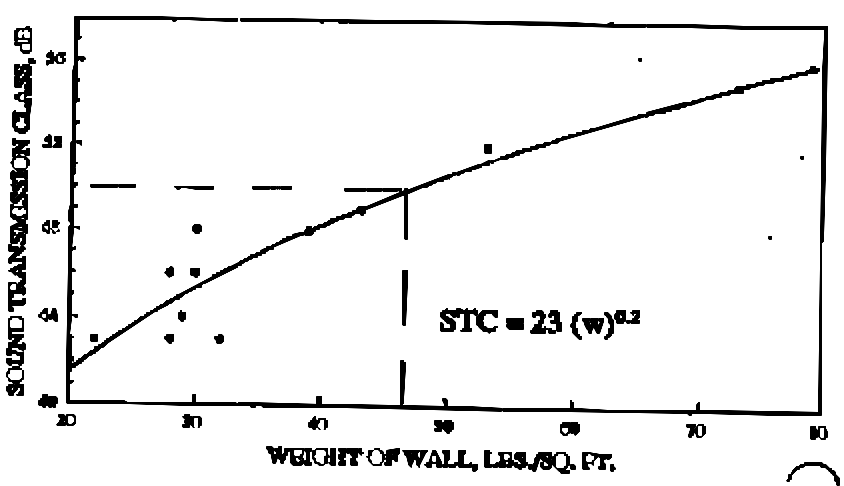
An important asset of concrete masonry in noise control is its reliability. Unlike the so-called "special" partition constructions, which are touted as sound barriers, concrete masonry walls require no special installation procedures to be effective. All too often the staggered stud isn't staggered; the decoupled membrane ends up rigidly connected; and the floating wall is sunk by poor workmanship in the field. The specially constructed stud wall that had an STC of 45 in the acoustical laboratory ends up with a lower STC in the field because of improper installation. This does not happen with concrete masonry walls. Designers know from experience that the concrete masonry wall is not as sensitive to workmanship and can be relied upon to act as an effective noise barrier.

Specification

Masonry units are not specified to a particular transmission class. Where the separation is required to provide a particular loss, the weight class or concrete density is selected by the consultant. The specifying authority should be familiar with the three concrete densities and specify accordingly.

Sound Absorption

Where design requires wall surfaces of high sound absorption consideration should be given to the use of a structural load bearing concrete masonry acoustical unit. Applications range from gymnasiums. music rooms to heavy duty industrial plants and transformer rooms. Confirm availability with local manufacturer.



Much of the earlier work of determining thermal performance of building elements was based upon "steady-state" coefficients such as conductance (C), resistance (R) and U-factors (U). However, buildings do not operate in a steady-state environment. To be more realistic, an evaluation of building thermal performance should include heat storage capacity of the envelope (thermal inertia) as well as resistance to heat flow.

On its own, masonry has low R values. Using core-fill insulation raises this value slightly but due to the requirement for reinforcement in our seismic zones, little benefit is gained. Insulation is best placed in a continuous layer inside, or outside the wall.

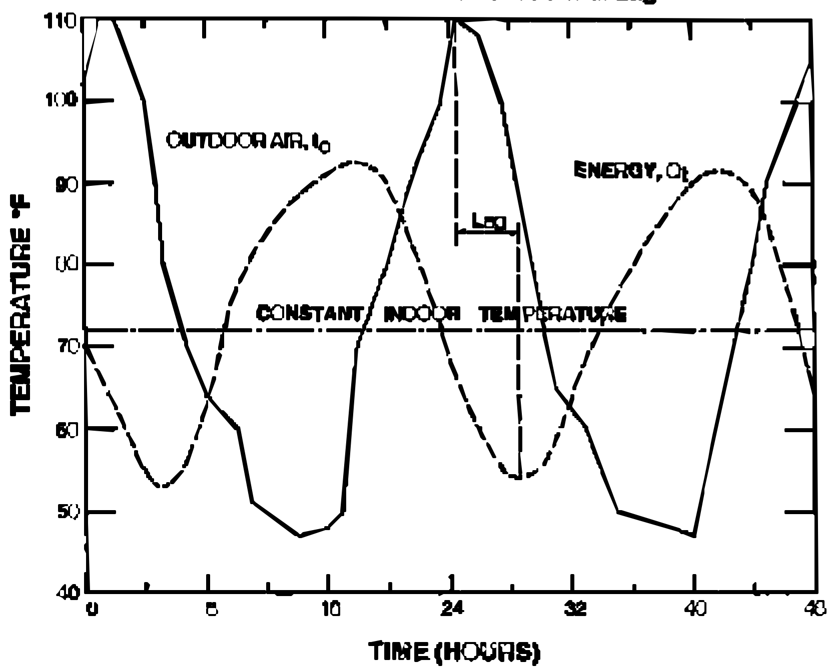
Thermal Properties (m^2 C° / W)

Block size:	100mm	150mm	200mm	250mm	300mm
RSI Factors CSA "A"	0.32	0.34	0.38	0.40	0.41

Walls constructed of 8" Hollow C.M.U.

	Details of Construction	**Density** 140 lbs/cu.ft
1	No Insulation	2.0
2	Cores filled with Vermiculite	3.6
3	Cores filled with Perlite	3.7
4	No Insulation, 1/2" gypsum board on furring	3.4
5	No insulation, 1/2" foil back gypsum board on furring	5.0
6	Same as 4 with 1" Extruded Polystyrene	7.0
7	Same as 4 with 2" Expanded Polystyrene	10.0
8	Same as 4 with 2" Extruded Polystyrene	12.0
9	Same as 4 with 2" Polyisocyanurate	16.4
10	Same as 4 with R-11 fibrous batt 2x3 studs set out from wall	13.0
11	Same as 4 with R-13 fibrous batt 2x3 studs set out from wall	15.0
12	Same as 4 with R-19 fibrous batt 2x4 studs set out from wall	21.0

FIGURE 1: Definition of Thermal Lag



Masonry wall exhibit overall thermal performance superior to that of walls with metal framing systems with insulation of the same RSI value because their mass gives masonry walls the following advantages:

- Effective RSI value of a masonry wall is higher than a metal framed wall because of the thermal bridging that occurs at highly conductive metal framing members. (See Appendix B and Appendix C of the Model National Energy Code for Buildings 1997)
- Masonry walls keep buildings warmer in winter and cooler in summer; they act as passive solar collectors, even if they are not designed to do so. “Daylighting” is one such process where the sun’s heat allowed in through windows is absorbed by the masonry and slowly released later.
- Masonry walls act as a heat sink, absorbing and storing heat, and releasing it when low temperatures prevail. This reduces energy flow peaks and makes possible the use of smaller, cheaper heating and air-conditioning equipment.

For example, a building with masonry exterior walls will take up to 8 hours to transfer a temperature differential of 20 deg. Celsius (36 deg. F) from outside to inside – eight times as long as a non-masonry building of the same size, design and insulation would take.

This means that on a hot summer day, the outside temperature cannot work its way through the masonry wall before the cooler evening temperature arrives. The process works in reverse in winter. The time lag buys valuable time for the building's heating and cooling systems.

With masonry exterior walls, buildings will stay cooler in summer and warmer in winter.

For more information on thermal mass effects, see the *Guide to Sustainable Design with Concrete,* available from the Cement Association of Canada website at www.cement.ca

CLEANING NEW MASONRY

Masonry is a material chosen for a variety of reasons, including its aesthetic appeal. The final appearance of masonry requires that effective cleaning procedures be employed to deliver an appearance consistent with design expectations. Three elements, working in concert, are required to fulfil these requirements:

- Care and protection during construction;
- Appropriate cleaning products and techniques; and
- Maintaining a "clean" appearance

1. Care and Protection During Construction

The extent of cleaning procedures can be significantly reduced with the employment of careful construction practices. These include:

- Clean and dry storage of masonry materials on site prior to construction;
- Working neatly during the laying phase, removing excess mortar before it sets;
- Covering the top of incomplete wall to prevent water intrusion during construction;
- Protecting wall bases from rain splash and turning inner scaffold planking on its edge to reduce rain induced splashes of mortar and job dirt onto the completed wall surface;
- Commencing cleaning as soon as is practical after mortar has cured;
- Protection from work of other trades (e.g. welding spatter, drilling run-off, grinding dust, concrete splash, membranes drips, etc.)

2. Appropriate Cleaning Products and Techniques

A sample test area which replicates, as closely as possible, actual field conditions (unit selection, mortar type, profiles, and ambient factors) should be cleaned to confirm both cleaning solution selection and concentration as well as to establish appropriate techniques. Method of application, dwell times, scrubbing and rinse procedures should be finalized. This test panel should be left for as long as possible (at least one week after application) before evaluating its effectiveness and accepting the test panel as the design expectation. Most masonry unit manufacturers recommend the use of proprietary cleaning compounds. These are specially formulated for specific masonry units and minimize secondary staining and other reactions triggered by uncontrolled acid reactions. Proprietary acidic cleaning solutions typically incorporate wetting agents, inhibitors and stain control agents to maximize cleaner effectiveness and minimize negative impacts on the masonry and mortar. Muriatic acid is a traditional cleaner that is still occasionally used, however it is not a proprietary or specialized masonry cleaning product.

The designer should rely on the recommendations of the masonry unit and cleaning product manufacturers that include the following considerations:

- Cleaning of a test area which represents, as closely as possible, actual field conditions including unit selection, mortar type, profiles, and ambient factors);
- Commencement of cleaning as soon as mortar has hardened sufficiently.
- Protection of adjacent surface which could be impacted by the cleaning process;
- Avoiding contact of metal tools and containers with acidic cleaning compounds;
- Removal of large mortar particles before cleaning;

- Thorough wetting of the surfaces to be cleaned to minimize absorption of the cleaning solution into the masonry and to prevent absorption of cleaning residue into surfaces underneath the areas being cleaned;
- Proper concentration of the cleaning solution;
- Appropriate dwell times for the cleaning solution;
- Scrubbing of the cleaning solution to "work" it into the materials to be removed;
- Thorough and complete rinsing of cleaning solution and solubilized materials;
- Avoidance of conditions that will minimize cleaner effectiveness (cold weather) or lead to premature drying of cleaning solution (hot and/or windy weather).

3. Maintaining a "Clean" Appearance

Once the masonry has been cleaned, care should be taken to minimize the need for recleaning. Appropriate design and maintenance include:

- Adequate wall cappings to prevent water intrusion (and subsequent efflorescence bloom);
- Caulking and flashings where required to effectively manage water movement;
- Water repellent treatment to minimize absorption of rain borne contaminants, algae growth, and efflorescence, applied as soon as practical after cleaning.

Protective treatments applied to the exposed surface of masonry are designed to provide a first line of defense against moisture intrusion. With the exception of single wythe masonry, sealing and coating treatments should not be expected to provide the sole line of protection but should be part of a redundant system incorporating drainage provisions as well as water resistant backups. Protective treatments may take the form of clear water repellents for brick and coloured concrete masonry units, or water repellent stains, paints and high build coatings (such as elastomerics) for plain concrete masonry units.

In selecting a suitable coating and sealing treatment, several questions need to be answered. They include:

- Are all flashings properly installed and functioning?
- How is water drained from the envelope assembly?
- Has allowance been made for movement and deflection?
- How are the interface between masonry and other materials detailed?
- What are the exposure requirements of the assembly?
- What aesthetic concerns must be considered?
- How is vapour diffusion handled across the wall assembly?
- Are substances other than water to be resisted by the masonry?

1. Coating Categories

There are a number of ways to categorize masonry wall coatings. One could use "breathability" as a category. Vapour impermeable coatings are usually intended only for application to the interior surface of masonry. Application of these types of coating to exterior surfaces can lead to moisture and efflorescence entrapment, potential spalling and delamination, as well as surface and coating degradation. By contrast, "breathable" coatings allow the diffusion of vaporous water through the surface treatment to the exterior environment.
Another form of coatings classification would be on the basis of opacity. Clear water repellents are intended to provide little or no change in masonry appearance. By contrast, pigmented coatings (stains and paints) are intended to significantly alter the colour and appearance of

the masonry surface. Aesthetic concerns will play a major role when opacity is used as material selection criteria.

Coatings may also be classified according to their ability to resist hydrostatic pressure. While clear water repellents may resist significant wind driven rain loads, high build coatings are usually required should masonry be exposed to prolonged hydrostatic pressure (such as below grade, fountains, etc.). For plain concrete masonry units exposed to above-grade wind driven rain (and where control of water ingress is paramount), the use of an elastomeric coating system is recommended.

Within each category of products, sub-classifications can be employed on the basis of such factors as chemical make-up, environmental impact, application conditions, longevity, and life-cycle cost to name a few. The designer must consider these different qualities when developing project specifications.

2. Clear Repellents

The use of masonry water repellents helps to prolong the satisfactory performance of masonry wall systems. The reduction in water absorption provided by water repellent treatments offer the following advantages:

- Maximize moisture resistance
- Reduction in efflorescence potential
- Reduction in algae and vegetative growth build up on masonry
- Maintenance of "natural" appearance of masonry during exposure to rain
- Reduction in absorption of rain borne contaminants
- Reduction in staining of masonry

3. Water Repellent Stains

Water repellent stains yield water repellency (like clear treatments) but also impart colour to the substrate. These materials are suited for use on concrete masonry units where a specific colour is desired, but the natural texture of the masonry is to be maintained. They are intended to provide the appearance of an integrally coloured block (including some tonal variations), but avoid the pore filling properties of paints and high build coatings. Water repellent stains furnish all of the properties of clear water repellents with the added feature of colour control.

4. Paints and Coatings

Paints and coatings are intended to alter the appearance of the masonry by the use of colour as well as texture (pore filling). They also provide a higher level of wind driven rain protection than clear water repellents. For single wythe plain concrete masonry units, where resistance to wind driven rain is a primary concern, it is recommended that a three coat elastomeric system be used. This involves the application of a coating of elastomeric primer (not just block filler) followed by two coats of an elastomeric finish with the intent of achieving a pinhole free coating on the masonry.

5. Surface Preparation

The successful performance of any coating depends greatly on the attention to surface preparation. Masonry should be carefully inspected prior to treatment. Cracks, voids and openings should be properly treated to prevent points for significant water ingress. Clear water repellents are not intended to bridge cracks.

Surfaces to be treated must be clean and free of dust, dirt, oil, grease, efflorescence, or any other substance that could prevent the penetration of the treatment or compromise its long term performance. Mechanical and/or chemical cleaning may be required to suitably prepare the surface for treatment (see section 1.6.1 in this manual). Should washing occur, sufficient drying time must be provided before coating application. Detailed instructions for surface preparation are provided by coating manufacturers and these should be followed carefully.

6. Performance Criteria

Although different categories of products utilize diverse testing procedures, the standard test method for water permeance of masonry is ASTM E-514 and products to be used on masonry should have been tested by the coating manufacturer to this standard. This procedure simulates a wind driven rain condition on a masonry assembly (joints and masonry units) and measures the relative resistance of the assembly to water leakage. While this procedure is particularly effective from a laboratory standpoint, the use of moisture absorption (R.I.L.E.M.) tubes provides portable field-testing of applied treatments. Testing undertaken by the Masonry Institute of B.C. has shown a close correlation of ASTM E-514 test results (in the laboratory) and moisture absorption tube values (in the field).

Coatings that remain on the surface of treated masonry (opaque coatings) that will be exposed to sunlight and weathering cycles should be tested in an accelerated weathering apparatus. Several ASTM procedures exist for this purpose (D-822 and G-26 in particular). While no direct correlation of hours of exposure to years of service life is possible, relative performance can be established.

For a detailed discussion of the CSA Masonry Standards see the full MIBC Technical Manual at www.masonrybc.org . The following standards are reviewed in this section:

CSA A165.1-04	Concrete Block	p.1
CSA A82-06	Clay Brick	p.3
CSA A179-04	Mortar	p.4
CSA A179-04	Grout	p.6
CSA A 370-04	Masonry Connectors	p.7
CSA A371-04	Masonry Construction	p.9

For information on CSA S304.1-04 Design of Masonry Structures see MIBC Tech. Man. *Section 1.2.1.*

This update is based upon the 2004 editions of the masonry standards referenced by the 2005 National Building Code, and the 2006 B.C. Building Code. The clay brick standard was issued in 2006 and must be referenced by project specifications,

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CONCRETE BLOCK - **CSA A165.1-04** (MIBC Tech. Man. Sec. 2.2)

Covers:		Not covered:	
	Compressive Strength Density (Weight) Drying & Curing Dimensions & Tolerances Major Defects		Minor chipping & cracks Texture or Profile Colour Fire, Sound or Thermal values

For a detailed Guide Specification see MIBC Technical Manual section 3.2

- **Typical spec - H / 15 / A / M**

  H = hollow

  15 = compressive strength

  15 MPa standard inventory strength (net area)

  20 to 30 available at a small cost premium

  A = standard (heavy) weight - sand and gravel, 18 kg (40 lbs) /unit

  Other options are: B & C: semi-light weight - partially pumice

  D: light weight - mostly pumice - fire block

  M = moisture controlled - cured, dried

Sample Spec: Concrete masonry units to CSA A165.1-04 requirements
Classification H/15/A/M

- **Quality control**

  Test data or Letter of Assurance from supplier if deemed necessary.
  Job site tests only if specified for critical high strength applications.

- **Fire ratings** (See Section 2.6.1 in MIBC Tech. Manual)

  Two Methods:

  1. Building Code

  - applies to block from any supplier
  - based on equivalent thickness and aggregate type from Table D-2.1.1
    in B.C. Building Code
  - typical 20 cm block – **1** ½ hrs.
  - can be increased by filling cores with grout or adding drywall etc.

  2. U.L.C.

  - available from certified suppliers based on tests and plant checks
  - higher values for same thickness
  - typical 20 cm ULC block - **2** hrs.; 20 cm pumice - 4 hrs.
  - small cost premium to cover ULC charge to manufacturer

- **Sound Ratings (STC)** (See Section 2.6.2 in MIBC Tech. Manual)

  - based on wall weight - check with suppliers or MIBC

- **Thermal values** (See Section 2.6.3 in MIBC Tech. Manual)

  - based on R value for block weights, and core fill or external insulation
  - heavy mass moderates temperature swings to provide superior performance for a given R value compared to lightweight systems.
  - Check with supplier or MIBC for values

CLAY BRICK - **CSA A82-06** (MIBC Tech. Man. Sec. 2.1)

Covers:	Compressive Strength Absorption, Durability Dimensions and Tolerances Colour and Texture Sampling Defect Tolerances	Not covered:	Fire, Sound or Thermal values

- **Typical spec**

Size, Colour, Texture, Manufacturer(s)

Type S – standard tolerances; tighter tolerances for project job lots.

Grade EG - "Exterior Grade" always required for our freeze/thaw climate.

Reclaimed brick can be damaged by freeze/thaw or may not meet current standards - confirm suitability before exterior use. New, Grade EG brick are available in textures similar to reclaimed units.

Structural clay units also are covered by CSA A82-06.

Sample Spec: Clay Face Brick [and Structural Brick] to meet CSA A82-06 requirements.
Grade EG, Type S

- **Quality control:**

Test data or Letter of Assurance from supplier if deemed necessary

- **Fire ratings:** (See Section 2.6.1 in MIBC Tech. Manual)

From B.C. Code based on equivalent thickness.

Typical face brick - 1 hr.

- **Sound and thermal ratings:** (See Section 2.6.2 & 3 in MIBC Tech. Manual)

Check with supplier or MIBC

Cavity insulation preferred over stud space insulation due to elimination of thermal bridging and protection of membranes.

MORTAR - **CSA A179-04** (MIBC Tech. Man. Sec. 2.3.1)

Covers:		Not covered:	
	Raw Materials Mortar Types - S & N Mixing Process Proportion or Property Specification		Mortar for stonework Colour Installation

- **Typical spec**

Two distinct methods for strength:

1. PROPORTION METHOD

- typical for Site-mixed mortar
- applies unless Property Method is specified
- "RECIPE" for volumes of sand and cementitious materials from CSA A 179 tables
- quality control by inspection of mix proportions at site - not by cube tests

2. PROPERTY METHOD

- typical for Pre-mixed dry or wet mortar
- must be specifically specified
- cube tests to meet strengths in CSA A179 Table 5 (MPa @ 28 days)

	Job / Plant Mixed (laying consistency)	Lab Prepared
Type S	**8.5**	**12.5**
Type N	**3.5**	**5**

- job and lab strengths are different due to different water contents.
- suppliers of pre-mixed mortar can provide current test results for quality control.

Sample Spec: Mortar to: CSA A179-04 requirements
Type S, mortar for structural masonry
Type S, mortar for veneer masonry
Proportion specification shall apply to field mixed mortar
Property specification shall apply to mortar manufactured off-site.

- **Mortar type & composition**

  - Mortar types are defined by their relative amounts of sand and cementitious materials.
  - Bond is a key property of mortar, and is associated with good workability, adhesion, cohesion and water retention - all of which improve with a higher proportion of lime or mortar cement in the mix.
  - Compressive strength is <u>not</u> the most important property for mortar, although reasonable strength is required for durability. A balance of strength and bond is, therefore, required for good mortar.

Type 'S'

Typically used for both structural and veneer block and brick. It provides moderately high strength with good bond.
Provides simple jobsite mixing where both structural and veneer masonry units are being installed.

Type 'N'

Once used for veneer brick and block, but now usually replaced by Type S.

Types 'O' and 'K'

Mortars with high lime contents used for historical restoration.
Cement/Lime mortars were historically recommended because their raw materials and resulting properties were well established. The Masonry Cements and Mortar Cements now commonly used are proprietary products, which replace separate cement and lime bags for site mixing. Current versions are now the most commonly used materials to meet Type S mortar strengths, without the addition of Type GU (10) cement. See manufacturers' data for further information.

GROUT ***(Block Fill)*** - **CSA A179-04** (MIBC Tech. Man. Sec. 2.3.2)

Covers:	Raw Materials Grout Type – coarse or fine Property or Proportion Spec Slump	Not covered: Installation (see A371-04)

- **Typical spec**

Most masonry grout (block fill) is “Coarse Grout”, with a maximum aggregate size of 12 mm. “Fine Grout” would only be used in small core units such as reinforced brick. Grout is usually supplied and pumped from ready-mix trucks, with quality control data available from the supplier. Field test cylinders may also be taken.

Grout strength specification is an area of some confusion. Because grout must flow for substantial distances through small core openings, it must be placed at a very high slump of 200 to 250 mm. This extra water is then absorbed into the units to provide a concrete mix with a lower water content - and higher final strength. Grout tested using standard non-absorptive plastic or metal cylinders will still contain the extra water, and will therefore show lower apparent strength results.

The latest CSA A179 recognizes this situation by referencing a 12.5 MPa grout strength when cylinders are used. The actual strength in the wall will be much higher, and will exceed the 15 MPa strength of typical concrete blocks. This grout strength is compatible with the f'_m design strengths contained in S304.1 for Masonry design. Many existing structural notes and specs call for 20 or 25 MPa grout - and do not recognize the non-absorptive cylinders situation. A 25 MPa high slump grout designed for cylinder testing may actually be 40 MPa in the wall. However, a 20 MPa grout may be preferred for pumping reasons in any case. If Structural Notes do not recognize the 12.5 MPa strength minimum, then a project cylinder test result below a 20 or 25 MPa specified strength should not treated as a cause for concern.

Sample Spec: Grout to CSA A179-04 requirements
Minimum compressive strength 12.5 MPa at 28 days by cylinder test under the property specification
Maximum aggregate size 12 mm diameter
Grout slump 200 to 250 mm

MASONRY CONNECTORS - CSA A370-04

(MIBC Tech. Man. Sec. 2.5)

Covers: Brick Ties
Anchors
Fasteners
Repair Connectors
Corrosion Protection

- **Corrosion Protection**

The 1994 edition introduced a requirement for stainless steel ties for walls over 11 m for high wind-driven rain areas such as coastal B.C. The 2004 edition has increased the threshold to 13 m, to recognize typical 4-storey low-rise buildings in B.C. Hot-dipped galvanized ties are the minimum requirement for lower walls, and for all walls in drier climates such as the B.C. interior. Climatic locations are defined in terms of an Annual Driving Rain Index (aDRI) in the standard.

CSA A370-04 REQUIREMENTS		
	Coastal B.C.	Interior B.C.
≤ 13m	Hot Dipped Galvanized	Hot Dipped Galvanized
> 13m	Stainless Steel	Hot Dipped Galvanized

BRICK TIES

- Wide range of two-piece adjustable types are available
- Must meet strict strength, free-play and deflection requirements
- Type and spacing determined by designer calculations based on manufacturer's tie test data, not from the standard. The tie designer may be specified to be retained by the contractor. Structural tie design is based on the B.C. Building Code requirements for wind and seismic affects on building elements and components.
- **Maximum spacing 600 mm vertically by 820 mm horizontally**
- Tie spacing may be greater for stiff back-up systems such as concrete block, compared to flexible systems such as wood or metal studs.
- **Ties now may be staggered, must be a top tie at every stud line.**
- Typically two piece ties for adjustability and ease of installation.
- Fasteners (Screws) - as per specifications for type of tie used.

"PRESCRIPTIVE" TIES

Old style strip and Z ties are no longer commonly used for commercial work due to their limited strength, cavity width and adjustability. Under Clause 10.2.2, their maximum prescriptive spacings in CSA A370 do not apply in higher seismic zones (seismic hazard index = 0.35, or high wind areas (q = 0.55 kN/m^2), and would have to be reduced by design analysis.

Sample Spec: Masonry connectors to CSA A370-04 requirements
Veneer ties shall be [hot dipped galvanized]
[stainless steel]
Veneer tie spacing shall be [ ] by [ ]
Acceptable veneer ties(s) [ ] manufactured by [ ]
Acceptable fastener(s) [ ] manufactured by [ ]

OR

Veneer tie type and spacing shall be provided from an engineer retained by the masonry contractor.

CONSTRUCTION - CSA A371-04

Covers:		Not covered:	
	Construction installation practices & tolerances		Masonry Design
	Reinforcement & Grouting		Tie Design
	Movement Joints & Flashing		Mortar & Grout
	Cold and Hot Weather		Masonry units
	Ties & Building Envelope		

- **Quality control**

By contractor supervision, and inspection by designer

- **Key items**

- CSA A371 applies to larger buildings – may differ from the NBC Part 9 for housing.

- MORTAR JOINTS

  - ± 3 mm tolerance, starting course bed joint max. 20mm

- ALIGNMENT TOLERANCES

  - now defined as tolerance "envelope". If back-up is out of position to meet tolerances, mason should notify general and designer.

- JOINT REINFORCEMENT – Structural Masonry

  - maximum spacing 600 mm in running bond and 400 mm in stack bond. Typically specified at 400 mm for running bond in higher seismic zones.

- BRICK TIES

  - place wire component in centre of veneer wythe(± 13) mm at specified spacing.

- THIN VENEERS (SLICES)

  - now limited to 3 m height with regular masonry mortar.

- MOVEMENT JOINTS
  - locations as per drawings - if not shown mason should ask designer (see MIBC Tech. Man. Sec. 2.4.2)
  - joints in brick should be clear of mortar, particularly for joints below shelf angles.
  - less difference between concrete and clay movements than previously thought.
- SUPPORT OF MASONRY BY WOOD
  - now allowed if specifically designed – design for durability.
- GLASS BLOCK
  - non-loadbearing, mortar type and joints, reinforcement and anchoring (also see manufacturers' literature)
- VENEER WALLS
  - airspace to be "reasonably clear of mortar fins and droppings."
  - beveling back of mortar bed helpful
  - airspace minimum 25 mm - accommodate building tolerances - up to ± 13 mm
  - notify designer if tolerances can't be met due to field conditions.
- FLASHINGS
  - type and location as specified and shown
  - peel and stick types provide good lap seals and corner details
  - turn-up at ends to form end dams
  - notify designer if drawings do not show flashing where "good practice" would suggest
  - metal cap flashing at tops of walls should slope back to roof to prevent dirt run-down on wall face, and extend 75 mm down over masonry units
- COLD AND HOT WEATHER
  - treatment of mortar materials and wall protection covered for various temperature ranges (seldom a concern for B.C. coastal areas).

- GROUTING
  - complete filling of reinforced cores and bond beams is essential for high lift grouting
  - requires clean cores, high slump grout
  - cleanouts (inspection holes) called for if total pour height over 1.5 m (5 ft.) May be waived by engineer under Clause 8.2.3.2.2 for non-critical walls or based on demonstrated good workmanship.

Masonry LEED Credits:

EA1 - Optimize Energy
- Thermal Mass in masonry walls moderates temperatures to reduce energy consumption and HVAC system size.

MR1 – Building Reuse
- Historic masonry building durability allows for reuse and renewal.

MR2 – Construction Waste Management
- Modularity minimizes waste.
- Demolition & construction waste can be crushed & recycled.

MR3 – Resource Reuse (salvage)
- Existing brick can be reused.

MR4 – Recycled Content
- Cement replacement with fly ash and slag in concrete products
- Recycled materials can replace aggregates in brick & block

MR5 - Local/Regional Materials
- Brick and block are usually available within 800 km

MR8 - Durable Building
- Masonry is a proven material for durability

Masonry benefits not in LEED

Structure/Finish Combination: Masonry can provide both the building structure, and the interior or exterior finishes. This reduces the need for the production, installation & maintenance of additional finish materials.

Indoor Air Quality:
- No off-gassing, toxicity or VOC's.
- Masonry does not support mould growth and is easily cleaned.

LEED® is a registered trademark of the U.S. Green Building Council

Recently the construction industry has seen an increased emphasis on sustainable design and "building green" by governments, design professionals and building owners. B.C. is leading the rest of Canada in accepting environmental building practices, and in the adoption of the LEED® rating system. This section reviews the positive environmental impacts of concrete block and clay brick masonry, and details how credits can be achieved under LEED.

SHADES OF GREEN

A measurement system is required if buildings are to be evaluated for their predicted environmental performance. The two systems that have received the most acceptance are LEED® (Leadership in Energy and Environmental Design), and Green Globes®. LEED will be recognized by most designers, as it has become the best known environmental assessment system in North America. It was developed in the U.S. by the US Green Building Council, and has been adapted for Canada under the Canada Green Building Council (www.cagbc.org). LEED Canada-NC 1.0 was issued in late 2004 and updated this past spring. Green Globes is a web based assessment tool that is administered by the Green Building Initiative (www.thegbi.org). These systems provide a long list of credits and points that may be achieved by meeting defined criteria. They provide rating levels based on the number of points awarded (i.e. LEED Gold). Other green building checklists have been developed for specific building types and geographic regions.

All of these systems are quite basic, with fixed credit weightings, and no climatic options such as those we are familiar with in our established building codes. They also fail to cover some of the sustainable design benefits provided by certain materials. The next stage in building evaluation will be the refinement of Life Cycle Assessment (LCA) tools such as the “Athena® Environmental Impact Estimator for Buildings”(www.athenasmi.ca). LCA attempts to provide a more detailed assessment of the environmental impact of various building materials over their full life cycle.

The key sustainable design topics that are addressed by masonry materials are discussed below.

DURABLE MATERIALS

The use of durable building materials is one of the most obvious characteristics of a building constructed in a sustainable manner. While durability is generally recognized as an important green building issue, it has proven to be difficult to incorporate into evaluation systems. While we all may feel we know it when we see it, durability is difficult to quantify, particularly for newer materials. One problem with the current U.S. LEED system is that it does not consider this key issue in its points system. This situation has been partially resolved in LEED Canada by the addition of a durable building credit. It only accounts for one point of the 70 available, but is a good step in the right direction.

The proven durability of masonry for structural, building envelope and interior finish applications will conserve resources over the building life cycle and reduce waste. The building itself can stay in service longer, with lower repair and maintenance requirements. Brick, block and stone products can last for the life of a building and can help a project qualify under this credit. However, masonry durability is best identified through the use of a life cycle assessment of maintenance, repair and replacement requirements.

The LEED Durable Building Credit MR8 references the Canadian Standard Association (CSA) standard *S478-95 - Guideline on Durability in Buildings*, and requires that the expected service life of components equal or exceed the design service life of the building. There was some initial concern about administrative requirements and liability issues for this credit, so the CaGBC has simplified and clarified the process, while maintaining the rigor of the credit.

PREDICTED SERVICE LIFE LIFE (Materials)	>	DESIGN SERVICE LIFE (Building)

LOCAL MANUFACTURE

The transportation of building products that are produced at a great distance from a construction project generates substantial environmental impacts. These impacts can obviously be reduced if materials from the local region are specified. In LEED credit MR5, the distance limit from the construction site for both the raw material and the production plant is defined by a 800 km radius by truck, and a 2400 km radius for rail or water transport.

Because there are dozens of concrete block plants located across Canada, there is a high likelihood that concrete block can be sourced within the LEED radius and in many cases much closer to a project. Modern, highly efficient brick plants produce a high volume of product. As a result there are less than a dozen large operations located across the country. However, because these plants are located close to the major construction markets, in most cases construction projects will fall within the LEED radius.

In B.C., all major centres are serviced by regional block and brick plants. In addition, mortar and blockfill grout materials are also locally available.

RECYCLED CONTENT

The use of recycled materials in the production of building materials is beneficial because it reduces the impacts from both the sourcing of new raw materials and the disposal of waste materials. For clay brick, recycled materials can replace some of the new clay or shale required for brick production. For concrete block, recycled materials can replace a portion of both the cement and the aggregate in the block mix design.

While clay and shale are abundantly available for brick production, it is worthwhile to minimize the amount of virgin material that must be processed and transported. In many cases, brick operations already grind and reuse any reject fired units as part of their raw material input. While environmentally sound, the recycling of this “grog” does not presently qualify as recycled content under LEED credit MR4 because it stays on the property and is considered as internal process waste. The use of other recycled materials from consumer or industrial products waste streams is under active investigation by the brick industry in Canada.

Supplementary Cementing Materials (SCMs), such as fly ash and ground granulated blast furnace slag (GGBFS), are being used increasingly as a replacement for part of the cement content in all concrete products. This now includes replacing some of the cement that makes up about 10% of a typical concrete block mix design. Fly ash is used in the west, while GGBFS from steel making is more common in eastern Canada. Fly ash is generated from cleaning the stack emissions of coal-burning electrical generating plants. Both of these materials have cementitious properties that make them suitable as replacements for 20 – 25% of the cement in concrete block.

The positive effects of SCM substitutions are given a very high weighting in LEED Canada because of their double benefit of reducing cement requirements while utilizing a waste material. The LEED Canada credit applies a multiplier of 2 to the reduction in cement content between the mix with SCMs and a base mix without SCMs. This cement reduction factor is not applied to the cement only, but rather, to the entire concrete product. The combination of these two factors can result in a **20-fold** increase in the impact for SCMs in concrete block, compared to what it would be if applied solely to the percentage of recycled content. SCMs are considered as pre-consumer recycled content.

Recycled materials can also replace some of the sand and gravel aggregate in concrete block production. Aggregate replacements could include post-consumer products such as recycled glass or recycled building demolition waste. They could also include pre-consumer recycled materials that have not passed through the consumer waste stream, but are waste products from manufacturing processes. While a multitude of potential recycled materials are being investigated, they must be carefully evaluated to determine if they are suitable for the manufacture, construction and long term serviceability of concrete block.

MIBC block producer members can supply product information that outlines their recycled content.

ENERGY REDUCTION WITH THERMAL MASS

Mass on both the exterior and interior of buildings can improve thermal performance. High mass materials such as concrete block and clay brick can produce energy savings over the life of a building, and their inclusion in project designs can help to achieve LEED credits. When compared with light weight buildings, with all other building conditions kept constant, thermally massive buildings can show energy savings benefits for two reasons:

1) There are reduced peaks and valleys in heating and cooling requirements, since mass absorbs, stores and releases heat to slow the building response time. These moderated demands can reduce overall heating and cooling energy, as well as reducing the size and cost of HVAC equipment.

2) Thermal mass can delay heating and cooling loads, and shift them to more efficient times in a 24-hour cycle.

Unlike insulation values, the effects of thermal mass are not simple to determine. However they can be identified by using computer simulations of building behavior. These programs are now often used in the evaluation of sustainable building projects. To illustrate how these principles may pertain to energy credit requirements; two computer simulation model analyses have been performed using masonry and concrete options on three versions of a typical 4-storey office building. The three versions varied in their respective weights, based on increasing amounts of masonry and concrete for structural and cladding materials. The high thermal mass case included brick veneer over a block back-up wall, along with concrete columns, floors and roof.

The results of these energy analyses showed that the use of high thermal mass can provide energy savings for each of five sample locations across Canada – including Vancouver. These forecasted energy savings can also be used to achieve higher energy credits under LEED. Contact the MIBC office for further information on these studies.

OTHER BENEFITS

- Building Reuse:
  The durability of historic brick and stone masonry allow older structures to be restored and renewed, rather than demolished. LEED Credit MR1.

- Resource Reuse:
  Brick and stone units can be reused as salvaged materials on new projects. Brick and block can be crushed and reused as structural fill and landscape material. LEED Credit MR3.

- Construction Waste Management:
  The modularity of masonry units minimizes site waste compared to other materials. Demolition and construction waste can be crushed and recycled. LEED Credit MR2.

- Structure/Finish Combination:
  Masonry structural and partition walls can be left exposed – eliminating the need for the installation and maintenance of additional finishes.

- Fire Resistance:
  The fire separation provided by concrete block fire walls saves lives and properties from destruction – and reduces material use and landfill waste due to replacement of fire damaged structures.

- Low Volatile Organic Compounds (VOC's):
  Most masonry products are "self-finishing", and require no coatings or finishes in interior applications. This eliminates the question of low VOC coverings. The masonry industry proposes that in the future, these products should therefore also qualify for low VOC credits.

CONCLUSION

The builders of the Great Wall in China, the Taj Mahal, and the domes of Florence and St. Peters may not have had LEED certification to consider, but their specification of durable masonry materials made their structures lasting examples of sustainable design. Today's masonry industry is actively exploring new raw materials, manufacturing improvements and wall system refinements to maximize the positive impact of masonry on modern construction – and welcomes questions and suggestions from designers, specifiers and owners in this effort.

For more information see "Guide to Sustainable Design with Concrete" at www.cement.ca.

TMC - Technical Masonry Certification

Today's efficient masonry walls are more weather-resistant, taller and slimmer than ever before. These high-tech assemblies combine decades of building science research with some of the most advanced materials available on the market today.

Bricklayers have always been an integral part of masonry construction. Craftsmen and their trowels have built structures that defy gravity and have withstood the test of time. If the skill of the mason was important in the past years, it has become even more so today. The masonry contractor needs to understand current practices and must be able to schedule the construction process around complex assembly requirements. The TMC certification program answers that need, and is a mandatory requirement for contractor membership in the MIBC.

A list of current TMC qualified MIBC commercial masonry contractor members is available on our website at: www.masonrybc.org

Since 2002, the Masonry Institute of B.C. has offered an advanced course for masonry contractors. The course includes class time and an exam that must be successfully completed before the TMC designation is earned. Topics covered include engineering basics, building envelope science and masonry code requirements. The TMC program is being updated for the 2004 CSA standards that have come into effect with the 2006 B.C. Building Code. All of the MIBC member contactor members will renew their TMC in 2007.

Have your masonry work done by certified masonry contractors by including the following in your specifications:

> ***"The masonry contractor shall be a member in good standing of the Masonry Institute of BC, and be qualified under the Technical Masonry Certification (TMC) program."***

TMC COURSE CONTENT:

MATERIALS

- Production, Standards, Properties
  - Block - A165.1
  - Brick - A82.
  - Mortar - A179

CONSTRUCTION - A371

WALL TYPES & PROPERTIES

- Single-wythe, Veneer
- Thermal, Sound, Fire

STRUCTURAL DESIGN

- Principles
- Masonry - S304.1
- Strength
- Grout, Reinforcement
- Details

BUILDING SCIENCE

- Air/Vapour movement
- Thermal
- Moisture

MASONRY RAINSCREEN VENEERS

- Rainscreen Description
- Codes, Standards and Specifications
- Cladding
- Cavity, Flashings, Ties
- Shelf Angles, Movement Joints

CLEANING & SEALING

QUALITY ASSURANCE

BUILDING GREEN WITH MASONRY

This checklist is designed to help ensure masonry projects are built to the high standards expected of masonry by providing assistance in the field review process.

This list is for use by those involved in the inspection of masonry as well as to provide the mason with a checklist of items to review for his own quality assurance program. This list aims to help ensure conformance to the masonry standards, to the specifications and to good workmanship standards.

Not all items will be applicable to a given project. The “Details” column can be used to record specific project requirements for an item. The “Comments” column may require expansion for multiple inspections.

Masonry Inspection Checklist

MATERIALS – ITEM	DETAILS	COMMENTS
1. CLAY MASONRY UNITS: a. Type, Size, Shapes, Tolerances		
b. Specified Colour & Texture		
c. Site Storage		
2. CMU'S: a. Strength, Sizes, Profiles, Shapes, Tolerances		
b. Fire Rating		
c. Specified Colour & Texture		
d. Site Storage		
3. PRECAST & STONE - Specified Type		
4. MORTAR & GROUT-Site Mixed:		
a. Specified Type, Colour		
b. Sand & Gravel to CSA A179 ??		
c. Water Potable, Site Storage		
5. MORTAR – Premixed: a. Specified Mortar Type		
~~b. Batch Time for Wet Mix, Lot Number for Dry Mix ??~~		
c. Site Storage		
6. GROUT-Premixed: a. Strength & Slump for Ready-mix		
~~b. Specified Type & Lot Number for Dry Mix ??~~		
7. CONNECTORS – Specified Types, Corrosion Resistance		
8. REINFORCING: a. Rebar Grade & Size		
b. Joint Reinforcing Type, Width, Corrosion Resistance		
9. FLASHING & / WEEP HOLE DEVICES: a. Specified Type		
b. Fastening, Priming & Sealing Material		
10. STEEL LINTELS - Specified Size, Corrosion Resistance		
11. Movement~~EXP., CONTR. &~~ FIRE JOINT MATERIALS Spec.		
12. WATER REPELLANT (If in masonry work) Spec. Type		
13. AIR BARRIER (If in masonry work) Specified Type		
14. CORE & CAVITY INSULATION (If in masonry work)		
Specified Type, Specified Size, Specified Attachment		
15. CLEANER - Specified Type		

WORKMANSHIP - ITEM	DETAILS	COMMENTS
1. FLASHING: a. Location & Dimension		
b. Laps Sealed, Secured to Back-up, End Dams		
2. MORTAR MIXING: a. Spec. Material/Proportion		
b. Mixing Time		
3. MORTAR APPLICATION: a. Joints Correctly Filled		
b. Cavities & Grouted Cells Reasonably Clear		
c. Spec. Joint Profile, Joints Properly Tooled, Re-tempering		
4. LAYING UNITS: a. Alignments & Joint Tolerances		
b. Minor Unit Defects Within Material Standard Limits		
c. Corbelling Within Limits		
d. Features as per Design: Arches, Sills, Soldiers, Prefab, etc.		
e. Fire Rated Units Where Specified		
5. VENEER TIES: a. Embedment in Mortar Within ~~Limits~~ ± 13		
b. Specified Spacing & Location		
c. Specified Fastening		
6. ANCHORS - Specified Location & Installation		
7. STEEL LINTELS & SHELF ANGLES: a. Spec. Location/Size		
b. Overhang ≤ 1/3 Width, Expansion Gap Under Shelf Angle		
8. WEEPHOLES & VENTS		
- Specified Type, Locations, Spacing and unobstructed		
9. AIR BARRIERS (If in masonry work)		
- Specified Application, Sealing at Ties and Penetrations		
10. INSULATION (If in masonry work)		
a. Specified Location, Core Insulation to Top		
b. Cavity Insulation Fastened, Oriented & Joined as Specified		
11. REINFORCING: a. Sizes, Spacing & Locations		
b. Position in Cell, Bar Laps		
c. Stirrup & Tie Bars		
d. Joint Reinforcing Size, Spacing & Laps		
12. GROUTING: a. Cells Clear		
b. Cleanouts (if required) - Spacing & Size, Cleaned, Closed		
c. Parapets Solid Grouted		
d. Pour & Lift Height		

13. WEATHER PROTECTION: a. Top of Wall Covered		
b. Cold Weather/Hot Weather Requirements		
14. MOVEMENT JOINTS		
a. Locations of Movement Joints / Type		
b. Vertical & Shelf Angle Expansion Joints Clear of Mortar		
c. Caulking Colour (by others)		
15. FIRESTOPPING - Location, Installation (if in masonry work)		
16. DRY CLEANING OF BLOCK		
- Mortar Smears & Droppings Removed		
17. WET CLEANING (If required or specified)		
a. Wall Adequately Cured		
b. Test Area Check		
c. Surroundings Protected		
d. Cleaning to Manufacturer's Requirements		
e. Adequate Pre-Soak, Rinse		
18. WATER REPELLENT (if in masonry work)		
a. Wall Adequately Clean & Dry		
b. Caulking & Flashing Complete, Surroundings Protected		
c. Application to Manufacturer's Requirements		

Project:____

Date of Substantial Completion:______________________________

Architect:______________________________ **Contact:**____________

Building Envelope: ________________________ **Contact:**____________

General Contractor:________________________ **Contact:**____________

Masonry Contractor:________________________ **Contact:**____________

Phone:____________

Masonry has been used for the most beautiful and enduring structures man has known; their fine quality and durability fulfil the owner's needs perfectly.

Any structure requires regular maintenance after construction and during its performance life. Masonry is susceptible to many of the same pollutants as other building materials, but cleaning and damp proofing must be performed with care and attention to manufacturers recommendations by knowledgeable tradesmen.

Maintenance of buildings may be broken into two general categories: 1) general inspection and maintenance to prolong the life and usefulness of a building; and 2) specific maintenance to identify and correct problems which may develop. This Maintenance Manual addresses both general and specific maintenance procedures. A checklist is provided for general inspections and specific repair techniques are described.

MASONRY UNITS:

Clay Brick:
Manufacturer:____________________
Type & Colour:____________________
Specifications:____________________
Supplied by:____________________

Glass Block:
Manufacturer:____________________
Pattern:____________________
Size:____________________
Specifications:____________________
Supplied by:____________________

Concrete Block:
Manufacturer:____________________________
Type & Colour:____________________________
Specifications:____________________________
Supplied by:____________________________
U.L.C. Fire Rating Certificate No.________________

Stone Work:
Type & Colour:____________________________
Style:____________________________
Specifications:____________________________
Supplied by:____________________________

Mortar: (List Manufacturers)
Type: S_____ N_____
Cement/Lime____________________________
Masonry Cement____________________________
Mortar Cement____________________________
Premixed Mortar____________________________
Pigment____________________________
Colour____________________________
% Wt. of Cement & Lime________________

Caulking:
Type & Colour:____________________________
Specifications:____________________________
Supplied by:____________________________

	Cleaning Material (Product, Manufacturer)	Water Repellent Coating (Product, Manufacturer)
Brick		
Natural Grey Concrete Block		
Coloured Concrete Block		
Glass Block		
Stone		

Note: Spec Data Sheets for recommended cleaning materials and water repellent coatings are to be attached.

GENERAL INSPECTION

A good, thorough inspection and maintenance program is often inexpensive to initiate and will prove advantageous in extending the life of a building. It is a good idea to become familiar with the materials used on a building and how they perform over a given time period.

It is suggested that periodic inspections be performed to determine the condition of the various materials used on a building. These inspections can be set for any given time period, i.e. monthly, yearly, etc. A suggested inspection period is "seasonal" so that the behaviour of building materials in various weather conditions can be noted. Inspection records, including conditions and comments, should be kept on the enclosed form to determine future "trouble spots". Check the Inspection & Maintenance Record for the recommended inspection schedule.

SPECIFIC MAINTENANCE

General

Problems resulting from moisture penetration may include: efflorescence, spalling, deteriorating mortar joints, interior moisture damage, etc. If one or more of these conditions becomes evident, the direct source of moisture penetration should be determined and action taken to correct both the visible effect and the moisture penetration source. Table 1 lists various problems appearing on masonry due to moisture and the most probable source of moisture penetration. The items checked in the table represent each source that should be considered when such problems occur.

After investigating all of the possible moisture penetration sources, the actual source may be determined through the process of elimination. Many times the source will be self evident as in the cases of deteriorated and missing materials; however, in instances such as improper flashing, differential movement, etc. the source may be hidden and determined only through some type of building diagnostics carried out by a building envelope consultant specializing in this field. In any case, it is suggested to first visually inspect for the self-evident source before retaining a consultant.

Once the source is determined, measures can then be taken to effectively remedy the moisture penetration source and its effects on the masonry.

Remedial Cleaning

Moisture penetration is a contributing factor to the formation of efflorescence. Generally, efflorescence is easily removed by natural weathering or by scrubbing with a brush and water. In some cases a weak muriatic acid solution may be used to remove stubborn efflorescence. Improper acid cleaning, i.e., absence of pre-wetting, insufficient rinsing and strong acid concentrations, may cause irreparable damage. Cement is affected by hydrochloric acid (muriatic acid); therefore, if any hydrochloric acid remains on the masonry, the mortar joints may become etched and/or deteriorated. Two types of efflorescence are not water-soluble; one type is a white efflorescence, composed of calcium carbonate. The other is a white or greyish haze, referred to as "white scum", composed of silicic acid or other silica compounds. Each of these two types of efflorescence requires unique removal solutions and the manufacturer of the masonry units and of the recommended cleaning material should be contacted before any cleaning is attempted.

After cleaning in accordance with manufacturer's recommendations, the mortar joints should be inspected. Tuck-pointing of the joints may be necessary. It should be noted that these and all cleaning procedures should first be tried in an inconspicuous area at different concentrations and judged on effectiveness.

REPAIR METHODS

Sealant Replacement

Missing or deteriorated caulking and sealants in contact areas between masonry and other materials, i.e., window and doorframes, expansion joints, etc. may be a source of moisture penetration. The sealant joints in these areas should be inspected. If the sealant is missing, a full bead of high-quality, permanently elastic sealant compound should be placed in the open joints. If a sealant material was installed, but has torn, deteriorated or lost elasticity, it should be carefully cut out. The opening must be clean of all old sealant material. A new sealant should then be placed in a clean joint. All joints should be properly primed before the new sealant material is applied. A backer rope material should be placed in all joints deeper than 3/4 in. (19 mm) or wider than 3/8 in. (10 mm).

Water Repellent Coating

Water-repellent treatments have to be renewed from time to time because of a gradual deterioration in their efficiency. The first effect is noticed when the surface no longer sheds the water that falls on it. This does not of itself indicate that the treatment has ceased to be effective; the pore surfaces behind the exposed face still retain an adequate degree of water-repellence for some considerable time.

Since the durability depends on the character of the surface and on the conditions of exposure, the frequency of renewal must be determined by experience with the selected water-repellents in the particular circumstances. Renewal is called for when signs of dampness begin to make an appearance, after first checking for other defects. However, it will usually be advisable to renew a treatment that has served its purpose for a reasonably long time, say 5 - 10 years, without waiting for dampness to appear again.

Tuck-pointing Mortar Joints

Moisture may penetrate mortar that has softened, deteriorated or developed visible cracks. When this is the case, tuck-pointing may be necessary to reduce moisture penetration. Tuck-pointing is a process of cutting out old mortar to a uniform depth and placing new mortar in the joint.

Prior to undertaking a tuck-pointing project, the following should be considered: 1) Whether or not to use power tools for cutting out old mortar. The use of power tools may damage the adjacent masonry units. 2) Any tuck-pointing operation should only be done by a qualified and experienced journeyman.

The old mortar should be cut out, by means of a toothing chisel or a special pointer's grinder, to a uniform depth of 3/4 in. (19 mm), or until sound mortar is reached. Care must be taken not to damage the edges of the masonry units. All dust and debris must be removed from the joint by brushing, blowing with air or rinsing with water.

Tuck-pointing mortar should be carefully selected and properly proportioned. For best results, the original mortar proportions should be duplicated.

SUMMARY

This Maintenance Manual has presented procedures to extend the useful life of the building and to retain the original beauty and performance of the structure. It is suggested that regular routine inspections of the building be carried out to determine where future maintenance may be required. All buildings are unique and will experience individual maintenance needs and schedules.

The information contained in this Maintenance Manual is based on the available data, recommendations from the manufacturers and experience of the Technical Committee of the Masonry Institute of B.C. Final decision on the use of this information must rest with the project designer, owner or both.

TABLE 1
Possible Effects and Sources of Moisture Penetration

	Sources of Moisture Penetration									
Effects of Moisture Penetration	Previous Acid Cleaning	Previous Sand Blasting	Plant Growth	Deteriorated Sealants / Caulks	Missing / Clogged Weepholes	Incompletely filled Mortar Joints	Capillary Rise	Broken / Loose Units	Differential Movement	Missing Flashing
Efflorescence	♦		♦	♦	♦	♦	♦	♦		♦
Deteriorated Mortar	♦	♦	♦	♦	♦	♦	♦	♦		♦
Spalled Units		♦		♦	♦	♦	♦			♦
Cracked Units				♦	♦	♦	♦		♦	♦
Rising Moistrure					♦		♦			♦
Corrosion of Backup Materials	♦			♦	♦	♦	♦	♦	♦	♦
Mildew / Algae Growth	♦			♦	♦	♦	♦	♦	♦	♦
Damaged Interior Finishes	♦		♦	♦	♦	♦	♦	♦	♦	♦

References

Brick Institute of America
TEK Notes 7 and 7F
National Concrete Masonry Association
TEK Notes 29, 44, 92 and 100
Masonry Institute of America
Marble & Stone Slab Veneer, 2nd Edition
Pittsburgh Corning
Glass Block Products & Design Brochure

MASONRY INSPECTION & MAINTENANCE RECORD

Building________________________________**Date**____________**Last inspection**______________

Location_____________________________________**Inspected by**____________________________

Recommended Inspection Schedule:
First 2 years - inspect every 6 months
Thereafter - inspect every 2 years

	OK	Problem Minor	Major	Location/Observation	Date of Repair
1. General Condition					
- General appearance					
- Efflorescence					
- Physical damage					
- Settlement cracks					
- Expansion/Contraction					
- Graffiti					
- Dirt and stains					
- Other					
2. Masonry Units					
- Cracked units					
- Spalling					
- Loose					
- Out of alignment					
- Other					
3. Mortar Joints					
- Missing/clogged weepholes					
- Clogged vents					
- Deteriorated					
- Cracks					
- Moss/algae growth					
- Other					

	OK	Problem Minor	Major	Location/Observation	Date of Repair

4. Flashing					
- Damage or missing					
- Corrosion					
- Correct slope					
- Open joints					
- Stains					
- Other					
5. Caps/Coping					
- Cracked units					
- Loose joints					
- Open joints					
- Not flashed beneath					
- Attachment					
- Other					
6. Water Repellent & Caulking					
- Deteriorated/Torn caulking					
i Masonry to masonry					
ii Masonry to doors & windows					
iii Masonry to flashing					
- Loose/flaking paint					
- Efflorescence					
- Water stains					
7. Other Observations					