MIBC TECHNICAL MANUAL

The purpose of this manual is to provide technical information to assist designers in the use of masonry wall systems for their projects. A variety of structural and veneer masonry assemblies are discussed, and details, specifications and project examples are provided.

The index page shows how the manual has been organized to provide the user with a quick reference to either general topic sections, or to specific detailed information. The Manual is a living document which is continuously updated with additional material and updates to existing pages. Such information will be available on our website at www.masonrybc.org

Comments or suggestions for improvements to the Manual are welcomed.

Financial support for the printing of this manual was provided by the Masonry Contractors Association of BC.

MASONRY INSTITUTE OF BC

The Masonry Institute of BC has evolved from masonry organizations that have been promoting the local masonry industry for over 30 years. The programs of the MIBC are supported by the Masonry Producers Association of BC, and the BC Chapter of the Canadian Masonry Contractors Association. The MIBC also represents the province in our national association, Masonry Canada.

The mandate of the MIBC is to enhance the development of masonry in BC through technical support to designers, educators and building officials. This is done through:

- daily inquiries and contacts by phone, fax and email
- office visits and presentations
- seminars and courses
- design manuals, literature, software, website
- representation in industry groups, building codes and research

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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.

In this publication, the **rainscreen veneer walls** category includes wall systems that use an exterior masonry wythe as a cladding, where an air

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.

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.

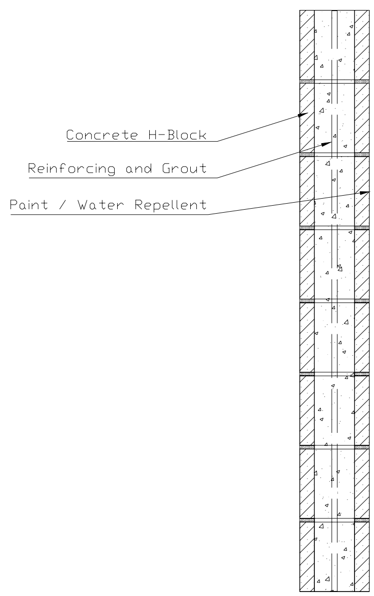
While rainscreen veneer walls are thin and light compared to most **structural walls**, the reputation for fitness-to-purpose associated with brick and stone-clad walls today derives in part from the robustness of masonry, even in single wythe veneer applications. See *Section 1.3* for further detailed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

STRUCTURAL WALLS

What is a loadbearing wall?

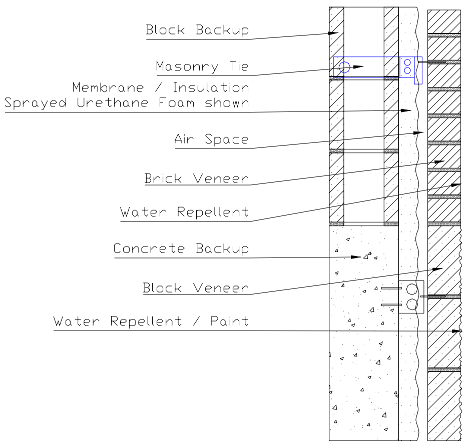
- These walls resist dead and live vertical loads.

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 sealers 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 now similar to limit states design methods for other materials. The introduction of *CSA S304.1-94* Masonry Design for Buildings (Limit States Design) made masonry design compatible with other structural systems and permited a more rational evaluation of safety. The format of the standard is similar to that of *CSA A23.3* for concrete. The previous *CSA S304-84* was based on working stress principles and will be phased out in the next edition of the standard which will be referenced by the 2005 National 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 factor for masonry of 0.55 is slightly lower than the equivalent concrete factor of 0.60. This is a conservative value used in the first edition of the limit states standard, and it is likely to be increased in the future to 0.60.

- 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

	Compressive strength, f'_m, of concrete block masonry			
Compressive strength of unit, MPa (net area) *	Type S mortar		Type N mortar	
	Hollow	Solid or grouted	Hollow	Solid or grouted
>40	22	17	14	10.5
30	17.5	13.5	12	9
20	13	10	10	7.5
15	9.8	7.5	8	6
10	6.5	5	6	4.5

*Linear interpolation is permitted.

Note: Requirements for concrete block masonry units are included in CSA Standard A165.1-94.

Note: For partially grouted walls, the area of grout may be ignored and the “Hollow” f'_m value used.

MINIMUM SEISMIC REINFORCEMENT

CSA S304.1 (clause 5.2.2) specifies minimum seismic reinforcement for loadbearing and non-loadbearing walls in various seismic regions. Reinforcement areas shown below must be oriented a minimum of 1/3 in either direction, with maximum 1200 mm spacing for vertical steel. In many cases, it will be found that this minimum seismic steel will also be adequate for flexural or axial load resistance.

Zone	**Area Required**	**Typical Spec 200mm Wall**
Loadbearing zones 2-6	Total 0.002 2/3 = 0.00133 1/3 = 0.00067	Vertical: 15M @ 800mm (0.00132) Horizontal: 2-15M @ 2400mm + Joint reinforcing @ 400mm (0.00117)
Non-loadbearing zones 4-6	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)

CSA S304.1-94 (clause 6.3.3.1 [c]) allowed non-reinforced masonry partitions if they were less than 200 kg/m2 in mass and 3 m in height. In consideration of the modest cost to provide minimum seismic reinforcement for these walls, this exception will be removed for higher seismic regions in the next edition.

In addition to flexural, axial and minimum seismic steel, vertical reinforcing is required at each side of openings over 1200mm long, each side of control joints, and at corners, ends and intersections of walls. Care should be taken to disperse the rebar throughout the wall, and to avoid congestion in vertical cores. Further information is provided in the "Guide Structural Notes" in *Section 3.3* of this manual.

NOMINALLY DUCTILE SHEAR WALLS (R = 2.0)

The *National Building Code of Canada 1995* (Table 4.1.9.1.B) and *CSA S304.1-94* (clause 6.3.3.2) contain provisions for a new category in the Force Reduction Factor table for "Nominally Ductile" masonry walls. A factor of 2.0 is applied in a similar manner to nominally ductile concrete walls. Regular reinforced masonry walls have an R factor of 1.5. Large differences in the ductility of framing systems in orthogonal directions should be avoided.

There can be advantages to using the factor 2.0 for tall shear walls in masonry. There are a number of provisions outlined in Appendix A of *CSA S304.1-94* which must be met to achieve the moderate ductility and energy absorption capacity presumed by the use of R = 2.0. These provisions ensure that the shear capacity exceeds the flexural capacity, which is providing the ductile mechanism.

DESIGN AIDS

There are two primary design aids for masonry limit states structural design:

- *ENGINEERED MASONRY DESIGN* Textbook
  by Glanville, Hatzinikolas, Ben-Omran
  (Text, design charts, *CSA S304.1-94*)

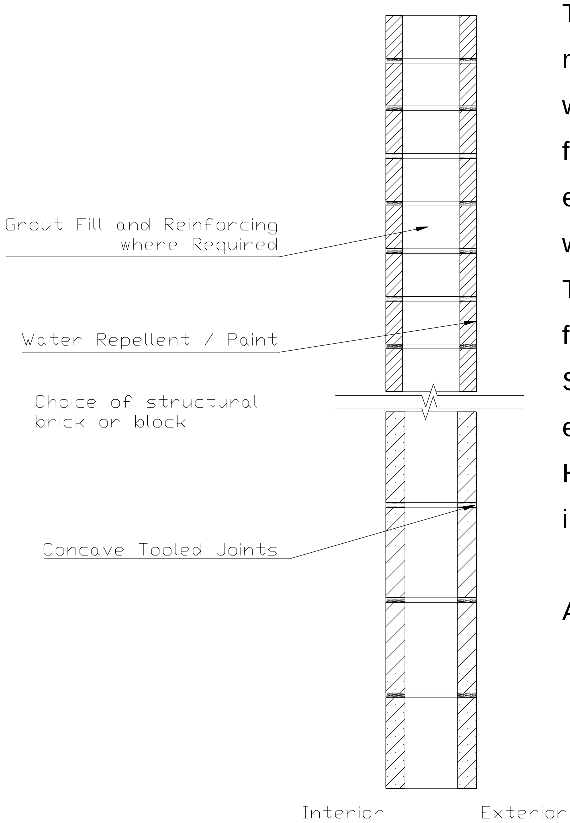
- *MASONRY LSD 95* Software
  (Interactive design of walls, columns, beams)

These are available through the Masonry Institute of B.C.

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.

SYSTEM 1: UNINSULATED STRUCTURAL WALL



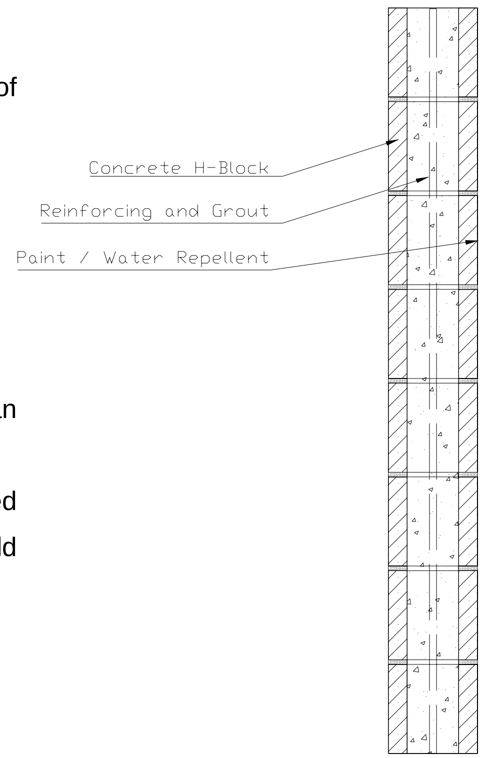
The use of hollow masonry provides an economical wall system with a masonry finish on both sides. A wide range of finishes can be achieved with different textures and colours of brick and block. Suitable reinforcing for seismic and structural strength can be placed within the wall. Recent engineering 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 *Section 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.

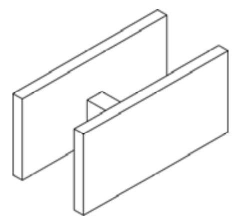
Advantages:

- Economical
- Masonry finish on both sides
- Accepts reinforcing

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 reduces head joint leakage potential.

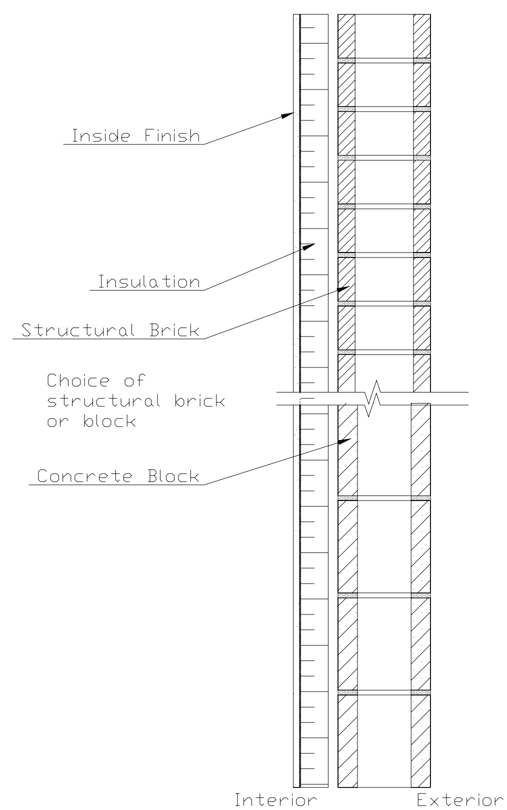
The finished wall has a high degree of structural strength and can be used both above and below grade as an economical alternative to formed-in-place concrete walls.

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 accomodates heavy reinforcing.
- Improved water resistance

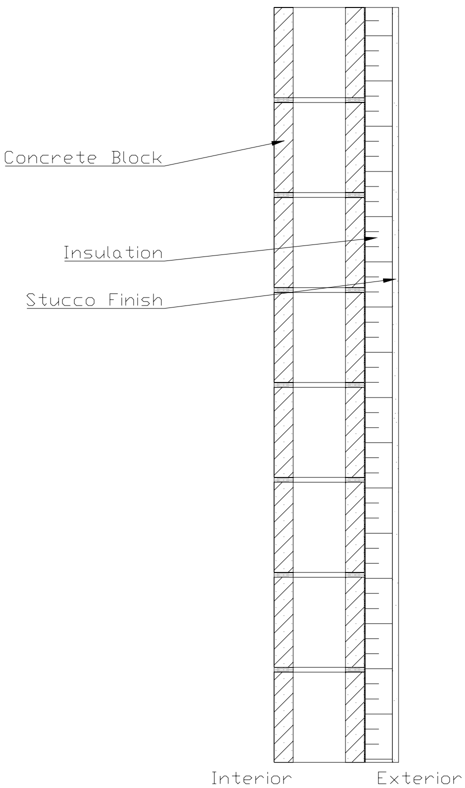
SYSTEM 3: INTERIOR INSULATION



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
- 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.
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	*Example 1*	*Example 2*
CONCRETE BLOCK						
Baseline:	**190mm**(20cm) smooth grey, 15MPa		**80.00**	**7.50**	*80.00*	*80.00*
Width	90mm	deduct	(7.00)	(0.65)		
	115mm	deduct	(10.00)	(1.00)		
	140mm	deduct	(10.00)	(1.00)		
	190mm		-Baseline Above–			
	240mm	add	21.00	2.00		
	290mm	add	32.00	3.00		
Height	90mm (1/2 high)	add	54.00	5.00		
Strength	20 MPa	add	2.00	0.20		
	30 MPa	add	3.00	0.30		*3.00*
Fire Rated - ULC		add	2.00	0.20		
Finish	Scored	add	10.00	0.90		
	Split Face	add	11.00	1.00	*11.00*	
	Split Rib	add	19.00	1.75		
	Split Ledge	add	24.00	2.25		*24.00*
Colour	Standard	add	20.00	1.85	*20.00*	
(incl. mortar)	Premium	add	27.00	2.35		
CLAY BRICK:						
Baseline:	190x90x290 or 390 mm		**170.00**	**16.00**		
Width	140mm	deduct	(10.00)	(1.00)		
EXTERIOR TREATMENT						
Clear water repellent		add	8.00	0.75	*8.00*	
Anti-graffiti repellent		add	16.00	1.50		
Elastomeric Paint Coating		add	16.00	1.50		*16.00*
REINFORCEMENT & GROUTING						
Including grout, joint reinforcing, placing of rebar						
Baseline	25% (vertical @ 800mm), 20cm width					
	33% (@600mm)	add	5.00	0.50		*5.00*
	50% (@400mm)	add	10.00	1.00		
	Solid Grouted	add	18.00	1.70		
	Solid Grouted H-block	add	22.00	2.00		
Example 1: (190mm split face, coloured, repellant)			*Total $/sq.m =*		*119.00*	
Example 2: (190mm split ledge, high-strength, painted, rebar @ 600)						*128.00*

These cost figures should be used for general comparisons only - not for estimating masonry work.
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.
For further information contact the Masonry Institute of B.C.

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 “rain screen” 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 aspects of rain screen 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 a 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.

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.

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.

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.

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 outermost enclosure elements and assemblies will be subjected to extremes of temperature, wetting and drying and should be free to move in response. The joints associated with a rain screen cladding need not be sealed and can accommodate thermal movement or other changes in in-service conditions.

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

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 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.

The cavity in a masonry wall provides:

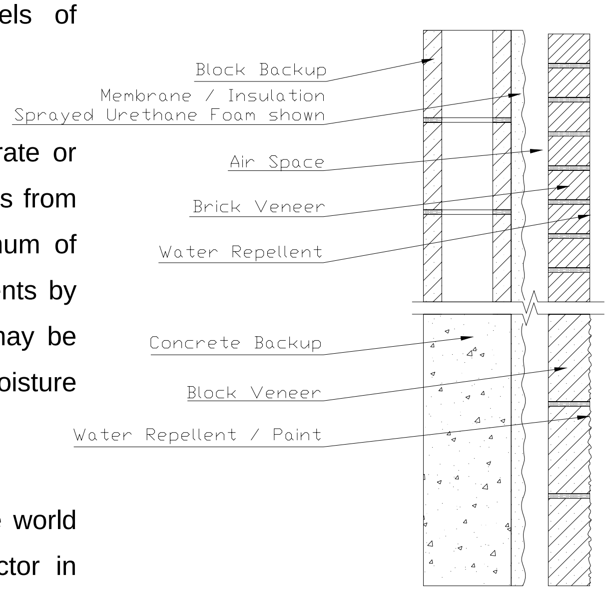
- drainage and drying
- a capillary break (gap) between cladding and back-up
- pressure moderation of wind driven rain
- for tolerances in the back-up wall location

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

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

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.



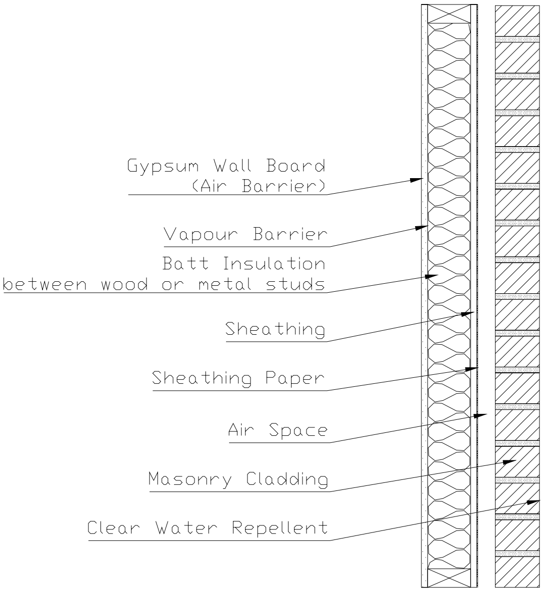
Buildings with a masonry back-up in a mild climate with moderate or controlled interior air conditions, may derive adequate airtightness from an uncoated concrete block back-up and require only a minimum of thermal insulation. Occasional wetting of masonry wall components by rain or condensation of moisture 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 forgiving 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.

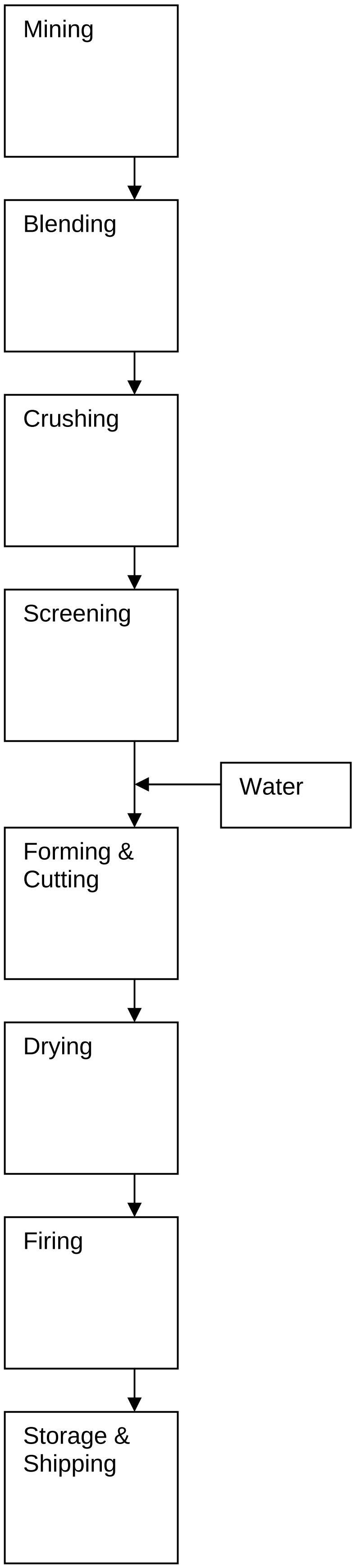
The additional wall thickness required for cavity insulation, the airspace and the masonry veneer may be offset by Floor Space Ratio relief under local jurisdiction bylaws. *(See Masonry Report 5.8 – Changes to Floor Space Ratio Definitions Encourage Better Exterior Walls)*

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.
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.	*Example*
CLAY BRICK				Courses /				
		Nominal size	Module	600mm				
Baseline:	Standard	90 x 63 x 190 mm	3"x8"	8		**140.00**	**13.00**	*140.00*
	Modular metric	90 x 57 x 190 mm	75 x 200 mm	9	add	11.00	1.00	
	Norman	90 x 63 x 290 mm	3"x12"	8	deduct	(14.00)	(1.30)	
	Econ, Saxon	90 x 90 x 290 mm	4"x12"	6	deduct	(21.00)	(2.00)	*(21.00)*
	Giant	90 x 90 x 390 mm	4"x16"	6	deduct	(21.00)	(2.00)	
Detailing								
	Coloured mortar				add	3.00	0.30	
	Soldier course (per metre or foot)				add	17.00	1.60	
	Rowlock course (per metre of foot)				add	25.00	2.30	
CONCRETE BLOCK								
Full Height		90 x 190 x 390 mm						
Baseline:		Smooth Grey				**70.00**	**6.00**	
Finish:		Scored			add	10.00	0.90	
		Split Face			add	11.00	1.00	
		Split Rib			add	19.00	1.75	
		Split Ledge			add	24.00	2.25	
Colour:		Standard			add	18.00	1.70	
(incl. mortar)		Premium			add	24.00	2.20	
1/2 High		90 x 90 x 390 mm						
Baseline:		Smooth grey				**105.00**	**9.75**	
		Split Face			add	15.00	1.40	
		Colour	Standard		add	25.00	2.30	
			Premium		add	33.00	3.00	
EXTERIOR TREATMENTS								
Clear Water Repellent					add	8.00	0.75	*8.00*
Anti-graffiti Repellent					add	16.00	1.50	
Elastomeric Paint Coating					add	16.00	1.50	
SYSTEM ITEMS								
Closer Tie Spacing		- 600 x 600 or 400 x 800			add	2.00	0.20	
		- 400 x 600			add	5.00	0.50	
Stainless Steel Ties		- 600 x 800			add	2.00	0.20	
Moisture/Air Barrier & Insulation - varies					add	20 - 30	2 - 3	
HIGH RISE								
10m - 20m					add	10-20%		
20m - 50m					add	15-25%		
		Example: (4x12 clay brick, repellant)					*Total $/sq.m =*	*127.00*

These cost figures should be used for general comparisons only - not for estimating masonry work.
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.
For further information contact the Masonry Institute of B.C.



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. Although brick may be 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, absorbtion, 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, ultra violet and chemical exposure. The qualities of brick have been proven through centuries of use.

MANUFACTURING PROCESS

Brick is formed by two principle methods: the extruded 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.

PRODUCTS

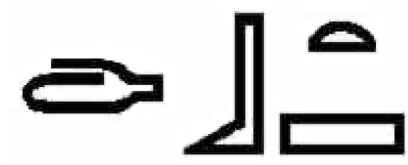
Clay masonry products are designated:

Burnt Clay Brick	CAN/CSA A82.1-M87
Hollow Clay Brick	CAN3-A82.8

A face brick, also known as a “solid” brick, is defined as a brick in which the core area is not more than 25% of its gross cross-sectional area. For hollow structural units the core area will be from 40 to 50% of the gross area.

GRADE

There are two grades of clay masonry products: SW and MW. These grades are known as Severe Weathering and Moderate Weathering. The SW grade unit is intended for use 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. The MW grade unit is intended for use where a moderate and lesser degree of resistance to frost action is required and where it is unlikely to be permeated with water when exposed to temperatures below freezing. SW is required by code for all exterior masonry in British Columbia.



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

Typical Specification:

Clay Face Brick:
to CAN/CSA A82.1-M87
Grade SW, Type FBS

TYPES

Three types of face or hollow brick are produced. Types FBS, FBX and FBA describe the three types of face brick available whereas HBS, HBX and HBA describe the three types of hollow structural brick produced.

Type FBS and HBS brick are for general use in exposed exterior and interior masonry walls and partitions, where normal colour ranges and variations in size are permitted. This is the most commonly used and specified brick type.

“Brick faces shall be free of cracks or other imperfections detracting from the appearance of the designated sample when viewed from a distance of 4.57m (15ft) for Type FBX and a distance of 6.10m (20ft) for Types FBS and FBA” as quoted from section 7.3 of the standard.

Type FBX and HBX brick are for special use in exposed exterior and interior masonry walls and partitions where a higher degree of mechanical perfection, narrow colour range, and minimum permissible variation in size are required.

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

It is specifically called to the attention of the designer that when the type of brick has not been specified, the requirements for FBS or HBS shall govern.

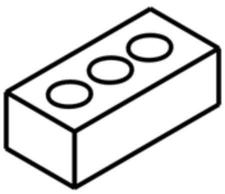
Sizes and Shapes

VENEER UNITS

Notes:

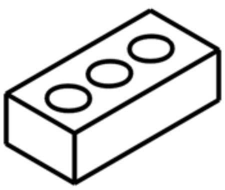
- *All sizes shown are **Width x Height x Length***
- *Many special shapes are also available. See your masonry manufacturer for more information.*
- *Thickness of mortar joints between units can be adjusted slightly by the mason to fit required length/height dimensions.*

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



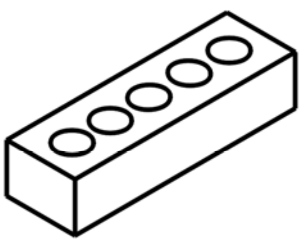
STANDARD

Size	Metric (mm)	Imperial (in)
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



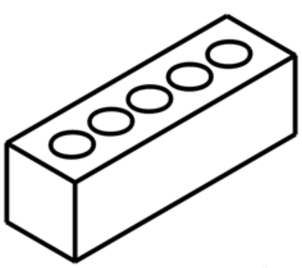
MODULAR

Size	Metric (mm)	Imperial (in)
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



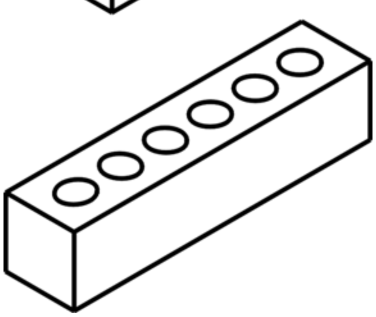
NORMAN

Size	Metric (mm)	Imperial (in)
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

Size	Metric (mm)	Imperial (in)
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

Size	Metric (mm)	Imperial (in)
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

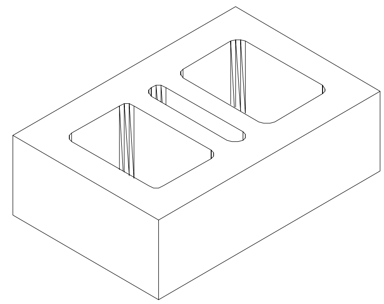
STRUCTURAL UNITS

See *Section 1.2.1* for information on structural design

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

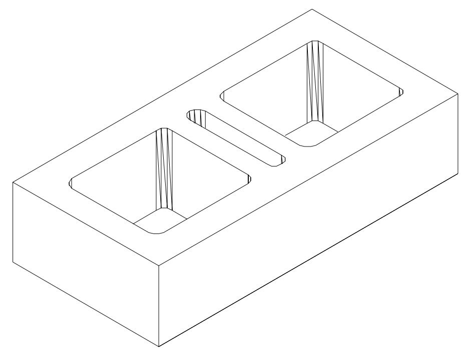
300 (12") STRUCTURAL

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)



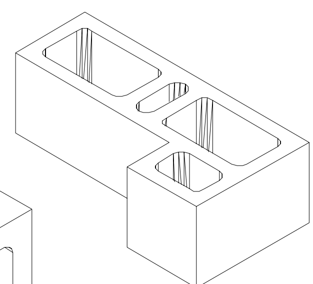
400 (16") STRUCTURAL

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)

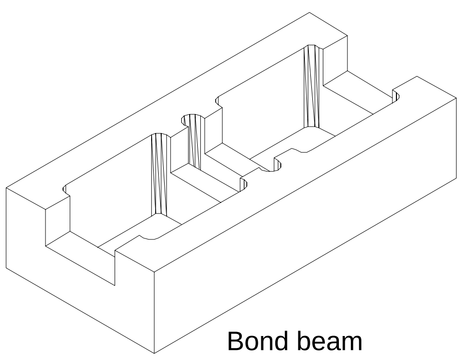


SAMPLE SHAPES

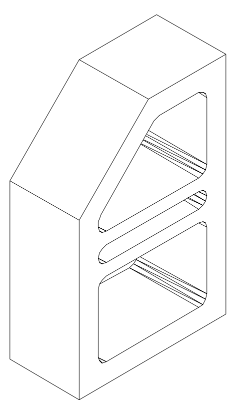
See manufacturer for full range of shapes available.



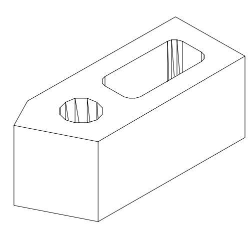
L-Corner



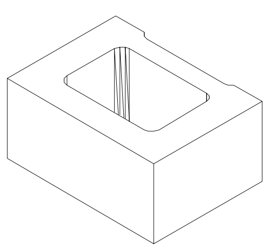
Bond beam



45° Cant



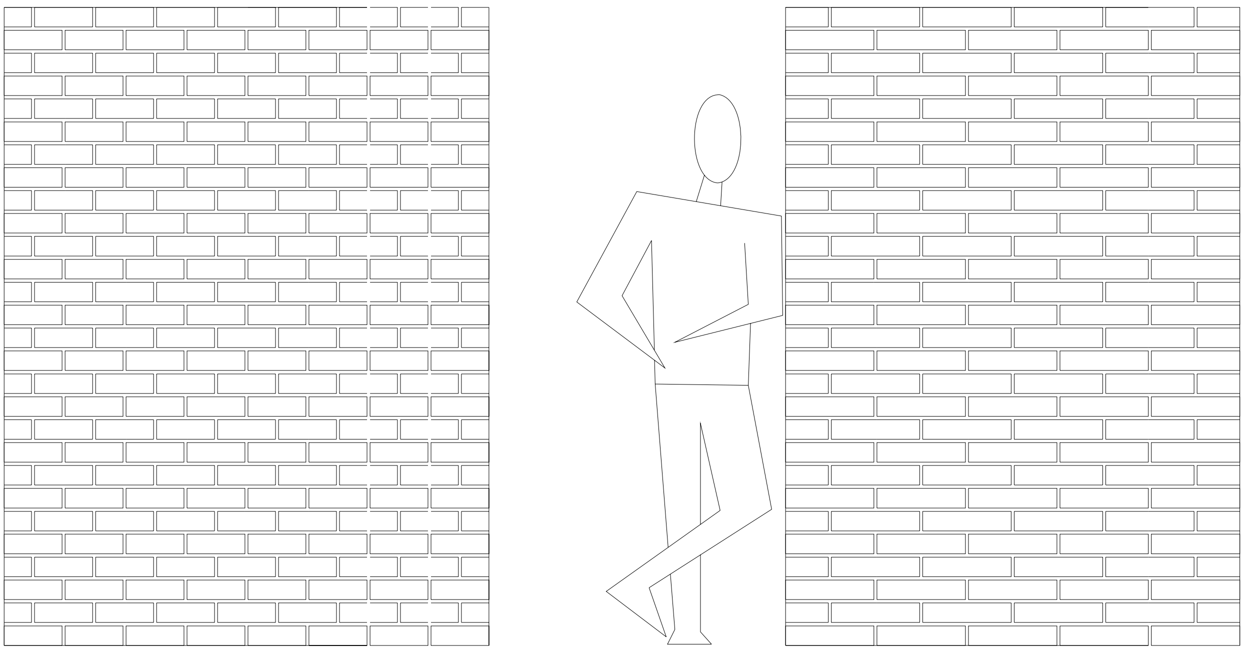
Squint



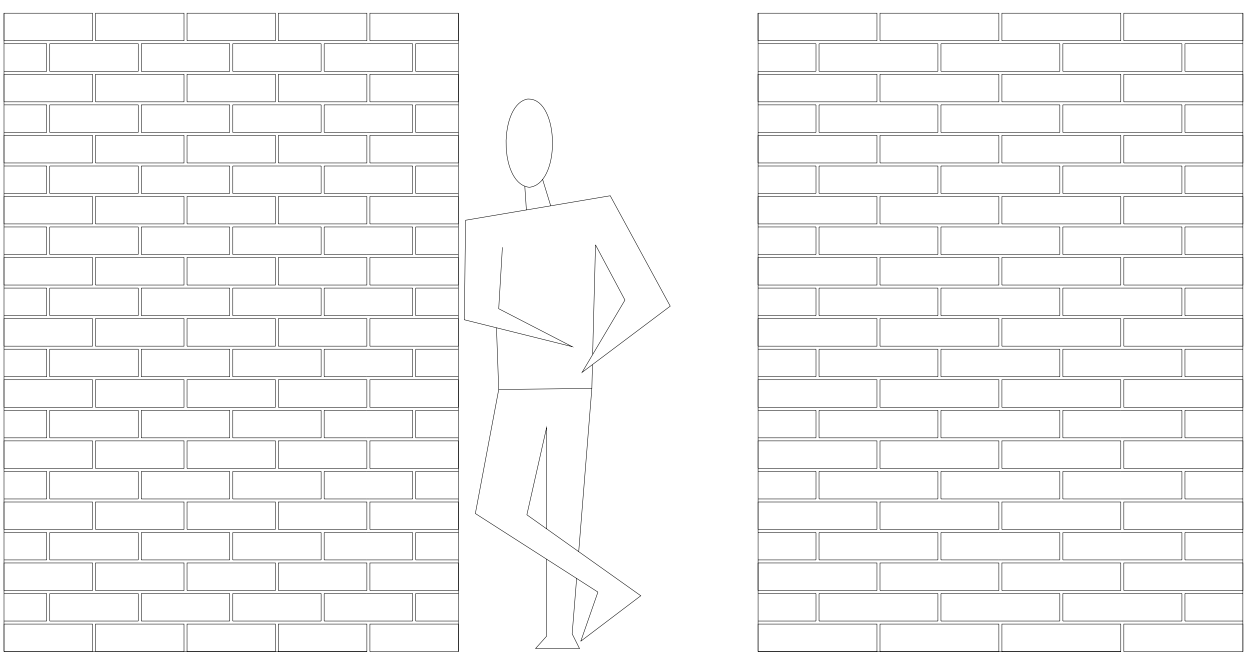
Half

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	1.08
Norman	0.90
Econ/Saxon	0.85
Giant	0.85

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.

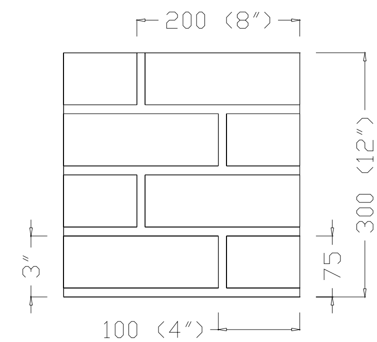
Special units such as L-corners and 214mm soldier units should be clearly identified in the specifications and masonry details.

Brick Modules

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 mo joint.



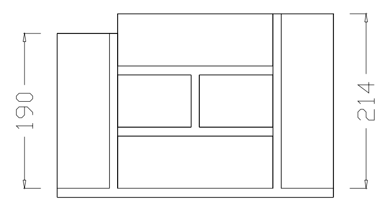
Horizontal	**Module:**	**100mm (4")**
	Brick:	190mm (7 1/2")
	Joint:	10mm (1/2")
Vertical	**Module:**	**75mm (3")**
	Coursing	4c=300mm (12")
	Brick:	64mm (2 1/2")
	Joint:	11mm (1/2")

Standard bricks are the same size whether specified as metric or

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.

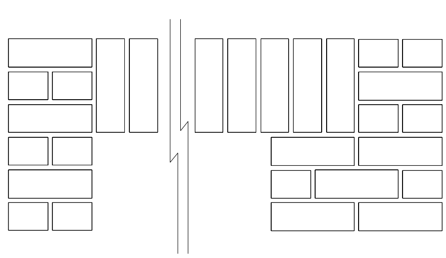
Bond: 1/2 bond is maintained around corners

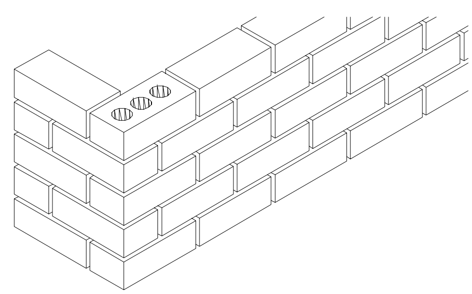


"Standard" soldiers will not line up with horizontal courses (left). When needed, special 214mm units can be used (right).

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

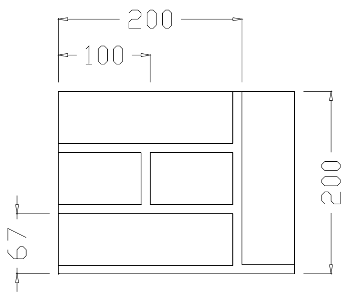
- Jams can be cut to suit to accept lintel angles
- A 214mm unit can be used to course out vertically
- A soldier course can be carried around the whole building to eliminate this coursing problem. A banding or horizontal effect will result.
- A soldier lintel looks better if it is extended beyond the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



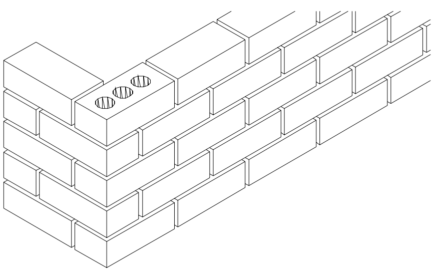


1/2 bond

Cost Factor = 1.08 $



- A “Modular” brick courses evenly as a soldier.



1/2 bond

MODULAR BRICK

“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 less economical than “Standard” brick walls because of the smaller unit size.

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 1/4”
		Joint:	3/8”+

With “Modular” brick:

Soldiers: “Modular” brick courses evenly as a soldier

Bond: 1/2 bond is maintained around corners

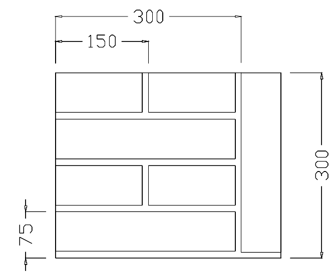
NORMAN BRICK

$ Cost Factor = 0.90

"Norman" brick are the same height as a "Standard" brick but 100mm (4") longer giving a 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.

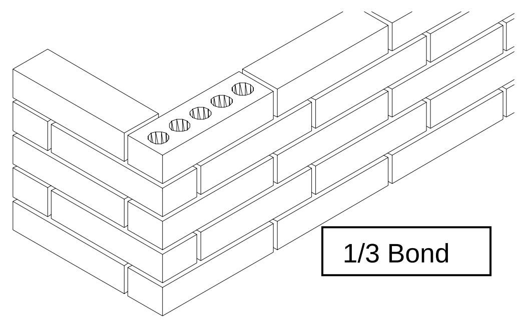


Imperial similar

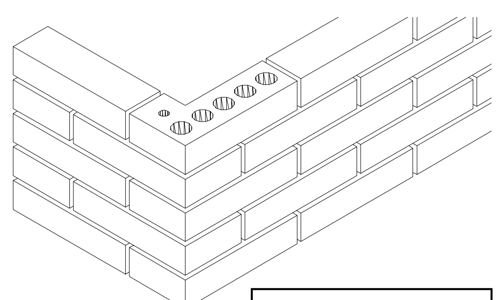
1/2 bond can also be accomplished using alternating 240mm (9-1/2") closer bricks at corners and wall ends but this alters the module and can result in additional cutting in other locations.

Metric	**Horizontal**	**Module:**	**150mm**
		Brick:	290mm
		Joint:	10mm
	Vertical	**Module:**	**75mm**
		Coursing	4c=300mm
		Brick:	64mm
		Joint:	11mm

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



1/3 Bond



1/2 bond using an L-Corner unit

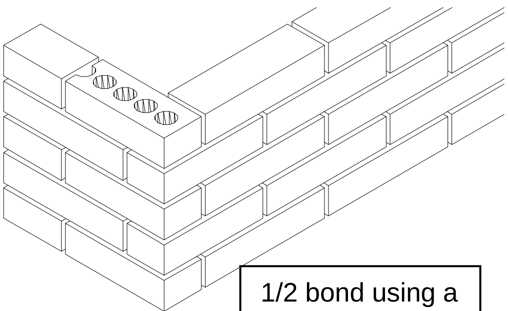
Notes:

- 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.

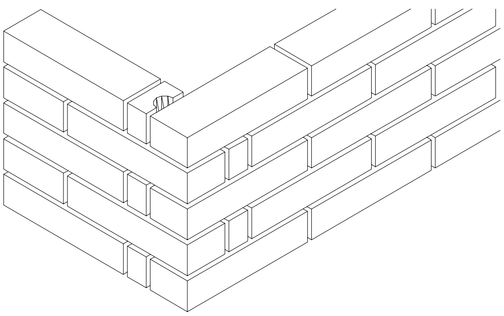
With “Norman” bricks:

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

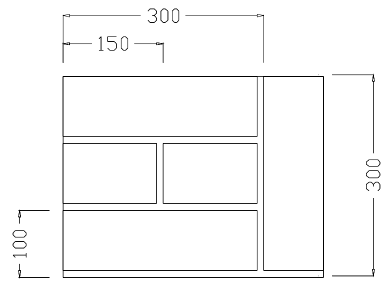
ECON / SAXON BRICK

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

Cost Factor = 0.85

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.

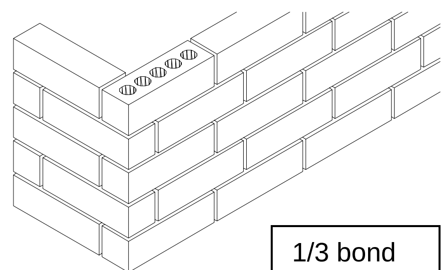


- Units used as soldiers course out evenly.

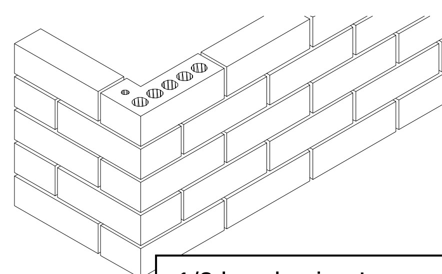
Metric	**Horizontal**	**Module:**	**150mm**
		Brick:	290mm
		Joint:	10mm
	Vertical	**Module:**	**100mm**
		Coursing	2c=200mm
		Brick:	90mm
		Joint:	10mm

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

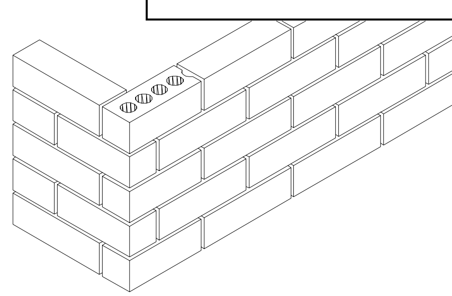
Note: Imperial and metric lengths are not equal



1/3 bond



1/2 bond using L-corners



1/2 bond using Closer units

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

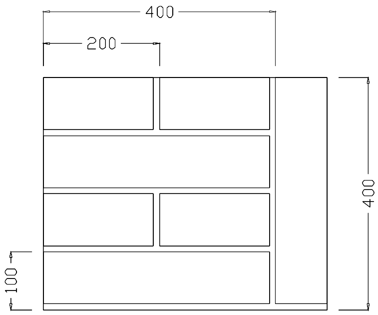
Soldiers: Match the height of 3 courses

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

GIANT BRICK

$ Cost Factor = 0.85

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).

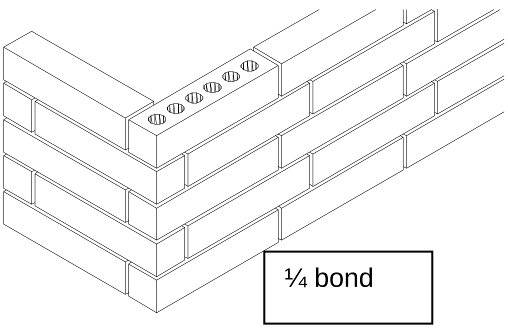


Imperial similar

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.

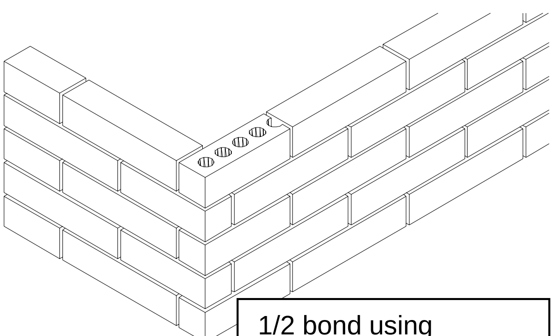


¼ bond

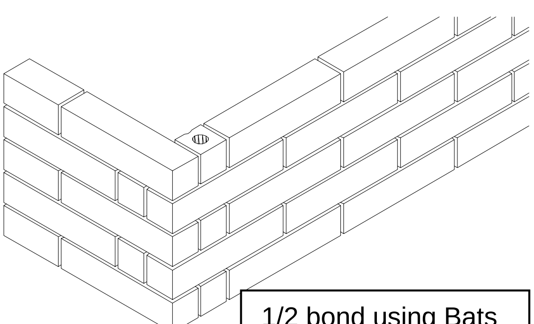
With “Giant” bricks:

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).



1/2 bond using Closers

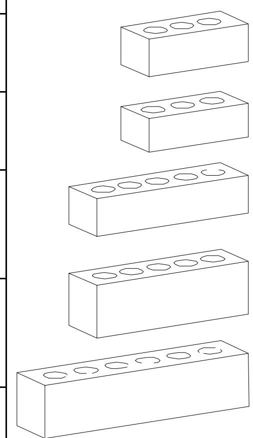


1/2 bond using Bats

BRICK MODULE SUMMARY TABLES

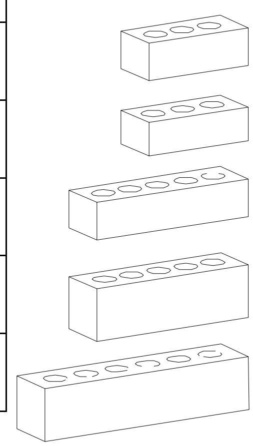
For metric bricks:

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	1.08	1/2 bond	Natural	3 courses
Norman	150x75	0.90	1/3 bond	L-corner: 140mm return Closer: 240mm	4 courses
Econ / Saxon	150x100	0.85	1/3 bond	L-corner: 140mm return Closer: 240mm	3 courses
Giant	200x100	0.85	1/4 bond	Closer: 290mm Bat: 90mm	4 courses (2 for half units)

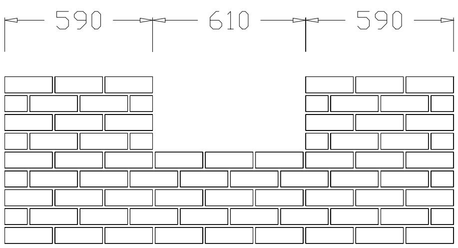


For imperial bricks:

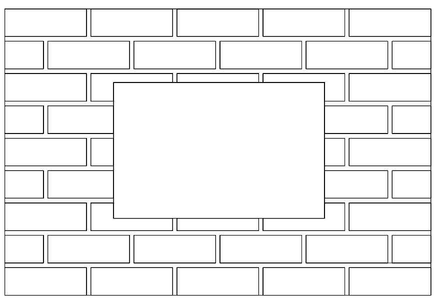
Brick	**Module (l x h)**	**Cost Factor**	**Natural Bond**	**1/2 Bond Corners**	**Soldiers**
Standard	4”x3”	1.00	1/2 bond	Natural	Special 8 1/2” unit matches 3 courses
Modular	4“x2 2/3“	1.08	1/2 bond	Natural	3 courses
Norman	6”x3”	0.90	1/3 bond	L-corner: 5 1/2” return Closer: 9 1/2“	4 courses
Econ / Saxon	6”x4”	0.85	1/3 bond	L-corner: 5 1/2” return Closer: 9 1/2“	3 courses
Giant	8”x4”	0.85	1/4 bond	Closer: 11 1/2" Bat: 3 1/2"	4 courses (2 for half units)



COLUMNS, PIERS and OPENINGS



Modular Layout

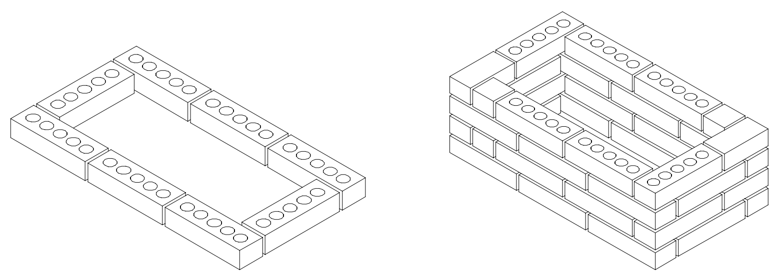


What not to do: this opening requires 16 cuts

When laying out 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.

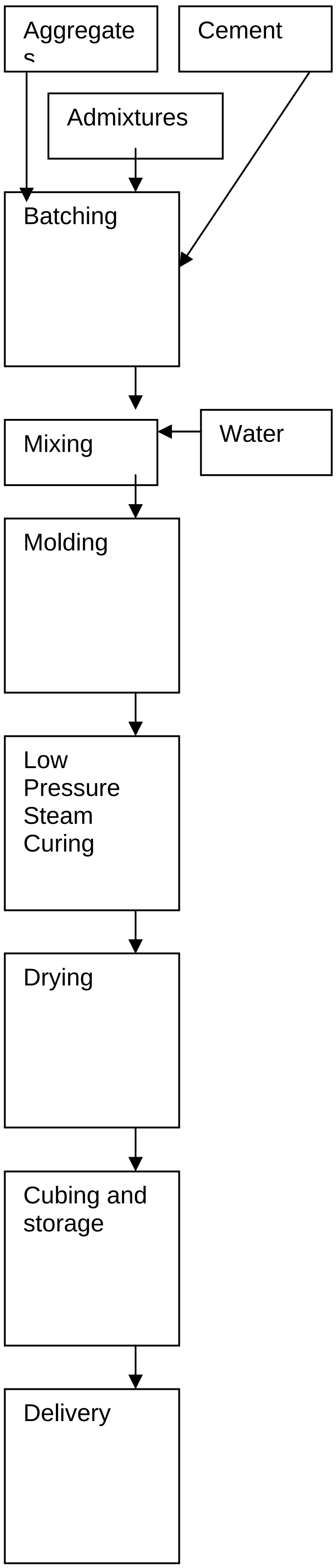
The horizontal dimension of the brick should be divisible by the module minus 1 mortar joint. (eg. A panel or column 3 Standard bricks wide would only have 2 joints and therefore be 590mm not 600mm. Conversely an opening in a brick panel 3 bricks wide would have to account for an extra joint (3 bricks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

PRODUCTS

Concrete masonry units are designed and specified as follows:

Concrete block CSA A165.1-94

Concrete brick CSA A165.2-94

Sample Spec: Concrete masonry units: To CSA A165.1-94

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. (See *section 1.2.3 - Cost Guide*)	
25		
30		
35		
	Oven dry density (kg/m^3)	**Maximum water absorption (kg/m^3)**
A	Over 2000	175
B	1800-2000	200
C	1700-1800	225
D	Less than 1700	300
N	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

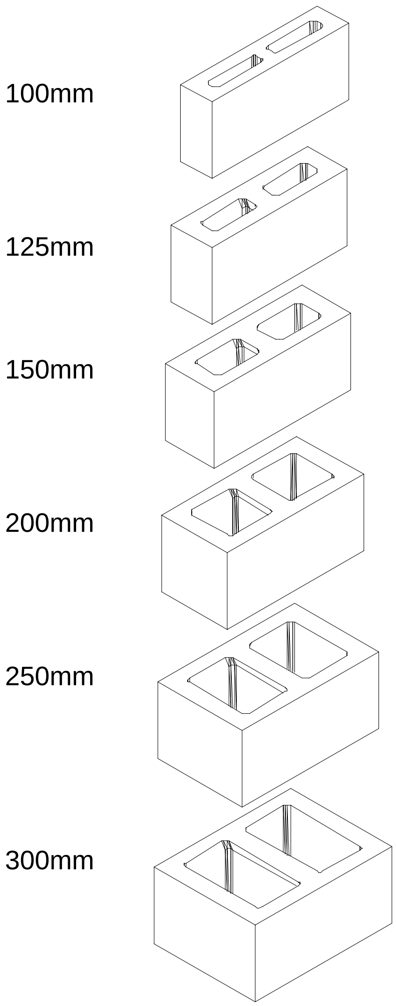
Concrete masonry units are made with either standard weight or lightweight aggregates, or a combination of the two.

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 units are typically made up with 50% sand and 50% pumice aggregate, with a density of 1800kg/m^3.
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, Shapes & Profiles

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

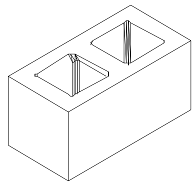
<u>The 125mm unit</u> (actually 115mm wide) is the narrowest block capable of:

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

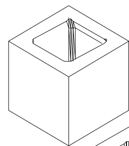
It is useful as a partition or exterior back-up to claddings.

SHAPES

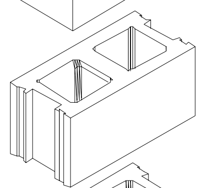
Double-ender



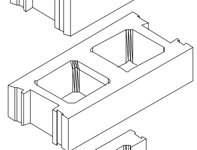
Half



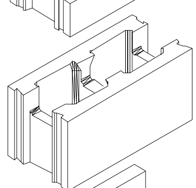
Stretcher



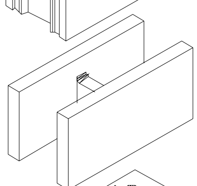
Half-high



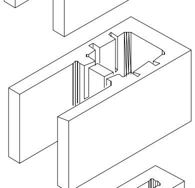
Bond-beam



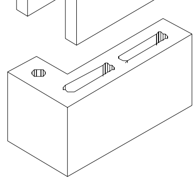
H-Block



Multi-block



L-corner (100mm)

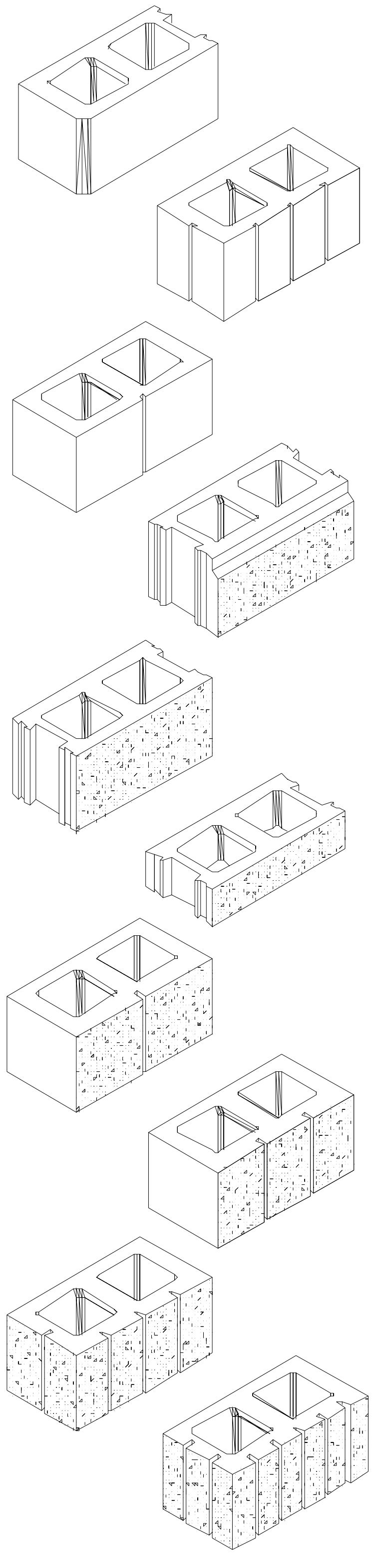


The H-Block unit offers special structural advantages:

- 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



Bullnose

Triple-score return

Single-score

Split ledge

Split face

Half-high split

Two-rib split

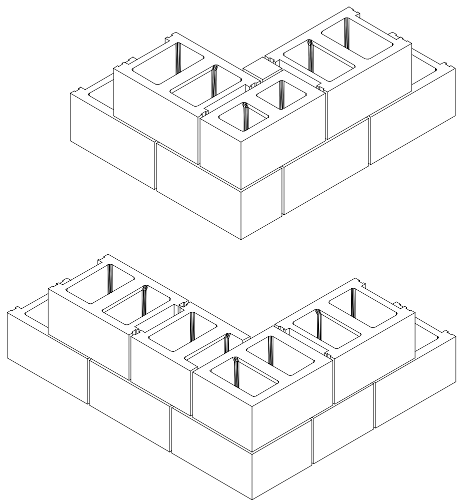
Three-rib split

Four-rib split return

Six-rib split return

MASONRY INSTITUTE OF BRITISH COLUMBIA

Modular Layout



300mm block corners

Work to 200mm module where possible.

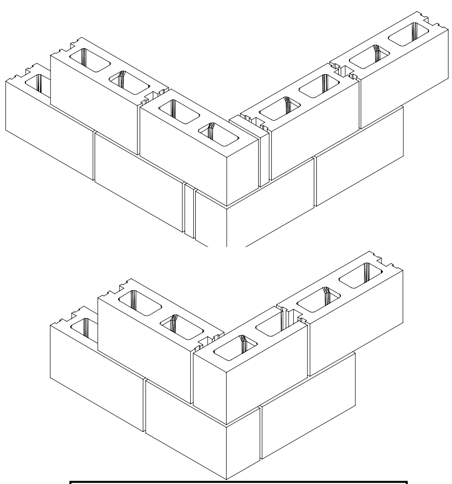
Openings should be placed at a modular distance from corners or other openings (distance between them in whole multiples of module (200mm))

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

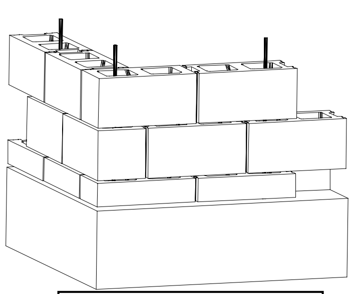
STRUCTURAL LAYOUT

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



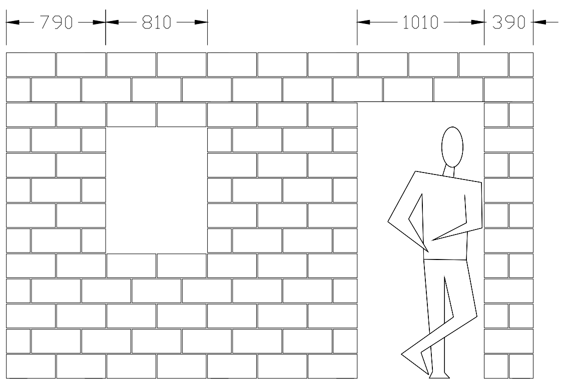
150mm block corners



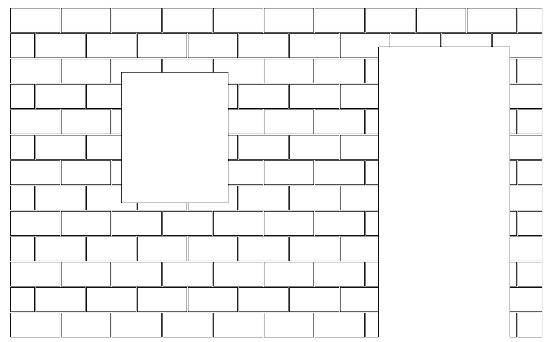
Dowel layout

LAYOUT EXAMPLES

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



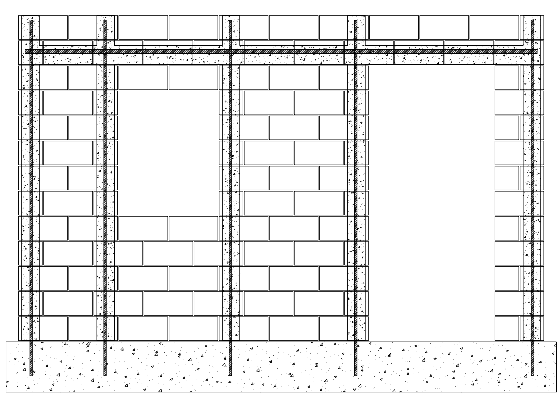
Proper layout with no cut units.



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

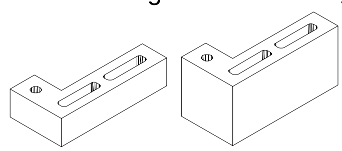
Reinforcement creates a grid of steel and grout within the concrete block wall. Modular design ensures the steel can be placed and grouted properly to meet design requirements.

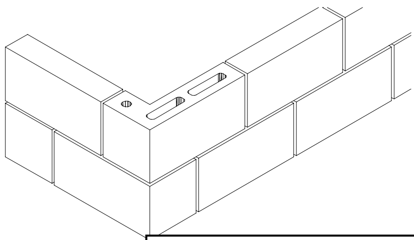


VENEER LAYOUT

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 return units.

100mm high 200mm high



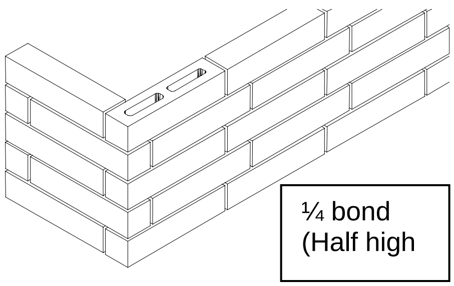


Corner of Full High with return L-corner

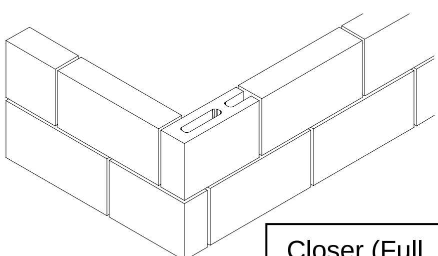
‘Half high’ units

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



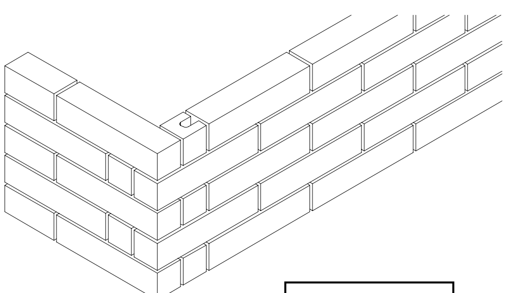
¼ bond (Half high



Closer (Full high)

‘Full high’ units

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



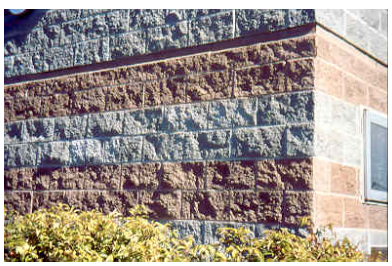
Bat (Half high)

Textures and Profiles:

Multiple Coloured splitface and 6-rib

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 during the production process.


Combination of coloured split ledge and natural splitface

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 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 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:


Painted splitface with smooth band

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.


Painted smooth for school corridor (Kid Proof !)

Caution for Coloured Smooth Block:

Due to the nature of the manufacturing process, 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.

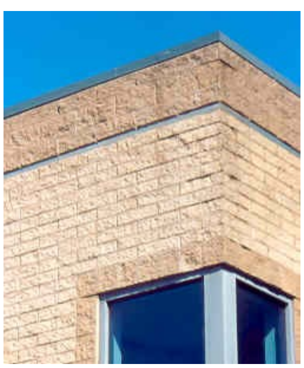
This wider range can occur because the “slick” on the smooth exterior surface of the block has a high cement and colour content, which is affected by small changes in moisture content, temperature and curing during manufacture. This is not the case for a splitface surface, because the splitting process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


Coloured splitface.
Note colour range in smooth bands.

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)

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

Hydraulic splitter creating splitface units.



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

For these reasons, the specification of coloured smooth units is not recommended for large wall elements without a review of these concerns by the designer with the block manufacturer.

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, as well as compensating for minor dimensional variations in the masonry units. 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 (i.e. lime). Good workability and water retentivity are essential for maximum bond. A mortar that has a higher cement content will be stronger but will provide less bond. Conversely, a mortar with less cement and more lime will be weaker and have better bond strength.

- Mortar bonds masonry units together. Good bond strength will significantly contribute to a masonry wall's integrity.
- 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 module), 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 color nicely and is the most economical.
In general, brick mortar color matches the brick in a lighter tone. Coloured mortars are usually used with coloured block to solidify the colour impact and to simplify cleaning after construction.

SPECIFYING MORTAR

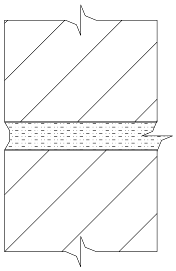
CSA A179-94 *Mortar and Grout for Unit Masonry* covers raw materials, mortar types, mixing process and mortar specifications. Mortar types within CSA A179-94 are designated by letters “S” or “N”: the former is used primarily for structural masonry while the latter is employed for veneer masonry construction. Mortar specification can be made either through the Proportion or Property methods. 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 A179-94*
Type S, mortar for structural masonry
Type S or N, mortar for 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.

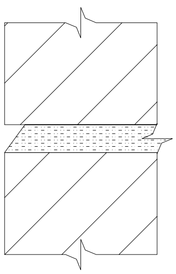
JOINT PROFILES

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



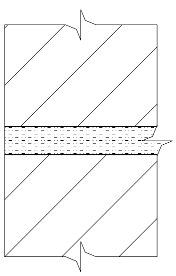
1. Concave Joint

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.



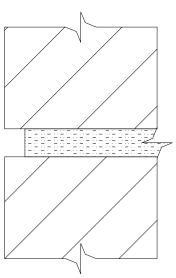
2. Weathered Joint

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 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 A179-94.

TYPES OF GROUT

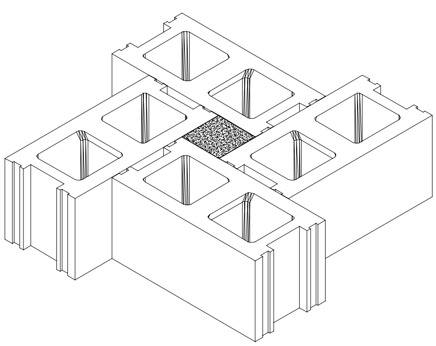
"Coarse Grout", the most commonly used type of grout, has a maximum aggregate size of 10 mm (3/8”). To properly fill the cores of masonry units and flow around reinforcement or other elements within the wall, the slump should be between 200 and 250mm (8”-10” slump).

"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 conditions the grout would experience in the wall and allows for a specimen to be tested very easily. Four masonry units are arranged so as to leave a square opening between them. Grout is poured into this opening and allowed to cure. The sample is then cured and tested to determine the compressive strength of grout placed in the wall and benefiting from the absorption of the surrounding masonry.

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, and will exceed the 15 MPa strength of typical concrete blocks. This grout strength is compatible with the design strengths contained in S304.1 for Masonry design.

Structural notes and specs that call for 20 or 25 MPa grout tested by cylinders should be changed to recognize the anomaly when non-absorptive cylinders are used. 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 A179-94
Minimum compressive strength 12.5 MPa at 28 days by cylinder test under the property specification
Maximum aggregate size 10 mm diameter
Grout slump 200 to 250 mm

INSTALLATION

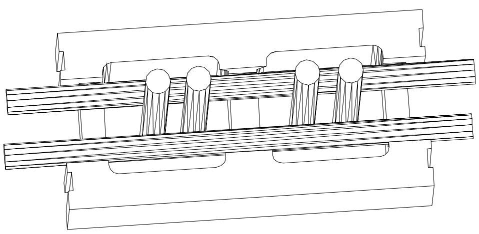
Unit cores that are to be grouted should be free of excessive mortar protrusions and mortar droppings at the base. Clean-out/inspection holes at the base of the reinforced cores will facilitate the removal of mortar droppings and confirm that grout has reached the bottom of the core. The requirement for clean-out/inspection holes may be waived by the designer where the installer has demonstrated an ability to achieve acceptable performance.

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 usually poured in 2.4m (8') lifts from bond-beam to bond-beam.
(For more detail, see *Section 3.3 - Guide Structural Notes*)

REINFORCEMENT



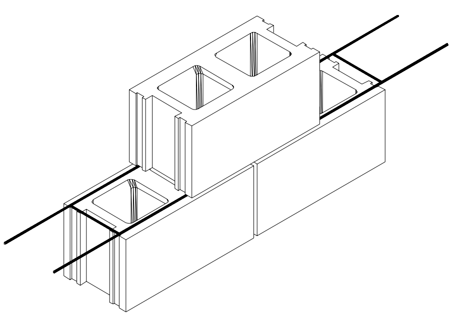
> 2 bars vertically and 2 bars horizontally in a 20cm wall is almost impossible to grout, particularly at splices where steel is doubled.

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. (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.

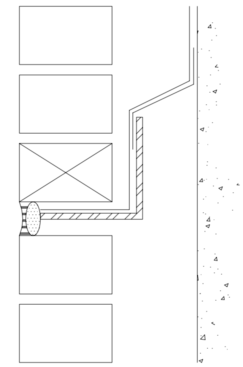
JOINT REINFORCEMENT



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 typically at 400 mm in seismic zones. Joint reinforcement resists wall cracking and contributes 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.

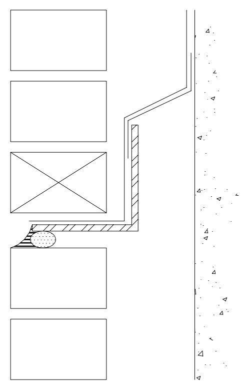


Caulked Brick-to-Brick

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.

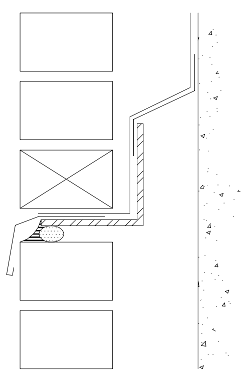


Caulked Brick-to-Toe of shelf angle

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:

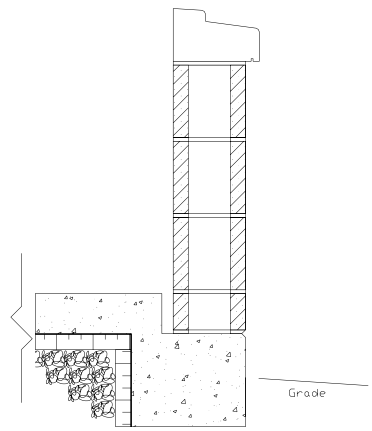
- Peel & stick (flashing grade) or torch-on modified bituminous membranes
- EPDM
- Prefinished sheet metal (painted galvanized steel)
- Fastening devices should be corrosion-resistant and compatible with the materials used (potential galvanic action between metals should be addressed)
- Primers and adhesives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

Installation

Through wall flashing should be installed on a smooth surface and care must be taken to ensure positive drainage to the exterior.
Overlaps and joints should be to manufacturer's recommendations.
Metal flashing joints must allow movement due to expansion / contraction.
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 should 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:***
> Manufacturer recommendations should be followed for material compatibility, surface preparation, priming requirements, overlaps and

Note: a "flashing effect" can be obtained without the addition of a flashing by shaping the support in such a way as to direct any moisture out through weepholes. The support must be able to withstand the presence of moisture, be waterproof and offer sufficient protection.



Natural flashing effect by using a base ledge

CAP FLASHINGS

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

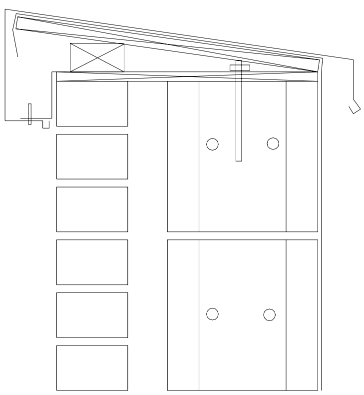
- acting as a barrier against moisture
- covering the top of the wall sufficiently to stop wind-driven rain from working its way up under the flashing
- eliminating stains caused by dirt-laden runoff

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 and care must be taken to ensure positive drainage to the exterior.
- Overlaps 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 are underlaid by a membrane or metal flashing

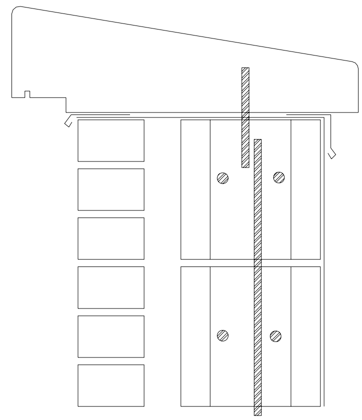
Coping materials

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)



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

Installation

Membrane installation:

Flashing should be installed on a smooth surface and care must be taken to ensure positive drainage to the exterior.
Overlaps should be to manufacturer's recommendations.

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

Coping installation:

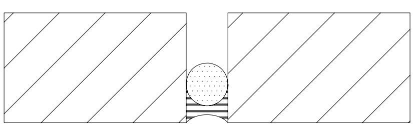
Copings are fastened through the membrane to the wall. All membrane penetrations must be properly sealed.

DESIGN CONSIDERATIONS

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

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

The National Building Code of Canada does not specify the spacing of movement joints and these are to be determined by the designer based on calculation or past experience. Though 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 taken at 6.5×10^{-6} per °C.

Concrete block undergoes a non-reversible shrinkage due to 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 9.4×10^{-6} per °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.

REINFORCED STRUCTURAL WALLS vs. VENEERS

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. The use of reinforcement in structural walls thus permits a larger spacing of movement joints.

Control 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 at the shelf angles to accommodate vertical movement.

JOINT LOCATION

In the selection of control 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.

Joint locations:

- Wall openings
- Changes in wall height
- Movement joints of foundations or other structural support elements
- Changes in support conditions
- Proximity to wall corners or intersections
- Changes in wall thickness
- At given spacings in a continuous wall

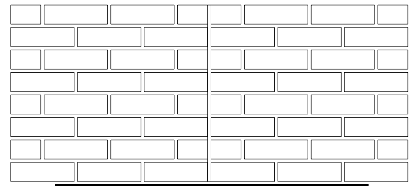
Typical Maximum Control Joint Spacings		
Wall Type	**Material**	**Movement joint spacing**
Veneer	Clay	7m – 10m
	Concrete	5m – 7m
Reinforced masonry	Clay	15m
	Concrete	15m

VERTICAL MOVEMENT JOINTS

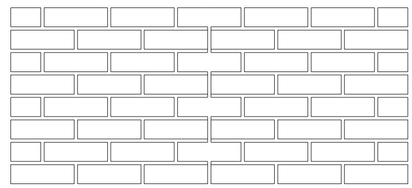
Vertical movement joints span masonry panels vertically (both structural and veneer). They allow for movement of the masonry along the length of the panel.

To construct a vertical joint, half units are used every other course (in running bond). In order to hide the joint, a caulking color that matches the units should be used. 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



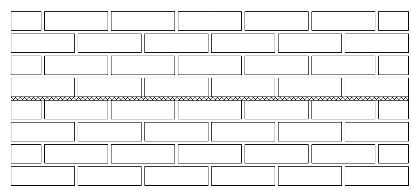
Caulk matches brick

HORIZONTAL MOVEMENT JOINTS

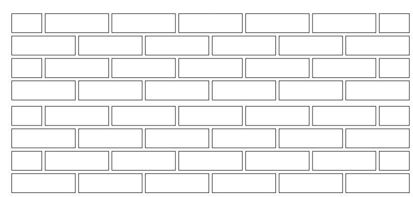
Horizontal movement joints span masonry veneer panels horizontally. They allow for movement of the masonry along the height of the panel.

Horizontal joints are located at each shelf angle.

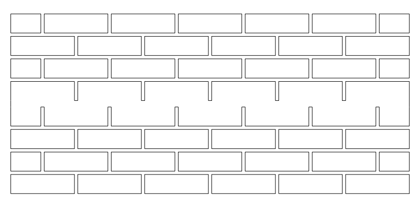
Since the thickness of a horizontal joint at shelf angles is larger than normal, it is important to minimize its impact. Joints are hidden by using caulking that matches the mortar in color and by incorporating them into horizontal banding designs.



Caulk does not match



Caulk matches mortar



Caulk matches brick

GENERAL

Brick tie requirements are outlined in CSA A370-94 Connectors for Masonry. This standard refers to the older kinds of ties, such as strip ties and Z ties as “Conventional “, even though they are seldom used in modern commercial construction. The newer, 2-piece, adjustable, engineered ties that are now in common use are unfortunately referred to as “Non-conventional”. This terminology will be clarified in the next edition of the standard.

CSA A370-94 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 National Building Code (NBC). 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 outlines introduced in the 1994 standard, which include 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 1995 NBC references the 1994 edition of CSA A370, "Connectors for Masonry". This standard requires stainless steel brick ties for buildings over 11 m high for areas subject to wind driven rain such as coastal B.C. For buildings under 11 m in coastal B.C., and for all buildings in the rest of B.C., hot dipped galvanized coatings are acceptable corrosion protection. The extra cost for stainless ties may be offset by other requirements discussed below. 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.

INCREASED TIE SPACING

Earthquake loads on brick ties are determined by a formula that includes an "S_p" factor for architectural parts or portions of buildings. The previous NBC Part 4 did not provide a specific factor for brick ties, so a factor the 15 for major connections was used to calculate seismic loads.

The 1995 NBC recognized the redundancy and behaviour of multiple brick ties with a new brick ties category with an S_p factor of 5. This change substantially reduced calculated tie loads, and often provides increased spacing between ties for higher seismic zones. The latest generation of strong, two piece adjustable ties can provide the opportunity to increase spacings up to the maximum allowable of 600 mm vertically by 800 mm horizontally (24" x 32").

Because the high seismic zones and the heavy wind-driven rain areas in B.C. are approximately concurrent, the increased spacing may partially or totally offset the stainless steel cost increase for buildings over II m, depending upon panel size and number of openings.

BRICK TIE DESIGN EXAMPLE

The structural design example below is based upon the requirements of the 1995 National Building Code; CSA S304.1-94 Masonry Design for Buildings (Limit States Design); and CSA A370-94 Connectors for Masonry.

The process begins with the calculation of earthquake and wind wall loads for a typical 2-storey school in Vancouver. Although calculated earthquake loads on ties have been corrected to a lower level by the 1995 NBC, the seismic case still governs the design for this location and building.

For this example, we try a tie with a factored resistance (design strength) of 1.5 kN (338 lb.). 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, which results in an area in this case of 0.72 m^2 (7.7 sq. ft.) per tie. However, the maximum spacing for any tie system is limited to a maximum of 600 mm by 800 mm (.48 m^2) (5.2 sq.ft.), so this spacing is specified.

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 of .36 m^2 (3.9 sq. ft.) is calculated, and the spacing is based on the 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 @ 3 m/storey
Brick veneer on both concrete block, and steel stud back-up @ 400 mm

1. LATERAL LOADS

- Seismic Load

$V_p = v.I.S_p.W_p$

$= (0.20)(1.3)(5.0)(1.60)$

$= 2.08$ kPa

v	= zonal velocity ratio	= 0.20 (Van.)
I	= seismic importance factor	= 1.3 (school)
S_p	= horizontal force factor	= 5.0 (ties)
W_p	= weight of cladding	= 1.60 kPa (clay brick or hollow 90mm block)
(α	= 1.0 for seismic)	

- Wind Load (factored)

$p = q_{10}\, C_e\, C_g\, C_p\, \alpha_w$

For a typical school building profile, the wind load would be approximately 1.3 kPa

Therefore SEISMIC GOVERNS

2. TIE STRENGTH

Examine spacing for a tie with a factored resistance of 1.5 kN (from manufacturers' test data literature)

3. TIE SPACING

a. Concrete Block Back-up (non-flexible)

Area = 1.5 kN/2.08 kPa

= 0.72 m^2/tie

Space at the maximum 600 mm vertically by 800 mm horizontally (.48 m^2)

b. Steel Stud Back-up (flexible)

Area = 1.5 kN/(2.08 kPa)(2)

[double tributary area for flexible back-up]

= 0.36 m^2/tie

check 40% of stud load:

(40%)(0.4m)(2.8m)(2.08) = 0.93kN/tie

OK, < 1.5 kN/tie capacity

Space at 600 mm vert. by 400 mm horiz. (.24 m^2)

- could go to 600 horizontal if stud spacing increased
- could consider higher capacity tie

c. Openings and Tops & Bottoms of walls

- at Openings: not more than 300mm from edge at maximum 600 mm spacing
- at Top: not more than 300mm to top row
- at Bottom: not more than 400mm to bottom row

Types of ties

- Rap tie
- Corrugated strip tie (for housing only)
- C-type tie
- Side mount tie
- Surface mount tie
- Wood tie
- Block shear tie
- Pac tie

Tie installation

Ties are designed to bind a masonry veneer to the structural backup and withstand wind and seismic loads.
It is imperative that the ties be properly installed so that they perform as required.

They should be properly fastened to the structure:

- Imbedded in mortar between the masonry units of a structural back-up wall
- Screwed securely to studs (wood or metal)

They should be well anchored in the veneer:

- imbedded in the mortar between the veneer units
- lie in the middle of the unit

Fire Ratings

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 walls made of gypsum wallboard are not required to endure the fire-hose test.

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 National Building Code of Canada. 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 fire ratings allowed by the "Underwriters Laboratories of Canada". The U.L.C ratings apply only to specific block shipments from certified suppliers.

EQUIVALENT THICKNESS

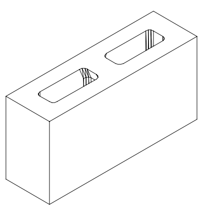
Equivalent thickness is the solid thickness that would be obtained if the same amount of concrete contained in a hollow unit were re-cast without core holes.

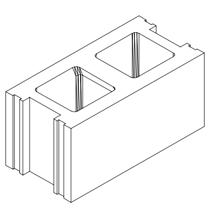
Calculating Estimated Fire Resistance Example: A 200 mm hollow masonry wall is constructed of Type N or S concrete units reported to be 56% solid. What is the estimated fire resistance of the wall? Equivalent Thickness = .56 x 190 = 106 mm. Which gives a 1.5 hour fire rating.

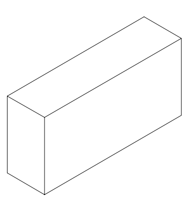
115mm BLOCK
Narrowest block offering:

- 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 – impossible to break through these walls
- Sound control – mass wall will dampen even the loudest noises
- Fire resistance – will not burn or allow fire to spread







Fire Ratings

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:
A four-hour firewall is required for 200mm nominal wall thickness.
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 is certified two hours.
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 NBC Chapter 2, Section 1.6)

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		43	46	46	50	52	53
solid filled	Standard Weight			50				

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

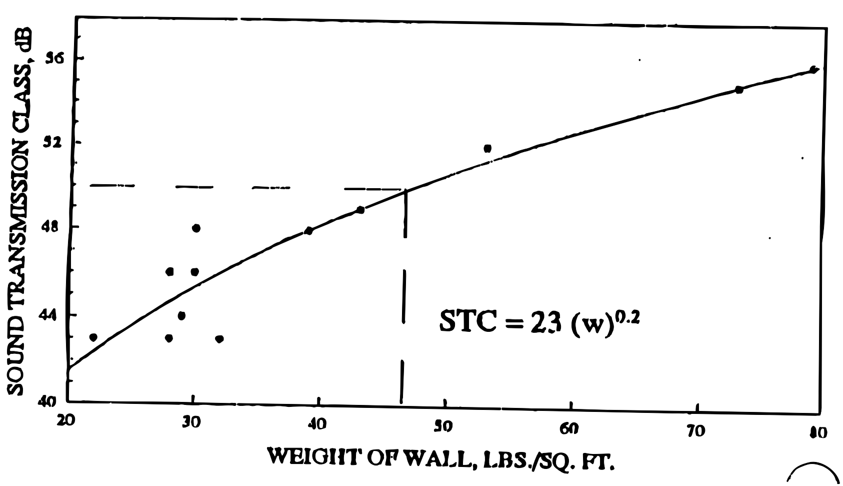
An important asset of concrete masonry in noise control is its reliability. Unlike the so-called "special" partition constructions, which are touted as sound barriers, concrete masonry walls require no special installation procedures to be effective. All too often the staggered stud isn't staggered; 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 an STC of 15 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 astructural 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 it’s 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 (bats), or outside (EIFS), of the wall.

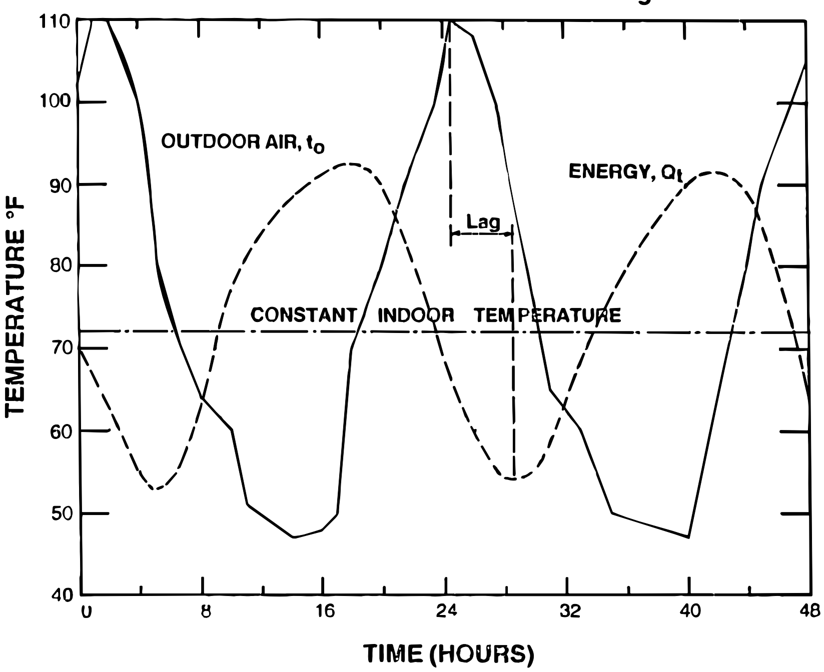
Thermal Properties (m^2 C° / W)

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 teir mass gives masonry walls the following advantages:

- Effective RSI value of a masonry wall is higher than a metal framed wall because two-dimentional heat flow andthermal bridging occurs at highly conductive metal framing members. (See appendix B and Apprendix 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. Celcius (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, your building will stay cooler in summer and warmer in winter!

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 defence 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 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. 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.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.

4. 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.

The following standards are reviewed in this section:

For information on CSA S304.1 Masonry Design for Buildings, see *Section 1.2.1.*

This update is based upon the 1994 editions of the masonry standards referenced by the 1995 National Building Code, and the 1998 B.C. Building Code. These standards are now under review in preparation for the 2005 NBC.

CONCRETE BLOCK - CSA A165.1-94

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

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

  H = hollow

  15 = compressive strength

  15 MPa standard inventory strength (net area)

  20 to 30 available at a 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 A165.1-94 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**

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)**

- based on wall weight - check with suppliers or MIBC

- **Thermal values**

- 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 A82.1-M87

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 FBS – standard tolerances

  Grade SW - "severe weathering" 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.

Sample Spec: Clay Face Brick to CAN3 A82.1 M87 requirements
Grade SW, Type FBS

- **Quality control:**

  Test data or Letter of Assurance from supplier if deemed necessary

- **Fire ratings:**

  From B.C. Code based on equivalent thickness. Typical face brick - 1 hr.

- **Sound and thermal ratings:**

  Check with supplier or MIBC

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

- **Structural Clay Units:**

Covered by CSA A82.8

MORTAR - CSA A179-94

Covers:	Raw Materials Mortar Types - S or N Mixing Process Proportion or Property Specs	Not covered:	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 A179 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 A179-94 requirements
Type S, mortar for structural masonry

Type S or N, 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 to 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 not the most important property for mortar, although reasonable strength is required for durability. Higher strength is achieved with a higher proportion of Type 10 cement.

A balance of strength and bond is, therefore, required for good mortar. Two practical proportions of cementitious materials are available:

Type 'S'
Typically used for both structural and veneer block and brick
Higher Type 10 cement content for moderately high strength

Type 'N'
Also used for brick veneer

Cement/Lime mortars were historically recommended because their raw materials and resulting properties were well established.

Masonry Cements are proprietary products, which replace separate cement and lime bags for site mixing. Recent versions, called Mortar Cements, are now frequently used to meet Type S mortar strengths without the addition of Type 10 cement. See manufacturers' data for further information.

GROUT (Block Fill) - CSA A179-94

Covers:	Raw Materials Grout Type – coarse or fine Property or Proportion Spec Slump	Not covered:	Installation

- **Typical spec**

Most masonry grout (block fill) is “Coarse Grout”, with a maximum aggregate size of 10 mm. “Fine Grout” would only be used in small core units such as reinforced brick. 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 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 strength results.

The latest CSA A179 recognizes this situation by calling for only 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 contradiction caused when non-absorptive cylinders are used. 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).

Sample Spec:	Grout to CSA A179-94 requirements Minimum compressive strength 12.5 MPa at 28 days by cylinder test under the property specification Maximum aggregate size 10 mm diameter Grout slump 200 to 250 mm

MASONRY CONNECTORS - CSA A370-94

Covers:	Brick Ties – Conventional (prescriptive) Non-conventional (typical two-piece adjustable ties used today) Anchors Fasteners Repair Connectors Corrosion Protection

- **Corrosion Protection - 1998 vs. 1994 Sstandards**

The 1994 edition requires stainless steel ties for walls over 11 m for high wind-driven rain areas such as coastal B.C. Other masonry only requires hot-dipped galvanized ties.

Tie design loads from the new B.C. Code are much lower for earthquake loading - allowing increased spacing for “non-conventional” tie design. This may some, or all of the premium for stainless steel ties.

CSA A370-94 REQUIREMENTS		
	Coastal B.C.	Interior B.C.
≤ 11m	Hot Dipped Galvanized	Hot Dipped Galvanized
> 11m	Stainless Steel	Hot Dipped Galvanized

- **“CONVENTIONAL” TIES**

Old style strip and Z ties are no longer commonly used for commercial work due to their limited strength, cavity width and adjustability. Maximum prescriptive spacings in CSA A370 may have to be reduced in seismic zones or high wind areas.

- **"NON-CONVENTIONAL" TIES NOW TYPICAL**

  - Wide range of two-piece adjustable types are available
  - Must meet strict strength, free-play and deflection requirements
  - Type and spacing determined by designer based on manufacturer's tie test data, not from the standard. The tie designer may be specified to be retained by the contractor.
  - **Maximum spacing 600 mm vertically by 800 mm horizontally**
  - Typically two piece ties for adjustability and ease of installation.
  - Fasteners (Screws) - as per specifications for type of tie used.

Sample Spec: Masonry connectors to CSA A370-94 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 [ ]

CONSTRUCTION - CSA A371-94

Covers:	Construction Practices & Tolerances Reinforcement, Grouting Movement Joints, flashing Cold and Hot Weather Construction Ties & Building Envelope	Not covered:	Masonry Design Tie Design

- **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

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

- BRICK TIES

  - place in centre of veneer wythe, ± 13 mm at specified spacing.

- THIN VENEERS (SLICES)

  - now limited to 3 m height

- MOVEMENT JOINTS

  - locations as per drawings - if not shown mason should ask designer
  - 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 - should be designed to provide durability.

- GLASS BLOCK
  - non-loadbearing, mortar type and joints, reinforcement and anchoring (also see manufacturers' literature)
- CAVITY 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
  - designer should be notified if tolerances can not 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 and adequate consolidation by puddling bars or vibration
  - cleanouts called for if total pour height over 1.5 m (5 ft.) (often waived by engineer based on good workmanship)

SECTION 4000

PART 1.0 GENERAL

1.1 Section Includes

.1 Furnish all labour, material, and equipment necessary for the supply, delivery and erection of masonry as indicated on the drawings and as hereinafter specified.
.2 Scaffolding and planks.
.3 Reinforcing steel within masonry walls excluding dowels from other work.
.4 Rigid insulation over which masonry is applied.
.5 Loose fill insulation in hollow masonry walls.
.6 Concrete grout in masonry.
.7 Through wall flashing and adhesives.
.8 Cleaning of masonry.
.9 Water repellant coating to exterior masonry surfaces.
.10 Precast elements hand set in mortar bed such as copings, sills.

1.2 Products Built-in But Not Supplied Under This Section

.1 Section 05500 - Metal Fabrications: Supply of miscellaneous metal fabrications for installation by this section.
.2 Section 08100 - Metal Doors and Frames: Supply and setting of metal frames for building in by this section.

1.3 Related Sections

.1 Section 03300 - Cast-in-Place Concrete: Dovetail anchor slots and reglets.
.2 Section 03400 - Precast Concrete
.3 Section 05410 - Wind Bearing Steel Studs
.4 Section 05510 - Structural Steel: Anchors to masonry
.5 Section 06100 - Rough Carpentry: Exterior Sheathing
.6 Section 07191 - Sheathing Membrane
.7 Section 07196 - Air Barriers
.8 Section 07270 - Fire Stopping
.9 Section [ ]: Parapet and Coping Flashing
.10 Section 07900 - Sealants
.11 Section [ ]: Window Frames
.12 Section [ ]: Door Frames
.13 Section 09250 - Gypsum Wallboard: Exterior gypsum sheathing

SPEC NOTE: Delete sections not appropriate to project.

1.4 References

.1 CAN3-A371-94 "Masonry Construction for Buildings"
.2 CAN3-A369.1M90 "Method of Test for Compressive Strength of Masonry Prisms"
.3 CAN3-A370-94 "Connectors for Masonry"
.4 CAN3-A165-SERIES-94 CSA "Concrete Masonry Units"
.5 CSA Standard A82.56-1976 "Aggregate of Masonry Mortar"
.6 CSA Standard A179-94 "Mortar and Grout for Unit Masonry"
.7 CAN/CSA-A82.1-M87 "Burned Clay Brick (Solid Masonry Units Made From Clay or Shale)"
.8 CAN3-A82-2-M78 (R84) "Methods of Sampling and Testing Brick"
.9 CAN3-A82.8-M78 (R84) "Hollow Clay Brick"

SPEC NOTE: The 94 editions of masonry standards are the most current, and are referenced by the 1995 National Building Code and the 1998 B.C. Building Code.

1.5 Submittal

.1 Submittal in accordance with Section 01300
.2 Submit [one] [two] samples of each type of [masonry units] [coloured mortar] [connector] [accessory] [flashing].
.3 Submit ULC certificates verifying compliance with requirements for fire resistance rated concrete masonry units.

SPEC NOTE: Requirements to submit specific test reports verifying compliance with standards to be included in this section.

1.6 Quality Assurance

.1 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.
.2 Use installers having proven experience on similar projects.
.3 Construct sample panel of face masonry, approximately 1200mm by 1200mm, located on site where directed. Show use of units, mortar, jointing and coursing. The panel to be typical of materials and workmanship specified and to establish the acceptable standard for the project. Do not commence work on site until panel has been approved by the Architect.

1.7 Delivery, Storage and Handling

.1 Deliver Materials to job site in dry condition.
.2 Keep materials dry until use, store under waterproof cover on pallets.
.3 Protect masonry units from damage.

1.8 Environment Requirements

.1 Air temperature 0^o to 4^o: Heat sand or mixing water to a minimum of 20^oC and a maximum of 70^oC.
.2 Air temperature -4^o to 0^oC: Heat sand and mixing water to a minimum of 20^oC and a maximum of 70^oC.
.3 Air temperature -7^o to -4^oC: Heat sand and mixing water to a minimum of 20^oC and a maximum of 70^oC. Provide heat to both sides of walls. Use windbreakers when wind speed is in excess of 25 km/hr.
.4 Air temperature -7^o and below: Heat sand and mixing water to a minimum of 20^oC and a maximum of 70^oC. Provide enclosures and heat to maintain an air temperature above 0^o. Ensure that temperature of unit when laid is not less than -7^o.

SPEC NOTE: Heating enclosures and heat are not normally provided by the mason contractor but by the general contractor.

.5 At temperatures below 0^oC, grouting may proceed providing temperature of grout during placing is not less than 20^oC and grout in the wall is maintained above 0^oC for a 24 hour period.
.6 Brace masonry walls as necessary to resist wind pressure and other lateral forces during construction.

SPEC NOTE: The bracing of masonry walls during construction is not normally provided by the mason contractor but by the general contractor under his scope of work.

PART 2 PRODUCTS

2.1 Mortar & Grout Materials

.1 Mortar and Grout: To CSA A179-1994.
.2 Cement: Normal Portland, Type 10, to CAN3-A5-M83.
.3 Masonry Cement: to CAN/CSA-A8-93
.4 Hydrated lime: Type "S", to ASTM-C-207.
.5 Pigments for mortar colour: Metallic oxide.
.6 Mortar Aggregate: Washed, clean, sharp and free of organic materials and conform to CSA A82.56-M1976.
.7 Grout Aggregate: Clean, uncoated grains of sound material and conform to CAN3-A23.1-M90 with coarse aggregates passing a 10mm sieve.
.8 Water: Potable, free of deleterious matter and acids and alkalis.
.9 Admixtures for mortar shall not be used without approval.

SPEC NOTE: Ready mixed wet mortars, and pre-bagged dry mortars are also available.

2.2 Material Source

.1 Use brands of products and materials from the same source for the entire project.

2.3 Mortar Mixes

.1 Use Type S, mortar for structural masonry as per CSA A179-94.
.2 Use Type S or N, mortar for veneer masonry in accordance with CSA A179-94
.3 The proportion specification shall apply to field mixed mortar; the property specification shall apply to mortar manufactured off-site.
.4 Use mortar within 2½ hours after mixing. Retemper using minimum amounts of water.
.5 Coloured mortar: [% by weight] of [manufacturer] [colour #].

SPEC NOTE: Mortar can make up to 20% of the wall area. Mortar colour has a significant effect on the overall colour of the wall. Coloured mortar is usually used with coloured concrete block.

2.4 Grout Mixes

.1 Grout: Minimum compressive strength of 12.5 MPa at 28 days by cylinder test, by property specification as per CSA A179-94.
.2 Maximum aggregate size: 10 mm diameter.
.3 Grout slump: not less than 200mm and not more than 250mm.

SPEC NOTE: Tests on high slump grout formed in non-absorbent cylinders will yield relatively low compressive strengths. The in-the-wall strength will be substantially higher due to absorption of the extra water by the masonry units. This is recognized in the CSA A179-94 requirement of 12.5 MPa, which should provide approximately 20 MPa in-the-wall. This strength is compatible with standard strength, 15 MPa block, and with S304.1 requirements.

2.5 Brick Masonry Units

.1 FACE BRICK:
  .1 Face brick: To CAN3 A82.1M87. Grade SW, Type FBS.
  .2 Dimensions: [width] x [height] x [length].
  .3 Texture(s):
  .4 Special shapes: as detailed on architectural drawing and as listed [ ].
  .5 Solid brick: where necessary to avoid exposing brick cores.
  .6 All brick shall be manufactured in one continuous run to ensure minimum colour and texture variation.
  .7 Acceptable manufacturer and colour: [ ]

.2 HOLLOW BRICK:
  .1 Hollow brick: To CAN3 A82.8-M87, Type 1(H).
  .2 Dimensions: [width] x [height] x [length].
  .3 Texture.
  .4 Special shapes: as detailed on architectural drawings and as listed [ ].
  .5 All brick shall be manufactured from one continuous run to ensure minimum colour and texture variations.
  .6 Acceptable manufacturer and colour: [ ].

2.6 Concrete Block

.1 Concrete masonry units: To CAN3-A165.1-94 classification H /[15,20,25,30]/[A,B,C,D]/ M.

SPEC NOTE: Use four facet system H/15/A/M for hollow normal weight and strength units.

1st Facet - Hollow or Solid
2nd Facet - Strength 15, 20, 25, 35 MPa (15 MPa standard inventory strength)
3rd Facet - Density:
A - Normal, (sand & gravel).
B & C - Semi lightweight, (sand, gravel & pumice).
D - Light weight, (sand and pumice), generally used for 4 hr. fire rated block.
4th Facet - Moisture Controlled - M, O (no limits)

.2 Nominal dimension shall be [width] [height] [length], as shown on drawings.
.3 Profile pattern: [ ] as located on drawings.
.4 Acceptable manufacturer and colour: [ ].
.5 Fire rating: [2] [3] [4] hour Underwriter Laboratories Certificate is required for units as indicated on drawings.

SPEC NOTE: There are two ways to achieve fire ratings: by equivalent thickness as per the National Building Code; and by U.L.C. fire test ratings. The NBC method applies to all manufacturers and requires no certification. The higher ratings by the U.L.C. method are only available from certified manufacturers, and must be specified and confirmed on a project basis.

.6 Special shapes; as detailed on architectural drawings and as listed.

2.7 Reinforcing

.1 Steel reinforcement to CAN3-A371-94.
.2 Joint reinforcement; min. 9 ga. galvanized ladder type.
.3 For reinforced masonry requirements refer to structural drawings and specifications.

2.8 Connectors

.1 Masonry connectors to CSA A370-94. Veneer ties shall be [hot dipped galvanized] [stainless steel].

.2 Acceptable veneer tie(s) [ ]. Acceptable tie fastener(s) [ ].

SPEC NOTE: Stainless steel ties are only required for walls over 11m in B.C. coastal areas. For other applications hot-dipped galvanized ties are acceptable. Note that the spacing of ties under the 1995 National Building Code may increase, which may offset the installed cost of stainless steel ties.

2.9 Flashing

.1 Concealed flashing shall be [EPDM] [Modified Bitumen]. Acceptable product [ ] manufactured by [ ].

.2 Exposed flashing shall be [Stainless Steel] [Galvanized]

.3 Flashing sealants shall be as recommended by the flashing manufacturer.

.4 [Weep and vent holes shall incorporate [ ] vent devices.]

2.10 Masonry Cleaning Compounds

.1 Compatible with masonry unit and acceptable to unit manufacturer for use on their products.

.2 Acceptable manufacturer: [ ] Product [ ].

2.11 Water Repellent Coatings

.1 Compatible with masonry unit, and acceptable to unit manufacturer for use with their products.

.2 Acceptable manufacturer: [ ] Product [ ].

PART 3 EXECUTION

3.1 Examination

.1 Before starting the work, check that existing surfaces and adjacent building components are of acceptable condition and placement. Report any defects in writing to the Consultant. Commencement of installation constitutes acceptance of existing conditions.

.2 Examine drawings and coordinate installation of masonry with related sections so that this work can be performed with a minimum of cutting and patching.

3.2 Preparation

.1 Protect adjacent finished materials from damage due to masonry work.

3.3 Installation

.1 Construct masonry work to CAN3-A371-94 requirements and tolerances.

.2 Use 10 mm nominal thickness joint for concrete block and [12 mm] [10 mm] joints for brick.

.3 Provide horizontal and vertical joints of uniform thickness except where adjustments are necessary to maintain the bond pattern or to adjust coursing.

SPEC NOTE: Nominal thickness of the mortar joints can be adjusted in the field for coursing to meet desired elevations. Mortar joint thickness may also have to be adjusted on site to account for tolerances in brick sizing.

.4 Build in miscellaneous items such as bearing plates, loose angles, bolts, anchors, inserts, sleeves and conduits. Supply and lay-out of these items to be by others.

.5 Build around frames previously set and braced by others. Fill hollow frames within masonry walls with mortar or grout and embed anchors.

.6 Install special units as may be required to form corners, returns, offsets, reveals and indents without cut ends being exposed and without losing bond pattern or module.

.7 Fit masonry closely against electrical and plumbing outlets so that collars, plates and covers will overlap and conceal all cuts.

.8 Cull out all masonry units not complying with applicable CSA standards for chips, cracks, broken corners.

.9 Construct masonry walls using running bond unless otherwise noted.

.10 Use special shaped units, job cut or purpose made where specified or required.
.11 Connect interior masonry partitions at intersections by bonding, anchors or reinforcing.
.12 Maintain bond pattern below and above openings.

3.4 Installing Units

.1 Do not wet concrete masonry wall units during erection of walls.
.2 Hollow Units: Use face shell bedding with full head and bed joints. Minimize mortar protruding or dropping into core spaces.
.3 Solid Units: Use full bedding for head and bed joints. Avoid bridging of airspace between veneer and back-up wall by bevelling back edge of bed joint.
.4 Tamp units firmly into place.
.5 Closure units must receive "double buttering" to ensure full head joints.
.6 Do not reset masonry units after laying. Where resetting of masonry is required, remove and clean units and reset in new mortar.
.7 Exposed joints shall be [concave] [raked], strike concealed joints flush.

SPEC NOTE: Concave tooled joints provide the highest resistance to water penetration due to their shape, compaction and bond. Raked joints are not as weather resistant and are not recommended in moderate-to-high exposure situations.

.8 After mortar has initially "set up", tool all joints where required, wipe wall surface with suitable brush or burlap to remove mortar protrusions and re-tool the joints.
.9 On completion of masonry, fill all holes and cracks, remove loose mortar and repair defective work.

3.5 Installing Connectors

.1 Install anchors, ties and fasteners to the requirements of CSA A370-94.
.2 Space specified ties at [ ] horizontally [ ] vertically.
.3 Embed wire components of veneer ties at the centre of the veneer, $\pm$ 13mm.

3.6 Reinforcing and Grouting

.1 Reinforce and grout masonry walls as indicated on the structural drawings and specifications.
.2 Lay horizontal reinforcing bars on the webs of bond beam units.
.3 Install vertical reinforcing steel to have a minimum clearance of 13mm from the masonry, and not less than one bar diameter between bars.
.4 Install joint reinforcing at 400mm maximum spacing. Ensure a minimum of 150mm overlap.
.5 Notify the Engineer 24 hours before grout pours.
.6 Vertical cells in hollow units to be filled shall have vertical alignment to maintain a continuous unobstructed cell area not less than 50mm x 75mm. Remove any excess overhanging mortar or other obstruction and debris from inside of cell walls.
.7 Provide cleanout openings at the bottom of all cores containing reinforcement where such lift or grout pours are in excess of 1500mm in height. Seal the cleanouts before grouting, after inspection. Cleanouts may be omitted if approved provisions are made to keep the grout space clean prior to grouting.
.8 Consolidate grout by puddling or vibrating during pouring.
.9 Fill all cells containing embedment and anchor bolts solidly with concrete grout.

3.7 Flashing

.1 Install thru-wall flashing at any horizontal interruption of the cavity behind a veneer such as: above wall bases, shelf angles, loose lintels and wall openings; below sills of segmented units; and as shown on drawings.
.2 Lap ends minimum 100mm and seal using adhesive as specified. Flashing to be turned up a minimum of 150mm and attached to the back up wall behind the back-up membrane.
.3 Ensure that all flashing is watertight and that all water is led out through weep holes. If flashing is pierced, waterproof these points carefully.
.4 Create flashing "dams" at both ends of lintels, sills and at wall ends.
.5 Install flashing membrane where veneer units may contact the back-up wall, such as at a brick jamb return.
.6 Create weepholes at a maximum spacing of 600mm immediately above horizontal flashings by [leaving open head joints] [installing specified vent devices].

3.8 Movement Joints

.1 Install vertical and horizontal movement joints as shown on the drawings.

.2 Brick expansion joints are to be kept free of mortar, ready to receive a back-up rod and sealant.

.3 Block control joints shall be raked back, ready to receive a back-up rod and sealant.

3.9 Protection

.1 Keep masonry dry using waterproof, non-staining coverings that extend over walls and down sides sufficient to protect walls from wind driven rain, until completed and protected by flashing or other permanent construction.

.2 Protect completed masonry in accordance with CSA A370-94

3.10 Field Quality Control

.1 Field mixed mortar shall be inspected for adherence to proportions for type specified as per CSA A179-94.

.2 Grout specimens shall be sampled and tested as per CSA-A179-94 for compressive strength and slump.

.3 Co-operate with independent inspection agency appointed and paid for by the owner.

3.11 Cleaning

.1 Protect adjacent building finishes potentially vulnerable to stains or corrosion from the cleaning agent.

.2 Prior to full scale cleaning, confirm suitability of materials and methods by cleaning inconspicuous test area.

.3 Soak wall with clean water and flush off all loose dirt and mortar.

.4 Apply the specified cleaning agent in accordance with the manufacturer's direction.

.5 Rinse all areas thoroughly with clean water to remove all cleaning solutions, dirt and mortar residue.

3.12 Water Repellent Coating

.1 Prior to application, an inconspicuous test area shall be coated to confirm compatibility, and to establish typical coverage rate and method of application.

.2 A representative of the coating manufacturer shall inspect and approve the surfaces and conditions before commencing with the application of the water repellant coating.

.3 Apply to exterior wall surface in accordance with manufacturer's directions. Protect all adjacent materials which are subject to damage, such as roofing, window framing, glass, metal panels, and other exposed metal. Immediately clean off any glass or framing coated in accordance with manufacturer's directions.

3.13 Cleanup

.1 Remove all debris resulting from the work of this section into refuse bins provided. Leave floor in broom clean condition.

SPEC NOTE: Text shown in italics is commentary to the content of the notes, and not intended for inclusion in the printed Standard Notes. The Guide Structural Notes shown below are intended for walls where specific engineering requirements for reinforcement, grouting, strength, etc. are not required. Where such details are required, they should be identified specifically in the drawings and specifications.

1. Masonry design shall conform to CSA S304.1-94; Masonry Design for Buildings (Limit States Design)

2. Materials and work shall conform to the following standards:

Workmanship: CSA A371-94; Masonry Construction for Buildings

Concrete Block: CSA A165.1-94; Concrete Masonry Units,
H/15/A/M

Structural Clay: CAN3 A82.8-M87; Hollow Clay Brick,
Type 1(H)

Masonry Mortar: CSA A179-94; Mortar and Grout for Unit Masonry
Type 'S'
Site mixed by Proportion Specification
Pre-mixed by Property Specification

Masonry Grout: CSA A179-94; Mortar and Grout for Unit Masonry
12.5 MPa at 28 days by cylinder test
under Property Specification
Slump 200 to 250 mm

SPEC NOTE: Because a cylinder test for grout includes extra water, which would otherwise be absorbed in the masonry wall units, the test results will be lower than the actual in-the-wall grout strength. The latest CSA A179.94, therefore, recommends a 12.5 MPa value for cylinder tests, with the expectation that the in-place strength will exceed the typical block strength of 15 MPa, and will produce the necessary f'_m design strength. Local testing has shown in-place strengths over 20 MPa for 12.5 MPa cylinder strength grout.

Reinforcement: CAN/CSA G30.18-M92; Grade 400

Joint Reinforcing: CSA G30.5-M1983 (R1998); 3.8 mm (9 ga.)
galvanized ladder type

Masonry Connectors: CSA A370-94; Connectors for Masonry

Guide Structural Notes

REINFORCEMENT

3. Unless noted otherwise, provide minimum seismic reinforcement as follows:

Wall Thicknes	Loadbearing or Shear Walls	Non Loadbearing Walls
150mm	Vert: 15M @ 800 Horiz: 3.8mm Joint Reinf. @ 400 1-15M @ 2400 in Bond Beam	Vert: 15M @1200 Horiz: 3.8mm Joint Reinf. @400 1-15M @ 2400 in Bond Beam
200mm	Vert: 15M @ 800 or 20M @1200 Horiz: 3.8mm Joint Reinf. @ 400 2-15M @ 2400 in Bond Beam	Vert: 15M @ 1200 Horiz: 3.8mm Joint Reinf. @ 400 1-15M @ 2400 in Bond Beam
250mm	Vert: 15M @ 600 or 20M @ 800 Horiz: 3.8mm Joint Reinf. @ 400 2-15M @ 2400 in Bond Beam	Vert: 15M @ 1200 Horiz: 3.8mm Joint Reinf. @ 400 1-15M @ 2400 in Bond Beam
300mm	Vert: 15M @ 400 or 20M @ 800 Horiz: 3.8mm Joint Reinf. @ 400 2-15M @ 2400 in Bond Beam	Vert: 15M @ 1200 Horiz: 3.8mm Joint Reinf. @ 400 1-15M @ 2400 in Bond Beam

<u>SPEC NOTE:</u> Additional reinforcement may be required to resist specific load conditions, and should be shown clearly on structural drawings.

Dowels in foundation are to match vertical bars. Vertical bars shall be centred in the wall. Provide 1-15M vertical bar at each side of door and window openings; at ends, corners and intersections of walls; and at each side of control joints. Bond beams shall be provided at all floor and roof locations, and at the top of parapets.

4. Lap reinforcement as follows *(Under review)*:

Reinforcement	Joint	10M	15M	20M
Lap:	150	450	650	900

5. Provide 2-15M in lintels over openings
- Extend 600mm beyond edge of openings
- Lintel depth = 200mm up to 1.5M span
  400mm 1.6 to 2.4M span

<u>SPEC NOTE:</u> Lintels carrying concentrated loads or heavy floor loads should be specifically designed.

GROUTING

6. Notify the Engineer min. 24 hrs prior to grout pours

7. Cores to be grouted shall be kept clear of mortar fins

8. Fill all bond beams, parapets, reinforced cores and cores at anchor bolts or embeds with grout. Consolidate grout by puddling or vibration

9. Provide clean-outs at bottom of all reinforced cores for pours over 1.5 m

SPEC NOTE: Cleanouts are waived in some circumstances based on demonstrated provisions to keep the grout space clean prior to grouting.

10. Max. total pour height 4 m. Pours of 3m or less may be placed in one lift. Pours exceeding 3m shall be placed in max. 2m lifts.

SPEC NOTE: If cores are congested by heavy reinforcement the pour height may have to be reduced or double bond beams used.

CONTROL JOINTS

Unless noted otherwise, provide:

11. Vertical control joints at a maximum spacing of 15 m and 7.5 from corners. Mortar joints shall be raked back, ready for caulking

12. Bond beam reinforcing shall project from one side 300 mm through the joint into tight fitting tubes. Joint reinforcement shall be terminated.

SPEC NOTE: Bond beams used as diaphragm chords should be specifically detailed.

CONSTRUCTION

13. Masonry walls shall be laid in running bond; to tolerances for line, plumb, level and joints as per CSA A371-94. Nominal joint width 10 mm.

14. Exposed mortar joints shall be tooled concave, concealed joints may be struck flush.

15. Provide lateral top support to non-loadbearing walls as per details. Locate bond beams in second course from the top as shown.

16. Cold and hot weather construction to CSA A371-94 requirements.

17. Protect masonry during construction as per CSA A371-94

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.

Labour has 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 now become even more so. The masonry contractor needs to understand current practices and must be able to schedule the construction process around complex assembly requirements. This new certification program answers that need.

The Institute offers an advanced course for masonry contractors: Two modules, 12 hours of class and two exams must be successfully completed before the TMC designation is earned. Topics covered include engineering basics, building envelope science and masonry code requirements.

Have your masonry work done by certified masonry contractors starting January 2003 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."***

MODULE 1

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

CONSTRUCTION - A371

WALL TYPES & PROPERTIES
  - Single-wythe, Veneer
  - Thermal, Sound, Fire

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

MODULE 2

BUILDING SCIENCE
  - Air/Vapour movement
  - Thermal
  - Moisture

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

CLEANING & SEALING

QUALITY ASSURANCE
  - Inspection

SYSTEMS COMPARISONS
  - Costs

RETROFITTING

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.

MASONRY INSTITUTE OF BRITISH COLUMBIA

MASONRY INSPECTION CHECKLIST

Some items may not apply to all projects - November, 2000

MATERIALS - ITEM	DETAILS	NOT APPLIC.	CON-FORMS	DOCU-MENTED	NON-CONFORMING
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. Cement/Lime Type					
b. Specified Admixture Type, Colour					
c. Sand & Gravel to CSA A179					
d. 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, Conformance to CSA370					
8. REINFORCING: a. Rebar Grade & Size					
b. Joint Reinforcing Type, Width, Corrosion Resistance					
9. FLASHING & WEEP HOLE DEVICES: a. Specified Type					
b. Fastening & Sealing Material					
10. STEEL LINTELS - Specified Size, Corrosion Resistance					
11. EXP., CONTR. & FIRE JOINT MATERIALS Spec. Types					
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	NOT APPLIC.	CON-FORMS	DOCU-MENTED	NON-CONFORMING
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 Adequately Clear					
c. Spec. Joint Profile, Joints Properly Tooled, Re-tempering					
4. LAYING UNITS: a. Alignments & Joints					
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					
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 Joint 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 - Spacing & Size, Cleaned, Closed						
c. Consolidation, 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 Control & Expansion Joints / Type						
b. Vertical & Shelf Angle Expansion Joints Clear of Mortar						
c. Caulking Colour (by others)						
15. FIRESTOPPING - Location, Installed as Specified						
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:**________________

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 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 Canadian Masonry Contractors Association. 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									
		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
Effects of Moisture Penetration	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					