Best Practice Guide

Full Height Basement Insulation

Ontario
Ministry of Municipal Affairs and Housing

Ontario Home Builders' Association

NAIMA CANADA

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Legal Status

This Best Practice Guide for Full Height Basement Insulation is not a substitute for the Ontario's 2006 Building Code. While care has been taken to ensure accuracy, the examples and explanations in this guide are given for the purposes of illustration only.
Readers must refer to the actual wording of the Ontario's 2006 Building Code O. Reg. documents (O. Regs. 350/06, 423/06, and 137/07)
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This Best Practice Guide for Full Height Basement Insulation is not a "how to" manual. Proper implementation of certain concepts addressed in the manual may require professional design. This publication should not be relied upon as a substitute for construction, engineering, and/or architectural advice. The Manual does not represent government policy. The Ontario Ministry of Municipal Affairs and Housing does not assume responsibility for errors or oversights resulting from the information contained herein.

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Foreword

Basements represent somewhat of a paradox in the Ontario new home construction industry. They have traditionally been the source of frustration for builders and consumers. Tarion reports that each year a significant percent of basements are constructed with serious defects. Simultaneously, an increasing number of consumers demand and expect that their basements function with a high level of performance in terms of comfort, livability, and moisture control. As demand for high performance basements increases, builders will need to adapt their construction methods to satisfy their buyers.

Ontario's 2006 Building Code defines energy efficiency and resource conservation as a legislative objective. Basements represent one of the major sources of heat loss within a home. As the industry moves towards a mandatory requirement for full height basement insulation ("FHBI") a the end of 2008, there is an opportunity to build better performing basements.

Improved basement insulation means every new house built every year in Ontario is more sustainable and consumes less energy. Energy efficiency in housing has been identified by an overwhelming majority of consumers as an important issue. This guide will help home builders work to meet this growing demand.

Purpose of this Guide

The purpose of this guide is to help the Ontario new home construction industry install full height basement insulation ("FHBI"). In response to requirements in Ontario's 2006 Building Code. This guide presents a variety of approaches to constructing a high performance basement in consideration of varying soil conditions, water conditions, and climate. Solutions presented here, while satisfying minimum code requirements, also provide the builder with a degree of flexibility that leverages the builder's ingenuity.

This guide identifies key issues to help builders assess and respond to the unique building characteristics that can enhance basement performance.

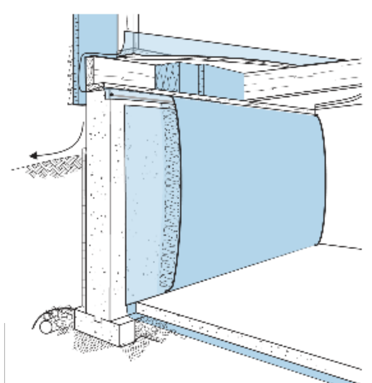


Fig. 1 High performance basement

Chapter 1

Introduction

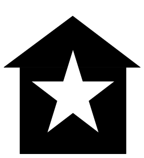
Introduction

Today's homebuyers are more aware of how space is used in their homes. The basement that in years past was largely unused except for storage or as utility space is seen today as potential living space. Creating a healthy, comfortable living space in the basement is a challenge for today's builders. Homebuyers are not willing to accept the damp, cold, wet, moldy basement of the past. They want a space that functionally performs like any above grade area in their home.

This guide is intended to help builders build the high performance basements that their customers want. The first step for any builder is to erect a basement that meets the Code minimum; however this guide goes beyond the minimum and introduces best practices stressing attention to detail and a firm understanding of materials, components, and systems and how they work together. Best Practices are identified throughout by a " ★ " symbol. This guide envisions basements that are not only healthier to live in, but are also well insulated and cost less to maintain. High performance basements mean healthier interior environments, reduced energy consumption, and a more durable and effective product.

A high performance basement is a collection of integrated systems. Interior and exterior components are designed to effectively respond to various soil, and climactic conditions. They are durable, cost-effective and capable of maintaining a dry, comfortable and healthy interior environment throughout the life-span of the home. The high performance basement balances initial capital costs with operating costs including those costs associated with heating, cooling, repair, and warranty. High performance basements strive to provide the best performance for the right price.

A high performance system protects the interior environment and maintains a level of comfort for the occupant. Moisture control, drainage, and frost protection are the primary concerns of the high performance basement. It responds to local soil conditions or in some cases it replaces native soils with engineered fills. A high performance basement works to control infiltrating moisture by simultaneously channeling rain or 'free' water downwards and away from the foundation, while also halting the wicking moisture. It predicts and protects against frost and the effects of freezing and thawing soils. It reduces the infiltration and exfiltration of air and other harmful gases from the surrounding soils. The basement must be capable of supporting the super-imposed loads of the structure above, while also resisting the lateral loads imposed by the surrounding soil, and the hydrostatic pressures of the water within the soil.



Best Practices are represented throughout this guide by the appearance of this symbol. These recommendations are not required by Ontario's 2006 Building Code, but are expert suggestions aimed at the reduction of commonly occurring problems in new home construction.

Best practice symbol Fig. 2

In a systems approach, potential problems are predicted and averted by applying a combination of materials and components that provide multiple layers of protection. Ultimately it is the builders responsibility to identify the risks associated with a particular site condition and select and execute the system that will best serve the safety and durability of the structure as well as the expectations of the homeowner.

To provide an effective system, an understanding of both common shortfalls and effective approaches is needed. Accordingly, this document proceeds from the general to the specific, beginning with Chapter 2 which extends beyond insulation and deals with common design and construction problems that can plague new home construction. With a general understanding of the these issues a builder can provide the best possible environment for the installation of full height basement insulation. Chapter 3 builds upon the general foundation provided by Chapter 2 and tackles the specifics of basements materials, components and systems, providing detailed information and illustration on how to provide a warm and comfortable basement while using a variety of common insulation and air sealing approaches. Finally, Chapter 4 concludes the document by Summarizing the various best practices in a single illustration.

Builders and other stakeholders from across the province have shared their experiences in developing this guide. They have contributed their know-how and their best practises. These builders have been successful in meeting the expectations of their discerning customers. Accordingly, this guide captures their valuable insights.

This document refers to all common materials, components, and systems by their generic names. Proprietary systems, comprising multiple components and materials may play a role in any high performance basement system, however, the choice ultimately belongs to the builder. For information on any systems referred to generically within this document builders should talk to their suppliers.

Note on proprietary systems

For the purposes of the document, "Full Height Basement Insulation" refers to Near Full Height Basement Insulation, according to Ontario's 2006 Building Code 12.3.2.4. (3), (4) which calls for insulation to be installed from the underside of the subfloor to the slab floor. A gap may be left at the base of the insulation, but no larger than 380 mm (15 inches) above the slab floor.

Note on full height basement insulation

All referenced articles and text excerpts from the Ontario's 2006 Building Code are taken from Division B of the Code, except where noted otherwise.

Note on Ontario's 2006 Building Code references used in this guide

When using this guide, readers should take care to read both the full extent of the text and carefully examine the images. Image and text are complementary components of the whole and must be understood together.

Note on the general use of this guide

Chapter 2

Design and Construction

Table 9.4.4.1.
Allowable Bearing Pressure for Soil or Rock
Forming Part of Sentence 9.4.4.1.(1)

Type and Condition of Soil or Rock	Maximum Allowable Bearing Pressure, kPa
Dense or compact sand or gravel	150
Loose sand or gravel	50
Dense or compact silt	100
Stiff clay	150
Firm clay	75
Soft clay	40
Till	200
Clay shale	300
Sound rock	500

....

9.4.4.3. High Water Table
(1) Where a foundation bears on gravel, sand or silt, and the water table is within a distance below the bearing surface equal to the width of the foundation, the allowable bearing pressure shall be 50% of that determined in Article 9.4.4.1.

9.4.4.4. Soil Movement
(1) Where a foundation is located in an area where soil movement caused by changes in soil moisture content, freezing, or chemical-microbiological oxidation is known to occur to the extent that it will damage a building, measures shall be taken to preclude such movement or to reduce the effects on the building so that the building's stability and the performance of assemblies will not be adversely affected.
(2) Any surcharge shall be in addition to the equivalent fluid pressure specified in Sentence (1).

Foundation Conditions: (9.4.4.)

Soils

Assessment and Identification

The relationship between a given basement system and the native soil around it is critically important. Each year a significant number of soil related claims are reported to the Tarion Warranty Corporation. Proper identification of potential soil related problems at the design stage can improve not only profit margins, but also help deliver a defect-free product.

Ontario contains a variety of soil types, from the Canadian Shield extending across the north of the province, to the mix of granular deposits of the Great Lakes lowlands. Identification and understanding of soil areas and types is essential for a successful builder. As stated by Dr. Karl Terzaghi in his 1943 book titled "Theoretical Soil Mechanics",

> "... our knowledge of the average physical properties of the subsoil and of the orientation of the the boundaries between the individual strata is always incomplete and often utterly inadequate."[1]

Successful builders usually follow normative approaches which rely solely on local experience and past performance on similar sites. In some cases, specific identification of soil types by area may be needed. The Ministry of Northern Development and Mines has published province-wide soil surveys that are easily available as well as many municipal maps that are often available through municipal engineering departments. Some of the necessary information can be attained from these free resources, however, consultation with more advanced sources such as engineering reports or detailed geological data may help to fill in the gaps between a working hypothesis and fact.

In general, there are two types of soils: fine grained and coarse grained. As a rule of thumb, coarse grained soils (cobbles, boulders, gravels, and sands) are good foundation soils, and drain freely. Fine grained soils (silts, and clays) are typically weak founding soils, because they are easily disturbed, and drain poorly. Subsequently these soils display a high potential for settlement problems. Builders may encounter unusual soil conditions which may require engineered foundation and/or fill design. Care and diligence should be taken by builders in such situations, to avoid costly repairs and delays.

Footing design tables in Part 9 of Ontario's 2006 Building Code assume a minimum bearing capacity of 75 Kpa. These tables should not be used for fottings on soils weaker than this.

Settlement

Every soil type behaves differently under long term loading resulting in variations in settlement beneath houses. Differential settlement is the most common foundation failure and is often preventable.

1. Terzaghi, Karl Dr. Theoretical Soil Mechanics. Cambridge: John Wiley and Sons. 1943.

Leda clays, typically found around Ottawa and in the St. Lawrence Valleys, are soft clays with low strength, that typically retain water, and consolidate when compressed. Large and often unpredictable settlement patterns are often observed in buildings built on leda clays. Building in soft clays often calls for special techniques such as pre-loading, the use of piles or reinforced 'raft' foundations. In all cases they require professional design.

Random fill soils often appear as a result of soils of unknown origin being moved from other locations. Generally, these soils are heterogeneous, without an easily identifiable structure, and often contain organic materials and/or other contaminants. Building directly on these soils can result in uneven settlement as well as off gasing from organic material.

Random fill should be removed if possible, or covered with a suitable layer of engineered fill which will bear the full weight of the structure. Sealing the slab with an impermeable barrier is also prudent, as off gasing can pass through the engineered fill. Professional design is normally called for.

Peat and organic soils are typically compressible, easily disturbed, and of a non-uniform composition. This makes them unsuitable to support building foundations. In addition they may contain combustible gases such as methane. Organic soils must be removed or replaced with an engineered fill. Measures may also be needed to control methane infiltration into the building from organic soils adjacent to a given site. Professional advice is recommended when these soils are encountered.

High Water Table

As a general rule, foundations should be built below the frost line, and consideration should be given to the level of the water table. Groundwater levels near the footings often require modifications to the footing size, installation of a waterproofing system and a means to resist the pressure from the water on the walls and slab. It could also mean a drainage system to dissipate the pressure from ground water. Professional design is normally recommended.

9.15.1.1. General

(3) Where a foundation is erected on filled ground, peat or sensitive clay, the footing sizes shall be designed in conformance with Sentence 4.2

(4) For the purpose of Sentence (3), sensitive clay means the grain size of the majority of the particles is smaller than 0.002mm (0.08 mil), including leda clay.

....

9.15.3.4. Basic Footing Widths and Areas

(1) Except as provided in Sentences (2) and (3) and in Articles 9.15.3.5. to 9.15.3.7., the minimum footing width or area shall comply with Table 9.15.3.4.

(2) Where the supported joist span exceeds 4.9 m in buildings with light wood-framed walls, floors and roofs, footing widths shall be determined according to,

(a) Section 4.2., or

(b) the following formula:

$W = w \cdot [\sum sjs / (storeys \cdot 4.9)]$

where,

W = minimum footing width,

w = minimum width of footings supporting joists not exceeding 4.9 m, as defined by Table 9.15.3.4.,

$\sum$ sjs = the sum of the supported joist lengths on each storey whose load is transferred to the footing, and

storeys = number of storeys supported by the footing

(3) Where a foundation rests on gravel, sand or silt in which the water table level is less than the width of the footings below the bearing surface,

(a) the footing width for walls shall be not less than twice the width required by Sentences (1) and (2), and Articles 9.15.3.5. and 9.15.3.6., and

(b) the footing area for columns shall be not less than twice the area required by Sentences (1) and (2), and Article 9.15.3.7.

....

Table 9.15.3.4.
Minimum Footing Sizes
Forming Part of Sentence 9.15.3.4.(1)

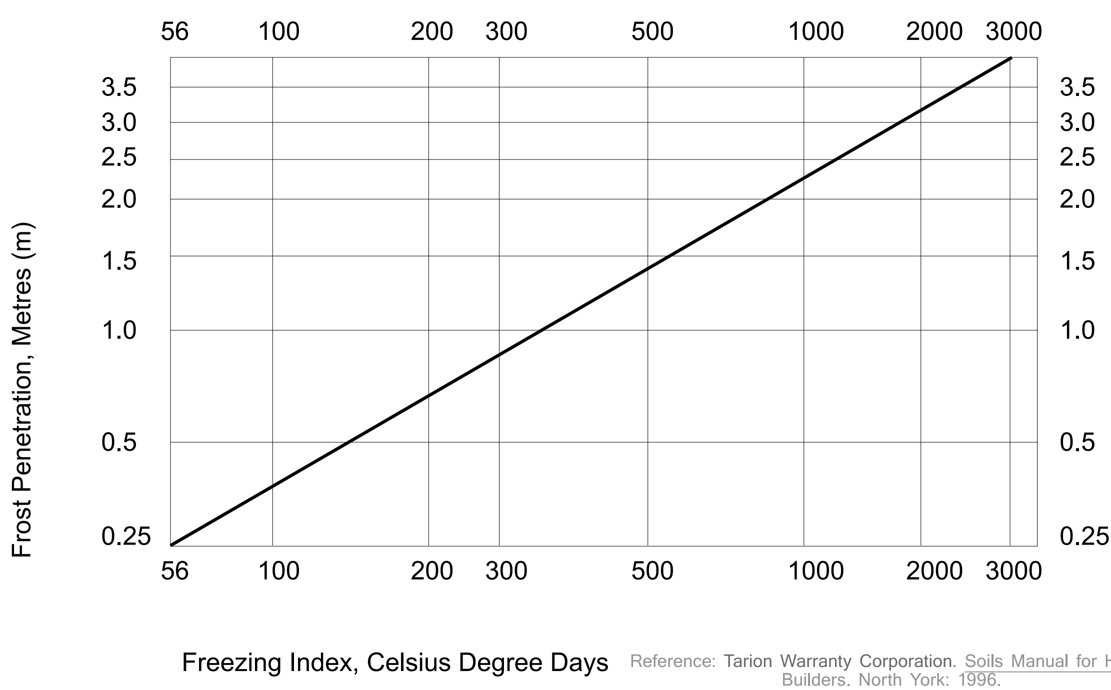
Column 1	Column 2	Column 3	Column 4
Number of Floors Supported	Minimum Width of Strip Footings, mm		Minimum Footing Area for Columns Spaced 3 m o.c.(1), m^2
	Supporting Exterior Walls(2)	Supporting Interior Walls(3)	
1	250	200	0.40
2	350	350	0.75
3	450	500	1.0

Notes to Table 9.15.3.4.:
See Sentence 9.15.3.7.(1). (1)
See Sentences 9.15.3.5.(1). (2)
See Sentence 9.15.3.6.(1). (3)

Footing and Foundations (9.15.1.1.)

Reference: Tarion Warranty Corporation. Soils Manual for Home Builders. North York: 1996.

Freezing index for Ontario **Fig. 3**



Reference: Tarion Warranty Corporation. Soils Manual for Home Builders. North York: 1996.

Frost depth by degree days **Fig. 4**

Footings, Frost and Backfilling

Frost Heave and Adfreezing

Heaving occurs when the wrong combination of fine grain soil, soil moisture, and soil temperature exists. In a fine-grained moist soil, a peculiar phenomenon occurs. At the freezing plane, water in the soil freezes into ice lenses. Water is drawn to the ice lens by wicking or capillarity from the unfrozen soil. Ice lenses are generally able to exert a sizeable uplifting, or "heaving" force, on foundations/footings leading to significant cracking.

In general, all footings should be built below the frost line to avoid significant heaving. Frost depths in particular areas can usually be determined by relying on past local experience and failing that, public data is available through Natural Resources Canada. Figures 3 and 4 can be used to calculate approximate frost depths across the province. Keep in mind that frost depth is typically proportional to the number of Celsius degree days. It should also be noted that foundation depths may be decreased where local experience has consistently shown that frost depths are less than the statistical estimates.

Frozen soil can also adhere to the outer surface of the foundation walls and footings and exert an upward force directly on the wall (Fig. 5). This is known as adfreezing. It can be particularly disastrous on concrete block foundations, pulling the individual blocks apart as soil lifts upwards.

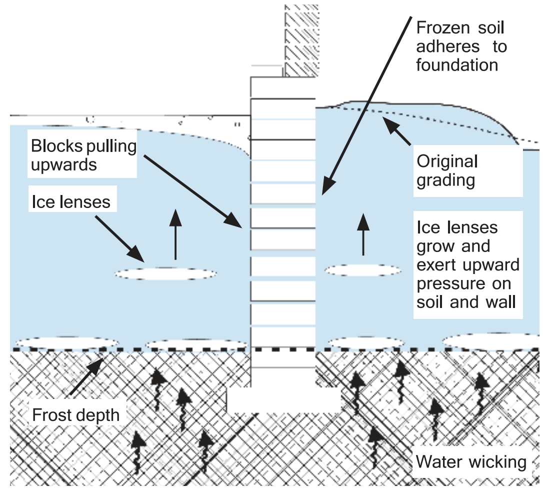


Fig. 5 Adfreezing

9.12.2.2. Minimum Depth of Foundations

(1) Except as provided in Sentences (4) and (5), the minimum depth of foundations below finished ground level shall conform to Table 9.12.2.2.

(2) Where a foundation is insulated in a manner that will reduce the heat flow to the soil beneath the footings, the foundation depth shall conform to that required for foundations containing no heated space.

(3) The minimum depth of foundations for exterior concrete steps with more than 2 risers shall conform to Sentences (1), (2) and (5).

(4) Concrete steps with 1 and 2 risers are permitted to be laid on ground level.

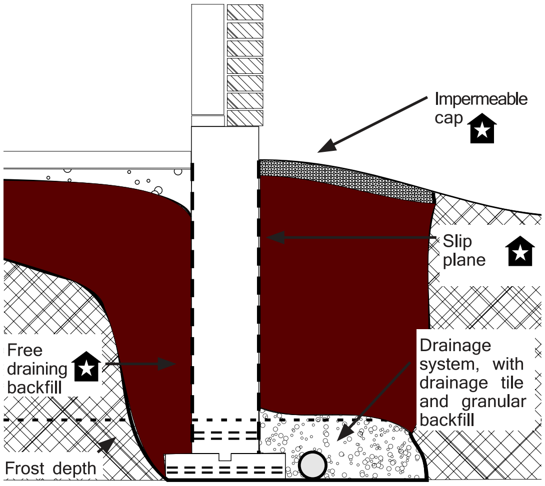
(5) The foundation depths required in Sentence (1) are permitted to be decreased where experience with local soil conditions shows that lesser depths are satisfactory, or where the foundation is designed for lesser depths.

Table 9.12.2.2.
Minimum Depths of Foundations
Forming Part of Sentence 9.12.2.2.(1)

Column 1	Column 2	Column 3	Column 4	Column 5
Type of *Soil*	Minimum Depth of *Foundation* Containing Heated *Basement* or Crawl Space(1)		Minimum Depth of *Foundation* Containing no Heated Space(2)	
	Good *Soil* Drainage(3)	Poor *Soil* Drainage	Good *Soil* Drainage(3)	Poor *Soil* Drainage
Rock	No limit	No limit	No limit	No limit
Coarse grained *soils*	No limit	No limit	No limit	Below the depth of frost penetration
Silt	No limit	No limit	Below the depth of frost penetration	Below the depth of frost penetration
Clay or *soils* not clearly defined	1.2 m	1.2 m	1.2 m but not less than the depth of frost penetration	1.2 m but not less than the depth of frost penetration

Notes to Table 9.12.2.2.:
(1)Foundation not insulated to reduce heat loss through the footings.
Including
(2) foundations containing heated space insulated to reduce heat loss through the
footings.
(3) Good soil drainage to not less than the depth of frost penetration.
(4) See Appendix A.

Depth of Foundations (9.12.2.1.)



Controlling frost **Fig. 6**

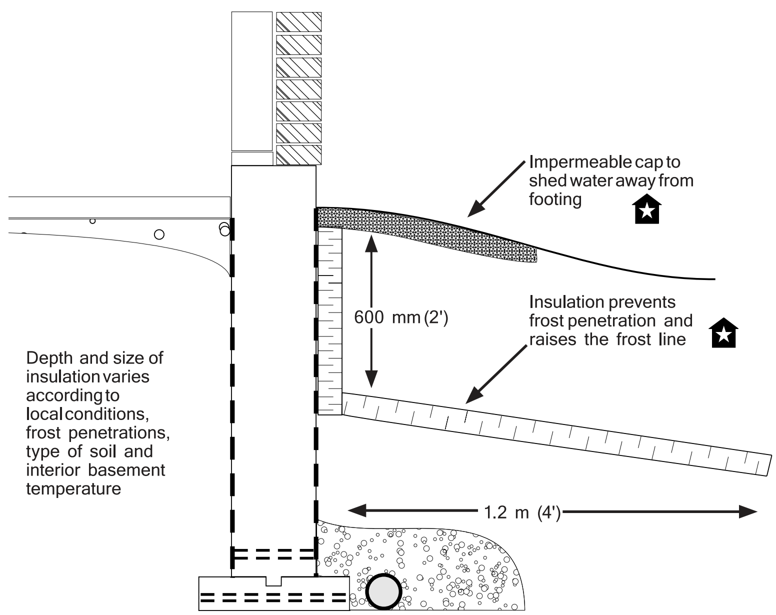
Silts and clays are typically not free draining and as a consequence display a high susceptibility to frost. When building in these soils special care needs to be taken to situate the footing well below the historical line of frost.

In order for frost heaving to occur, three conditions must be present:

1. frost susceptible soil
2. available water
3. freezing temperatures

Preventing frost related problems in the simplest manner involves controlling at least one of the three conditions for frost heaving. Ensure that foundations are below the frost line called for by soil conditions. Install an adequate and functioning drainage system with a properly graded backfill. This is the most important thing a builder can do to ensure that the soil around the foundation remains dry, and warm.

For poorly draining soils extra care should be taken to avoid frost (Fig. 6). For example, a granular backfill is one option builders may choose to reduce the possibility of ice formation. A more advanced solution involves insulating around the footing to artificially raise the frost line and keep soils warm and unfrozen (Fig. 7). Creating a slip plane is also an effective method to prevent ice from adhering to foundations (Fig. 6). These special solutions should be carried out as part of an overall engineered foundation system design.



Frost protected footing with impermeable cap **Fig. 7**

Backfilling

Proper backfilling is an important step in building a well functioning foundation system. Care and attention needs to be paid to both the method and materials used to backfill to avoid problems. The backfill soil should allow infiltrating water to drain to the drainage tile. The most common practice is to backfill with the native excavated soil, however a granular, or engineered backfill is sometimes required when native soils drain poorly. When native soil is used, all boulders (larger than 250 mm (10 inches) in diameter) must be removed from the backfill along with all construction debris and any materials that would decompose and lead to soil settlement. Any areas that are prone to settle will disrupt the slope of the final grading area and could cause pooling of water.

Proper backfilling loads the structure in such a way that the weight of the soil is safely distributed throughout the foundation. This involves backfilling first at the corners (proceeding around the foundation in a clockwise pattern), then along the shorter walls, and finally along the longer sections (Fig. 8). This practice will help prevent stress cracking during backfill, which can allow water infiltration.

When backfilling, soil should be carefully placed at the bottom of the trench so as not to disturb the drainage tile and granular cover. Backfill material should be placed gradually and uniformly in small lifts and compacted to an appropriate density. Heavy machinery and construction equipment should be kept at an adequate distance from the foundation. The backfill must not tear or damage the drainage membrane on the wall. Foundation walls should be adequately braced (ie. laterally supported by joists and subfloor) during backfilling unless they are designed as cantilevered reinforcing walls.

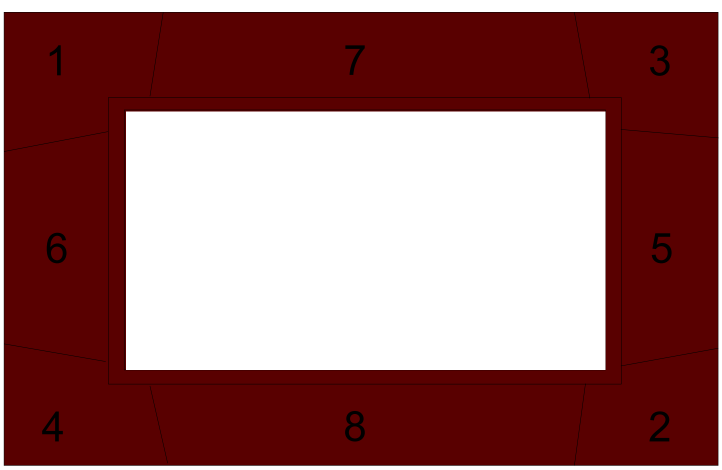


Fig. 8 Proper backfill method

9.12.3.1. Placement of Backfill

(1) Backfill shall be placed to avoid damaging the foundation wall, the drainage tile, drainage layer, externally applied thermal insulation, waterproofing and dampproofing of the wall.

9.12.3.2. Grading of Backfill

(1) Backfill shall be graded to prevent drainage towards the foundation after settling.

9.12.3.3. Deleterious Debris and Boulders

(1) Backfill within 600 mm of the foundation shall be free of deleterious debris and boulders larger than 250 mm diam.

(2) Except as permitted in Sentence (3), backfill shall not contain pyritic material or material that is susceptible to ice lensing in concentrations that will damage the building to a degree that would adversely affect its stability or the performance of assemblies separating dissimilar environments.

(3) Backfill with material of any concentration that is susceptible to ice lensing is permitted where foundation walls are cast-in-place concrete, concrete block insulated on the exterior or concrete block protected from the backfill by a material that serves as a slip plane.

9.12.3.4. Lateral Support of Foundation Wall

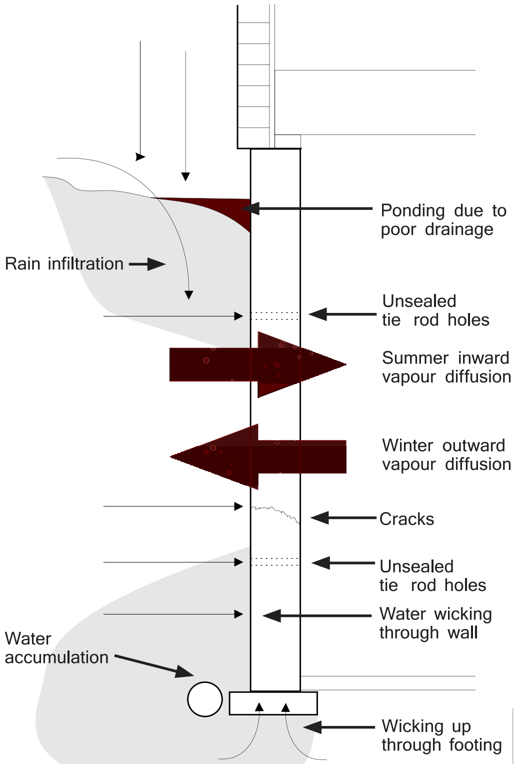
(1) Where the height of foundation wall is such that lateral support is required, or where the required concrete strength of the wall has not been reached, the wall shall be braced or laterally supported before backfilling.

Backfill (9.12.3.)

Moisture Control

Maintaining a dry basement requires that an effective strategy to deal with moisture be developed before the foundation is erected on site. Moisture interacts with a basement foundation in a number of ways:

Bulk Water: Refers to free water (ie, surface, rain, and/or melting snow, etc)
Ground Water: Water that infiltrates the soil as a water table and exerts a hydrostatic pressure against a foundation.
Capillary Water: Dampness from soil and/or moist concrete.
Ice: Frozen water in soil.
Water Vapour: Gaseous form of water found within air (in side/outside) and in soil.



Common leakage points **Fig. 9**

Typically there are a number strategies for handling moisture around a foundation. The drainage system, which includes foundation wall drainage, dampproofing, and drainage tile, controls and channels water away from a building, preventing water from migrating through the foundation to the interior. This approach seeks to avoid the unwanted accumulation of water against the foundation. On the other hand, waterproofing is intended to be a continuous and impermeable layer like the hull of a ship that isolates the foundation from a high water table.

Strategies to control capillary water involve surrounding the foundation with a continuously impermeable membrane that prevents the sponge-like concrete from soaking up surrounding water. High performance foundations will attempt to control the movement of water vapour by diffusion or air leakage.

Drainage Systems

Exterior drainage systems intend to drain water away from foundations and prevent accumulation which can penetrate to the interior. Gravel can provide effective draingage as can any number of proprietary systems that have been approved for use in Ontario.

Drainage Tiles

Drainage tile, commonly known as weeping tile, is placed around the footings and is intended to collect and direct infiltrating moisture to a sewer, sump pit, or dry ditch, in order to keep it from penetrating into the interior. Drainage tile should be placed on undisturbed and well compacted soil, with the top of the tile located below the bottom of the slab, and sloped towards a sewer or sump pit. Typically, 150 mm (6 inches) crushed stone covers the weeping tiles, which are also sometimes covered with a filter cloth, to prevent fine soils from clogging the pipe.

9.14.3.2. Minimum Size
(1) Drain tile or pipe used for foundation drainage shall be not less than 100 mm in diam.

9.14.3.3. Installation
(1) Drain tile or pipe shall be laid on undisturbed or well-compacted soil so that the top of the tile or pipe is below the bottom of the floor slab or crawl space.
(2) Drain tile or pipe with butt joints shall be laid with 6 mm to 10 mm open joints.
(3) The top half of joints referred to in Sentence (2) shall be covered with sheathing paper, 0.10 mm polyethylene or No.15 asphalt or tar-saturated felt.
(4) The top and sides of drain pipe or tile shall be covered with not less than 150 mm of crushed stone or other coarse clean granular material containing not more than 10% of material that will pass a 4 mm sieve

Foundation drainage (9.14.3.)

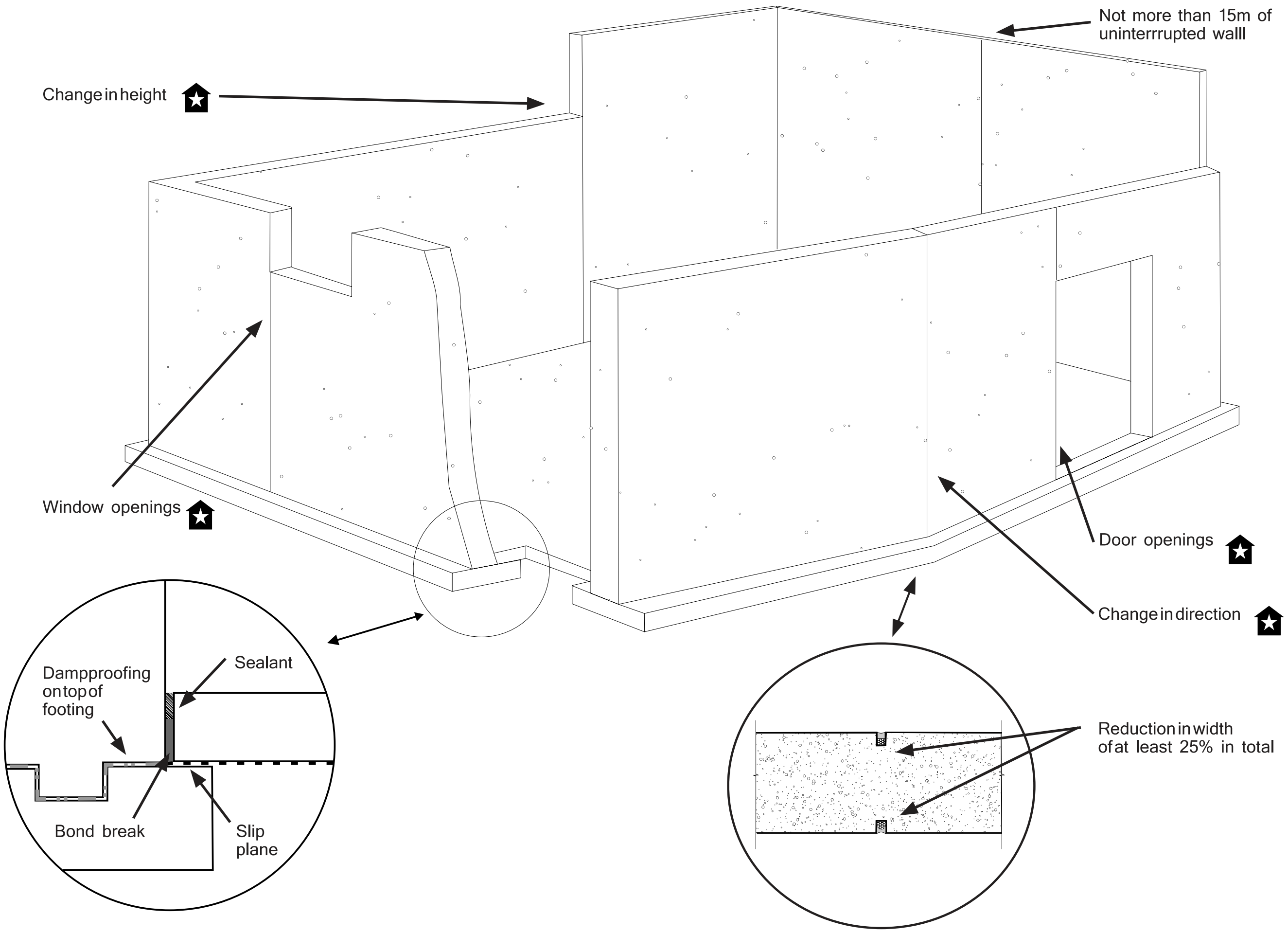


Fig. 10 Crack control joints

Crack Control Joints

During the curing process, cast-in-place concrete walls experience a significant amount of shrinkage which can lead to cracking in unpredictable and often unreachable locations. Control joints intentionally weaken the foundation wall and encourage cracking to occur at controlled locations that can be sealed from water infiltration as they are built. A system of control joints spaced not more than 15 m (44 feet 3 inches) apart and placed at any change of direction, height, or thickness and at wall openings induces cracking at these specific locations and permits sealing to avoid water penetration (Fig. 10). As a best practice the Canadian Standards Association recommends control joints every 5 m (16.5 feet).[2]

Ontario's 2006 Building Code requires control joints to be installed on wall sections longer than 25 m (83 feet) at intervals not more than 15 m (44 feet 3 inches). Control joints are formed by decreasing the width of the foundation wall by at least 25 percent (Fig. 11) to induce cracking at specific locations where cracking is likely to occur. Installing a flexible gasket or other sealant within the joint controls water penetration when the wall does crack.

2. Concrete Construction for Housing and Small Buildings. CAN/CSA-A438-00. 2000

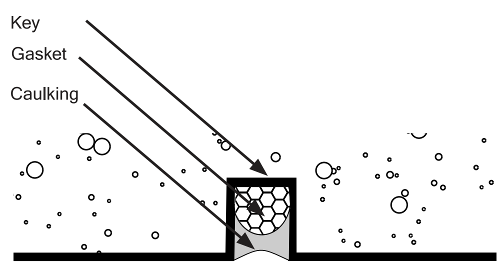


Fig. 11 Detail: control joint

9.15.4.9. Crack Control Joints

(1) Crack control joints shall be provided in foundation walls more than 25 m long at intervals of not more than 15 m.

(2) Joints required in Sentence (1) shall be designed to resist moisture penetration and shall be keyed to prevent relative displacement of the wall portions adjacent to the joint.

Crack control joints (9.15.4.9.)

9.14.4.1. Type of Granular Material

(1) Granular material used to drain the bottom of a foundation shall consist of a continuous layer of crushed stone or other coarse clean granular material containing,

(a) not more than 10% of material that will pass a 4 mm sieve, and

(b) no pyritic material in a concentration that would adversely affect its stability or the performance of assemblies separating dissimilar environments.

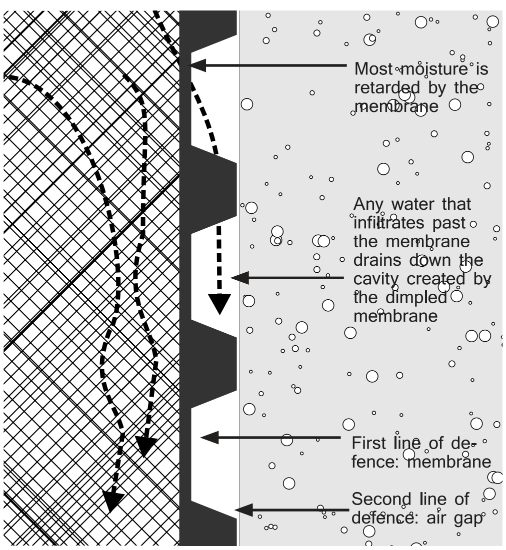
9.14.4.2. Installation

(1) Granular material described in Article 9.14.4.1. shall be laid on undisturbed or compacted soil to a minimum depth of not less than 125 mm beneath the building and extend not less than 300 mm beyond the outside edge of the footings.

9.14.4.3. Grading

(1) The bottom of an excavation drained by a granular layer shall be graded so that the entire area described in Article 9.14.4.2. is drained to a sump conforming to Article 9.14.5.2.

Granular drainage protection (9.14.4.)



Section through an air gap membrane **Fig. 12**

Granular Drainage Protection

Ontario's 2006 Building Code requires not less than 150 mm (6 inches) of crushed stone or similar coarse grained materials be placed on top of the drainage tile to prevent it from being plugged by fine soil particles from the backfill that can migrate down with the migration of rain water. The granular layer provides a buffer between the native soil and the drainage tile allowing water to freely percolate down to the drainage tile without fear of clogging the pipe.

Geo-Textile Protection

When building in areas known to contain poorly draining soils an extra layer of protection is often required to prevent clogging of the drain tile. A geo-textile can be installed on top of the required granular over the drain tile. While this layer does increase the cost of the drainage system, it is a wise approach to ensure a durable drainage system, and avoid a costly remedial.

Sealing Tie Rod Holes

Tie rod holes represent a common source of water infiltration (Fig. 9) as they are often not adequately sealed. Proper care of tie rod holes involves removing all ties from the hole and filling the hole with non-shrink grout. Alternatively, many proprietary products are available to deal with tie rod holes.

Parging

Parging represents the first line of defence against water infiltration. ‘Sealing’ a wall with a parge coat does not provide a waterproof coating over the foundation but rather is intended to fill cracks at masonry joints in block foundations. Parging provides a smooth and uniform coating, similar to cast-in-place concrete, that sheds water instead of allowing it to accumulate and penetrate through openings, and indentations.Parging is not necessary for cast-in-place concrete walls.

Wall Drainage Systems

Wall drainage is an important part of the foundation drainage system. It not only provides a capillary break between the foundation wall and the soil, but also offers a drainage pathway for any water that does penetrate past the membrane. It decreases the likelihood of water infiltration through the foundation wall to the building interior.

There are a variety of wall drainage products on the market, some of which also provide exterior insulation. The most common systems however, are simple rolls of dimpled plastic membrane which are literally wrapped around the foundation and terminated at grade. The membrane (Fig. 12) provides a first line a protection against water infiltration. A second line of protection is provided by maintaining an air gap between the membrane and the foundation wall. Sealing the top of the membrane prevents surface ground water and organic material from getting behind the membrane and degrading its performance. A number of proprietary interior drainage products are available and can be effective in providing interior foundation wall drainage particularly in retrofit situations.

Interior Dampproofing

Interior dampproofing or moisture barriers are materials applied on the inside of a foundation wall to prevent wicking of water from the concrete to wood studs which may rest up against the concrete or unit masonry foundation wall. Water that can wick by capillarity from the concrete to unit masonry into the lumber could lead to wood decay and mold formation. Applying a moisture retarder on the inside face of a foundation wall creates a capillary break that isolates wooden members from any moisture. Providing a 12 mm (1/2 inch) air space can be equally effective.

9.13.2.6. Interior Dampproofing of Walls
(1) Where a separate interior finish is applied to a concrete or unit masonry wall that is in contact with the soil, or where wood members are placed in contact with such walls for the installation of insulation or finish, the interior surface of the foundation wall below ground level shall be dampproofed.
(2) The dampproofing required in Sentence (1) shall extend from the basement floor and terminate at ground level.
(3) No membrane or coating with a permeance less than 170 ng/(Pa.s.m^2) shall be applied to the interior surface of the foundation wall above ground level between the insulation and the foundation wall.

Interior dampproofing (9.13.2.6.)

Dampproofing

The capillary structure of concrete and unit masonry allows it to absorb and release large quantities of moisture to the inside of the basement. Concrete, acts much like a sponge when it comes into contact with wet soil or water that is allowed to pond against it during construction. Wicking water makes concrete feel damp and can cause wood or other materials to decay if they come in contact with it.

9.23.2.2. Protection from Decay
(1) Ends of wood joists, beams and other members framing into masonry or concrete shall be treated to prevent decay where the bottom of the member is at or below ground level, or a 12 mm air space shall be provided at the end and sides of the member.
(2) Air spaces required in Sentence (1) shall not be blocked by insulation, vapour barriers or air tight materials.

Protection from decay (9.23.2.2.)

A basic strategy to combat wicking moisture is to install a capillary break between the soil and the foundation wall. This strategy ensures that moisture bound within the capillary 'pores' of the soil cannot migrate into the pores of the foundation wall. This can be provided in a variety of ways, but the most common approach is to simply apply a layer of moisture impermeable material like liquid asphalt to the exterior. Referred to as Dampproofing, the material isolates the concrete from contact with the soil. Dimple plastic wall drainage systems can also provide effective dampproofing as the plastic membrane acts as a capillary break.

An area that is often overlooked in terms of capillarity is the top of the footing. Similar to the way a tree can wick from the soil, a footing can wick water up from the soil underneath it. Before dampproofing, a shear key should be laid in the top of the footing immediately after it is poured. The key is necessary to develop the desired resistance to lateral loads applied by the soil[3]. Dampproofing the top of the footing (Fig. 13) helps eliminate moisture within the foundation wall.

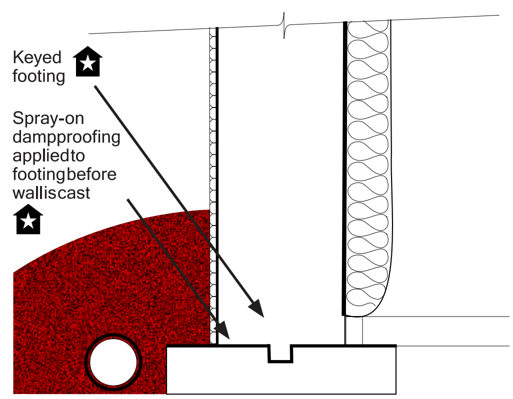
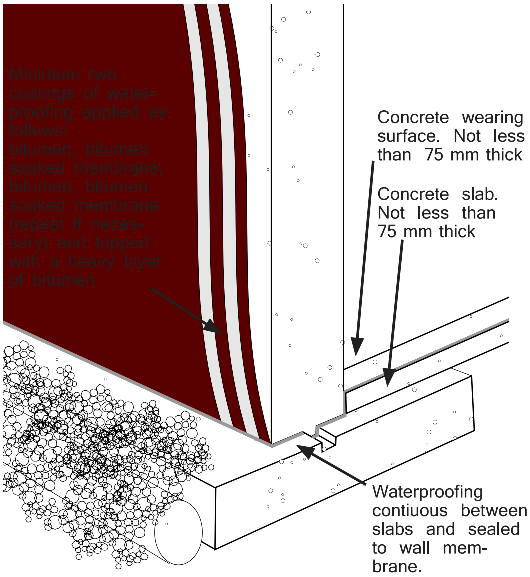


Fig. 13 Dampproofed footing

3. 1999 Code and Construction Guide for Housing. Ontario Ministry of Municipal Affairs and Housing and Tarion Warranty Corporation. Toronto. 1998. [2-10].



Waterproofed footing **Fig. 14**

9.13.3. Waterproofing
9.13.3.1. Required Waterproofing

(1) Where hydrostatic pressure occurs, waterproofing is required for exterior surfaces of,
(a) floors-on-ground, and
(b) below ground walls, where the exterior finished ground level is at a higher elevation than the ground level inside the foundation walls.

(2) Roofs of underground structures shall be waterproofed to prevent the entry of water into the structure.

....

9.13.3.4. Preparation of Surface

(1) Unit masonry walls that are to be waterproofed shall be parged on exterior surfaces below ground level with not less than 6 mm of mortar conforming to Section 9.20.

(2) Concrete walls that are to be waterproofed shall have all holes and recesses resulting from removal of form ties sealed with mortar or waterproofing material.

(3) The surface of insulating concrete form walls that are to be waterproofed shall be repaired and free of projections and depressions that could be detrimental to the performance of the membrane to be applied.

9.13.3.5. Application of Waterproofing Membranes

(1) Concrete or unit masonry walls to be waterproofed shall be covered with no fewer than 2 layers of bitumen-saturated membrane, with each layer cemented in place with bitumen and coated overall with a heavy coating of bitumen.

9.13.3.6. Floor Waterproofing System

(1) Basement floors-on-ground to be waterproofed shall have a system of membrane waterproofing provided between 2 layers of concrete, each of which shall be not less than 75 mm thick, with the floor membrane mopped to the wall membrane to form a complete seal.

Waterproofing (9.13.3.)

Sub-slab moisture control

Dampproofing the underside of the basement slab usually consists of a sheet of 0.15 mm (6 mil) polyethylene laid before the floor slab is poured (with all joints overlapped a minimum of 100 mm (4 inches) (9.13.2.7.)). The polyethylene reduces wicking up through the foundation, and in the event of a crack, the sheeting is effective in isolating the crack from soil gas infiltration. Alternatively, a 25 MPa concrete is allowed by Ontario's 2006 Building Code as an option for controlling below slab moisture.

Waterproofing

Waterproofing seeks to completely isolate the foundation walls from the inward hydrostatic pressure of a high water table. Waterproofing systems typically rely on an engineered systems approach that features a sump pump, to control rising water levels.

Typically, layers of bitumen are applied followed by a bitumen soaked membrane, and this is repeated no fewer than two times, and finally covered with a heavy coating of bitumen (Fig. 14). For concrete block structures the procedure is the same except a layer of parging is first applied to the exterior to provide a smooth surface for the bitumen to adhere to. A successful system relies on multiple levels of protection acting together.

Under foot, a slab of minimum 75 mm (3 inches) (9.13.3.6.) is cast and a waterproofing membrane is laid on top. This membrane must be laid between the footing and wall, and tied into the exterior waterproofing system to create a continuous 'hull' throughout the basement. Finally a concrete 'wearing' surface of equal thickness is cast over the floor membrane to create the final interior floor. There are also numerous proprietary systems designed and marketed to feature all-in-one construction and rapid application. In all cases structural reinforcement is required to resist the pressure from the high water table. As well, a system that relieves the water pressure is also often called for.

Vapour Barriers

All foundation wall assemblies must be provided with a barrier to retard the diffusion of water vapour. Vapour barriers need to be installed over thermally insulated components to retard vapour diffusion from the interior. They should always be installed on the warm side of the insulation and need not be air tight unless they also act as air barriers.

All vapour barriers must have a vapour permeance of no greater than 60 ng /(Pa•s•m^2). Materials with suitable vapour permeance are numerous. Polyethylene sheeting is among one of many membrane type products commonly used for vapour protection. Extruded polystyrene insulation at time can also provide a suitable level of protection. Another approach involves applying a coating of vapour retarder paint to the inside of the drywall. All systems must be installed according to 9.25.4.2. of Ontario's 2006 Building Code.

Site Grading and Drainage

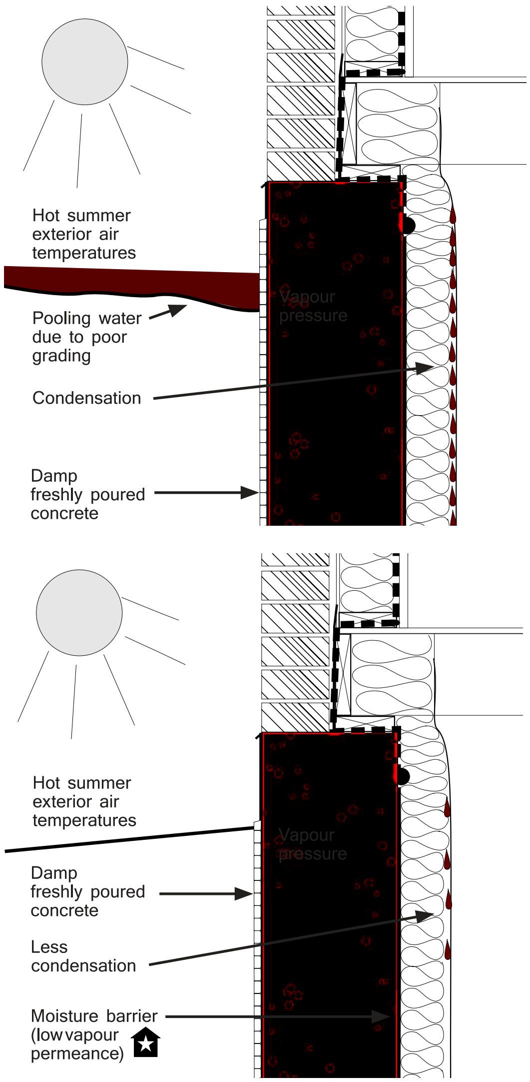
Poor site drainage can result in ponding, and uneven settlement. While builders must be careful to maintain drainage away from the foundation throughout construction, successful site drainage is the product of diligent planning that for the most part is not complete until the final stages of construction.

In most cases drainage systems create an 'apron' around the perimeter of the house directing all free water down and away from the envelope. It is suggested that builders maintain a minimum 5% slope around the house for the first 1.5m (5 feet) and 1.5% slope for the rest of the property. Free water is diverted in all directions away from the structure to either local drainage systems, or to depressed areas meant to collect and control free water. Splash pads play a key role in creating this apron as they direct free water from downspouts away from the foundation. Splash pads should extend a minimum of 1 metre (3 ft) away from the envelope in order to be effective. A "swale" or small ditch is needed to direct water towards the street or back line of the lot. In general, swales should run the length of both sides of the lot line (between houses), be at least 6" deep and sloped at least 3 to 1 towards the street and/or back lot.

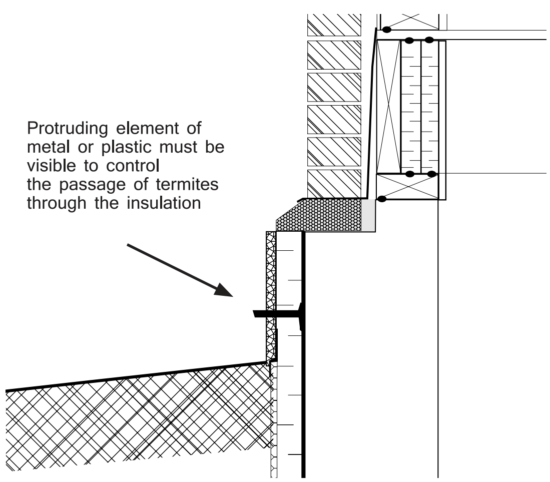
Proper drainage is often difficult between houses where densities are high, and space between them minimal. Diverting water from two adjacent, closely-spaced structures is often overwhelming for simple sloped drainage systems. Special attention needs to be paid to site drainage particularly in these difficult situations.

Generally speaking successful site drainage system should follow these guidelines:

- Foundation walls should be minimum 150 mm (6 inches) above the finished grade.
- Splash pads should be installed under every downspot and ex tend a minimum of 1m (3 feet) away from the foundation.
- Structures should be built a minimum 0.5 m (1.5 feet) above street level.
- A minimum 1.5% slope should be maintained across the entire site and a slope of 5% be maintained around the house for the first 1.5m (5 feet).
- Swales should be dug a minimum of 150mm (6 inches) deep.
- Swales should maintain a slope of at least 3 to 1 to the street and/or back lot.
- Surface drainage must be directed away from window wells, stairwells, and walk-outs.
- Grading should be performed early and often.
- The final grading should be carried out with great care and diligence.



Vapour permeance and moisture barriers **Fig. 15**



Termite barrier **Fig. 16**

Summertime Moisture Control

Freshly cast-in-place foundation walls normally contain thousands of litres of water. Excess moisture can be a problem, particularly in the first few months after the foundation is poured. Foundation walls also readily wick up water from the soil and from free water that may pond against them as a result of poor grading practices. Rain that hits the foundation wall can also be absorbed. When the sun strikes the foundation wall it can heat the wall and drive litres of water into the buildings interior by vapour diffusion (Fig. 15). On average, it takes between one and two years for the excess water within a "green" concrete foundation wall to dry out.

On a hot summer day, when the sun strikes the foundation wall water vapour pressure can build up drive water vapour towards the cool basement interior where it condenses on the foundation side of the polyethylene.

Air leakage also plays a role as warm moist outside air is driven through unintentional openings in the header assembly. The infiltrating air pushed by wind can penetrate air permeable insulations and cause condensation on the foundation side of the polyethylene vapour barrier.

Summertime moisture problems can be controlled by recognizing the mechanisms that drive moisture through foundation walls and by taking the right steps to avoid problems. These include:

- proper initial grading to avoid water ponding next to the foundation wall,
- ensuring dampproofing or drainage layers extend above grade,
- ensuring a capillary break exists between the footing and the wall,
- ensuring a proper air barrier is installed at the header,
- allowing where possible the cast-in-place concrete foundation wall to dry out before installing the vapour barrier.
- installing a low vapour permeance membrane (eg. polystyrene, 2 mil polyethylene, building paper, etc.) against the interior of the foundation wall below grade.

Termite Protection

In areas known to have termites, where a foundation is insulated using an exterior insulation that could conceal the passage of termites between the soil and the sill plate, a special termite barrier must be installed (Fig. 16) according to Ontario's 2006 Building Code (9.3.2.9.). This metal or plastic barrier must be installed above grade and protrude through the insulation forcing termites out of the insulation and making them visible to see. Other more active methods for preventing termite infestation are also available. Expert advice is always recommended when dealing with termites.

Preventing Air Leakage

In wintertime, air leaking out of the building (exfiltration) can carry with it heat and moisture. This leakage can result in increased potential for condensation on cold envelope components as it exfiltrates. Air that infiltrates in winter is often cold and dry and can make the basement space uncomfortable particularly as a living space. In summertime infiltrating air brings with it heat and humidity and can cause occupant discomfort and condensation. Uncontrolled air leakage also makes effective ventilation difficult. Taken together, these concerns make controlling air leakage a priority in modern buildings.

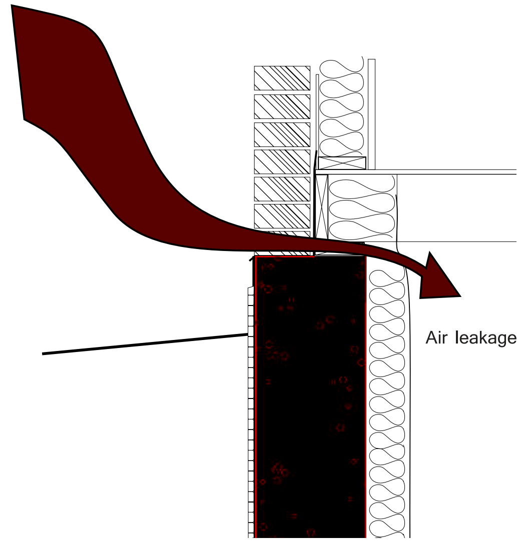


Fig. 17 Wind driven infiltration at the header

Typical Sources of Air Leakage

Generally, the number one source of air infiltration in new homes is located at the top of the foundation wall (Fig. 17). Other sources of air leakage in basements are found around the edges of the slab and around floor drains and sump pits in the slab. Air that can enter the interior from under the slab is troubling because it may carry soil gases which can adversely affect occupants.

Air Barriers

Air barrier materials must have an air permeance of less than 0.02 L/(s•m^2) @ 75 Pa. Common materials include 0.15 mm (6 mil) polyethylene, house wrap, plywood, and numerous other proprietary products. Regardless of the material actually used, all joints and discontinuities must be sealed. The air barrier system is a continuous system of envelope materials and components that together resist air leakage. For example, a header wrap can be connected with acoustical caulking to the foundation wall (which is sealed at the slab) (Fig. 18) to create an air barrier system. Any number of approaches can be devised to provide air tightness. The air barrier system must also be durable and be able to resist wind and structurally induced loads that may occur.

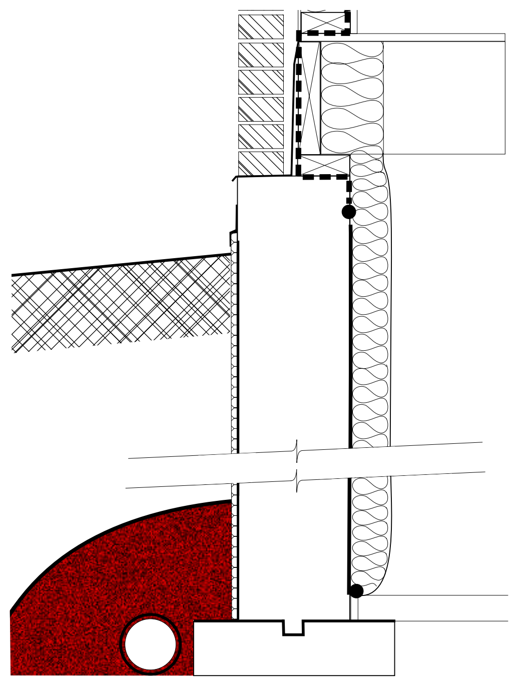


Fig. 18 Sealed foundation wall and header

Header Systems

Header wraps are often used to provide continuity at the junction between wood framed floor systems and the concrete foundation wall. Other systems for sealing this area include creating a structural air barrier by caulking the joints between framing members and the top of the foundation wall. Rigid polystyrene foam placed vertically between the foundation wall and the subfloor and caulked at both ends is a very popular approach in the Atlantic provinces. Finally, spray foam insulation applied to the header cavity between the top of the foundation wall and subfloor has also been proven to provide a suitable level of air tightness. These four systems are among the many, different approaches used by builders across the nation. Corners are always a challenge and require special care to ensure air barrier continuity. Header wraps, for example should overlap a minimum of 100 mm (4 inches) at the corner and be continuously sealed near the end of the each piece.

Controlling Heat Loss

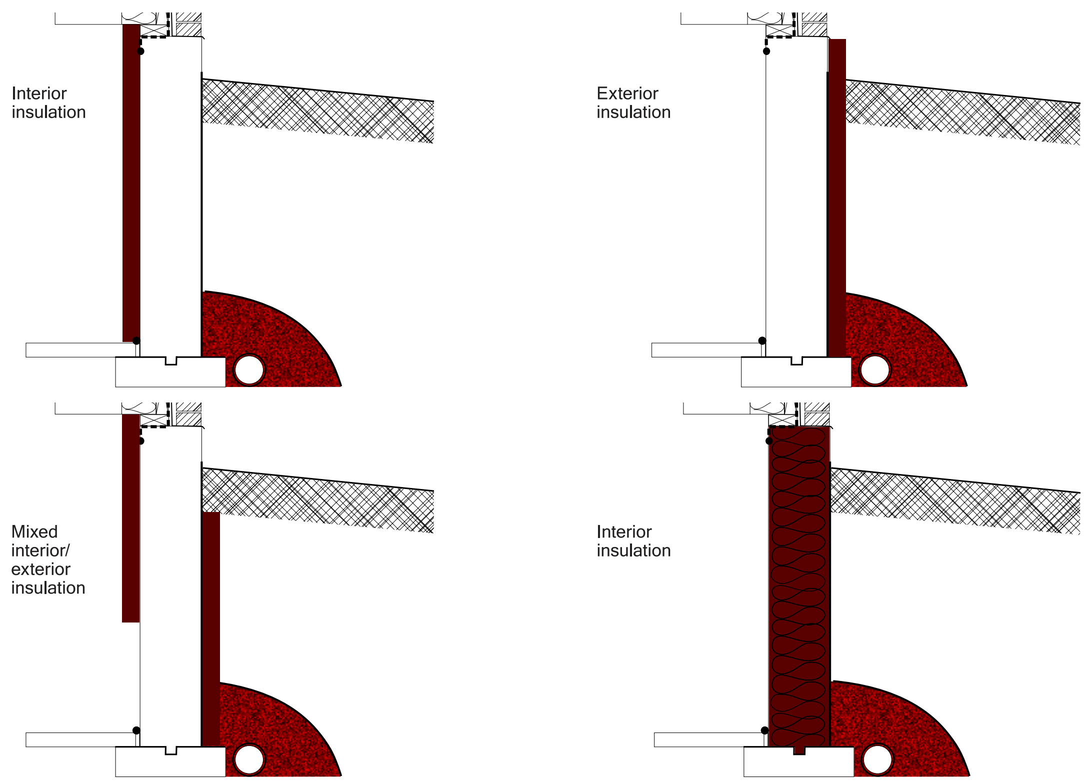
Insulation as Part of the Envelope as a Whole

Insulation represents the primary method to control heat loss within a building. Insulation separates heated spaces from unheated spaces. Insulation also helps to reduce the incidence of condensation, and reduce energy consumption and operating costs.

Ontario's 2006 Building Code requires that foundation walls separating heated spaces from unheated space have a thermal resistance rating RSI 2.11 (R12), and RSI 3.34 (R19) for houses with electric space heating. Until December 31st 2008, insulation should be installed to extend not less than 600 mm (2 feet) below the grade. After December 31st 2008, all basement insulation should be installed from the underside of the subfloor to the slab floor. A gap may be left at the base of the insulation, but no larger than 380 mm (15 inches) above the slab floor. For crawl spaces insulated with an insulation that may be damaged by water, a 50 mm (2 inches) clearance between the bottom of the insulation and the slab is required.

Popular Full Height Insulation Options

There are numerous approaches commonly used in insulating foundations:



Insulation placement options **Fig. 19**

Heat Loss Through the Foundation

While the majority of heat is lost above grade through the envelope. Heat is also lost to the soil through conduction. However, soil is an insulator and the deeper the soil the more insulation it will provide. Less heat is lost the longer the path of travel, in other words the more insulative material that is has to pass through (Fig. 20).

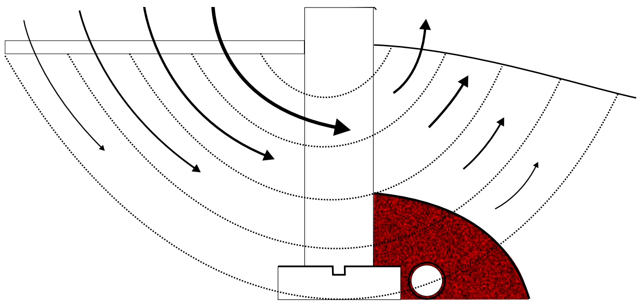


Fig. 20 Heat loss through the foundation

For slabs on grade heat loss can be reduced through a number of insulation placement options, or combinations of options (Fig. 21) which aim to obstruct the heat flow path.

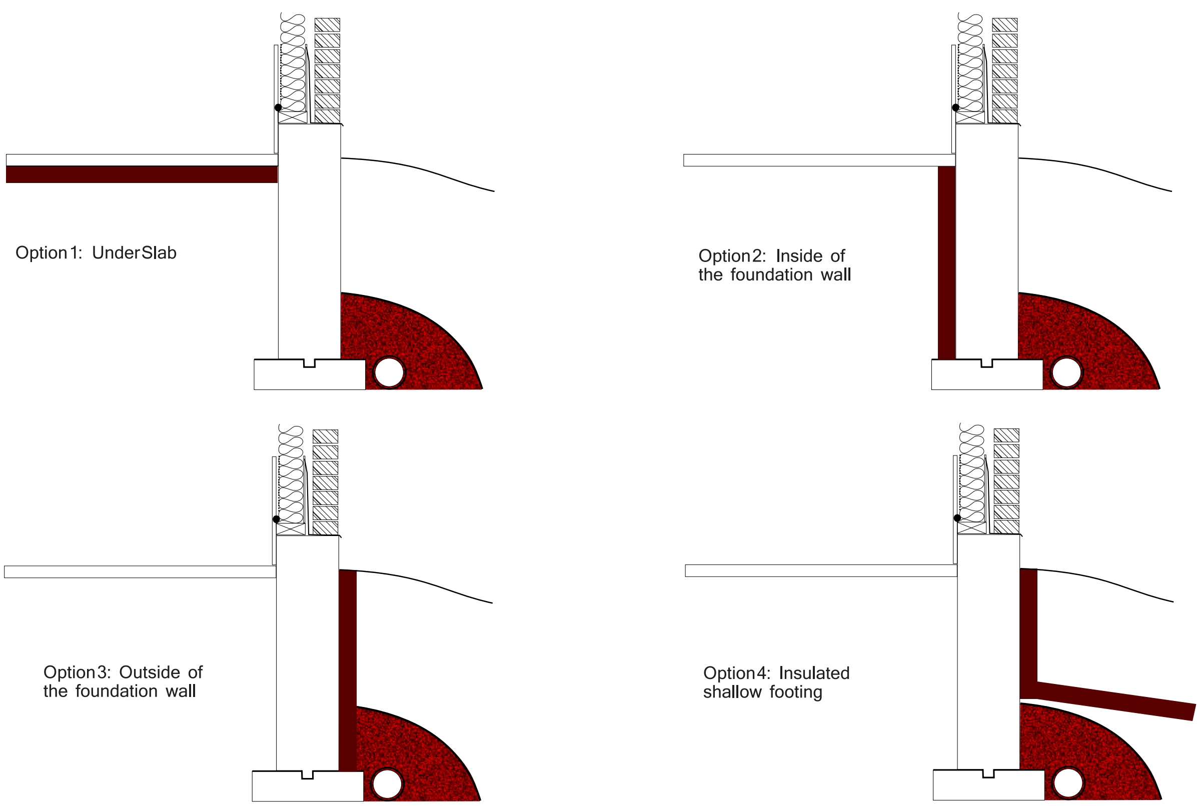
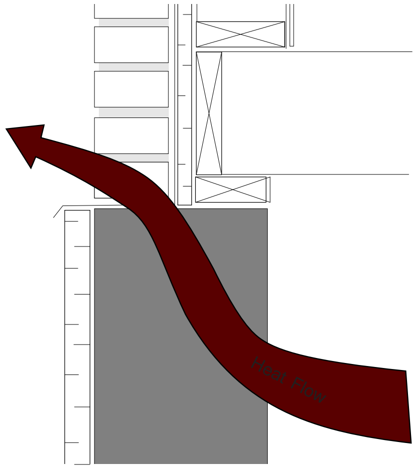
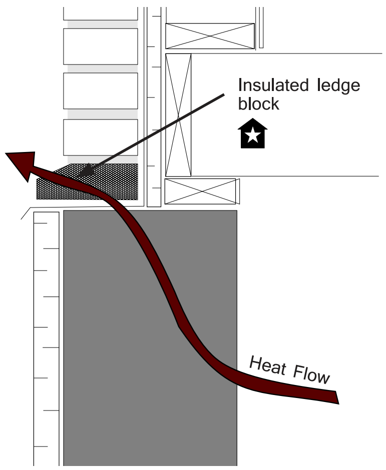


Fig. 21 Options for insulating slabs on grade



Thermal bridging through a foundation wall **Fig. 22**



Reducing thermal bridging **Fig. 23**

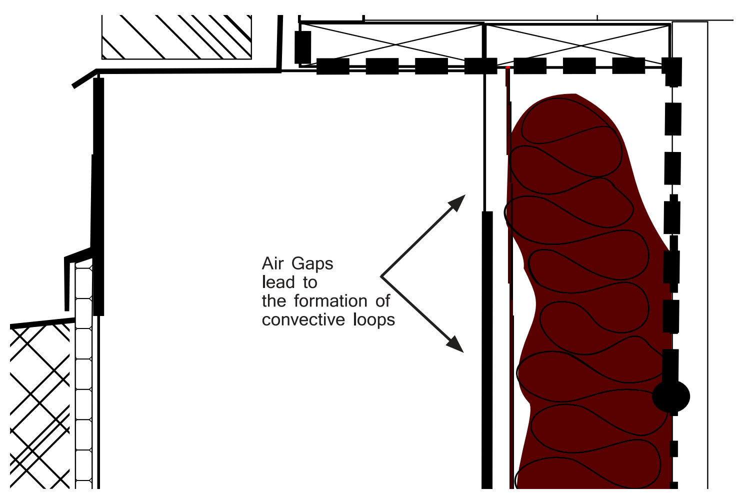
Thermal Bridging

Thermal bridges are paths within a building envelope that allow heat to move through an assembly essentially short-circuiting the insulation. Bridges are formed at points of discontinuous insulation where conductive materials and components are in contact with both warm interior elements and cold exterior components. Aside from increased heat loss, thermal bridges can contribute to discomfort, increased condensation, and the degradation of interior finishes.

A common thermal bridge in foundations occurs when exterior foundation insulation is used and masonry construction or brick veneer is supported by the foundation wall (Fig. 22). The warm foundation wall loses heat strongly through the thermal bridge created at the base of the veneer. Using an insulating block or brick reduces heat loss through this bridge (Fig. 23).

Heat Loss by Convection

In general, insulation should be installed continuously along the full length and width of an envelope separating a heated space from an unheated one. It must maintain uniform and continuous contact with the one surface of low air permeance. Batts of insulation in particular must be installed so that they are in continuous contact with the wall. Air that is able to move around the insulation will reduce its ability to act as insulation (Fig. 24). Gaps as small as 10 mm (1/2 in) can cause convective currents within mineral batt insulation that will reduce its effectiveness. Foam insulation must also be installed with care to minimize cracking and dents in rigid foam boards. All foam plastic products that form part of a wall or ceiling assembly must be protected by gypsum board, plaster, plywood, hardboard, insulating fibreboard, particleboard, OSB, waferboard or a thermal barrier that meets the requirements of Ontario's 2006 Building Code.



Incorrect insulation in a frame wall **Fig. 24**

Radon: Harmful Soil Gases

The high performance basement aims to provide a healthy and comfortable living space within the basement. This means a tighter envelope, which minimizes air exchange with exterior air and soils.

In general, there are two commonly occurring and harmful gases (9.13.4.) found in soils that builders must guard against. The first of these is radon, a radioactive element found in trace amounts in some parts of the province. Long-term health risks due to exposure to even small amounts of radon are of great concern. The second is methane, an explosive gas that is given off as organic material decays. In areas where either of these gases are identified measures must be taken to protect occupants from exposure.

Where either of these two gases are known to represent a danger to the occupants, builders must comply with Supplementary Standard SB-9. If required, a soil gas barrier must be installed at walls, roofs, and floors in contact with the ground. In the basement, a soil gas barrier must be installed below the slab with all joints overlapped a minimum of 300 mm (12 in). All joints between footing and wall must be sealed in conjunction with this barrier. As well, all other penetrations through the slab, including drain pipes and sump pits should be sealed. Where soil gas levels exceed the Canadian Action Level[4] for radon content, a subfloor depressurization system is required.

Subfloor Depressurization

For homes that have been built in areas identified as having soil gas problems (see SB-9), an active method is required to control gas infiltration. Subfloor depressurization uses fans to create a negative pressure below the slab drawing soil gas up through a duct to the outdoors, reducing the likelihood that soil gas enters the basement (Fig. 25). The basement should be sealed as an adjunct to depressurization. Proprietary systems are also available that can be erected inside the foundation using framed walls and sleeper floors, creating a depressurized cavity on the interior of the entire foundation and space for infiltrating water to drain down. This space is sealed and mechanically ventilated to the exterior by fans. These systems create an extra line of defence that is actively monitored and vented. As a result, these systems may reduce the infiltration of soil gases and help control foundation moisture, and mold growth.

When installed, Ontario's 2006 Building Code requires that any air that is removed from beneath the slab be replaced by make-up air. Ontario's 2006 Building Code also requires that a depressurization system does not lower the soil temperature below the slab nor adversely effect the soil composition in such a way as to undermine the durability of the foundation as a whole (SB-9, 10 (b)). These systems typically require professional design to ensure the system works as intended.

It should be noted that under normal circumstances the air barrier systems is the primary defence for the interior against soil gas infiltration. Depressurization systems to a great extent depend on a properly installed air barrier along the basement floor.

4. Exposure Guidelines for Indoor Residential Air Quality. Health Canada. HC H 49-58. Ottawa. 1987.

9.13.4.1. Soil Gas Control

(1) Where methane or radon gases are known to be a problem, construction shall comply with the requirements for soil gas control in Supplementary Standard SB-9.

9.13.4.2. Required Soil Gas Control

(1) Except as provided in Sentence (2), all wall, roof and floor assemblies in contact with the ground shall be constructed to resist the leakage of soil gas from the ground into the building.

(2) Construction to resist leakage of soil gas into the building is not required for,

(a) garages and unenclosed portions of buildings,

(b) buildings constructed in areas where it can be demonstrated that soil gas does not constitute a hazard, or

(c) buildings that contain a single dwelling unit and are constructed to provide for subfloor depressurization in accordance with Supplementary Standard SB-9.

(3) Where soil gas control is required, a soil gas barrier shall be installed at walls and roofs in contact with the ground according to Supplementary Standard SB-9.

(4) Where soil gas control is required, it shall consist of one of the following at floors in contact with the ground:

(a) a soil gas barrier installed according to Supplementary Standard SB-9, or

(b) where the building contains a single dwelling unit only, a subfloor depressurization system installed according to Supplementary Standard SB-9.

Soil gas control (9.13.4.)

Subfloor Depressurization

1) Except as required in Sentence (3), granular material shall be installed below the floor-on-ground according to Sentence 9.16.2.1.(1).

2) A pipe not less than 100 mm in diameter shall be installed vertically through the floor, at or near its centre, such that

a) its bottom end opens into the granular fill described in Sentence (1), and

b) its top end will permit connection to depressurization equipment.

3) The granular material described in Sentence (1), near the centre of the floor, shall be not less than 150 mm deep for a radius of not less than 300 mm centred on the pipe described in Sentence (2).

4) The upper end of the pipe described in Sentence (2) shall be provided with a removable seal.

5) The pipe described in Sentence (2) shall be clearly labelled to indicate that it is intended only for the removal of soil gas from below the floor-on-ground.

6) Except as provided in Sentence (8), when a building constructed in accordance with Sentences (1) to (5) is complete, testing shall be conducted according to EPA 402-R-93-003, "Protocols for Radon and Radon Decay Product Measurements in Homes," to determine the radon concentration in the building.

7) A copy of the results of testing required in Sentence (6) shall be provided by the building owner to the authority having jurisdiction.

8) The testing required in Sentence (6) shall include basement concentration measurements.

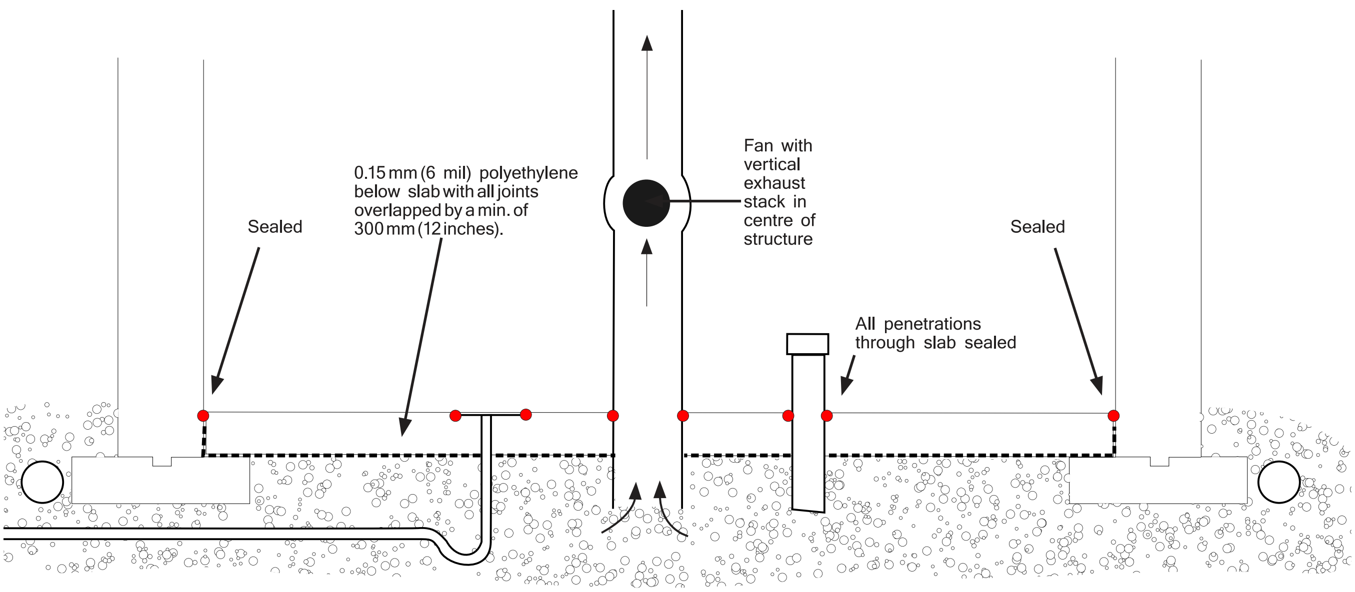
9) Where the radon concentration determined as described in Sentences (6) and (8) exceeds the Canadian Action Level for radon in residential indoor air, as specified in HC H46-2/90-156E, "Exposure Guidelines for Residential Indoor Air Quality," a subfloor depressurization system shall be installed to reduce the radon concentration to a level below the Canadian Action Level.

10) Where a subfloor depressurization system is installed,

a) makeup air shall be provided as specified in Article 9.32.3.8., and

b) measures shall be taken to ensure that any resultant decrease in soil temperature will not adversely affect the foundation.

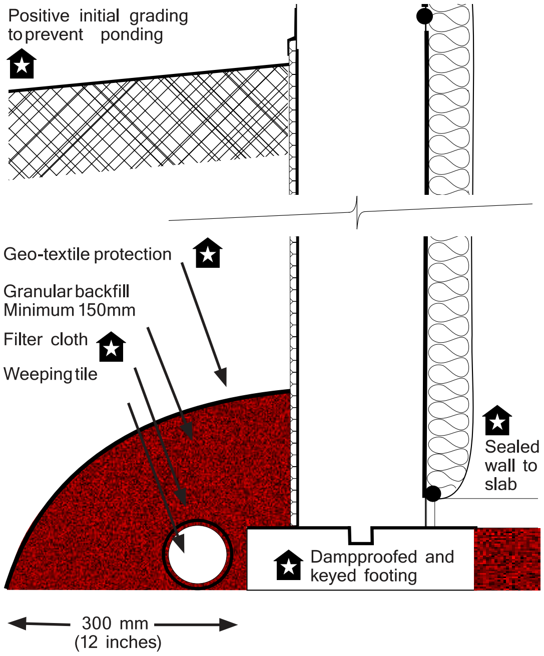
Subfloor Depressurization (SB-9)



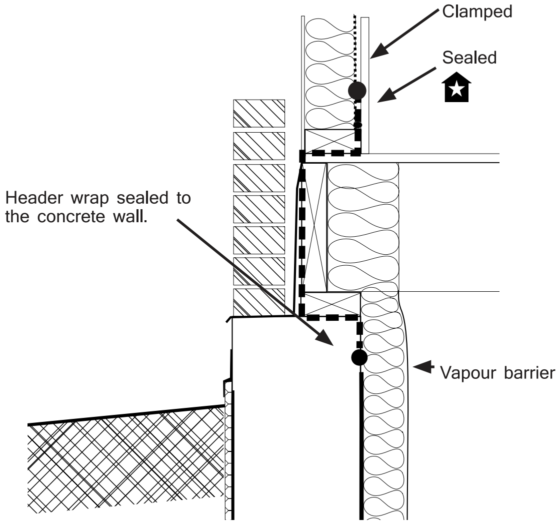
Subfloor air depressurization system **Fig. 25**

Chapter 3

Materials, Components & Systems



Best drainage and capillarity practices **Fig. 26**



Best air sealing practices **Fig. 27**

Best Practices

Drainage

a) Install drainage layer to extend above grade, seal the top (Fig. 26)
b) Install sloped drainage tile covered in filter cloth (Fig. 26)
c) Use appropriate granular cover over the drainage tile (125mm (4 7/8in) extending at least 300mm (1') outside the footing) , with a geo-textile layer over the granular (Fig. 26)
d) Slope initial grade away from foundation to prevent ponding

Capillarity Water

a) Apply dampproofing to top of footing (Fig. 26)
b) Apply dampproofing over entire exterior wall (Fig. 26)
c) Provide capillary break under slab (Fig. 25)

Adfreezing

a) Apply a slip plane to the exterior of the foundation wall to prevent ice from adhering.

Air Sealing

a) Ensure header is properly sealed:
if using header wrap, tightly seal bottom of the header wrap to the top of the foundation wall or air/vapour barrier (Fig. 27)
b) Clamp the top of the header wrap to above grade air barrier or better yet seal it with acoustical sealant to the above grade walls air/vapour barrier (Fig. 27)
c) Exterior air barrier systems (e.g. house wrap) need to connect to the concrete foundation wall
d) Concrete block walls should utilize an interior air barrier at the foundation wall. (e.g. interior polyethylene) which is continuous and sealed to the slab.
e) Ensure the slab is sealed to the foundation wall (Fig. 26)

Moisture Barrier

a) Interior dampproofing installed above grade must have a vapour per meance of not less than 170 ng/Pa•m^2•s. Below grade, Ontario's 2006 Building Code (9.13.2.6.) requires interior dampproofing to be applied, or a 12 mm (1/2 inch) air space be maintained extending from the slab to just above grade if wood framing is used against the foundation wall.
b) Install a low vapour permeance membrane that terminates at grade to reduce summertime inward vapour diffusion in all systems (Fig. 28).

Insulation

a) Ensure insulation is installed without gaps or air space between it and the foundation wall (Fig. 28)
b) Ensure it is applied to the correct thickness in the header space.
c) Ensure insulation provides the appropriate R-value for its intended application and that the height is in accordance with OBC Article 12.3.2.4. (Fig. 28)

Vapour Barriers

a) Ensure the vapour barrier covers all thermally insulated components on their wintertime warm side and is properly installed in the header space areas.

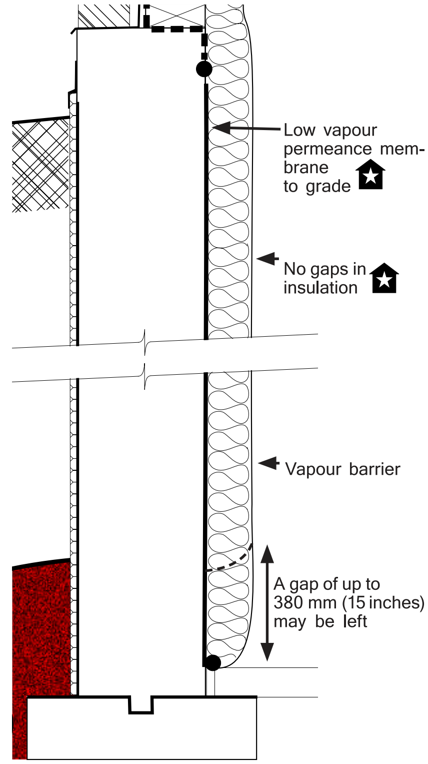


Fig. 28 Best insulation and moisture practices

12.3.3.9. Foundation Wall Insulation

(1) Sentence (2) applies to construction for which a permit has been applied for before January 1, 2009.

(2) Foundation walls enclosing heated space shall be insulated from the underside of the subfloor to not less than 600 mm below the adjacent exterior ground level.

(3) Sentence (4) applies to construction for which a permit has been applied for after December 31, 2008.

(4) Foundation walls enclosing heated space shall be insulated from the underside of the subfloor to not more than 380 mm above the finished floor level of the basement.

(5) Insulation applied to the exterior of a slab-on-ground floor shall extend down at least 600 mm below the adjacent exterior ground level or shall extend down and outward from the floor or wall for a total distance of at least 600 mm measured from the adjacent finished ground level.

Foundation Wall Insulation (12.3.3.9.)

Insulating a New Home

As poured-in-place concrete cures, moisture is driven from the material (especially in summertime). Much of the moisture moves inwards and becomes trapped by the polyethylene and appears as condensation.

In general, there are a few things builders can do to minimize potential moisture problems with freshly poured foundations:

Insulate late: Builders should wait as long as possible before applying insulation to a freshly poured concrete foundation wall.

Finish with the seasons: Typically, basements finished in the late winter and early spring show considerable moisture problems. Those poured in early spring and finished in late summer or poured in late summer and finished in the fall rarely show problems. If possible, builders should avoid insulating newly poured concrete during the hottest months.

Air condition wisely: In many cases air conditioning in the basement is a contributing factor to condensation. Limiting air conditioning use during the first summer of occupancy may help reduce condensation.

Don't water concrete: If workability of the concrete is an issue, avoid adding water to the mix, as this extra moisture will eventually be expelled into the interior the house. Super plasticizers are one option for increasing on-site workability without adding moisture.

Insulation Materials

In new home construction, a limited number of materials provide the primary resistance to heat loss. Each material behaves differently in different environments. Each has come to be used within specific applications. Ontario's 2006 Building Code requires that foundation walls separating heated spaces from unheated spaces must have a minimum thermal resistance rating of RSI 2.11 (R12), and RSI 3.34 (R19) for houses with electric space heating in. Until December 31st 2008, the insulation must be installed to extend from the underside of the subfloor to not less than 600 mm (2 feet) below grade. After December 31st 2008, all basement insulation must be installed to extend from the underside of the subfloor to the slab floor. A gap may be left at the base of the insulation, but no larger than 380 mm (15 inches) above the slab floor.

Fibreglass Batts and Blankets

Fibreglass is a lightweight and easily installed insulation. The material is inexpensive, and widely available. If the insulation comes in contact with moisture, its thermal performance can be compromised. Similarly, if air is allowed to circulate behind the insulation, thermal resistance is diminished. Installed batts also must not be compressed. They must be installed with one face in uniform contact with an air barrier material to reduce the likelihood of convection currents through the material. When installing fibreglass in a crawl space builders must allow 50 mm (2 inches) clearance between the bottom of the batt and the slab to avoid water damage.

Rigid Polystyrene

There are a variety of rigid polystyrene board insulations: Expanded type 1, 2, or 3 and Extruded type 2, 3, or, 4. Expanded polystyrene is referred to generically as beadboard and is generally less moisture resistant than extruded.

Extruded polystyrene products are composed of closed cells and are better suited to wet environments, particularly below grade. Extruded (XPS) boards meet the Code requirements for air barrier materials, expanded polystyrene (EPS) products do not. All four types of polystyrene must be protected by a covering that meets the requirements of Ontario's 2006 Building Code (e.g. drywall). Some polystyrene products are resistant to vapour flow and provide adequate vapour protection, while other foam products may require a separate vapour barrier to be installed in addition. The product manufacturers should be consulted to better match specific needs to product characteristics.

Spray Foam

Spray foam insulation products combine a custom fit with the air resistance qualities of rigid foam. Spray foam is available as a medium density rigid material or a low density semi flexible product. The two products differ in density, RSI value, and water vapour permeance.

Due to its ability to expand and adhere, spray insulations are well suited for basement wall , header as well as specialty applications, such as insulating headers and rim joists, or insulating under cantilevers, projections, and bump-outs. A specially trained contractor is needed for all spray installations. For interior applications, sprayed areas must be covered with the appropriate thermal barrier as required by the code.

Mineral Wool

Mineral wool or 'rock wool' is an insulating material made of basalt and recycled slag material and comes in many forms. Mineral wool has similar insulating characteristics to glass fibre (see Table 1).

Rock wool can also be used in rigid sheets on the interior and the exterior of foundations. Exterior boards are easily installed along the perimeter of a foundation. There are many proprietary products that also provide a drainage layer. The boards act as a capillary break and drainage layer diverting water downwards to the weeping tile.

Type	RSI per mm (R-value per 1 inch)	Density kg/m³ (lb/ft³)	Permeance ng/Pa•m²•s (grain/ft²hr(in.Hg)
Batt:			
Glass fibre	0.022 (3.2)	12-18(0.75-1.2)	1666 (29)
Mineral wool	0.024 (3.5)	12-18(0.75-1.2)	1666 (29)
Rigid Boardstock:			
Expanded type (EPS) 1,2, and, 3	0.026 (3.8) to 0.030 (4.4)	14.4-25.6 (0.61-2.5)	115-300 (2.0-5.2)
Extruded type (XPS) 2,3 and, 4	.035 (5.0)	22.4-32 (1.4-2.0)	23-92 (0.4-1.6)
High density glass fibre	0.029 (4.2) to 0.031 (4.5)	64-144(4.0-9.0)	1725 (30)
Foil Face Polyisocyanurate	0.041 (6.0)	varies	<0.26 (15)
Spray Insulation:			
Cellulose fibre	0.025 (3.6)	varies	varies
Polyurethane (medium density)	0.038 (5.5) 0.041 (6.0)	varies	varies
Polyurethane (low density semi flexible)	0.025 (3.6)	varies	varies

5. Builder's Manual. Canadian Home Builder's Association. Ottawa. 2001 [90].

Table 1: RSI and R Values for Insulation Types[5]

Table 1

Air Sealing

When sealed at the junction of slab and footing, a concrete foundation wall can act as an effective barrier to air infiltration, provided that the header area is sealed. There are numerous techniques used for sealing the header area. Header wraps are a popular system as applying the flexible membranes is easily performed on site (Fig. 29). Once anchor bolts are in place on the top of the foundation wall, a foam gasket is placed on top of the wall to help fill in irregularities. A header wrap is then placed over the gasket and the anchor bolts. The wrap is then draped down the interior face, and sealed to the foundation wall, or to other interior air barrier using acoustical sealant. The sill plate is then bolted down securing the gasket and header wrap in place. The header and joists are constructed normally, and the header wrap is then flipped up over the subfloor and temporarily tacked in place. Once the stud wall has been erected over the header wrap and fastened in place, the header wrap can be pulled up to overlap the interior air/vapour barrier and clamped in place by the gypsum board. As a best practice this connection should be clamped and sealed using an acoustical sealant.

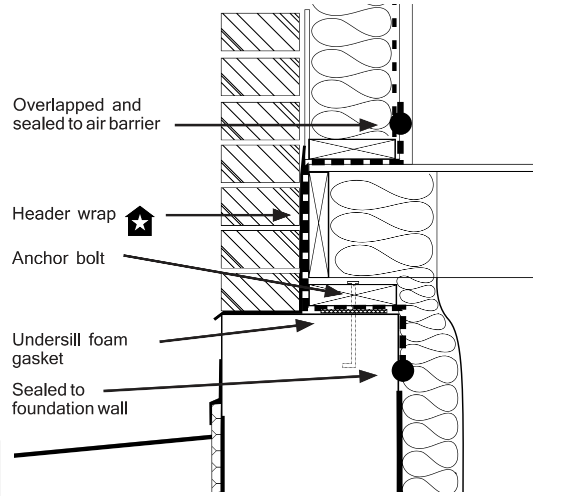


Fig. 29 Header wrap

A structural air barrier approach features standard wood frame floor construction, except that every connection between framing members is continuously sealed using an acoustical sealant (Fig. 30). Other popular approaches feature the use of board insulations that have a low air permeance, sealed with sealant. For example, a rigid polystyrene approach uses standard sheets of rigid polystyrene insulation placed behind the header, and sealed at the top and bottom (Fig. 31). In this approach the type of insulation and the thickness of the assembly must provide the required level of air tightness, water vapour protection and thermal resistances as prescribed by the code A bead of sealant is also required between the bottom plate and subfloor. This system is very popular in the Atlantic provinces. A spray foam approach is similar, as it fills the entire area between the top of the foundation wall and sub-floor with spray insulation (Fig. 32). Sealant it required under the bottom plate in this case as well.

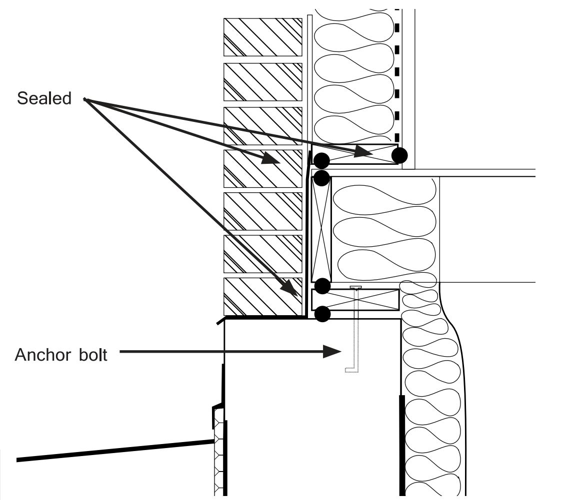


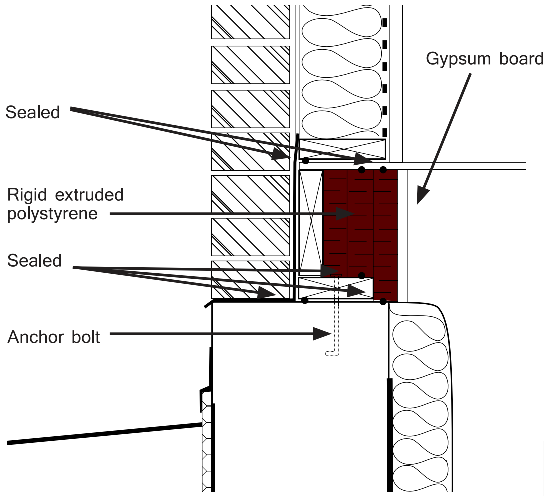
Fig. 30 Structural air barrier

Sealants

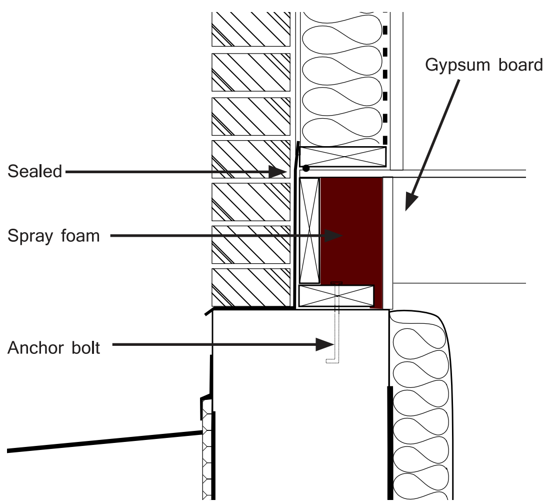
Depending on the material selected as an air barrier, an appropriate sealant must be selected that will maintain a long-term and non-corrosive seal. For example, acoustic sealant has been proven as an efficient seal when using polyethylene air barriers, or header wraps. When sealing an air barrier, attention to continuity needs to be paid by the installation crews, as an unbroken bead of sealant must be maintained or the air barrier will be discontinuous.

Sill Gaskets

Sill gaskets or 3 mm (1/8 inch) polysyrene foam strips are usually placed underneath sill plates on new homes. This material does not provide 'air tightness.' It is intended to separate the sill from the concrete, fill in irregularities along the top of the foundation wall and provide very modest resistance to wind-driven air leakage.



Rigid polystyrene **Fig. 31**



Spray foam approach **Fig. 32**

Fire Protection of Foam Plastic Insulation

Foam plastic products require protection from fire. Foam plastic products used in basements typically must be covered by gypsum board, plaster, plywood, hardboard, insulating fibreboard, particleboard, OSB, waferboard, or any thermal barrier that meets the requirements of Ontario's 2006 Building Code Sentence 9.10.17.10. Thermal barriers over foam plastic must be attached to a structural member to perform effectively. Connection details are not show in this guide.

Protection from Damage

Installed insulation must be protected from damage, as damaged insulation will have a significantly reduced performance, and may leave assemblies susceptible to convective loops and/or condensation. Exterior insulation, where used above grade and exposed to weather, must be covered with a minimum of 6 mm (1/4 inch) cement board or plywood, or 12 mm (1/2 inch) of parging.

Protection from Contact with Moisture

Batt insulation in particular, becomes less efficient the more moisture it contacts. Ontario's 2006 Building Code requires that batt insulation in an unfinished basement be fitted with a vapour barrier on the inside to protect the wall from condensation in winter.

When crawl spaces are insulated with insulation susceptible to water damage a 50 mm (2 inch) gap must be left between the insulation and the top of the crawlspace slab.

Unit Masonry Foundations

Many Ontario builders employ unit masonry construction when erecting foundations. Unlike cast-in-place concrete, a wall created out of masonry units does not provide an effective barrier against the infiltration of air. To ensure an air tight interior space, builders must create a continuous air barrier in-board of the foundation wall, running from the header area down to the slab/wall intersection.

For example, when using fibreglass blankets, polyethylene sheeting can be sealed to the header system and sealed at the slab/wall intersection. If a full height blanket approach is employed the stacked fibreglass blankets must be joined with tape or another suitable sealant at their intersection. When insulating with a frame wall, air barrier continuity is achieved using the same approach as for cast-in-place construction.

Due the hollow shape of most unit masonry, convective loops often form within the hollow cavity. To prevent convection, the cavity must be filled or the first course must be filled or 'capped' with concrete according to Ontario's 2006 Building Code section 12.3.2.4(8).

Basement Strategies: Risk Management

When choosing an insulation system for a new home, consideration needs to be given to the intended interior use of the basement, the exterior site conditions, and the long-term operating costs. While all of the insulation systems presented in this guide are capable of meeting the minimum requirements of Ontario's 2006 Building Code, each system has properties which are better suited to certain conditions and uses. Cost should be considered as a property of a given system. The cost of the total system must be related to intended use of the interior space and the severity of the exterior site conditions. Over-design ensures a comfortable living space but adds unnecessary cost to a given system, while under-design reduces initial cost, while increasing the risk of an uncomfortable interior and/or system failure.

On the ideal site, featuring freely draining soils, properly sloped grading, proper orientation, a dry climate, minimal interior usage, and a low and stable water table simply meeting minimum requirements will likely deliver an ideal product. This alignment of conditions however, is seldom a reality. "In most cases, exceeding minimum Code requirements will be necessary to achieve acceptable levels of performance corresponding to modern consumer expectations..."[6]

When even one of theses factors poses a threat, a high performance system is needed and this often means increased cost. For example, in areas with poorly draining soils an exterior hydro-phobic insulation is recommended that can isolate the concrete from continual contact with moisture. Using XPS on the exterior for example, increases the initial cost (both in terms of capital and labour), but reduces the risk of call-backs, future repairs, and many moisture related issues.

Operational costs must also be considered in choosing a system. It is a reasonable assumption that heating costs, no matter the chosen method, will continue to increase. A system that provides adequate protection against moisture, like exterior XPS may not provide very high levels of thermal resistance which could mitigate heating costs. On the other hand, an ICF system with a better overall thermal performance increases the initial capital costs, but minimizes the effect of increasing heating costs. Large initial costs however, may in some cases never fully balance out in terms of energy savings.

What is needed in every scenario is a system that balances performance and cost (initial and long-term), and caters to the specific requirements of the site. The end result being a system that simultaneously minimizes risk (of failure) and cost (initial/builder costs, and operational/owner costs). A risk assessment is always necessary prior to construction to deliver a satisfactory product.

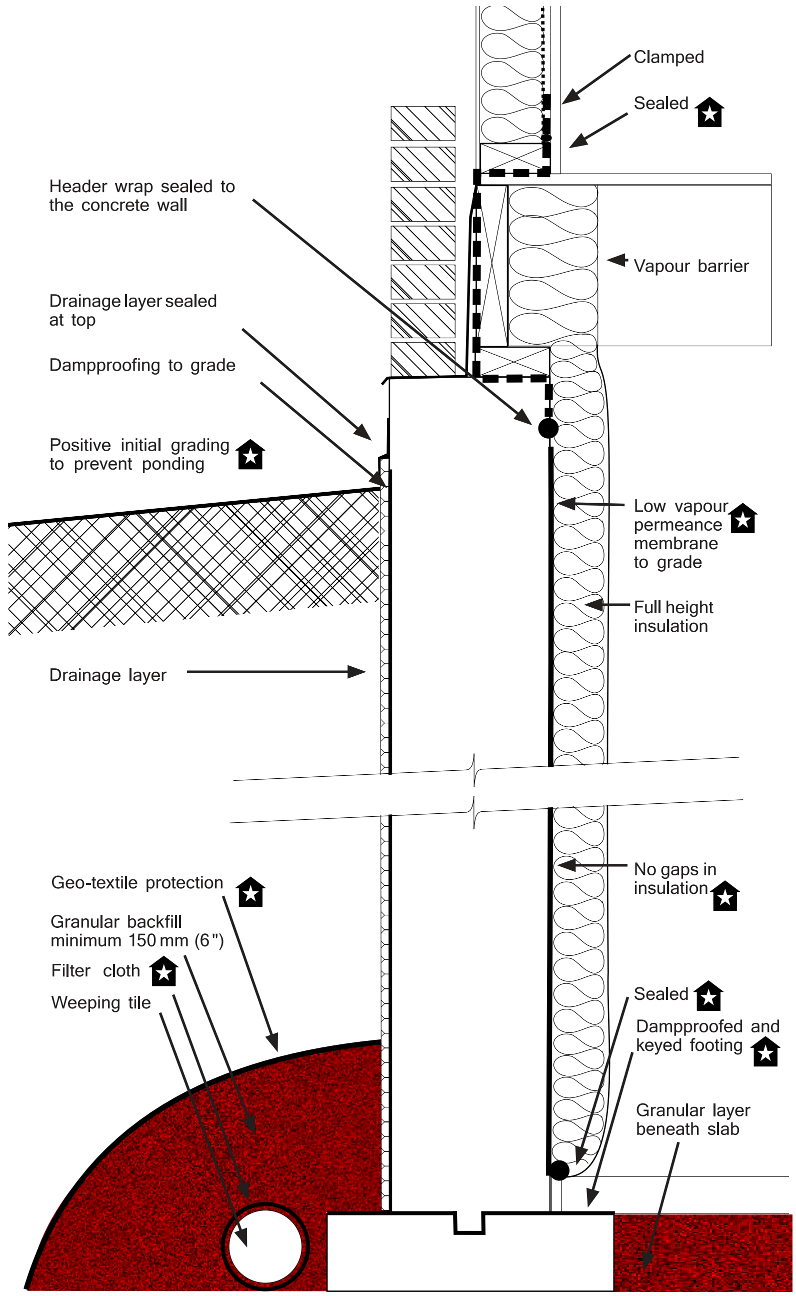
6. Economic Assessment of Residential Basement System Insulation Options. *Technical Series 07-103* Canadian Housing and Mortgage Corporation. Toronto. 2007 [4].

Interior Blanket System

Blanket insulation has become among the most common basement insulation systems. Blanket systems (Fig. 33) are cost effective, easily installed, and have good insulative potential, and as such they are a favoured system of builders. At the same time, steps must be taken to avoid potential condensation problems that can progress from nuisance to callback.

Insulation blankets are placed against the foundation wall and held in place by the tension of a 0.15 mm (6 mil) polyethylene sheet (which acts as a vapour barrier) and that is usually mechanically fastened to the concrete. Batts can extend any distance from joist to slab, and can be cut in long sections for easy installation.

As a best practice, the installation of a blanket system should ensure that the fibreglass or mineral wool insulation maintains continuous contact with the foundation wall, as even a small gap can create convective loops that can short circuit the insulation layer. This means that sufficient tension must be maintained by the polyethylene covering. Placing a low vapour permeance material behind the blanket (such as polystyrene) can reduce the incidence of summer condensation.



Section: Blanket system **Fig. 33**

Interior Framed Wall Systems

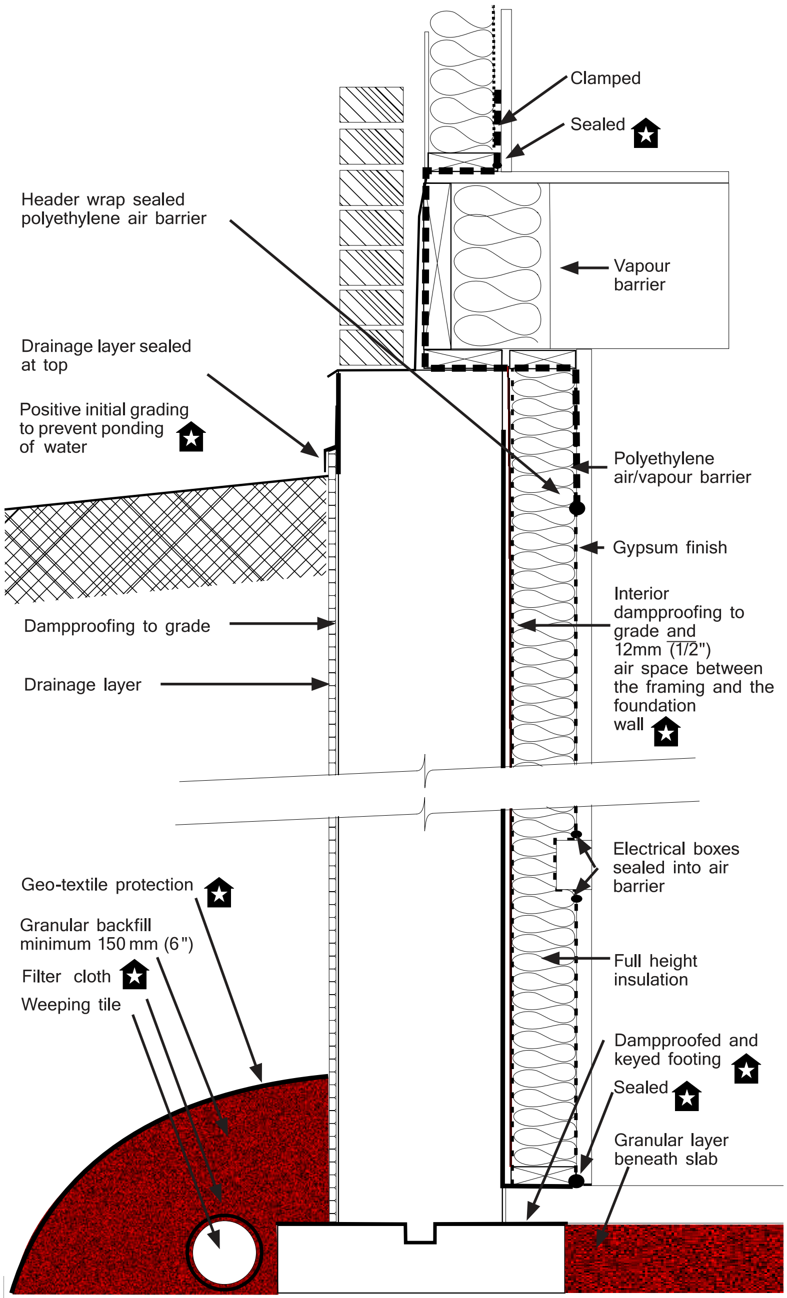


Fig. 34 Section: Interior frame wall with batt infill

A traditional method of insulating basements full height involves erecting a non-structural frame wall on the interior of the basement and filling the cavities between studs with insulation (Fig. 34). The thermal resistance can be easily increased by standing the framing members away from the foundation wall to accommodate thicker insulation.

Wood framing members are highly susceptible to decay when in contact with moisture. Similarly, fibreglass and mineral wool batts perform best when kept dry. As a best practice, wood framing should not come in contact with the foundation wall. In all cases, wood framing should stand-off from the wall and should be separated from the concrete by interior dampproofing below grade. Header wraps can be sealed to the air vapour barrier installed on the warm side of the frame wall, which in turn should be sealed to the slab at the base of the wall. All electrical outlets must be set into the framing cavities, and must also be sealed and integrated as part of the air barrier system.

Frame wall systems provide builders with the option to use many different insulation approaches. While batts of fibreglass are the traditional norm, spray foam infil is becoming a popular method of finishing a basement frame wall system. In this approach spray foam is injected into and rapidly fills the cavities between framing members, pressing tightly against the foundation wall. Loose-fill insulation may also be used to fill the vertical cavity, so long as the installation meets the requirements of Section 9.25 of Ontario's 2006 Building Code.

No matter the chosen method of insulating a frame wall, insulation must be continuously installed between the framing members, and maintain tight contact with the foundation wall. All frame wall assemblies must also be covered and electrical boxes installed and sealed.

Exterior Polystyrene Systems

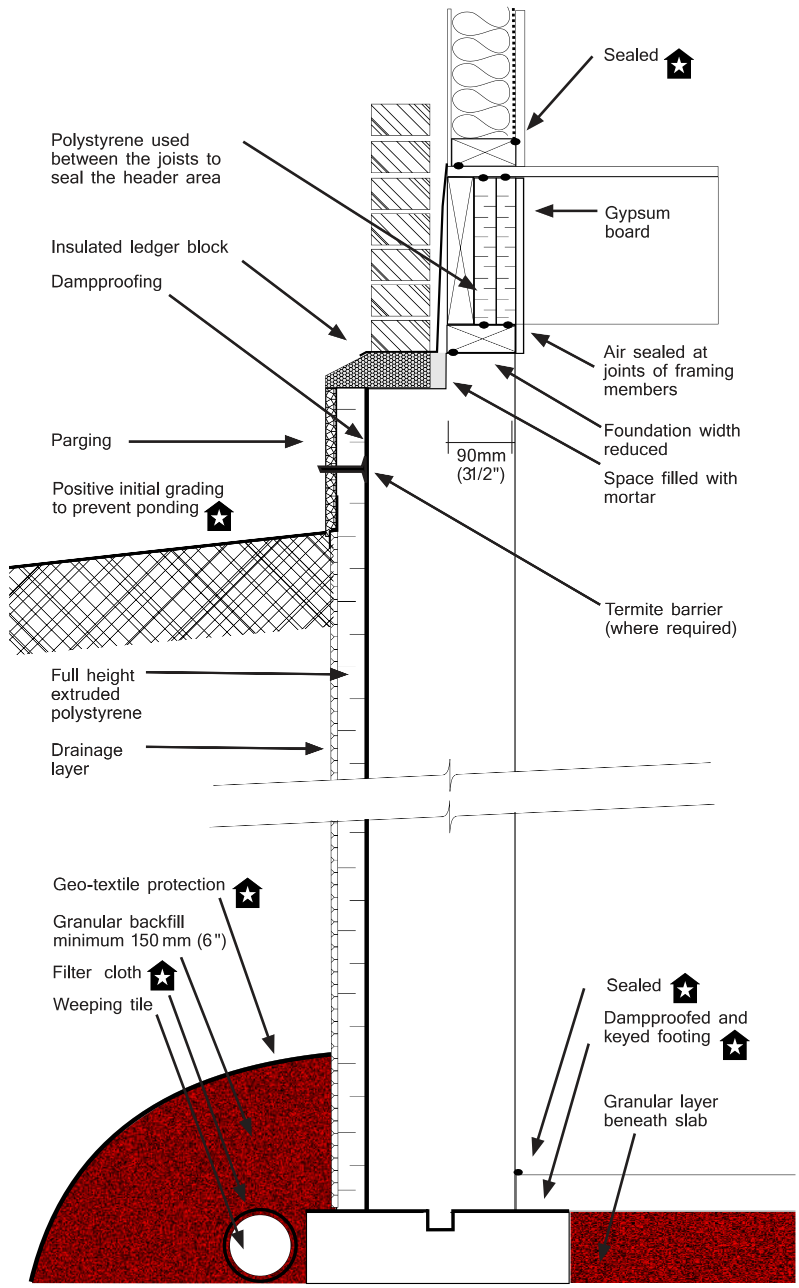
Exterior insulation has many clear benefits over traditional interior insulation approaches. From a heat transfer point of view, external insulation ensures that the structural wall is not exposed to the temperature swing across the seasons and the wear and tear it implies. This reduces thermal stress and the likely-hood of cracking as well as the effects of freeze/thaw cycles. Placing the insulation on the exterior also saves valuable space on the interior. Most importantly, extruded polystyrene placed on the exterior of the foundation (fig. 35) resists moisture flow, provides a buffer between the soil, as well a slip plane against adfreezing.

Exterior insulation systems increase the potential for thermal bridging between the warm foundation wall and the cold brick veneer. If an insulated ledger block is to be installed below the first course of the brick veneer in order to reduce thermal bridging, the reduced section of the concrete wall should not be less than 90 mm (3/12 inches). The space between the ledger block and reduced section must be filled with mortar (9.15.4.7.). Insulation should also extend the full height of the exterior, terminating at the bottom of the ledger block.

Installers must also be sure to extend the flashing over the top of the insulating block and install weep holes as required.

Above grade, exterior insulation must be protected from damage by parging, cement board, or plywood sheeting according to Ontario's 2006 Building Code sentence 9.25.2.3.(6).

It should be noted that while many polystyrene products are resistant to vapour flow and provide adequate vapour protection, other foam products may require a separate vapour barrier to be installed in addition. The product manufacturers should be consulted to better match specific needs to product characteristics.



Section: Exterior rigid polystyrene **Fig. 35**

Exterior Free Draining Systems

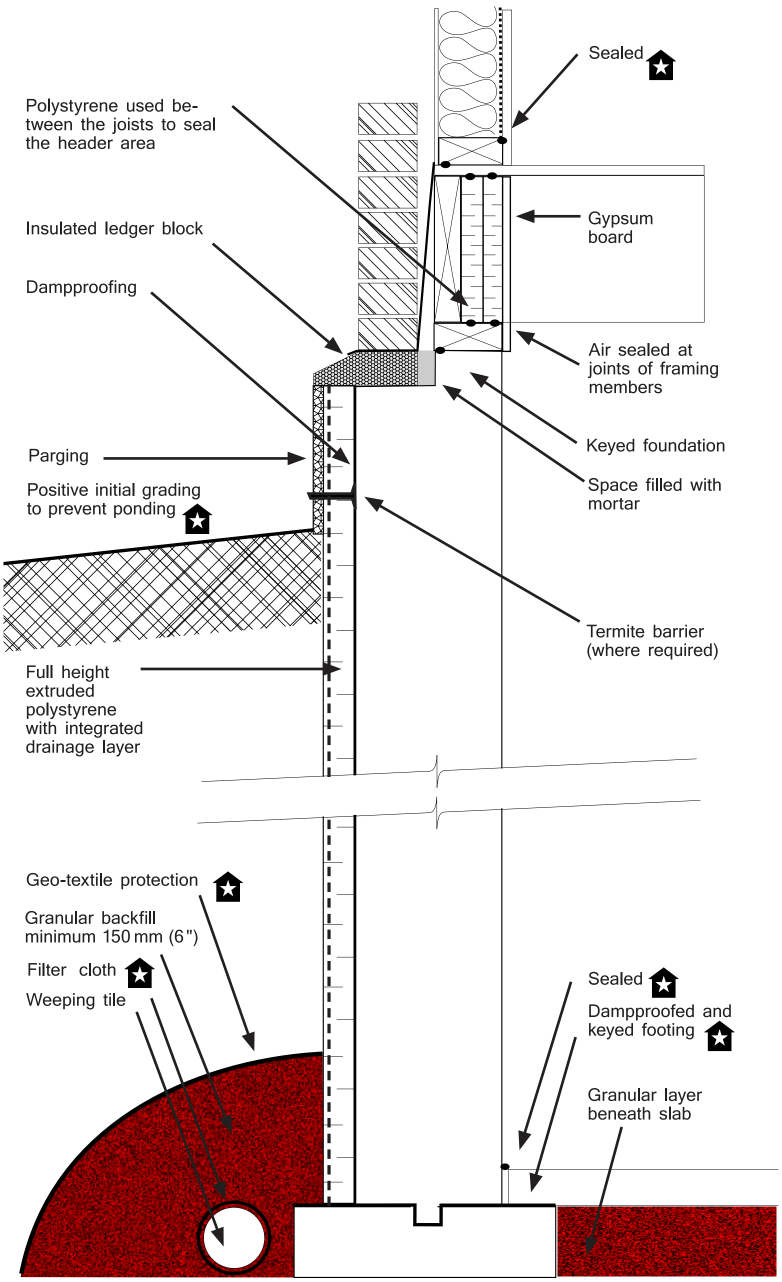


Fig. 36 Section: Exterior free draining polystyrene

A free draining exterior extruded polystyrene layer can serve to provide both effective drainage and insulation. Free draining exterior insulation provides the same benefits as non-draining exterior polystyrene namely, reducing thermal stresses and cracking, the potential for adfreezing, and moisture penetration. In addition, it can offer a system of vertical channels that collects and transports water down and away from the foundation wall, to the drainage tile system.

Above grade protection is needed as well as a ledger block (Fig 36). The advantage to free draining exterior polystyrene is that the drainage layer extends right up to the brick veneer, making it difficult for any free water to get in behind the drainage layer, as is common with unsealed roll-on drainage membranes.

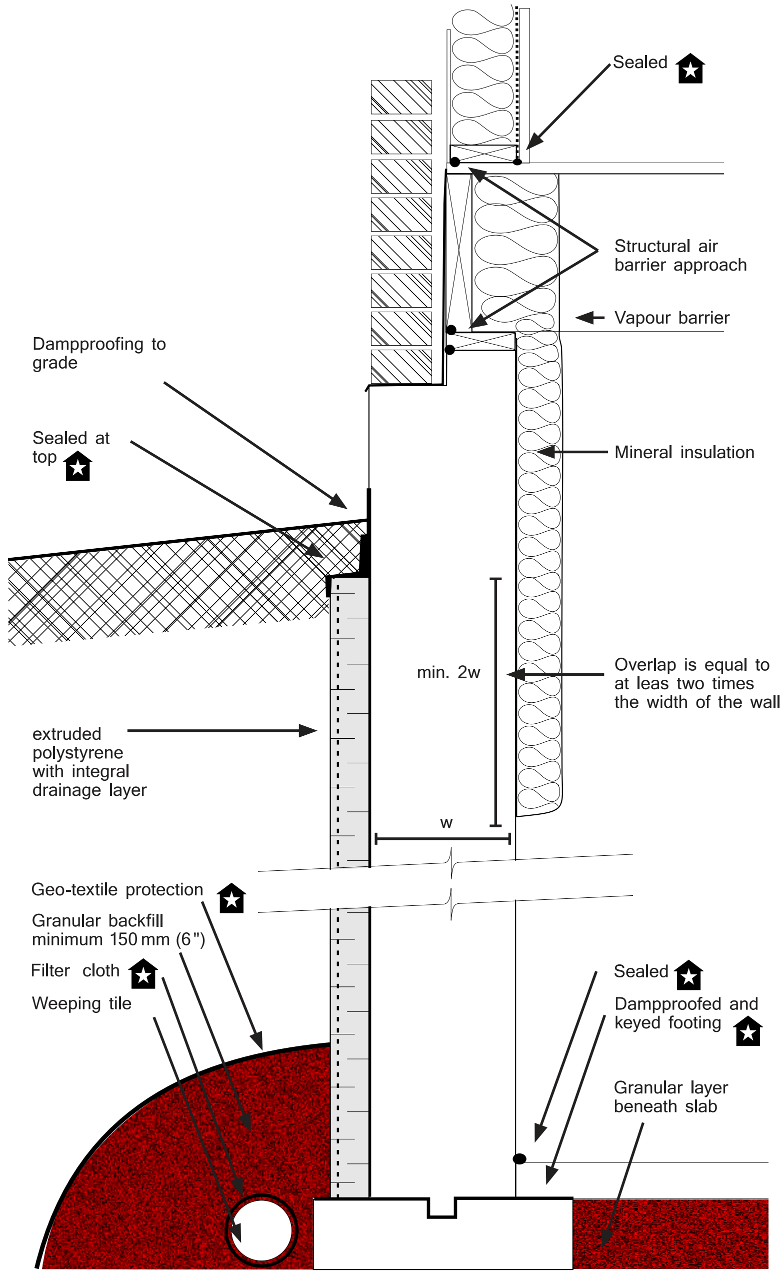
Some foam products may provide adequate vapour protection, while others may require a separate vapour barrier to be installed in addition. Product manufacturers should be consulted to ensure the correct specification.

Mixed Interior/Exterior Systems

A mixed interior/exterior approach to FHBI is a simple way to modify the standard 600 mm (two-foot) below grade basement product to meet the requirements for full height insulation (Fig. 37). This system features a sheet of extruded polystyrene with an integral drainage layer on the exterior extending up from the footing to grade level and a standard blanket insulation on the interior which overlaps the extruded polystyrene by a distance equal to at least twice the width of the foundation wall.

It should also be noted that while this system provides the necessary nominal insulation values for a fully insulated basement wall, a significant amount of thermal bridging exists at the overlap. This effect can be reduced by increasing the overlap of exterior and interior insulation.

If using unit masonry, an interior air barrier system must be created that links the header and slab/wall intersections in a continuous barrier against air infiltration. A vapour permeable air barrier membrane can be used to connect a header wrap to the basement slab.



Section: Interior blanket/exterior polystyrene combination **Fig. 37**

Interior Polystyrene Systems

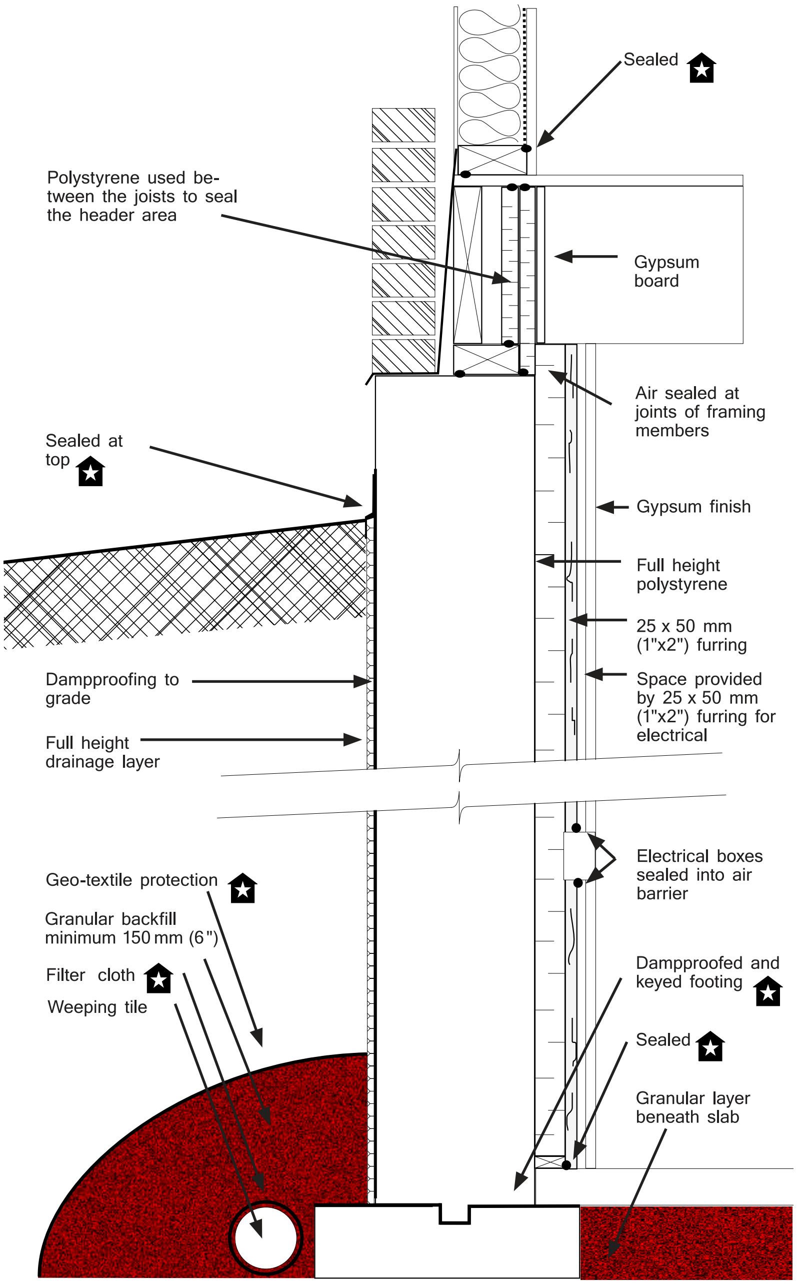


Fig. 38 Section: Interior polystyrene with strapping

The use of rigid polystyrene board strapped directly to the foundation wall is popular with many builders (Fig. 38). Rigid polystyrene board requires less space than a frame wall. It can act as a vapour barrier and certain types of extruded polystyrene do not require an additional layer of polyethylene to be installed over the rigid foam.

Installation is simple as the boards are laid against the foundation wall and are held in place by furring attached to the concrete or unit masonry (connection detail not shown) vertically at intervals providing an air space for electrical wires. Finish materials such as gypsum board can then be attached to the furring. Using a rigid foam system does however require a precision forming job for cast-in-place concrete and good workmanship for unit masonry, as the foundation wall must be as smooth as possible so that the insulation can rest firmly and continuously against the wall. Foundation walls must be prepared, and any irregularities patched up before installation can begin.

Ontario's 2006 Building Code requires that all extruded polystyrene be protected according to Article 9.10.17.10.

Builders should be aware that some extruded polystyrene products can act as a suitable barrier to air infiltration. If a suitable product is used, the XPS must be installed in a continuous fashion and sealed to the header, at slab, and at all intersections to provide a continuous air barrier.

Insulating Concrete Forms

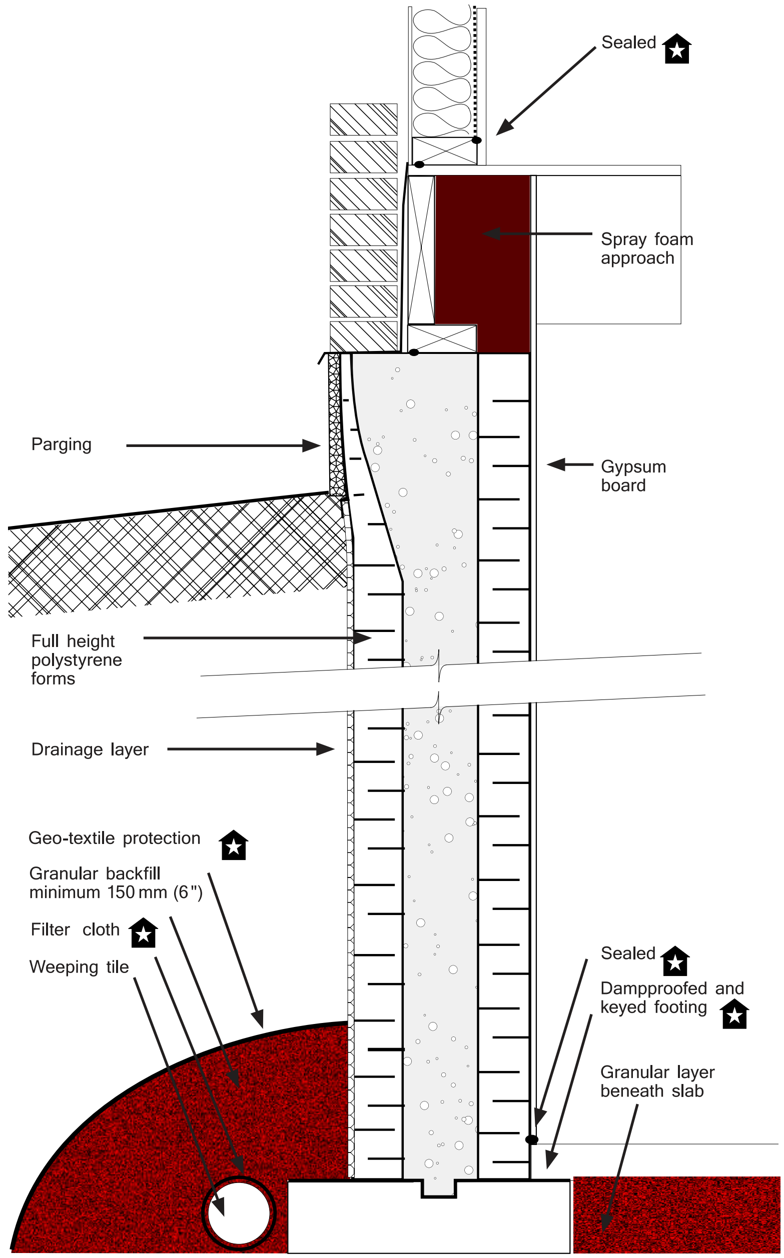
Insulating concrete forms (ICFs) offer the builder a system that combines concrete construction and insulation (Fig. 39). The system offers exceptional thermal resistance and protection from moisture. Application requires experienced installation crews and careful planning to avoid potential problems.

Courses of lightweight, hollow polystyrene blocks are fitted and sealed together to create a form, which is braced to resist the loads involved in placing the concrete. Rebar is added as necessary, according to the ICF system requirements. Fresh concrete is carefully vibrated to eliminate any air pockets or voids. All of the forms must be carefully monitored from below for any distortions, which can lead to blow-outs.

Once the concrete has sufficiently cured the braces can be removed. By surrounding a highly conductive material like concrete with foam insulation structural elements are subjected to fewer thermal stresses reducing the potential for cracking. In addition, the system provides protection against adfreezing, and moisture penetration.

On the interior, ICFs take up little more space than a typical foundation wall. ICFs are easily finished as most systems provide nailing surfaces for sheathing and finishing materials.

Some ICF systems may provide adequate vapour protection, while other may require the addition of an interior vapour barrier. In all cases, manufacturer instructions should be followed in constructing this system.



Section: Insulating concrete forms **Fig. 39**

Preserved Wood Foundations

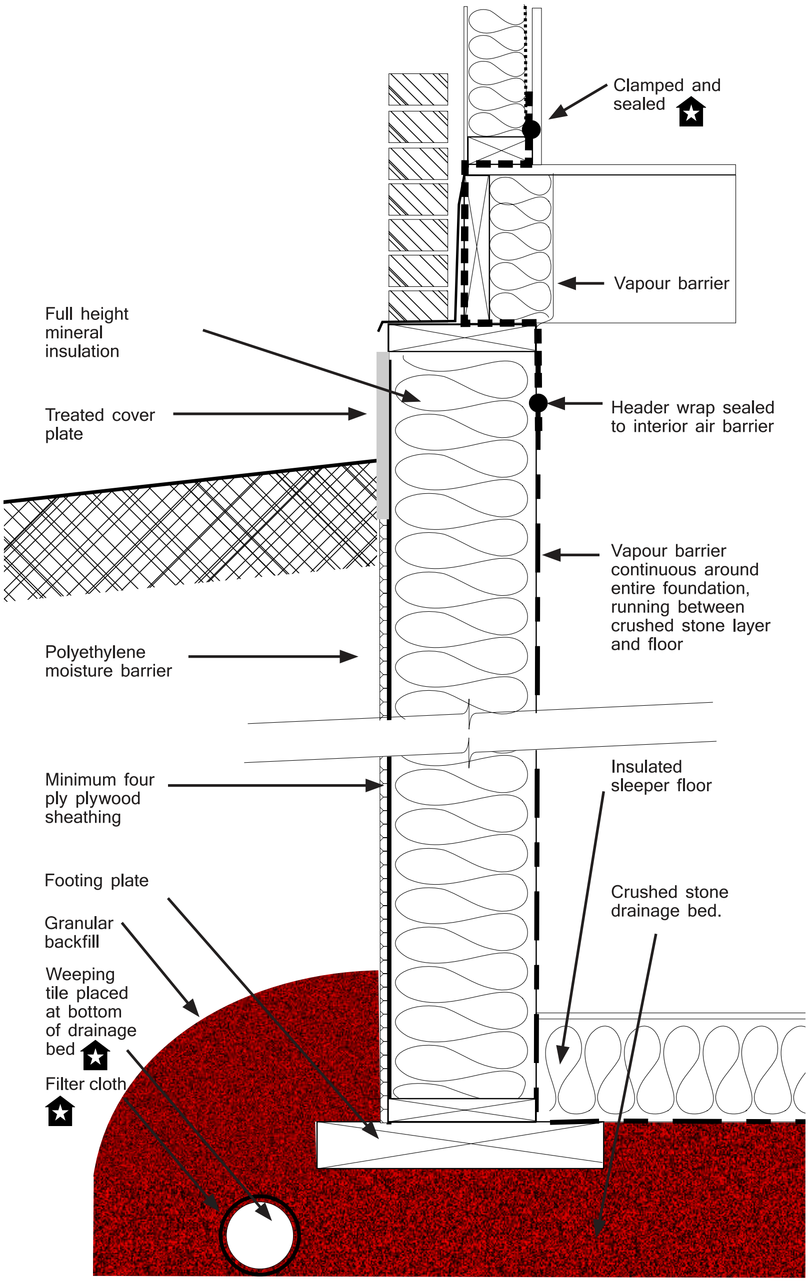


Fig. 40 Section: Preserved wood foundation

Preserved wood foundations (PWF), uses all preserved wood components (Fig. 40). Literally an extension of above ground frame walls, stud walls are constructed on top of footing plates, which rest upon a bed of gravel or crushed stone. The stud walls are covered with minimum 4 ply plywood sheathing able to resist the lateral loads applied by the soil. Framed foundation walls are insulated in the same manner as above grade stud walls.

Minimum four ply plywood sheathing must be sealed at the joints with a waterproof, and durable sealant, and then covered with a polyethylene moisture retarder down the exterior of the foundation walls, ending at the footing[7]. The main difference between PWFs and traditional concrete foundation walls is that a PWF system is a waterproofing approach and does not require a drainage layer. Drainage in a PWF system is performed by a necessary granular backfill, and a crushed stone layer beneath the foundation slab and under the footing. This 'porous' layer is most important, providing a capillary break around the foundation, and quickly removing all free water from the vicinity of the foundation.

For poorly draining native soils, granular backfill should be used for backfill and extend to within 300 mm (12 inches) of the surface. When using a granular substitute, ensure that the top 300mm (12 inches) of backfill does not have a greater porosity than the surrounding native soil.

7. Construction of Preserved Wood Foundations. CAN/CSA-S406-92. Toronto. 1992.

Unit Masonry Foundations

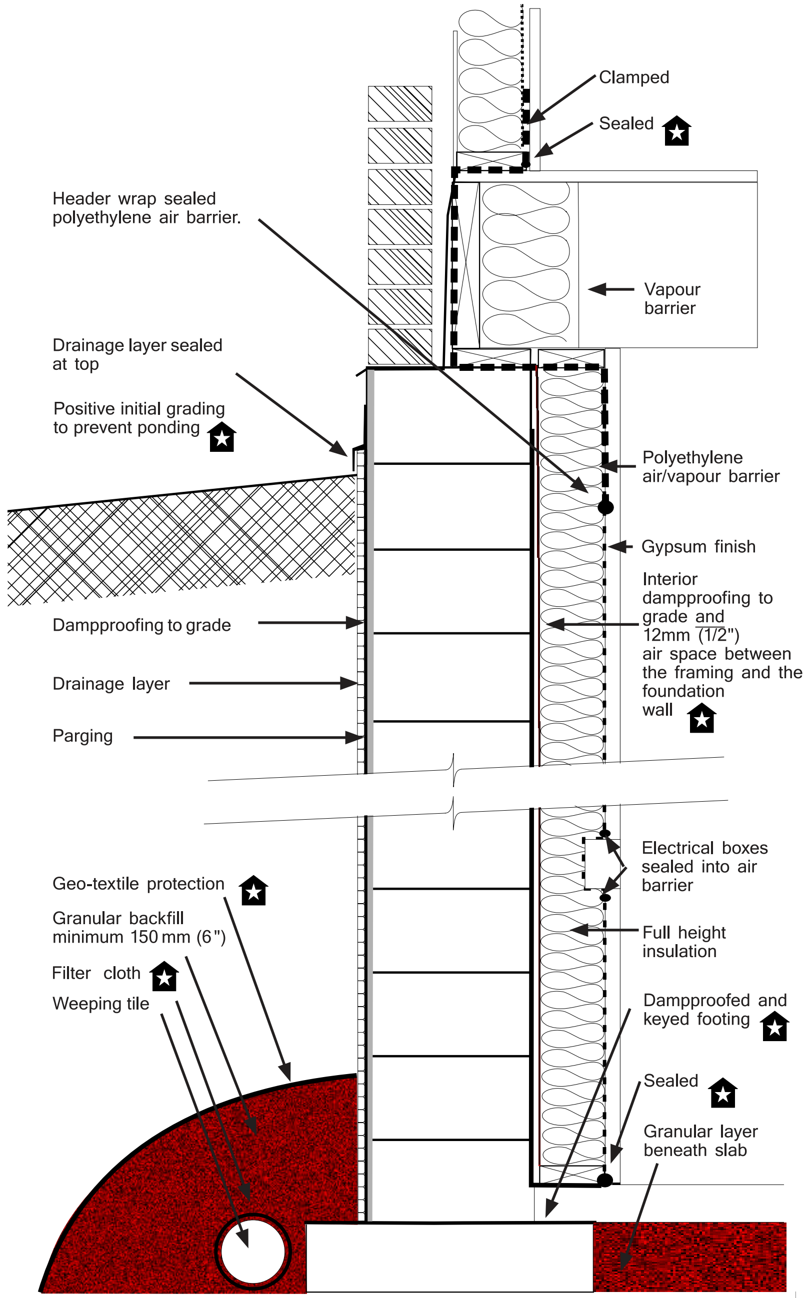
When insulating unit masonry walls is virtually identical to insulating cast-in-place concrete systems, except that unit masonry walls always need an interior air barrier system (Fig 41).

Framed wall/unit masonry systems are the most easily installed systems as air barrier continuity is achieved in much the same fashion as in cast-in-place concrete systems. For unfinished basements outfitted with blanket systems the polyethylene air/vapour barrier used to hold the blankets in place must be sealed to the header system and the slab/wall intersection to create a continuous, full height barrier. If two blankets are stacked to create full height insulation, they must be sealed at their intersection with tape, or another sealant.

When building with a unit masonry foundation, the polyethylene vapour barrier used to hold the blankets in place must be sealed to the header system and the slab creating a continuous air barrier inboard of the foundation wall.

The jointing and open cavities of unit masonry walls typically make them poor air barriers and the polyethylene needs to be sealed to perform this junction.

Exterior polysytrene insulation boards may be used to create an exterior barrier against air infiltration. XPS systems can provide air barrier protection if the board provides sufficient resistance to air movement. Typically, it must be sealed at top, bottom and all joints with an effective and durable sealant. If an insulation system is used that is not a barrier to the movement of air then an interior air barrier approach needs to be used.



Section: Unit masonry wall with frame and fibreglass batts **Fig. 41**

Chapter 4

Best Practices

The High Performance Basement

Best practices in new home construction represent a set of techniques and skills above and beyond the minimum standards prescribed by Ontario's 2006 Building Code (Fig. 42).

Best practice solutions are often inexpensive and simple to apply. One of the simplest best practices involves applying a spray-on dampproofing to the top of the footing before the wall is erected, preventing wicking which can occur throughout the entire lifespan of a house. Keeping the interior space dry is the first priority. Careful installation of the drainage tile system is also important. For example, ensure that the slope of the pipe will provide effective drainage. Cover the granular layer with a geo-textile cloth to prevent the drainage system from becoming clogged. On the surface, grading should take place early and often so that no free water pools against the foundation wall.

After the wall is placed, a slip plane, as simple and inexpensive as polyethylene can be added to the exterior of a foundation to prevent frozen soil from adhearing to the concrete or unit masonry. On the interior, a low vapour permeance membrane can be a simple and effective tool in all systems for preventing wicking moisture within the concrete from diffusing into the interior, which can decay wood and damage finished walls. Vapour barriers should be fitted to thermally insulated components. Insulation should be continuous (without any gaps) along the foundation wall, and should not be damaged, overly compressed or exposed to sources of moisture.

Air infiltration is of extreme importance to the best practice builder, as it is the cause of many problems. First of all, a simple seal along the junction of the slab and footing will prevent air leakage from below grade. Header areas are the largest source of air leakage as the air barrier is often damaged during construction, or is not properly sealed. Builders may use one of the common approaches discussed herein, or any number of other approaches, but a best practice builder is one that takes responsibility to ensure these areas are properly sealed.

The tools and techniques of the best practice builder are often simple and inexpensive, but require planning, know-how, and dedication to deliver a quality home.

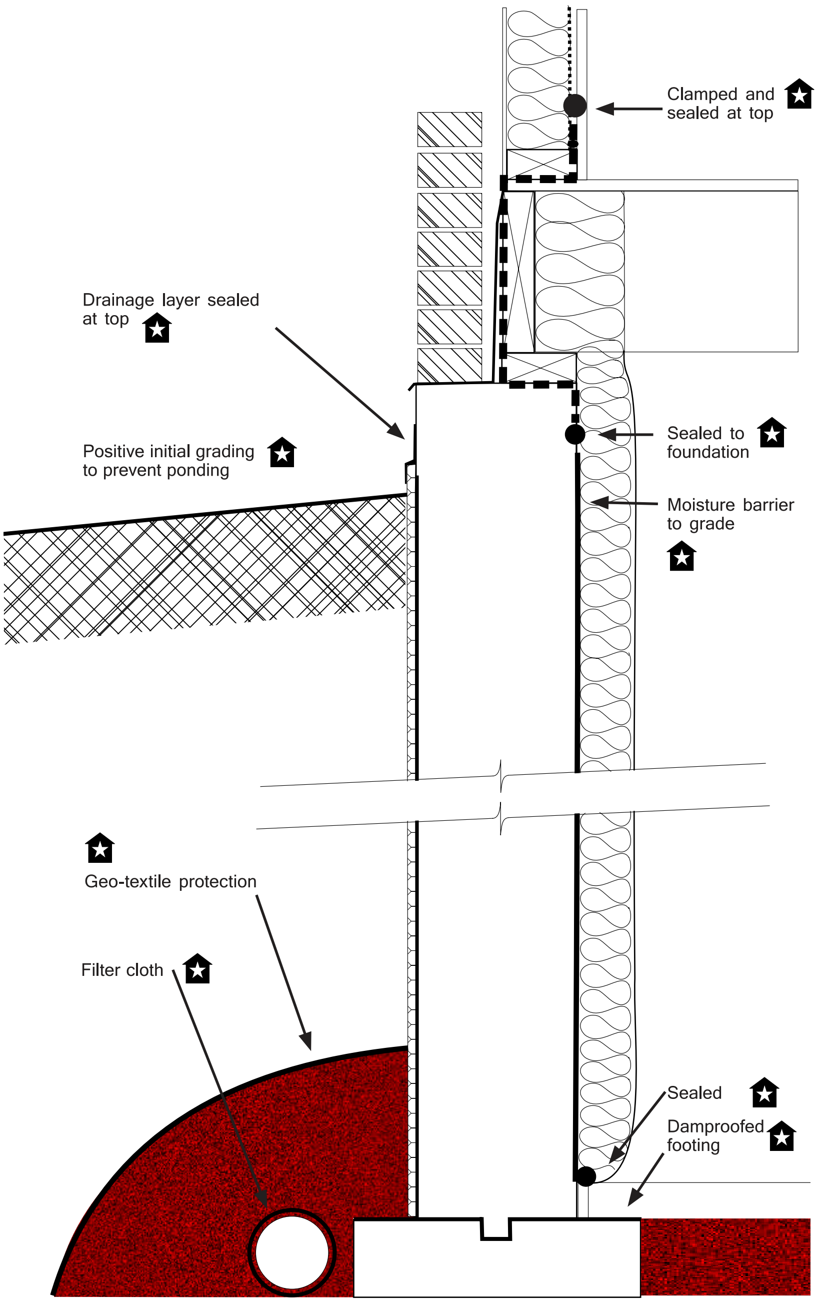


Fig. 42 Section: Best practices

Appendix

Ontario's 2006 Building Code References

9.3.1. Concrete
9.3.1.1. General

(1) Except as provided in Sentence (2), nominally unreinforced concrete shall be designed, mixed, placed, cured and tested in accordance with CAN/CSA-A438, “Concrete Construction for Housing and Small Buildings”.

(2) Nominally unreinforced site-batched concrete shall be designed, mixed, placed and cured in accordance with Articles 9.3.1.2. to 9.3.1.9.

(3) Except as provided in Sentence (4), reinforced concrete shall be designed to conform to the requirements of Part 4.

(4) For flat insulating concrete form walls not exceeding 2 storeys, and having a maximum floor to floor height of 3 m, in buildings of light frame construction containing only a single dwelling unit, the concrete and reinforcing shall comply with Part 4 or,

(a) concrete shall conform to CAN/CSA-A23.1, “Concrete Materials and Methods of Concrete Construction”, with a maximum aggregate size of 19 mm, and

(b) reinforcing shall,

(i) conform to CAN/CSA-G30.18-M, “Billet Steel Bars for Concrete Reinforcement”,

(ii) have a minimum specified yield strength of 400 MPa, and

(iii) be lapped a minimum of 450 mm for 10M bars and 650 mm for 15 mm bars.

9.3.1.2. Cement

(1) Cement shall meet the requirements of CAN/CSA-A3001, “Cementitious Materials for Use in Concrete”.

9.3.1.3. Concrete in Contact with Sulfate Soil

(1) Concrete in contact with sulfate soil, which is deleterious to normal cement, shall conform to the requirements in Clause 15.5 of CAN/CSA-A23.1, “Concrete Materials and Methods of Concrete Construction”.

9.3.1.4. Aggregates

(1) Aggregates shall,

(a) consist of sand, gravel, crushed rock, crushed air-cooled blast furnace slag, expanded shale or expanded clay conforming to CAN/CSA-A23.1, “Concrete Materials and Methods of Concrete Construction”, and

(b) be clean, well-graded and free of injurious amounts of organic and other deleterious material.

9.3.1.5. Water

(1) Water shall be clean and free of injurious amounts of oil, organic matter, sediment or any other deleterious material.

9.3.1.6. Compressive Strength

(1) Except as provided elsewhere in this Part, the compressive strength of unreinforced concrete after 28 days shall be not less than,

(a) 32 MPa for garage floors, carport floors and all exterior flatwork,

(b) 20 MPa for interior floors other than those for garages and carports, and

(c) 15 MPa for all other applications.

(2) Concrete used for garage and carport floors and exterior steps shall have air entrainment of 5 to 8%.

9.3.1.7. Concrete Mixes

(1) For site-batched concrete, the concrete mixes described in Table 9.3.1.7. shall be considered acceptable if the ratio of water to cementing materials does not exceed,

(a) 0.45 for garage floors, carport floors and all exterior flatwork,

(b) 0.65 for interior floors other than those for garages and carports, and

(c) 0.70 for all other applications.

(2) The size of aggregate in unreinforced concrete mixes referred to in Sentence (1) shall not exceed,

(a) 1/5 the distance between the sides of vertical forms, or

(b) 1/3 the thickness of flatwork.

*****See Table 9.3.1.7.*****

9.3.1.8. Admixtures

(1) Admixtures shall conform to ASTM C260, “Air-Entraining Admixtures for Concrete”, or ASTM C494 / C494M, “Chemical Admixtures for Concrete”, as applicable.

9.3.1.9. Cold Weather Requirements

9.3.1.9. Cold Weather Requirements

(1) When the air temperature is below 5°C , concrete shall be,

(a) kept at a temperature of not less than 10°C or more than 25°C while being placed, and

(b) maintained at a temperature of not less than 10°C for 72 h after placing.

(2) No frozen material or ice shall be used in concrete described in Sentence (1).

9.3.2.9. Termite and Decay Protection

...

(2) In localities where termites are known to occur and foundations are insulated or otherwise finished in a manner that could conceal a termite infestation,

(a) a metal or plastic barrier shall be installed through the insulation and any other separation or finish materials above finished ground level to control the passage of termites behind or through the insulation, separation or finish materials, and

(b) all sides of the finish supporting assembly shall be visible to permit inspection.

Table 9.3.1.7

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7
Maximum Size of Coarse Aggregate, mm	Materials, volume					
	Cement		Fine Aggregate (damp average course s		Course Aggregate (gravel or crushed st	
	Parts	L[(1)]	Parts	L	Parts	L
14	1	28	1.75	49	2	56
20	1	28	1.75	49	2.5	70
28	1	28	2	56	3	84
40	1	28	2	56	3.5	98

9.4.4.4. Soil Movement

(1) Where a foundation is located in an area where soil movement caused by changes in soil moisture content, freezing, or chemical-microbiological oxidation is known to occur to the extent that it will damage a building, measures shall be taken to preclude such movement or to reduce the effects on the building so that the building's stability and the performance of assemblies will not be adversely affected.

(2) Any surcharge shall be in addition to the equivalent fluid pressure specified in Sentence (1).

Section 9.3. Materials, Systems and Equipment

Section 9.13. Dampproofing, Waterproofing and Soil Gas Control

9.13.1. General

9.13.1.1. Application

(1) This Section applies to the control of moisture and soil gas ingress through walls, floors, and roofs in contact with the ground.

9.13.2. Dampproofing

9.13.2.1. Dampproofing

(1) Except as provided in Article 9.13.3.1., where the exterior finished ground level is at a higher elevation than the ground level inside the foundation walls, exterior surfaces of foundation walls below ground level shall be dampproofed.

(2) Except as provided in Sentence (3) and Article 9.13.3.1., floors-on-ground shall be dampproofed.

(3) Floors in garages, floors in unenclosed portions of buildings and floors installed over granular fill in conformance with Article 9.16.2.1. need not be dampproofed.

(4) Dampproofing in Sentence (1) is not required where the exterior surfaces of foundation walls below ground level are waterproofed.

9.13.2.2. Material Standards

(1) Except as otherwise specified in this Section, materials used for exterior dampproofing shall conform to,

(a) CAN/CGSB-37.1-M, "Chemical Emulsified Type, Emulsified Asphalt for Dampproofing",

(b) CAN/CGSB-37.2-M, "Emulsified Asphalt, Mineral Colloid Type, Unfilled, for Dampproofing and Waterproofing and for Roof Coatings",

(c) CGSB 37-GP-6Ma, "Asphalt, Cutback, Unfilled, for Dampproofing",

(d) CAN/CGSB-37.16-M, "Filled, Cutback Asphalt for Dampproofing and Waterproofing",

(e) CGSB 37-GP-18Ma, "Tar, Cutback, Unfilled, for Dampproofing",

(f) CAN/CGSB-51.34-M, "Vapour Barrier, Polyethylene Sheet, for Use in Building Construction", or

(g) CAN/CSA-A123.4, "Asphalt for Constructing Built-Up Roof Coverings and Waterproofing Systems."

9.13.2.3. Standards for Application

(1) The method of application of all bituminous dampproofing materials shall conform to,

(a) CAN/CGSB 37.3-M, "Application of Emulsified Asphalts for Dampproofing or Waterproofing",

(b) CGSB 37-GP-12Ma, "Application of Unfilled Cutback Asphalt for Dampproofing", or

(c) CAN/CGSB-37.22-M, "Application of Unfilled, Cutback Tar Foundation Coating for Dampproofing".

9.13.2.4. Preparation of Surface

(1) Unit masonry walls that are to be dampproofed shall be,

(a) parged on the exterior face below ground level with not less than 6 mm of mortar conforming to Section 9.20., and

(b) coved over the footing when the first course of block is laid.

(2) Concrete walls to be dampproofed shall have holes and recesses resulting from the removal of form ties sealed with cement mortar or dampproofing material.

(3) The surface of insulating concrete form walls that are to be dampproofed shall be repaired and free of projections and depressions that could lead to detrimental to the performance of the membrane to be applied.

9.13.2.5. Application of Dampproofing Material

(1) Dampproofing material shall be applied over the parging or concrete below ground level.

9.13.2.6. Interior Dampproofing of Walls

(1) Where a separate interior finish is applied to a concrete or unit masonry wall that is in contact with the soil, or where wood members are placed in contact with such walls for the installation of insulation or finish, the interior surface

of the foundation wall below ground level shall be dampproofed.

(2) The dampproofing required in Sentence (1) shall extend from the basement floor and terminate at ground level.

(3) No membrane or coating with a permeance less than 170 ng/(Pa.s.m2) shall be applied to the interior surface of the foundation wall above ground level between the insulation and the foundation wall.

9.13.2.7. Dampproofing of Floors-on-Ground

(1) Where floors are dampproofed, the dampproofing shall be installed below the floor, except that where a separate floor is provided over a slab, the dampproofing is permitted to be applied to the top of the slab.

(2) Where installed below the floor, dampproofing membranes shall consist of polyethylene not less than 0.15 mm thick, or type S roll roofing.

(3) Joints in dampproofing membranes described in Sentence (2) shall be lapped not less than 100 mm.

(4) Where installed above the slab, dampproofing shall consist of,

(a) no fewer than 2 mopped-on coats of bitumen,

(b) not less than 0.05 mm polyethylene, or

(c) other material providing equivalent performance.

9.13.2.8. Dampproofing of Preserved Wood Foundation Walls

(1) Preserved wood foundation walls shall be dampproofed as described in CAN/CSA-S406, "Construction of Preserved Wood Foundations".

9.13.3. Waterproofing

9.13.3.1. Required Waterproofing

(1) Where hydrostatic pressure occurs, waterproofing is required for exterior surfaces of,

(a) floors-on-ground, and

(b) below ground walls, where the exterior finished ground level is at a higher elevation than the ground level inside the foundation walls.

(2) Roofs of underground structures shall be waterproofed to prevent the entry of water into the structure.

9.13.3.2. Material Standards

(1) Except as otherwise specified in this Section, materials used for exterior waterproofing shall conform to,

(a) CAN/CGSB-37.2-M, "Emulsified Asphalt, Mineral-Colloid Type, Unfilled, for Dampproofing and Waterproofing and for Roof Coatings",

(b) CAN/CGSB-37.16-M, "Filled, Cutback Asphalt for Dampproofing and Waterproofing", or

(c) CAN/CSA-A123.4, "Asphalt for Constructing Built-Up Roof Coverings and Waterproofing Systems".

9.13.3.3 Standards for Application

(1) The method of application of all bituminous waterproofing materials shall conform to CAN/CGSB-37.3-M, "Application of Emulsified Asphalts for Dampproofing or Waterproofing".

9.13.3.4. Preparation of Surface

(1) Unit masonry walls that are to be waterproofed shall be parged on exterior surfaces below ground level with not less than 6 mm of mortar conforming to Section 9.20.

(2) Concrete walls that are to be waterproofed shall have all holes and recesses resulting from removal of form ties sealed with mortar or waterproofing material.

(3) The surface of insulating concrete form walls that are to be waterproofed shall be repaired and free of projections and depressions that could be detrimental to the performance of the membrane to be applied.

9.13.3.5. Application of Waterproofing Membranes

(1) Concrete or unit masonry walls to be waterproofed shall be covered with no fewer than 2 layers of bitumen-saturated membrane, with each layer cemented in place with bitumen and coated overall with a heavy coating of bitumen.

9.13.3.6. Floor Waterproofing System

(1) Basement floors-on-ground to be waterproofed shall have a system of membrane waterproofing provided between 2 layers of concrete, each of which shall be not less than 75 mm thick, with the floor membrane mopped to the wall membrane to form a complete seal.

9.13.4. Soil Gas Control

9.13.4.1. Soil Gas Control

(1) Where methane or radon gases are known to be a problem, construction shall comply with the requirements for soil gas control in Supplementary Standard SB-9.

9.13.4.2. Required Soil Gas Control

(1) Except as provided in Sentence (2), all wall, roof and floor assemblies in contact with the ground shall be constructed to resist the leakage of soil gas from the ground into the building.

(2) Construction to resist leakage of soil gas into the building is not required for,

(a) garages and unenclosed portions of buildings,

(b) buildings constructed in areas where it can be demonstrated that soil gas does not constitute a hazard, or

(c) buildings that contain a single dwelling unit and are constructed to provide for subfloor depressurization in accordance with Supplementary Standard SB-9.

(3) Where soil gas control is required, a soil gas barrier shall be installed at walls and roofs in contact with the ground according to Supplementary Standard SB-9.

(4) Where soil gas control is required, it shall consist of one of the following at floors in contact with the ground:

(a) a soil gas barrier installed according to Supplementary Standard SB-9 , or

(b) where the building contains a single dwelling unit only, a subfloor depressurization system installed according to Supplementary Standard SB-9.

9.13.4.3. Material Standards

(1) Materials used to provide a barrier to soil gas ingress through floors-on-ground shall conform to CAN/CGSB-51.34-M, "Vapour Barrier, Polyethylene Sheet, for Use in Building Construction".

Section 9.14. Drainage

9.14.1. Scope

9.14.1.1. Application

(1) This Section applies to subsurface drainage and to surface drainage.

9.14.1.2. Crawl Spaces

(1) Drainage for crawl spaces shall conform to Section 9.18.

9.14.1.3. Floors-on-Ground

(1) Drainage requirements beneath floors-on-ground shall conform to Section 9.16.

9.14.2. Foundation Drainage

9.14.2.1. Foundation Wall Drainage

(1) Unless it can be shown to be unnecessary, drainage shall be provided at the bottom of every foundation wall that contains the building interior.

(2) Except as permitted in Sentences (4) to (6), where the insulation on a foundation wall extends to more than 900 mm below the adjacent exterior ground level,

(a) a drainage layer shall be installed adjacent to the exterior surface of a foundation wall consisting of,

(i) not less than 19 mm mineral fibre insulation with a density of not less than 57 kg/m3 , or

(ii) not less than 100 mm of free draining granular material, or

(b) a system shall be installed that can be shown to provide equivalent performance to that provided by the materials described in Clause (a).

(3) Where mineral fibre insulation, crushed rock backfill or other drainage layer medium is provided adjacent to the exterior surface of a foundation wall,

(a) the insulation, backfill or other drainage layer medium shall extend to the footing level to facilitate drainage of ground water to the foundation drainage system, and

(b) any pyritic material in the crushed rock shall be limited to a concentration that will not damage the building to a degree that would adversely affect its stability or the performance of assemblies separating dissimilar environments.

(4) Except when the insulation provides the drainage layer required in Clause (2)(a), when exterior insulation is provided, the drainage layer shall be installed on the exterior face of the insulation.

(5) The drainage layer required in Sentence (2) is not required,

(a) when the foundation wall is not required to be dampproofed, or

(b) when the foundation wall is waterproofed.

(6) The drainage layer in Sentence (2) is only required where the foundation wall is constructed after the day this Regulation comes into force.

(7) Where drainage is required in Sentence (1), the drainage shall conform to Subsection 9.14.3. or 9.14.4.

9.14.3. Drainage Tile and Pipe

9.14.3.1. Material Standards

(1) Drain tile and drain pipe for foundation drainage shall conform to,

(a) ASTM C4, "Clay Drain Tile and Perforated Clay Drain Tile",

(b) ASTM C412M, "Concrete Drain Tile (Metric)",

(c) ASTM C444M, "Perforated Concrete Pipe (Metric)",

(d) ASTM C700, "Vitrified Clay Pipe, Extra Strength, Standard Strength and Perforated",

(e) CAN/CGSB-34.22, "Asbestos-Cement Drain Pipe",

(f) CAN/CSA-B182.1, "Plastic Drain and Sewer Pipe and Pipe Fittings",

(g) CSA G401, "Corrugated Steel Pipe Products", or

(h) NQ 3624-115, "Polythylene (PE) Pipe and Fittings – Flexible Corrugated Pipes for Drainage – Characteristics and Test Methods".

9.14.3.2. Minimum Size

(1) Drain tile or pipe used for foundation drainage shall be not less than 100 mm in diam.

9.14.3.3. Installation

(1) Drain tile or pipe shall be laid on undisturbed or well-compacted soil so that the top of the tile or pipe is below the bottom of the floor slab or crawl space.

(2) Drain tile or pipe with butt joints shall be laid with 6 mm to 10 mm open joints.

(3) The top half of joints referred to in Sentence (2) shall be covered with sheathing paper, 0.10 mm polyethylene or No.15 asphalt or tar-saturated felt.

(4) The top and sides of drain pipe or tile shall be covered with not less than 150 mm of crushed stone or other coarse clean granular material containing not more than 10% of material that will pass a 4 mm sieve.

9.14.4. Granular Drainage Layer

9.14.4.1. Type of Granular Material

(1) Granular material used to drain the bottom of a foundation shall consist of a continuous layer of crushed stone or other coarse clean granular material containing,

(a) not more than 10% of material that will pass a 4 mm sieve, and

(b) no pyritic material in a concentration that would adversely affect its stability or the performance of assemblies separating dissimilar environments.

9.14.4.2. Installation

(1) Granular material described in Article 9.14.4.1. shall be laid on undisturbed or compacted soil to a minimum depth of not less than 125 mm beneath the building and extend not less than 300 mm beyond the outside edge of the footings.

9.14.4.3. Grading

(1) The bottom of an excavation drained by a granular layer shall be graded so that the entire area described in Article 9.14.4.2. is drained to a sump conforming to Article

9.14.5.2.

9.14.4.4. Wet Site Conditions

(1) Where because of wet site conditions soil becomes mixed with the granular drainage material, sufficient additional granular material shall be provided so that the top 125 mm is kept free of soil.

9.14.5. Drainage Disposal

9.14.5.1. Drainage Disposal

(1) Foundation drains shall drain to a sewer, drainage ditch or dry well.

9.14.5.2. Sump Pits

(1) Where gravity drainage is not practical, a covered sump with an automatic pump shall be installed to discharge the water into a sewer, drainage ditch or dry well.

(2) Covers for sump pits shall be designed to resist removal by children.

9.14.5.3. Dry Wells

(1) Dry wells are permitted to be used only when located in areas where the natural groundwater level is below the bottom of the dry well.

(2) Dry wells shall be not less than 5 m from the building foundation and located so that drainage is away from the building.

9.14.6. Surface Drainage

9.14.6.1. Surface Drainage

(1) The building shall be located or the building site graded so that water will not accumulate at or near the building and will not adversely affect adjacent properties.

9.14.6.2. Drainage away from Wells or Septic Disposal Beds

(1) Surface drainage shall be directed away from the location of a water supply well or septic tank disposal bed.

9.14.6.3. Window Wells

(1) Every window well shall be drained to the footing level or other suitable location.

9.14.6.4. Catch Basin

(1) Where runoff water from a driveway is likely to accumulate or enter a garage, a catch basin shall be installed to provide adequate drainage.

9.14.6.5. Downspouts

(1) Downspouts shall conform to Article 9.26.18.2.

Section 9.15. Footings and Foundations

9.15.1. Application

9.15.1.1. General

(1) Except as provided in Articles 9.15.1.2. and 9.15.1.3., this Section applies to,

(a) concrete or unit masonry foundation walls and concrete footings not subject to surcharge,

(i) on stable soils with an allowable bearing pressure of 75 kPa or greater, and

(ii) for buildings of wood frame or masonry construction,

(b) wood frame foundation walls and wood or concrete footings not subject to surcharge,

(i) on stable soils with an allowable bearing pressure of 75 kPa or greater, and

(ii) for buildings of wood frame construction, and

(c) flat insulating concrete form foundation walls and concrete footings not subject to surcharge,

(i) on stable soils with an allowable bearing pressure of 100 kPa or greater, and

(ii) for buildings of light frame or flat insulated concrete form construction that are not more than 2 storeys in building height, with a maximum floor to floor height of 3 m, and containing only a single dwelling unit.

(2) Foundations for applications other than as described in Sentence (1) shall be designed in accordance with Section 9.4.

(3) Where a foundation is erected on filled ground, peat or sensitive clay, the footing sizes shall be designed in conformance with Section 4.2.

(4) For the purpose of Sentence (3), sensitive clay means the grain size of the majority of the particles is smaller than 0.002 mm, including leda clay.

9.15.1.2. Permafrost

(1) Buildings erected on permafrost shall have foundations designed by a designer competent in this field in accordance with the appropriate requirements of Part 4.

9.15.1.3. Foundations for Deformation Resistant Buildings

(1) Where the superstructure of a detached building conforms to the requirements of the deformation resistance test in CAN/CSA-Z240.2.1, “Structural Requirements for Mobile Homes”, the foundation shall be constructed in conformance with,

(a) the remainder of this Section, or
(b) CSA Z240.10.1, “Site Preparation, Foundation, and Anchorage of Mobile Homes”.

9.15.2. General
9.15.2.1. Concrete
(1) Concrete shall conform to Section 9.3.
9.15.2.2. Unit Masonry Construction
(1) Concrete block shall conform to CSA A165.1, “Concrete Block Masonry Units”, and shall have a compressive strength over the average net cross-sectional area of the block of not less than 15 MPa.
(2) Mortar, grout, mortar joints, corbelling and protection for unit masonry shall conform to Section 9.20.
(3) For concrete block foundation walls required to be reinforced,
(a) mortar shall be Type S, conforming to CSA A179, “Mortar and Grout for Unit Masonry”,
(b) grout shall be coarse, conforming to CSA A179, “Mortar and Grout for Unit Masonry”, and
(c) placement of grout shall conform to CSA A371, “Masonry Construction for Buildings”.
9.15.2.3. Pier Type Foundations
(1) Where pier type foundations are used, the piers shall be designed to support the applied loads from the superstructure.
(2) Where piers are used as a foundation system in a building of 1 storey in building height, the piers shall be installed to support the principal framing members and shall be spaced not more than 3.5 m apart along the framing, unless the piers and their footings are designed for larger spacings.
(3) The height of piers described in Sentence (2) shall not exceed 3 times their least dimension at the base of the pier.
(4) Where concrete block is used for piers described in Sentence (2), they shall be laid with cores placed vertically, and where the width of the building is 4.3 m or less, placed with their longest dimension at right angles to the longest dimension of the building.
9.15.2.4. Wood Frame Foundations
(1) Foundations of wood frame construction shall conform to,
(a) CAN/CSA-S406, “Construction of Preserved Wood Foundations”, or
(b) Part 4.

9.15.3. Footings
9.15.3.1. Footings Required
(1) Footings shall be provided under walls, pilasters, columns, piers, fireplaces and chimneys that bear on soil or rock, except that footings are permitted to be omitted under piers or monolithic concrete walls if the safe loadbearing capacity of the soil or rock is not exceeded.
9.15.3.2. Support of Footings
(1) Footings shall rest on undisturbed soil, rock or compacted granular fill.
(2) Granular fill shall not contain pyritic material in a concentration that would adversely affect its stability or the performance of assemblies separating dissimilar environments.
9.15.3.3. Application of Footing Width and Area Requirements
(1) Except as provided in Sentence 9.15.3.4.(2), the minimum footing width or area requirements provided in Articles 9.15.3.4. to 9.15.3.7. shall apply to footings where,
(a) the footings support,
(i) foundation walls of masonry, concrete, or flat insulating form foundation walls,
(ii) above ground walls of masonry, flat insulating form foundation walls or light wood frame construction, and
(iii) floors and roofs of light wood frame construction,
(b) the span of supported joists does not exceed 4.9 m, and
(c) the specified live load on any floor supported by the footing does not exceed 2.4 kPa.
(2) Except as provided in Sentence 9.15.3.4.(2), where the span of the supported joists exceeds 4.9 m, footings shall be designed in accordance with Section 4.2.
(3) Where the specified live load exceeds 2.4 kPa footings shall be designed in accordance with Section 4.2.
9.15.3.4. Basic Footing Widths and Areas
(1) Except as provided in Sentences (2) and (3) and in Articles 9.15.3.5. to 9.15.3.7., the minimum footing width or area shall comply with Table 9.15.3.4.
(2) Where the supported joist span exceeds 4.9 m in buildings with light wood-framed walls, floors and roofs, footing widths shall be determined according to,
(a) Section 4.2., or
(b) the following formula:

$$W = w \cdot [\sum sjs / (storeys \cdot 4.9)]$$

where,
W = minimum footing width,
w = minimum width of footings supporting joists not exceeding 4.9 m, as defined by Table 9.15.3.4.,
∑ sjs = the sum of the supported joist lengths on each storey whose load is transferred to the footing, and
storeys = number of storeys supported by the footing
(3) Where a foundation rests on gravel, sand or silt in which the water table level is less than the width of the footings below the bearing surface,
(a) the footing width for walls shall be not less than twice the width required by Sentences (1) and (2), and Ar-

Table 9.15.3.4

Column 1	Column 2	Column 3	Column 4
Number of Floors Supported	Minimum Width of Strip Footings, mm		Minimum Footing Area for Columns Spaced 3 m o.c.(1), m^2
	Supporting Exterior Walls(2)	Supporting Interior Walls(3)	
1	250	200	0.40
2	350	350	0.75
3	450	500	1.0

ticles 9.15.3.5. and 9.15.3.6., and

(b) the footing area for columns shall be not less than twice the area required by Sentences (1) and (2), and Article 9.15.3.7.

*****see table 9.15.3.4*****

Notes to Table 9.15.3.4.:
See Sentence 9.15.3.7.(1). (1)
See Sentences 9.15.3.5.(1). (2)
See Sentence 9.15.3.6.(1). (3)

9.15.3.5. Adjustments to Footing Widths for Exterior Walls

(1) The strip footing widths for exterior walls shown in Table 9.15.3.4. shall be increased by,

(a) 65 mm for each storey of masonry veneer over wood frame construction supported by the foundation wall,

(b) 130 mm for each storey of masonry construction supported by the foundation wall, and

(c) 150 mm for each storey of flat insulating concrete form wall construction supported by the foundation wall.

9.15.3.6. Adjustments to Footing Widths for Interior Walls

(1) The minimum strip footing widths for interior loadbearing masonry walls shown in Table 9.15.3.4. shall be increased by 100 mm for each storey of masonry construction supported by the footing.

(2) Footings for interior non-loadbearing masonry walls shall be not less than 200 mm wide for walls up to 5.5 m high and the width shall be increased by 100 mm for each additional 2.7 m of height.

9.15.3.7. Adjustments to Footing Area for Columns

(1) The footing area for column spacings other than shown in Table 9.15.3.4. shall be adjusted in proportion to the distance between columns.

9.15.3.8. Footing Thickness

(1) Footing thickness shall be not less than the greater of,

(a) 100 mm, or

(b) the width of the projection of the footing beyond the supported element.

9.15.3.9. Step Footings

(1) Where step footings are used,

(a) the vertical rise between horizontal portions shall not exceed 600 mm, and

(b) the horizontal distance between risers shall be not less than 600 mm.

Table 9.15.4.2A

Column 1	Column 2	Column 3	Column 4
Type of *Foundation* Wall	Minimum Wall Thickness, Mm	Maximum Height of Finish Ground Above *Basement* Floor or Crawl Space Ground Cover, m	
		Foundation Wall Laterally Unsupported at the Top(1)	*Foundation* Wall Laterally Supported at the Top(1)
Solid concrete, 15 Mpa min. strength	150	0.8	1.5
	200	1.2	2.15
	250	1.4	2.3
	300	1.5	2.3
Solid concrete, 20 Mpa min. strength	150	0.8	1.8
	200	1.2	2.3
	250	1.4	2.3
	300	1.5	2.3
Unreinforced Concrete Block	140	0.6	0.8
	190	0.9	1.2
	240	1.2	1.8
	290	1.4	2.2

9.15.4. Foundation Walls

9.15.4.1. Permanent Form Material

(1) Insulating concrete form units shall be manufactured of polystyrene conforming to the performance requirements of CAN/ULC-S701, "Thermal Insulation, Polystyrene, Boards and Pipe Covering", for Type 2, 3 or 4 polystyrene.

9.15.4.2. Foundation Wall Thickness and Required Lateral Support

(1) Except as required in Sentence (2), the thickness of foundation walls made of unreinforced concrete block or solid concrete and subject to lateral earth pressure shall conform to Table 9.15.4.2.A. for walls not exceeding 2.5 m in unsupported height.

*****see Table 9.15.4.2.A.*****

Note to Table 9.15.4.2.A.:
See Article 9.15.4.3. (1)

(2) The thickness of concrete in flat insulating concrete form foundation walls shall be not less than the greater of,

(a) 140 mm, or

(b) the thickness of the concrete in the wall above.

(3) Foundation walls made of flat insulating concrete form units shall be laterally supported at the top and at the bottom.

(4) Where average stable soils are encountered and wind loads on the exposed portion of the foundation are no greater than 0.70 kPa, the thickness and reinforcing of foundation walls made of reinforced concrete block and subject to lateral earth pressure shall conform to Table 9.15.4.2.B. and Sentences (5) to (10).

*****see Table 9.15.4.2.B.*****

Notes to Table 9.15.4.2.B.:
See Article 9.15.4.3. (1)
No reinforcement required. (2)
Design to Part 4. (3)

(5) For concrete block walls required to be reinforced, continuous vertical reinforcement shall,

(a) be provided at wall corners, wall ends, wall intersections, at changes in wall height, at the jambs of all openings and at movement joints,

(b) extend from the top of the footing to the top of the foundation wall,

(c) where foundation walls are laterally unsupported at the top, have not less than 600 mm embedment into the footing, and

(d) where foundation walls are laterally supported at the top, have not less than 50 mm embedment into the footing, if the floor slab does not provide lateral support at the wall base.

(6) Where foundation walls are laterally unsupported, the footing shall be designed according to Part 4 to resist overturning and sliding, if the maximum height of finished ground above the basement floor or crawl space ground cover exceeds 1.50 m.

(7) At the base of concrete block walls required to be reinforced and where the height of finished ground above the basement floor or crawl space ground cover exceeds 2.0 m, not less than one 15M intermediate vertical bar reinforcement shall be installed midway between adjacent continuous vertical reinforcement, and shall,

Table 9.15.4.2B

Column 1	Colun 2	*Column 3*	*Column 4*	*Column 5*	*Column 6*
Minimum Wall Thickness, mm	Maximum Height of Finished Ground above *Basement* Floor or Crawl Space Ground Cover,m	*Foundation* Wall Laterally Unsupported at T		*Foundation* Wall Laterally Supported at Top (1	
		Continuous Vertical Reinforcement		Continuous Vertical Reinforcement	
		Minimum Bar Size	Maximum Bar Spacing, m	Minimum Bar Size	Maximum Bar Spacing, m
190	1.0	25M	1.2	(2)	(2)
	1.2	25M	1.2	(2)	(2)
	1.4	25M	1.2	15M	1.2
	1.6	25M	0.8	15M	1.2
	1.8	25M	0.6	20M	1.2
	2.0	25M	0.4	20M	1.2
	2.2	(3)	(3)	25M	1.2
	2.4	(3)	(3)	25M	1.2
240	1.4	25M	1.0	(2)	(2)
	1.6	25M	1.0	(2)	(2)
	1.8	25M	0.8	(2)	(2)
	2.0	25M	0.8	20M	1.8
	2.2	25M	0.8	25M	1.8
	2.4	25M	0.6	25M	1.8

(a) extend to not less than 600 mm above the top of the footing, and
(b) have not less than 50 mm embedment into the footing, if the floor slab does not provide lateral support at the wall base.

(8) For concrete block walls required to be reinforced, a continuous horizontal bond beam containing at least one 15M bar shall be installed,
(a) along the top of the wall,
(b) at the sill and head of all openings greater than 1.20 m in width, and
(c) at structurally connected floors.

(9) In concrete block walls required to be reinforced, all vertical bar reinforcement shall be installed along the centre line of the wall.

(10) In concrete block walls required to be reinforced, ladder or truss type lateral reinforcement not less than 3.8 mm (No. 9 ASWG) shall be installed in the bed joint of every second masonry course.

9.15.4.3. Foundation Walls Considered to be Laterally Supported at the Top

(1) Sentences (2) to (4) apply to lateral support for walls described in Sentence 9.15.4.2.(1).

(2) Foundation walls shall be considered to be laterally supported at the top if,
(a) such walls support solid masonry superstructure,
(b) the floor joists are embedded in the top of the foundation walls, or
(c) the floor system is anchored to the top of the foundation walls with anchor bolts, in which case the joists may run either parallel or perpendicular to the foundation walls.

(3) Unless the wall around an opening is reinforced to withstand earth pressure, the portion of the foundation wall beneath an opening shall be considered laterally unsupported, if,
(a) the opening is more than 1.2 m wide, or
(b) the total width of the openings in the foundation wall constitutes more than 25% of the length of the wall.

(4) For the purposes of Sentence (3), the combined width of the openings shall be considered as a single opening if the average width is greater than the width of solid wall between them.

(5) Flat insulating concrete form foundation walls shall be considered to be laterally supported at the top if the floor joists are installed according to Article 9.20.17.5.

9.15.4.4. Foundation Walls Considered to be Laterally Supported at the Bottom

(1) Flat insulating concrete form foundation walls shall be considered to be laterally supported at the bottom where the foundation wall,
(a) supports backfill not more than 1.2 m in height,
(b) is supported at the footing by a shear key and is supported at the top by the ground floor framing, or
(c) is dowelled to the footing with not less than 15M bars spaced not more than 1.2 m o.c.

9.15.4.5. Reinforcement for Flat Insulating Concrete Form Foundation Walls

(1) Horizontal reinforcement in flat insulating concrete form foundation walls shall,
(a) consist of,
(i) one 10M bar placed not more than 300 mm from the top of the wall, and
(ii) 10M bars spaced not more than 600 mm o.c., and
(b) be located,
(i) in the inside half of the wall section, and
(ii) with a minimum cover of 30 mm from the inside face of the concrete.

(2) Vertical wall reinforcement in flat insulating concrete form foundation walls shall,
(a) conform to,
(i) Table 9.15.4.5.A. for 140 mm walls,
(ii) Table 9.15.4.5.B. for 190 mm walls, and
(iii) Table 9.15.4.5.C. for 240 mm walls,
(b) be located in the inside half of the wall section with a minimum cover of 30 mm from the inside face of the concrete wall, and
(c) where interrupted by wall openings, be placed not more than 600 mm from each side of the openings.

(3) Cold joints in flat insulating concrete form foundation walls shall be reinforced with at least one 15M bar spaced not more than 600 mm o.c. and embedded not less than 300 mm on both sides of the joint.

(4) Reinforcing around openings in flat insulating concrete form foundation walls shall comply with Articles 9.20.17.3. or 9.20.17.4.

*****see Table 9.15.4.5.A.*****

*****see Table 9.15.4.5.B.*****

*****see Table 9.15.4.5C*****

9.15.4.6. Extension above Ground Level

(1) Exterior foundation walls shall extend not less than 150 mm above finished ground level.

9.15.4.7. Reduction in Thickness

(1) Where the top of a foundation wall is reduced in thickness to permit the installation of floor joists, the reduced section shall be not more than 350 mm high and not less than 90 mm thick.

(2) Where the top of a foundation wall is reduced in thickness to permit the installation of a masonry exterior facing, the reduced section shall be,

Table 9.15.4.5A

Column 1	Column 2	Column 3	Column 4
Maximum Height of Finished Ground Above Finished *Basement* Floor, m	Maximum Vertical Reinforcement		
	Maximum Unsupported *Basement* Wall Height		
	2.44 m	2.75 m	3.00 m
1.35	10M at 400 mm o.c.	10M at 400 mm o.c.	10M at 400 mm o.c.
1.60	10M at 400 mm o.c.	10M at 380 mm o.c.	10M at 380 mm o.c.
2.00	10M at 380 mm o.c.	10M at 380 mm o.c.	10M at 380 mm o.c.
2.20	10M at 250 mm o.c.	10M at 250 mm o.c.	10M at 250 mm o.c.
2.35	n/a	10M at 250 mm o.c.	10M at 250 mm o.c.
2.60	n/a	10M at 250 mm o.c.	10M at 250 mm o.c.
3.00	n/a	n/a	15M at 250 mm o.c.

Table 9.15.4.5B

Column 1	Column 2	Column 3	Column 4
Maximum Height of Finished Ground Above Finished *Basement* Floor, m	Maximum Vertical Reinforcement		
	Maximum Unsupported *Basement* Wall Height		
	2.44 m	2.75 m	3.00 m
2.20	none required	10M at 400 mm o.c.	10M at 400 mm o.c.
2.35	n/a	10M at 300 mm o.c.	10M at 300 mm o.c.
2.60	n/a	10M at 300 mm o.c.	15M at 400 mm o.c.
3.00	n/a	n/a	15M at 400 mm o.c.

Table 9.15.4.5C

Column 1	Column 2	Column 3	Column 4
Maximum Height of Finished Ground Above Finished *Basement* Floor, m	Maximum Vertical Reinforcement		
	Maximum Unsupported *Basement* Wall Height		
	2.44 m	2.75 m	3.00 m
2.20	none required	none required	none required
2.60	n/a	15M at 400 mm o.c.	15M at 400 mm o.c.
3.00	n/a	n/a	15M at 400 mm o.c.

(a) not less than 90 mm thick, and
(b) tied to the facing material with metal ties conforming to Sentence 9.20.9.4.(3) spaced not more than,
(i) 200 mm o.c. vertically, and
(ii) 900 mm o.c. horizontally.

(3) The space between wall and facing described in Sentence (2) shall be filled with mortar.

9.15.4.8. Corbelling

(1) Corbelling of masonry foundation walls supporting cavity walls shall conform to Article 9.20.12.2.

9.15.4.9. Crack Control Joints

(1) Crack control joints shall be provided in foundation walls more than 25 m long at intervals of not more than 15 m.

(2) Joints required in Sentence (1) shall be designed to resist moisture penetration and shall be keyed to prevent relative displacement of the wall portions adjacent to the joint.

9.15.4.10. Interior Masonry Walls

(1) Interior masonry foundation walls not subject to lateral earth pressure shall conform to Section 9.20.

9.15.5. Support of Joists and Beams on Masonry Foundation Walls

9.15.5.1. Support of Floor Joists

(1) Except as permitted in Sentence (2), foundation walls of hollow unit masonry supporting floor joists shall be,
(a) capped with not less than 50 mm of solid masonry or concrete, or
(b) have the top course filled with mortar or concrete.

(2) Capping required in Sentence (1) is permitted to be omitted,
(a) in localities where termites are not known to occur,
(b) when the joists are supported on a wood plate not less than 38 mm by 89 mm, and
(c) when the siding overlaps the foundation wall not less than 12 mm.

9.15.5.2. Support of Beams

(1) Not less than a 190 mm depth of solid masonry shall be provided beneath beams supported on masonry.

(2) Where the beam referred to in Sentence (1) is supported below the top of the foundation walls, the ends of such beams shall be protected from the weather.

9.15.5.3. Pilasters

(1) Pilasters shall be provided under beams that frame into unit masonry foundation walls 140 mm or less in thickness.

(2) Pilasters required in Sentence (1) shall be not less than 90 mm by 290 mm and shall be bonded or tied into the wall.

(3) The top 200 mm of pilasters required in Sentence (1) shall be solid.

9.15.6. Parging and Finishing of Foundation Walls

9.15.6.1. Foundation Walls Below Ground

(1) Concrete block foundation walls shall be parged on the exterior face below ground level as required in Section 9.13.

9.15.6.2. Foundation Walls Above Ground

(1) Exterior surfaces of concrete block foundation walls above ground level shall have tooled joints, or shall be rendered, parged or otherwise suitably finished.

9.15.6.3. Form Ties

(1) All form ties shall be removed at least flush with the concrete surface.

Section 9.16. Floors-on-Ground

9.16.1. Scope

9.16.1.1. Application

(1) This Section applies to floors that are supported on ground or granular fill and that do not provide structural support for the superstructure.

9.16.1.2. Structural Floor Slabs

(1) Floors-on-ground that support loads from the superstructure shall be designed in conformance with Part 4.

9.16.1.3. Required Floors-on-Ground

(1) All spaces within dwelling units, except crawl spaces, shall be provided with a floor-on-ground, where,
(a) access is provided to the space, and
(b) a floor supported by the structure is not provided.

9.16.1.4. Dampproofing and Waterproofing

(1) Dampproofing and waterproofing shall conform to

9.16.2. Material Beneath Floors

9.16.2.1. Required Installation of Granular Fill

(1) Except as provided in Sentence (2), not less than 100 mm of coarse clean granular material containing not more than 10% of material that will pass a 4 mm sieve shall be placed beneath floors-on-ground.

(2) Granular material need not be installed under,
(a) slabs in garages, carports or accessory buildings, or
(b) buildings of industrial occupancy where the nature of the process contained in the occupancy permits or requires the use of large openings in the building envelope even during the winter.

9.16.2.2. Support of Floors

(1) Material that is susceptible to changes in volume due to variations in moisture content or chemical-microbiological oxidation shall not be used as fill beneath floors-on-ground in a concentration that will damage the building to a degree that would adversely affect its stability or the performance of assemblies separating dissimilar environments.

(2) Material that is susceptible to changes in volume due to freezing shall not be used as fill beneath floors-on-ground that will be subjected to freezing temperatures.

(3) Except as provided in Sentence (4), fill beneath floors-on-ground shall be compacted.

(4) Fill beneath floors-on-ground need not be compacted where the material is clean coarse aggregate containing not more than 10% of material that will pass a 4 mm sieve.

9.16.3. Drainage

9.16.3.1. Control of Water Ingress

(1) Except as provided in Article 9.16.3.2. or where it can be shown to be unnecessary, ingress of water underneath a floor-on-ground shall be prevented by grading or drainage.

9.16.3.2. Hydrostatic Pressure

(1) Where groundwater levels may cause hydrostatic pressure beneath a floor-on-ground, the floor-on-ground shall be,
(a) a cast-in-place concrete slab, and
(b) designed to resist such pressures.

9.16.3.3. Floor Drains

(1) When floor drains are required, the floor surface shall be sloped so that no water can accumulate.

9.16.4. Concrete

9.16.4.1. Surface Finish

(1) The finished surface of concrete floor slabs shall be trowelled smooth and even.

(2) Dry cement shall not be added to the floor surfaces to absorb surplus water.

9.16.4.2. Topping Course

(1) Where a topping course is provided for a concrete floor slab, it shall consist of 1 part cement to 2.5 parts clean,

well graded sand by volume, with a water/cement ratio approximately equal to that of the base slab.

(2) When concrete topping is provided it shall not be less than 20 mm thick.

9.16.4.3. Thickness

(1) Concrete slabs shall be not less than 75 mm thick exclusive of concrete topping.

9.16.4.4. Bond Break

(1) A bond-breaking material shall be placed between the slab and footings or rock.

9.16.4.5. Compressive Strength

(1) Where dampproofing is not provided the concrete used for floors-on-ground shall have a compressive strength of not less than 25 MPa after 28 days.

(2) Where dampproofing is provided as described in Article 9.13.2.7., the concrete used for floors-on-ground shall have a compressive strength of not less than 15 MPa after 28 days.

Section 9.25. Heat Transfer, Air Leakage and Condensation Control

9.25.1. Scope

9.25.1.1. Application

(1) This Section applies to the application of thermal insulation and measures to control condensation, heat transfer and air leakage for buildings of residential occupancy intended for use on a continuing basis during the winter months.

(2) Insulation and sealing of heating and ventilating ducts shall conform to Sections 9.32. and 9.33.

9.25.1.2. General

(1) Sheet and panel-type materials shall be installed in accordance with Sentence (2), if the material,

(a) has an air leakage characteristic less than 0.1 L/(s·m2) at 75 Pa,

(b) has a water vapour permeance less than 60 ng/(Pa·s·m2) when measured in accordance with ASTM E96, "Water Vapor Transmission of Materials", using the desiccant method (dry cup), and

(c) is incorporated into a building assembly required by Article 9.25.2.1. to be insulated.

(2) Sheet and panel-type material described in Sentence (1) shall be installed,

(a) on the warm face of the assembly,

(b) except as provided in Sentences (3) to (5), at a location where the ratio between the total thermal resistance of all materials outboard of its innermost impermeable surface and the total thermal resistance of all materials inboard of that surface is not less than that required in Table 9.25.1.2., or

(c) outboard of an air space that is vented to the outdoors and, for walls, drained.

*****see Table 9.25.1.2.*****

Notes to Table 9.25.1.2.:

See Supplementary Standard SB-1. (1)

(3) Wood-based sheathing materials not more than 12.5 mm thick and complying with Article 9.23.16.2. need not comply with Sentence (1).

(4) Where the mild climate indicator, determined in accordance with Sentence (6), is greater than 6300, the position of low air- and vapour-permeance materials within the assembly relative to the position of materials providing thermal resistance shall be determined according to Part 5 where,

(a) the intended use of the interior space requires the indoor relative humidity to be maintained above 35% over the heating season and the ventilating and air-conditioning system is designed to maintain that relative humidity, or

(b) the intended use of the interior space will result in an indoor relative humidity above 35% over the heating season and the ventilating and air-conditioning system does not have the capacity to reduce the relative humidity to 35% for any period over that period.

(5) Where the mild climate indicator, determined in ac-

Table 9.25.1.2

Column 1	Column 2
Heating Degree Days of *Building* Location[(1)], Celsius Degree-days	Minimum Ratio, Total Thermal Resistance Outboard of Material's Inner Surface to Total Thermal Resistance Inboard of Material's Inner Surface
up to 4 999	0.20
5 000 to 5 999	0.30
6 000 to 6 999	0.35
7 000 to 7 999	0.40
8 000 to 8 999	0.50
9 000 to 9 999	0.55
10 000 to 10 999	0.60
11 000 to 11 999	0.65
12 000 to 12 999	0.75

cordance with Sentence (6), is less than or equal to 6300, the position of low air- and vapour-permeance materials within the assembly relative to the position of materials providing thermal resistance shall be determined according to Part 5 where,

(a) the intended use of the interior space requires the indoor relative humidity to be maintained above 60% over the heating season and the ventilation and air-conditioning system is designed to maintain that relative humidity, or

(b) the intended use of the interior space will result in an indoor relative humidity above 60% over the heating season and the ventilating and air-conditioning system does not have the capacity to reduce the relative humidity above 60% for any period over that period.

(6) The mild climate indicator (MCI) shall be calculated according to the following formula:

MCI = abs(2.5% JMT) · 200 + DD

where,

abs(2.5% JMT) = absolute value of 2.5% January mean temperature, and

DD = degree-days

(7) For walls, the air space described in Clause (2)(c) shall comply with Clause 9.27.2.2.(1)(a).

9.25.2. Thermal Insulation

9.25.2.1. Required Insulation

(1) All walls, ceilings and floors separating heated space from unheated space, the exterior air or the exterior soil shall be provided with thermal insulation in conformance with Sections 12.2. and 12.3. to prevent moisture condensation on their room side during the winter and to ensure comfortable conditions for the occupants.

9.25.2.2. Insulation Materials

(1) Except as required in Sentence (2), thermal insulation shall conform to the requirements of,

(a) CAN/CGSB-51.25-M, "Thermal Insulation, Phenolic, Faced",

(b) CAN/CGSB-51-GP-27M, "Thermal Insulation, Polystyrene, Loose Fill",

(c) CAN/ULC-S701, "Thermal Insulation, Polystyrene, Boards and Pipe Covering",

(d) CAN/ULC-S702 "Mineral Fibre Thermal Insulation for Buildings",

(e) CAN/ULC-S703, "Cellulose Fibre Insulation (CFI) for Buildings",

(f) CAN/ULC-S704, "Thermal Insulation, Polyurethane and Polyisocyanurate, Boards, Faced",

(g) CAN/ULC-S705.1, "Thermal Insulation – Spray Applied Rigid Polyurethane Foam, Medium Density – Material Specification", or

(h) CAN/ULC-S706, "Wood Fibre Thermal Insulation for Buildings".

(2) The flame-spread rating requirements contained in the standards listed in Sentence (1) shall not apply.

(3) Insulation in contact with the ground shall be inert to the action of soil and water and be such that its insulative properties are not significantly reduced by moisture.

(4) Type 1 expanded polystyrene insulation as described in CAN/ULC-S701, "Thermal Insulation, Polystyrene, Boards and Pipe Covering", shall not be used as roof insulation applied above the roofing membrane.

9.25.2.3. Installation of Thermal Insulation

(1) Insulation shall be installed so that there is a reasonably uniform insulating value over the entire face of the insulated area.

(2) Insulation shall be applied to the full width and length of the space between furring or framing.

(3) Except where the insulation provides the principal resistance to air leakage, thermal insulation shall be installed so that at least 1 face is in full and continuous contact with an element with low air permeance.

(4) Insulation on the interior of foundation walls enclosing a crawl space shall be applied so that there is not less than a 50 mm clearance above the crawl space floor if the insulation is of a type that may be damaged by water.

(5) Insulation around concrete slabs-on-ground shall be located so that heat from the building is not restricted from reaching the ground beneath the perimeter, where exterior walls are not supported by footings extending below frost level.

(6) Where insulation is exposed to the weather and subject to mechanical damage, it shall be protected with not less than,

(a) 6 mm asbestos-cement board,

(b) 6 mm preservative-treated plywood, or

(c) 12 mm cement parging on wire lath applied to the exposed face and edge.

(7) Except as permitted in Sentence (8) insulation and vapour barrier shall be protected from mechanical damage by a covering such as gypsum board, plywood, particleboard, OSB, waferboard or hardboard.

(8) In unfinished basements, the protection required in Sentence (7) need not be provided for mineral fibre insulation provided it is covered with polyethylene vapour barrier of at least 0.15 mm in thickness.

(9) Insulation in factory-built buildings shall be installed so that it will not become dislodged during transportation.

9.25.2.4. Installation of Loose-Fill Insulation

(1) Except as provided in Sentences (2) to (5), loose-fill insulation shall be used on horizontal surfaces only.

(2) Where loose-fill insulation is installed in an unconfined sloped space, such as an attic space over a sloped ceiling, the supporting slope shall not be more than,

(a) 4.5 in 12 for mineral fibre or cellulose fibre insulation, and

(b) 2.5 in 12 for other types of insulation.

(3) Loose-fill insulation may be used in wood-frame walls of existing buildings.

(4) Where blown-in insulation is installed in above-ground or below-ground wood frame walls of new buildings,

(a) the density of the installed insulation shall be sufficient to preclude settlement,

(b) the insulation shall be installed behind a membrane that will permit visual inspection prior to installation of the interior finish,

(c) the insulation shall be installed in a manner that will not interfere with the installation of the interior finish, and

(d) no water shall be added to the insulation, unless it can be shown that the added water will not adversely affect other materials in the assembly.

(5) Water repellent loose-fill insulation may be used between the outer and inner wythes of masonry cavity walls.

(6) Where soffit venting is used, measures shall be taken,

(a) to prevent loose-fill insulation from blocking the soffit vents and to maintain an open path for circulation of air from the vents into the attic or roof space, and

(b) to minimize air flow into the loose-fill insulation near the soffit vents to maintain the thermal performance of the material.

9.25.2.5. Installation of Spray-applied Polyurethane

(1) Spray-applied polyurethane insulation shall be installed in accordance with CAN/ULC-S705.2, "Thermal Insulation – Spray-Applied Rigid Polyurethane Foam, Medium Density, Installer's Responsibilities – Specification".

9.25.3. Air Barrier Systems

9.25.3.1. Required Barrier to Air Leakage

(1) Thermally insulated wall, ceiling and floor assemblies shall be constructed so as to include an air barrier system that will provide a continuous barrier to air leakage,

(a) from the interior of the building into wall, floor, attic or roof spaces sufficient to prevent excessive moisture condensation in such spaces during the winter, and

(b) from the exterior inward sufficient to prevent moisture condensation on the room side during winter.

9.25.3.2. Air Barrier System Properties

(1) Sheet and panel type materials intended to provide the principal resistance to air leakage shall have an air leakage characteristic not greater than 0.02 L/(s·m2) measured at an air pressure differential of 75 Pa.

(2) Where polyethylene sheet used to provide the air-tightness in the air barrier system shall conform to CAN/CGSB-51.34-M, "Vapour Barrier, Polyethylene Sheet for Use in Building Construction".

9.25.3.3. Continuity of the Air Barrier System

(1) Where the air barrier system consists of an air-impermeable panel-type material, all joints shall be sealed to prevent air leakage.

(2) Where the air barrier system consists of flexible sheet material, all joints shall be,

(a) sealed, or

(b) lapped not less than 100 mm and clamped, such as between framing members, furring or blocking and rigid panels.

(3) Where an interior wall meets an exterior wall, ceiling, floor or roof required to be provided with an air barrier protection, the air barrier system shall extend across the intersection.

(4) Where an interior wall projects through a ceiling or extends to become an exterior wall, spaces in the wall shall be blocked to provide continuity across those spaces with the air barrier system in the abutting walls or ceiling.

(5) Where an interior floor projects through an exterior wall or extends to become an exterior floor, continuity of the air barrier system shall be maintained from the abutting walls across the floor assembly.

(6) Penetrations of the air barrier system, such as those created by the installation of doors, windows, electrical wiring, electrical boxes, piping or ductwork, shall be sealed to maintain the integrity of the air barrier system over the entire surface.

(7) Access hatches installed through assemblies constructed with an air barrier system shall be weatherstripped around their perimeters to prevent air leakage.

(8) Clearances between chimneys or gas vents and the surrounding construction that would permit air leakage from within the building into a wall or attic or roof space shall be sealed by noncombustible material to prevent such leakage.

9.25.4. Vapour Barriers

9.25.4.1. Required Barrier to Vapour Diffusion

(1) Thermally insulated wall, ceiling and floor assemblies shall be constructed with a vapour barrier sufficient to prevent condensation in the wall spaces, floor spaces or attic or roof spaces.

9.25.4.2. Vapour Barrier Materials

(1) Vapour barriers shall have a permeance not greater than 60 ng/(Pa·s·m2), measured in accordance with ASTM E96, "Water Vapor Transmission of Materials", using the desiccant method (dry cup).

(2) Where the mild climate indicator, determined in accordance with Sentence 9.25.1.2.(6), is greater than 6300, vapour barriers shall be designed according to Part 5, where,

(a) the intended use of the interior space requires the indoor relative humidity to be maintained above 35% over the heating season and the ventilating and air-conditioning system is designed to maintain that relative humidity, or

(b) the intended use of the interior space results in an average monthly indoor relative humidity above 35% over the heating season and the ventilating and air-conditioning system does not have the capacity to reduce the average monthly relative humidity to 35% or less over that period.

(3) Where the mild climate indicator, determined in accordance with Sentence 9.25.1.2.(6), is less than or equal to 6300, vapour barriers shall be designed according to Part 5, where,

(a) the intended use of the interior space requires the indoor relative humidity to be maintained above 60% over the heating season and the ventilating and air-conditioning system is designed to maintain that relative humidity, or

(b) the intended use of the interior space results in an average monthly indoor relative humidity above 60% over the heating season and the ventilating and air-conditioning system does not have the capacity to reduce the average monthly relative humidity to 60% over that period.

(4) Where polyethylene is installed to serve as the vapour barrier, it shall conform to CAN/CGSB-51.34-M, "Vapour Barrier, Polyethylene Sheet for Use in Building Construction".

(5) Membrane-type vapour barriers other than polyethylene shall conform to CAN/CGSB-51.33-M, "Vapour Barrier, Sheet, Excluding Polyethylene, for Use in Building Construction".

(6) Where a coating is applied to gypsum board to function as the vapour barrier, the permeance of the coating shall be determined in accordance with CAN/CGSB-1.501-M, "Method for Permeance of Coated Wallboard".

9.25.4.3. Installation of Vapour Barriers

(1) Vapour barriers shall be installed to protect the entire surfaces of thermally insulated wall, ceiling and floor assemblies.

(2) Vapour barriers shall be installed sufficiently close to the warm side of insulation to prevent condensation at design conditions.

9.32.3.8. Protection Against Depressurization

(1) When determining the need to provide protection against depressurization, consideration must be given to,

(a) whether the presence of soil gas is deemed to be a problem, and

(b) the presence of solid fuel-fired combustion appliances.

(2) Where a solid fuel-fired combustion appliance is installed, the ventilation system shall include a heat recovery ventilator that is designed to operate so that the flow of exhaust air does not exceed the flow of intake air in any operating mode, and that complies with the requirements of Article 9.32.3.11.

12.3.2. Thermal Insulation for Buildings of Residential Occupancy

12.3.2.1. Required Insulation

(1) All walls, ceilings, floors, windows and doors that separate heated space from unheated space, the exterior air or the exterior soil shall have thermal resistance ratings conforming to this Subsection.

(2) Insulation shall be provided between heated and unheated spaces and between heated spaces and the exterior, and around the perimeter of concrete slabs-on-ground.

(3) Reflective surfaces of insulating materials shall not be considered in calculating the thermal resistance of building assemblies.

(4) Except as permitted in Articles 12.3.2.3., 12.3.2.4., 12.3.2.6., 12.3.2.7. and 12.3.2.9., the minimum thermal resistance of insulation shall conform to Table 12.3.2.1.

*****see Table 12.3.2.1.*****

Notes to Table 12.3.2.1:

(1) Number of degree-days for individual locations are contained in Supplementary Standard SB-1.

12.3.2.2. Elements Acting as a Thermal Bridge

Table 12.3.2.1

Column 1	Column 2	Column 3	Column 4
Building Element Exposed to the Exterior or to Unheated Space	Minimum RSI Value Required		
	Zone 1 Less than 5000 degree-days	Zone 2 5000 or more degree-days	Electric Space Heating Zones 1 & 2
Ceiling below *attic or roof space*	7.00	7.00	8.80
Roof assembly without *attic or roof space*	4.93	4.93	4.93
Wall other than *foundation* wall	3.34	4.22	5.10
Foundation walls enclosing heated space	2.11	2.11	3.34
Floor, other than slab-on-ground	4.40	4.40	4.40
Slab-on-ground containing heating pipes, tubes, ducts or cables	1.76	1.76	1.76
Slab-on-ground not containing heating pipes, tubes, ducts or cal	1.41	1.41	1.76
Basement floor slabs located more than 600 mm below grade	—	—	—

(1) Except for a foundation wall, the insulated portion of a wall that incorporates wood stud framing elements that have a thermal resistance of less than RSI 0.90 shall be insulated to restrict heat flow through the studs by a material providing a thermal resistance at least equal to 25 per cent of the thermal resistance required for the insulated portion of the assembly in Sentence 12.3.2.1.(4).

(2) Except as provided in Sentence (3), the thermal resistance of the insulated portion of a building assembly in Sentence 12.3.2.1.(4) that incorporates metal framing elements, such as steel studs and steel joists, that act as thermal bridges to facilitate heat flow through the assembly, shall be 20 per cent greater than the values shown in Table 12.3.2.1., unless it can be shown that the heat flow is not greater than the heat flow through a wood frame assembly of the same thickness.

(3) Sentence (2) does not apply to building assemblies incorporating thermal bridges where the thermal bridges are insulated to restrict heat flow through the thermal bridges by a material providing a thermal resistance at least equal to 25 per cent of the thermal resistance required for the insulated portion of the assembly in Sentence 12.3.2.1.(4).

12.3.2.4. Insulation of Foundation Walls

(1) Sentence (2) applies to construction for which a permit has been applied for before January 1, 2009.

(2) Foundation walls enclosing heated space shall be insulated from the underside of the subfloor to not less than 600 mm below the adjacent exterior ground level.

(3) Sentence (4) applies to construction for which a permit has been applied for after December 31, 2008.

(4) Foundation walls enclosing heated space shall be insulated from the underside of the subfloor to not more than 380 mm above the finished floor level of the basement.

(5) The insulation required by Sentences (2) and (4) may be provided by a system installed,

(a) on the interior of the foundation wall,

(b) on the exterior face of the foundation wall, or

(c) partially on the interior and partially on the exterior,

provided the thermal performance of the system is equivalent to that permitted in Clauses (a) or (b).

(6) Insulation around concrete slabs-on-ground shall extend not less than 600 mm below exterior ground level.

(7) The minimum RSI value required in Table 12.3.2.1. for the perimeter of a slab-on-ground is permitted to be reduced by 50% if the underside of the entire slab-on-ground is insulated.

(8) If a foundation wall is constructed of hollow masonry units, one or more of the following shall be used to control convection currents in the core spaces,

(a) filling the core spaces,

(b) at least one row of semi-solid blocks at or below grade, or

(c) other similar methods.

(9) Masonry walls of hollow units that penetrate the ceiling shall be sealed at or near the ceiling adjacent to the roof space to prevent air within the voids from entering the attic or roof space by,

(a) capping with masonry units without voids, or

(b) installation of flashing material extending across the full width of the masonry.

12.3.2.5. Enclosed Unheated Space

(1) Where an enclosed unheated space is separated from a heated space by glazing, the unheated enclosure may be considered to provide a thermal resistance of RSI 0.16.

12.3.3.9. Foundation Wall Insulation

(1) Sentence (2) applies to construction for which a permit has been applied for before January 1, 2009.

(2) Foundation walls enclosing heated space shall be insulated from the underside of the subfloor to not less than 600 mm below the adjacent exterior ground level.

(3) Sentence (4) applies to construction for which a permit has been applied for after December 31, 2008.

(4) Foundation walls enclosing heated space shall be insulated from the underside of the subfloor to not more than 380 mm above the finished floor level of the basement.

(5) Insulation applied to the exterior of a slab-on-ground floor shall extend down at least 600 mm below the adjacent exterior ground level or shall extend down and outward from the floor or wall for a total distance of at least 600 mm measured from the adjacent finished ground level.

12.3.3.13. Air Infiltration

(1) Windows that separate heated space from unheated space or the exterior shall be designed to limit the rate of air infiltration to not more than 0.775 L/s for each metre of sash crack when tested at pressure differential of 75 Pa in conformance with ASTM E283, “Determining the Rate of Air Leakage Through Exterior Windows, Curtain Walls, and Doors Under Specified Pressure Differences Across the Specimen”.

(2) Manually operated exterior sliding glass door assemblies that separate heated space from unheated space or the exterior shall be designed to limit air infiltration to not more than 2.5 L/s for each square metre of door area when tested in conformance with Sentence (1).

(3) Except where the door is weather-stripped on all edges and protected with a storm door or by an enclosed unheated space, exterior swing type door assemblies for dwelling units, individually rented hotel rooms and suites shall be designed to limit the rate of air infiltration to not more than 6.35 L/s for each square metre of door area when tested in conformance with Sentence (1).

(4) Door assemblies other than those described in Sentences (2) and (3), that separate heated space from unheated

space or the exterior shall be designed to limit the rate of air infiltration to not more than 17.0 L/s for each metre of door crack when tested in conformance with Sentence (1).

(5) Caulking material to reduce air infiltration shall conform to the requirements in Subsection 9.27.4.

(6) The junction between the sill plate and the foundation, joints between exterior wall panels and any other location where there is a possibility of air leakage into heated spaces in a building through the exterior walls, such as at utility service entrances, shall be caulked, gasketed or sealed to restrict such air leakage.

(7) Air leakage between heated space and adjacent roof or attic space caused by the penetration of services shall be restricted in conformance with the requirements of Subsection 9.25.3.