Residential Basement Wall Design

[Orig. 10/19] [Revised 8/22 for 2018 VRC code] [Revised 4/25 for 2021 VRC code]

The following VRC code requirements are for your reference when designing residential basement walls for houses 3 stories above grade plane or less.

All residential building permit applications for houses with exterior basement walls that retain more than 4 feet of unbalanced fill (ie. when the basement floor slab is at least 4 feet below the exterior finished grade) shall provide the following information:

Part I: Provide **building elevation details**.
pg. 6

Part II: Provide a **typical basement wall section detail**.
pg. 7-10

Part III: If you are using a **poured concrete basement wall** with a **brick facing**, there are important structural issues to consider, which should be included in the basement wall detail mentioned in Part II.
pg. 11-14

Otherwise, please continue to Part IV.

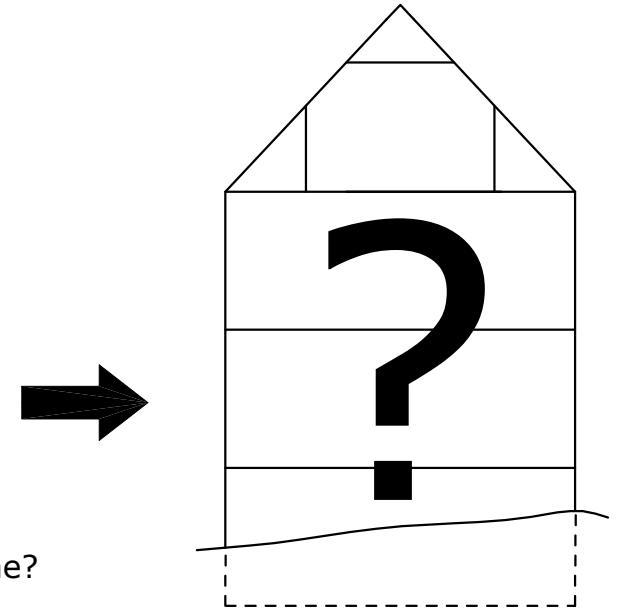
Part IV: If you are using a **walk-out basement wall** that is **constructed of wood stud framing**, a walk-out basement wall section detail will be required as well. There are also important structural issues that will need to be considered here as well.
pg. 15-16

Otherwise, please continue to Part V.

Part V: Blocking will need to be shown on first floor joist layout plans at gable end walls.
pg. 17-18

- END -

Does My House Exceed 3 Stories Above Grade Plane When I Have A Basement?



Introduction

The Virginia Residential Code (VRC) will allow you to build a house that is a maximum 3 stories above grade plane. Any house that exceeds 3 stories above grade plane will need to be built under the Virginia Construction Code (VCC).

The house design scenario to the right can be troublesome as to whether the structure does, in fact, exceed 3 stories above grade plane. The answer lies in two specific areas:

1) Is the habitable space in the attic area considered a story above grade plane?
2) Is the basement considered a story above grade plane?

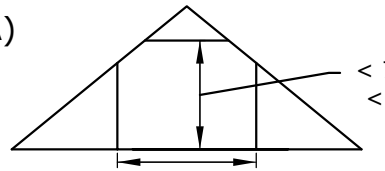
1) Is the habitable space in the attic considered a story above grade plane?

A) If the headroom space in the attic is less than 7'-0" in height; OR if the headroom space is 7'-0" or greater, but the occupiable floor area is less than 70 square feet, then the space is not habitable. Therefore, you have an "ATTIC" and it is NOT a story above grade plane.

B) If the headroom space in the attic is 7'-0" or greater in height AND the occupiable floor area is 70 square feet or greater, then you have a "HABITABLE ATTIC" and it is NOT a story above grade plane.

C) Any habitable attic that exceed 2/3 of the floor area of the story below; OR any habitable attics that exceed 400 square feet in area shall NOT be called a "habitable attic", but shall be a "STORY ABOVE GRADE PLANE".

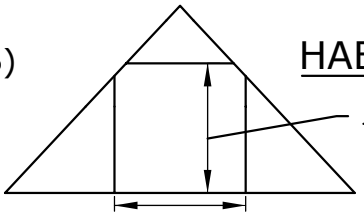
A)



ATTIC

< 7'-0"; OR ≥ 7'-0" and < 70 SF of floor area

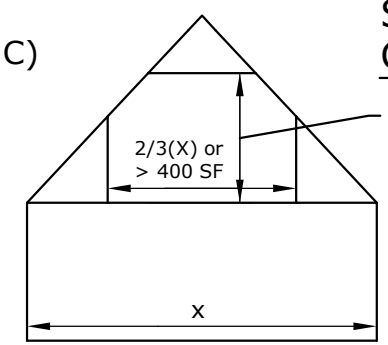
B)



HABITABLE ATTIC

≥ 7'-0" AND ≥ 70 SF of floor area

C)



STORY ABOVE GRADE PLANE

≥ 7'-0" AND exceeds 2/3 of the area of the floor below OR is > 400 SF

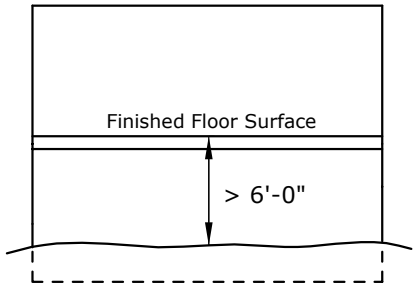
Code references

Min. room area requirements - VRC 304
Min. ceiling height requirements - VRC 305
3-story above grade limit for R-5 occupancies - VCC 310.6.1
Def. of ATTIC; ATTIC, HABITABLE ATTIC; STORY ABOVE GRADE - VRC Ch. 2
Habitable attics and story above grade plane - VRC R326.3

2) Is the basement considered a story above grade?

A) If the finished floor surface of the story above is more than 6'-0" above the grade plane, then the bottom floor is considered to be a "STORY ABOVE GRADE PLANE" and is NOT a basement.

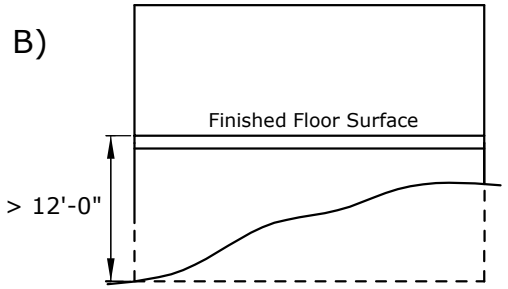
A)



STORY ABOVE GRADE PLANE

B) If the finished floor surface of the story above is more than 12'-0" above the finished ground level at any point, then the bottom floor is considered to be a "STORY ABOVE GRADE PLANE" and is NOT a basement.

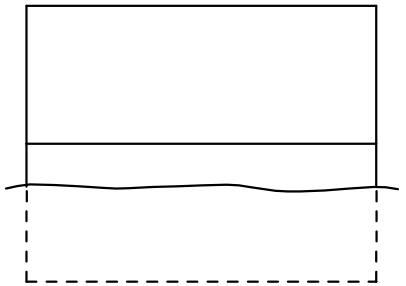
B)



STORY ABOVE GRADE PLANE

C) If neither of the requirements in A) and B) are met, then the bottom floor is considered to be a "BASEMENT" and is NOT a story above grade plane.

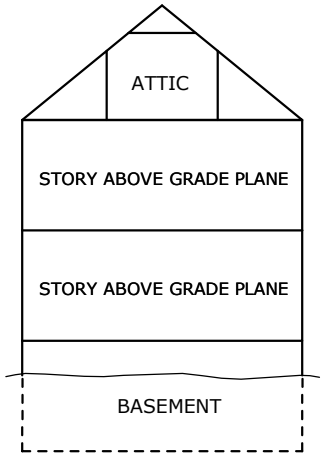
C)



BASEMENT

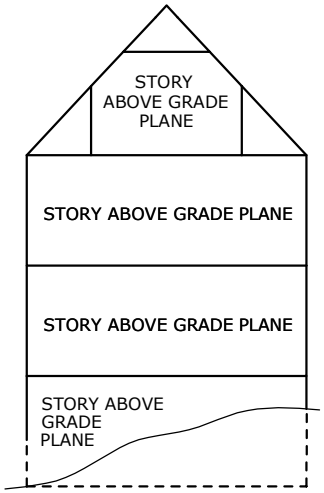
Code references
Def. of BASEMENT; STORY ABOVE GRADE PLANE - VRC Ch. 2

SEE NEXT PAGE FOR POSSIBLE FLOOR COMBINATION EXAMPLES



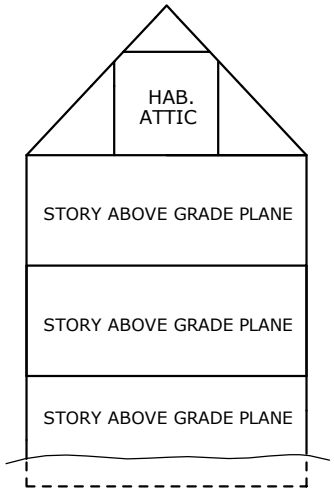
3 FLOORS,
BUT 2 STORIES
ABOVE GRADE PLANE

VRC CODE



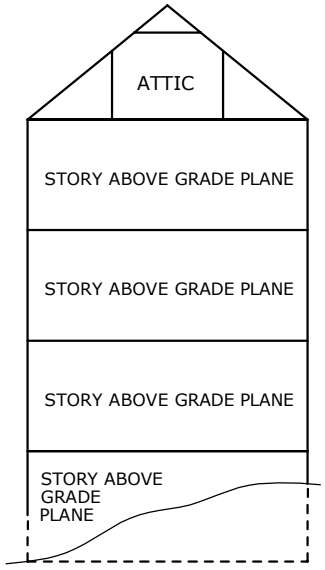
4 FLOORS,
AND 4 STORIES
ABOVE GRADE PLANE

VCC CODE



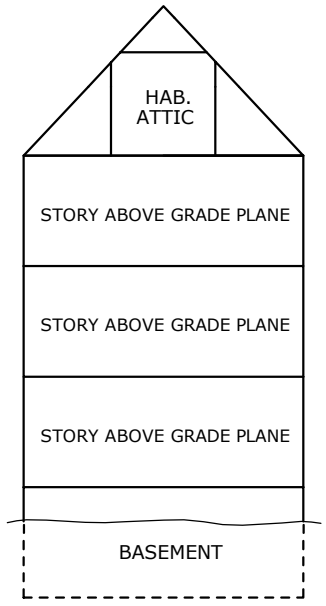
4 FLOORS,
YET 3 STORIES
ABOVE GRADE PLANE

VRC CODE



4 FLOORS,
AND 4 STORIES
ABOVE GRADE PLANE

VCC CODE



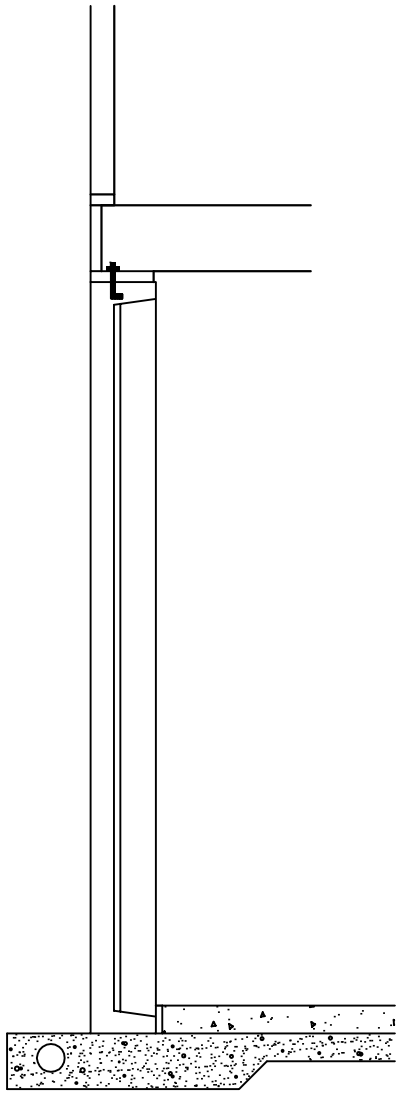
5 FLOORS,
YET 3 STORIES
ABOVE GRADE PLANE

VRC CODE

Precast Basement Wall Systems

Introduction

Precast basement walls are poured concrete walls that have been manufactured off-site, shipped to the construction site in various sections, and are set in place and fastened together. It is a tested assembly and has been approved for use by various evaluation services.



If a precast basement wall is to be used, the following information will need to be provided with your building permit application:

1) The manufacturer's shop drawings showing the proposed basement wall layout. The shop drawings should show the following: A) Design loading, B) footing design, material, and thickness, as well as any pad footing sizes and locations that may be required for point load supports D) soil bearing capacity, E) max. allowable total uniform load, F) seismic design category, and G) basic wind speed design.
2) A copy of the manufactuer's installation instructions booklet.
3) Four building elevations complying with Part I of this document.
4) An accurate wall section detail (such as what is shown on the left).
5) If a walk-out basement wall will be constructed of wood stud framing in lieu of precast concrete walls, then please comply with the requirements of Part IV of this document.

Note:

Precast basement walls are still subject to the code requirements for waterproofing and draintile, brick facing support, and first floor gable end wall blocking, as mentioned in Parts II, III, and V of this document. However, many precast basement wall systems already have design guidelines for these situations in their installation instruction booklet.

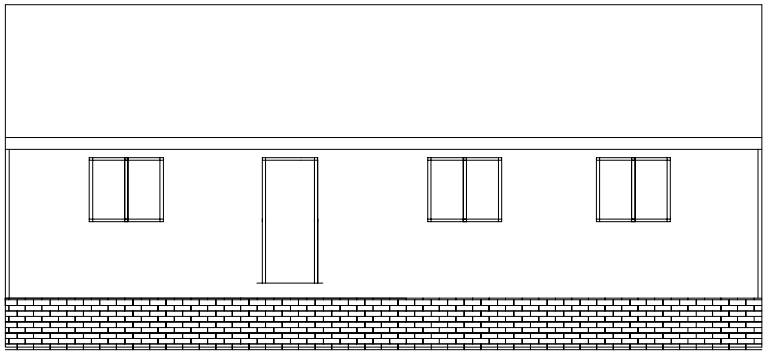
Code references

Precast concrete foundation walls - VRC 404.5
Precast concrete - VRC 402.3

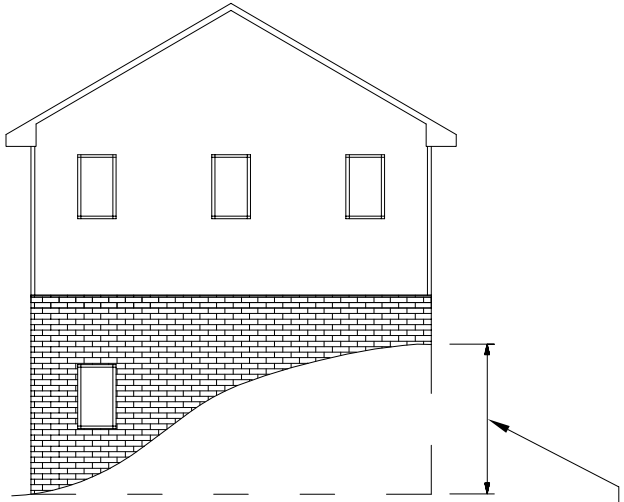
Elevation Details for a Basement House

Provide four building elevations (front, rear, left, right) that show:

A) The approximate finished grade height,
B) All exterior door and window openings in the foundation wall, and
C) The location of window wells, if required.

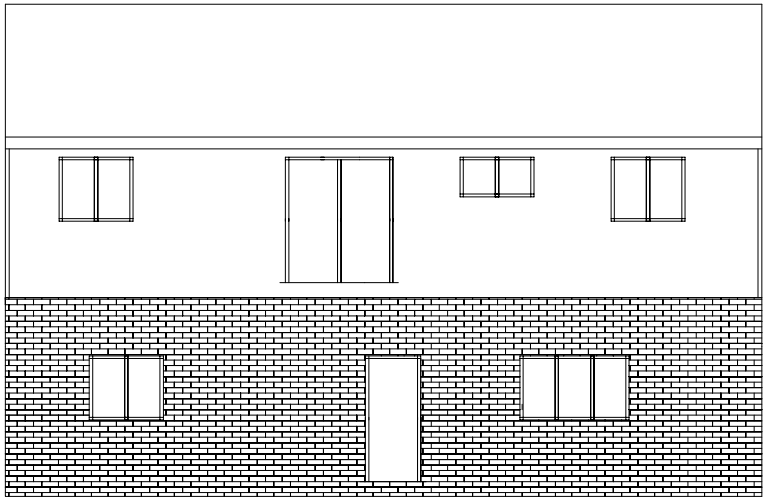


FRONT

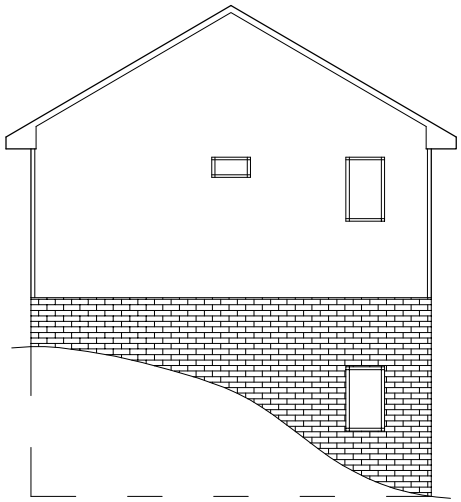


LEFT

Note: Use the tallest backfill height for the "Maximum Unbalanced Backfill Height", see Part II.



REAR



RIGHT

Part II: Provide a **Typical Basement Wall Section Detail**. The basement wall shall be designed using one of the three options listed below:

1) The prescriptive requirements of IRC 404.1 (Onsite soil backfill) –

If the basement walls are to be backfilled with the soils that are present on the lot, then the code tables listed below may be used to design the basement wall. Note: A soils report (with testing performed by a geotechnical engineer) will be required in order to determine what type of soil is present on the lot (ie. GP, SM, SC soils etc.). If soil types MH, CH, OH, or PT are detected, then the basement wall will need to be engineered. See "3) Engineered design" below. The soil type specified in the report will then need to be used with the following tables:

If a **masonry** wall is to be used, then Table R404.1.1(1) will need to be used to design the thickness of the basement wall. If the table sends you to footnote "e", then Table R404.1.1(2), Table R404.1.1(3), or Table R404.1.1(4) will need to be used to design the wall thickness and the vertical steel reinforcement that is required in the basement wall.

If a **poured concrete** wall is to be used, then Table R404.1.2(2), Table R404.1.2(3), or Table R404.1.2(4) will need to be used to design the vertical steel reinforcement required in the basement wall.

The basement wall section shall include:

A. Basement wall thickness and material used (if masonry, please indicate if hollow or solid masonry units will be used),
B. Basement wall height, measured from the top of the basement slab to the underside of the first floor framing,
C. Maximum unbalanced backfill height, measured from the top of the basement slab to the top of the backfill height,
D. Vertical reinforcement size and spacing, if required. Horizontal reinforcing is required as per Table R404.1.2(1),
E. Waterproofing and a foundation drainage board, as required by R404.1.1 and R406.2,
F. A foundation draintile system, as required by R405.1,
G. Footing size and reinforcement (if required), and
H. Anchor bolt size and spacing, per R403.1.6

See page 9 for a basement wall example using onsite soil backfill

2) The prescriptive requirements of IRC 404.1 using granular (gravel) backfill –

If the basement walls are to be backfilled with gravel backfill, then the code tables listed below may be used to design the basement wall using the "GW, GP, SW, SP 30" column.

If a **masonry** wall is to be used, then Table R404.1.1(1) will need to be used to design the thickness of the basement wall [NOTE: Table R404.1.1(2), Table R404.1.1(3), or Table R404.1.1(4) can also be used, if so desired].

If a **poured concrete** wall is to be used, then Table R404.1.2(2), Table R404.1.2(3), or Table R404.1.2(4) will need to be used to design the vertical steel reinforcement required in the basement wall.

The basement wall section shall include:

A. Basement wall thickness and material used (if masonry, please indicate if hollow or solid masonry units will be used),
B. Basement wall height, measured from the top of the basement slab to the underside of the first floor framing,
C. Maximum unbalanced backfill height, measured from the top of the basement slab to the top of the backfill height (also, specify that gravel backfill will be used here),
D. Vertical reinforcement size and spacing, if required. Horizontal reinforcing is required as per Table R404.1.2(1),
E. Waterproofing, as required by R406.2,
F. A foundation draintile system, as required by R405.1.
G. Footing size and reinforcement (if required), and
H. Anchor bolt size and spacing, per R403.1.6

See page 10 for a basement wall example using granular (gravel) backfill

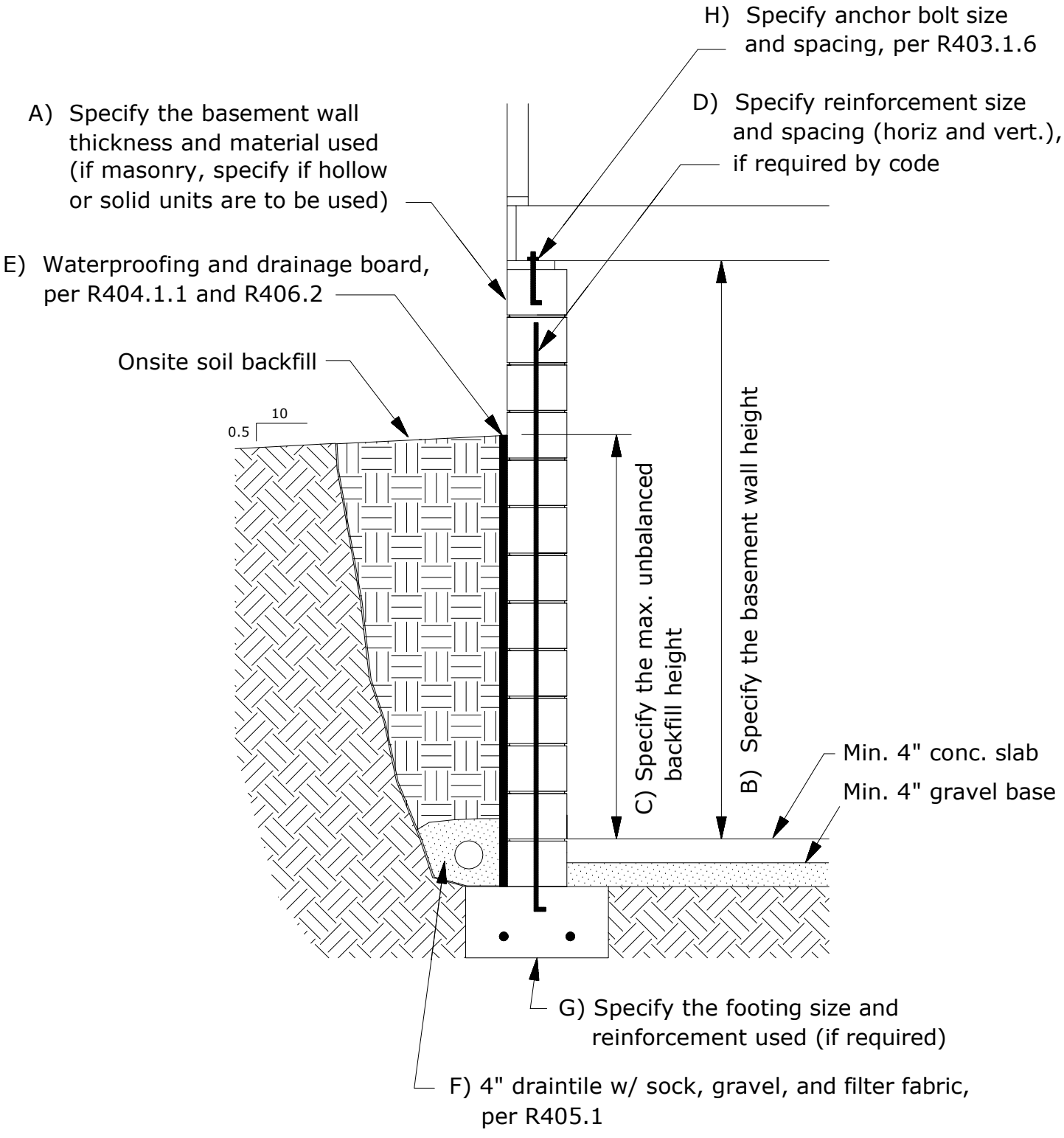
3) Engineered design, as per R404.1.1 –

A registered design professional may be used to design the basement wall. If a soils report specifies that soil types MH, CH, OH, or PT are present on the lot, then a registered design professional will be REQUIRED to design the basement wall.

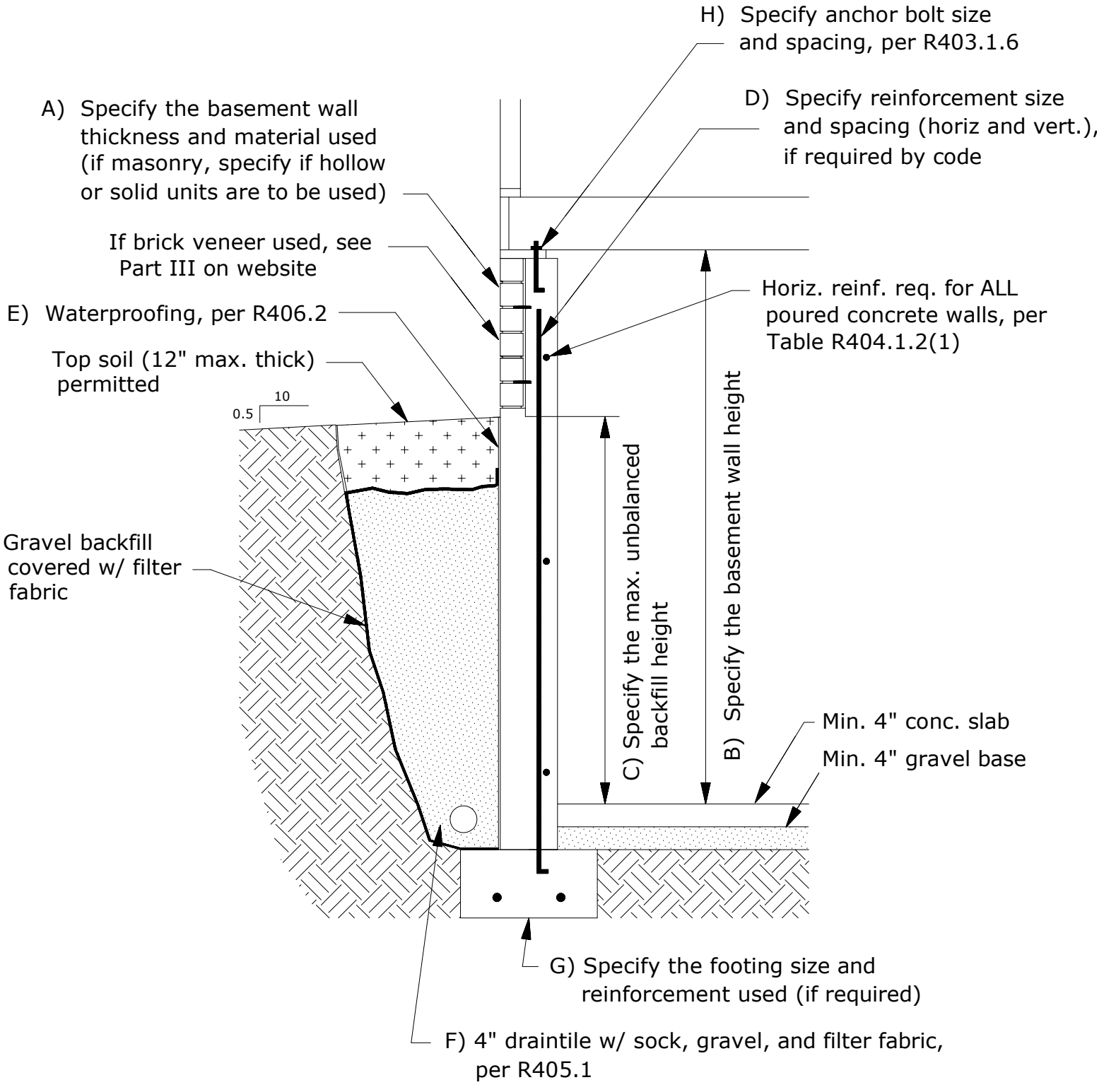
The basement wall section shall include:

A) Basement wall thickness and material used (if masonry, please indicate if hollow or solid masonry units will be used),
B) Basement wall height, measured from the top of the basement slab to the underside of the first floor framing,
C) Maximum unbalanced backfill height, measured from the top of the basement slab to the top of the backfill height,
D) Reinforcement size and spacing, if necessary (horizontal and vertical),
E) Backfill material used (if other than onsite soils),
F) Waterproofing, as required by R406.2,
G) A foundation draintile system, as required by R405.1,
H) A foundation drainage board, if required by the registered design professional,
I) Footing size and reinforcement (if required), and
J) Anchor bolt size and spacing, per R403.1.6.

BASEMENT WALL EXAMPLE
USING ONSITE SOIL BACKFILL



BASEMENT WALL EXAMPLE
USING GRANULAR (GRAVEL) BACKFILL



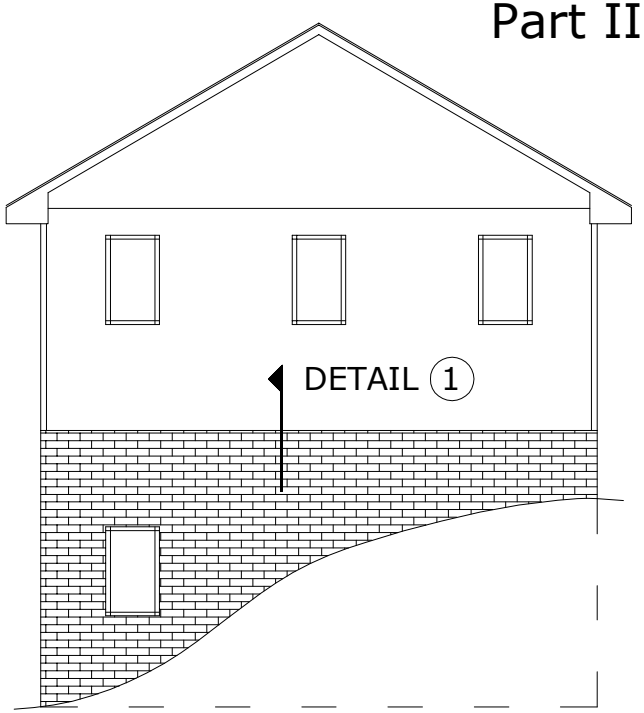
Poured Concrete Basements Walls with a Brick Facing

Introduction

A design issue occurs for houses on basement wall foundations when a brick veneer is used.

Per ACI 530-05, section 2.1.5.2, a 4" brick can only support building loads if the collar joint is filled with mortar AND the brick is secured to the CMU or concrete wall behind with rigid wall ties.

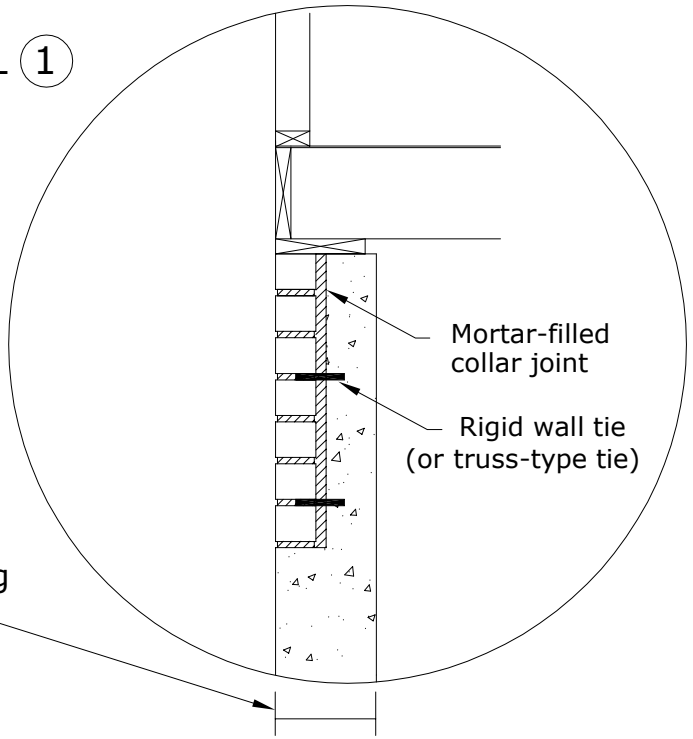
If this is done, then the brick and CMU/concrete wall will act together as a composite wall and will support the building loads above adequately. See Detail 1. Also, for poured concrete walls, the total width of the brick and concrete wall may be used to design the wall per Tables R404.1.2(1) thru (4). No design considerations will need to be given to the first floor jost framing above (as seen with Option 2 on the next page).



Option 1 - Use rigid wall ties and mortar-filled collar joint to create a structural brick/concrete composite wall

If this option is chosen, then please show rigid wall ties and a mortar-filled collar joint on the Typical Basement Wall Section Detail mentioned in Part II.

DETAIL 1



Note: This document does not cover the required horiz. and vert. reinforcing required by R404.1. See Part II for more info.

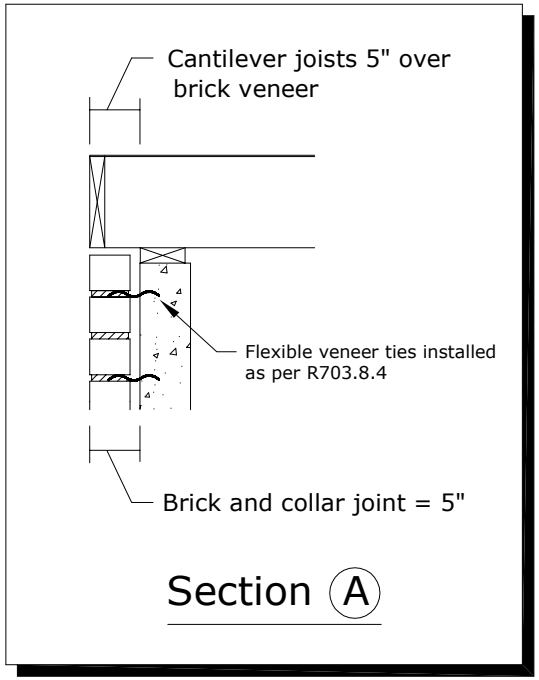
Option 2

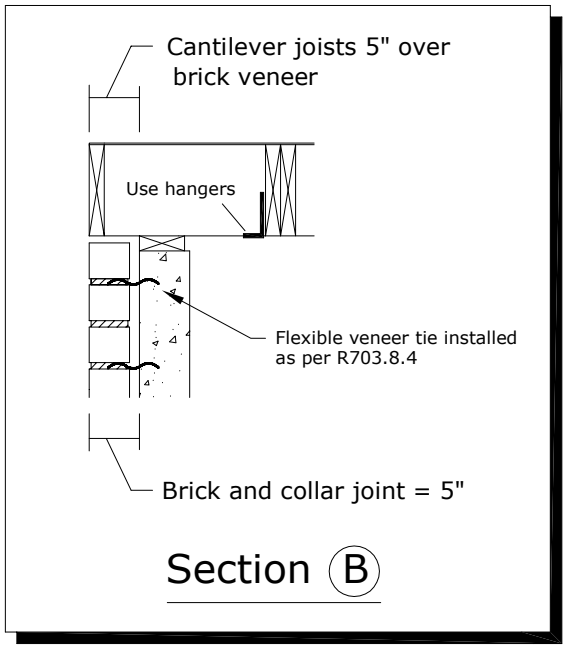
In some cases, it may not be feasible to use rigid wall ties, particularly if a poured concrete wall is to be used (Note that flexible veneer ties are still required to hold the brick veneer to the wall). In this case, the 4" brick has to be treated as a veneer only and cannot support any other building loads, as per VRC R703.8.3.

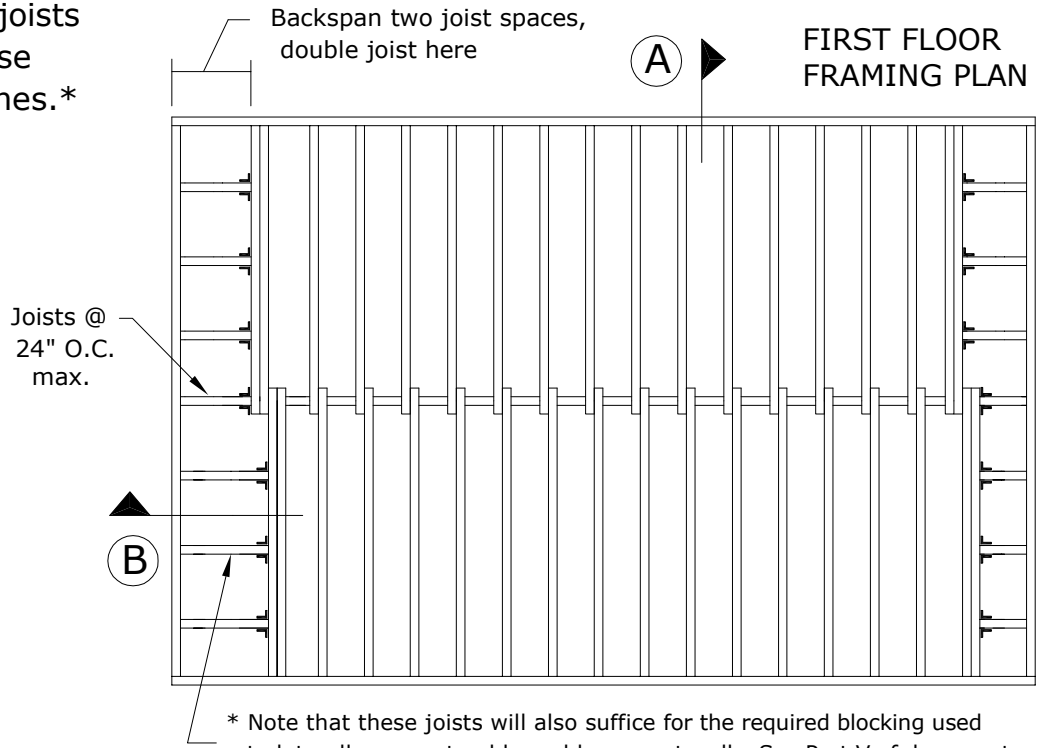
The solution in this case would be to treat the floor joists as if they are cantilevering over the brick veneer 5 inches. Most floor joists of any size can cantilever this short distance and support the building loads above. See Section A detail.

There is a problem, however, at the two gable ends of the house. The rim joists here, which would be supporting all building loads above, would be bearing directly onto the brick veneer.

The solution in this case would be to backspan two joists spaces, double the floor joist here to create a beam, and run floor joists perpendicular and 2'-0" O.C. over the basement wall. These joists will also be cantilevering over the brick veneer 5 inches.*





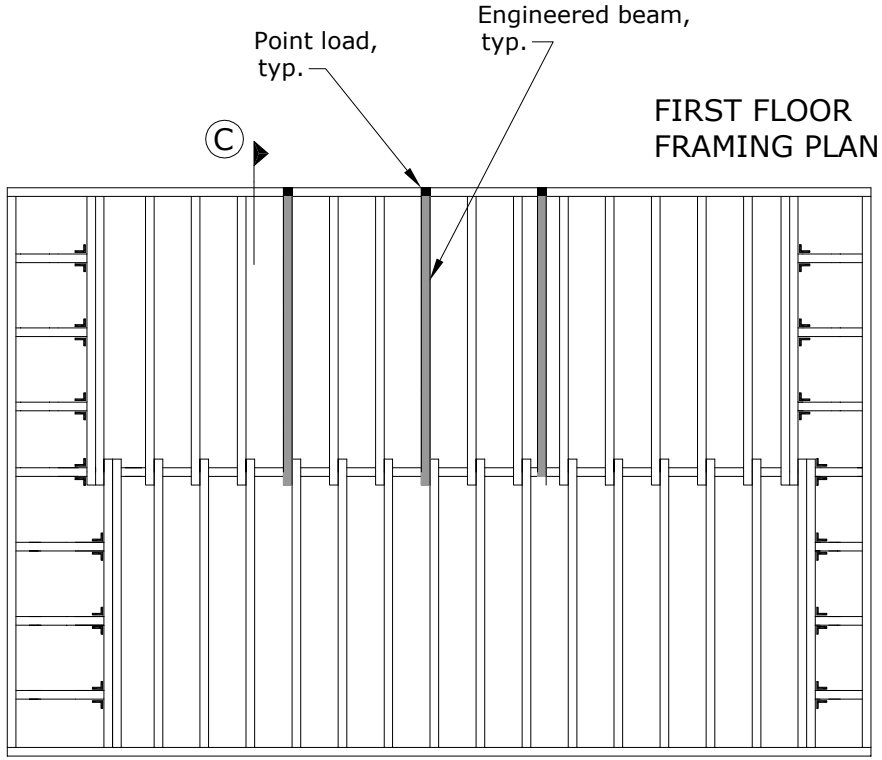


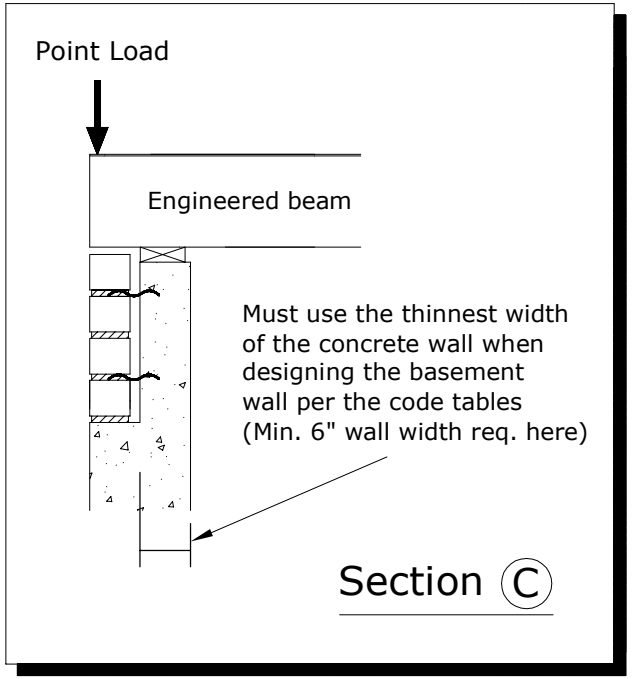
* Note that these joists will also suffice for the required blocking used to laterally support gable end basement walls. See Part V of document.

Option 2 (con't)

Another problem occurs when you have point loads exceeding 2,000 lbs that occur at the end of the floor joists. The floor joist typically cannot support heavy point loads over a 5" cantilevered distance and will fail due to shear.

The solution in this case would be to add engineered beams (ie. microlams, LVL, etc.) to your floor framing to support the point loads over the 5" cantilever. See Section C detail. A lumber supplier will need to provide you with a floor framing plan AND calculation sheets to show how and where these point loads are to be supported.



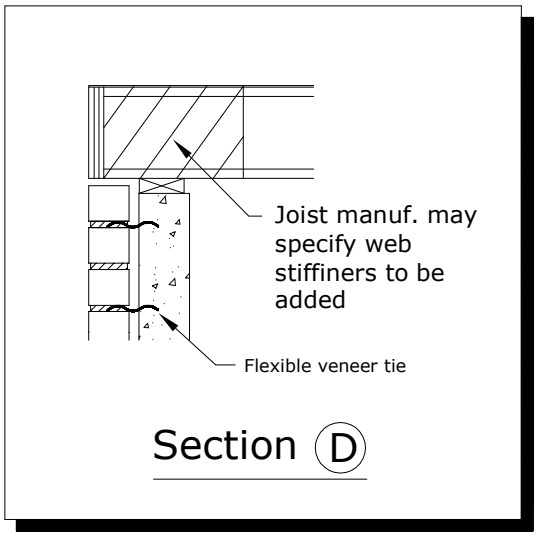


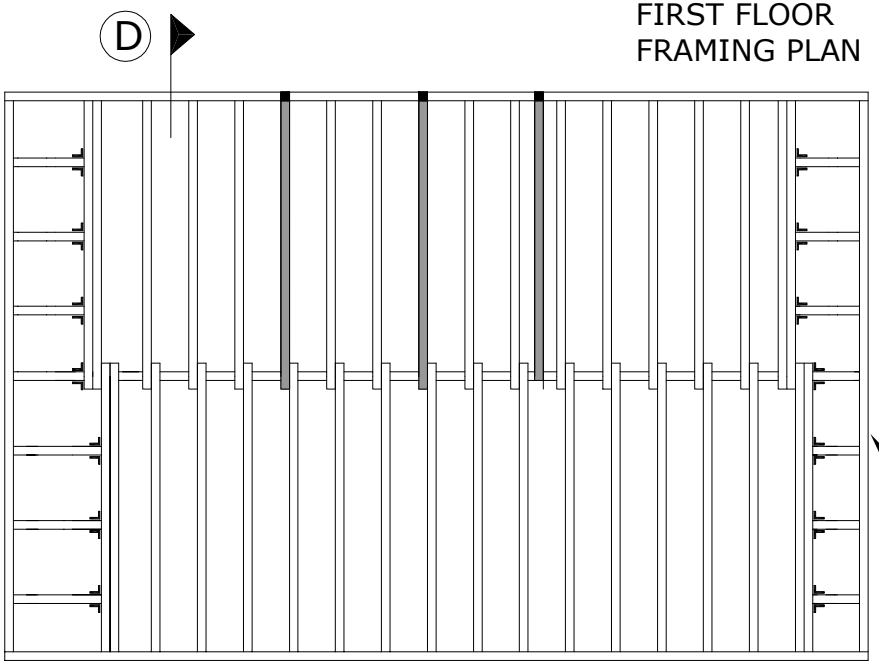
A third problem occurs when designing poured concrete walls per Tables R404.1.2(2) thru (4). Since the brick is non-structural, it must be considered as a veneer. R404.1.5.2 states that when a concrete basement wall is reduced in thickness to provide a shelf for the support of a masonry veneer, the vertical reinforcement required by the tables shall be based on the thickness of the thinner portion of the concrete wall. Note that the code tables require at least a minimum 6" width concrete wall. See note in Section C detail above.

Option 2 (con't)

If I-joists are to be used, please provide a first floor joist layout from the lumber supplier with the joists designed as shown.

Depending on the load being supported at the end of the joist, the lumber supplier may require web stiffiners to be added to the end of the joist. See Section D detail. Web stiffiner installation instructions will typically be shown on the lumber supplier's I-joist calculation sheets that should be provided.





Option 2 - Use flexible wall ties to create a non-structural, brick veneer

If this option is chosen, then please show flexible wall ties and cantilevered floor joists over the brick veneer on the Typical Basement Wall Section Detail mentioned in Part II.

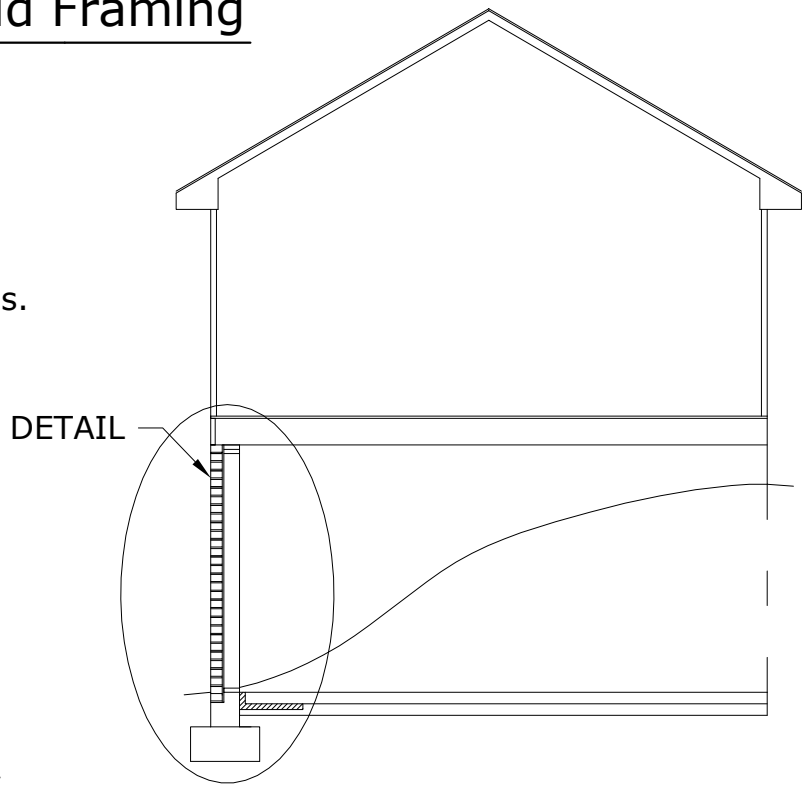
Also, please provide a first floor framing plan showing the reversed floor joists on the gable ends of the house. If engineered beams are required to support any point loads over the brick veneer, then please have the lumber supplier provide this first floor layout showing where these beams are to be located, as well as the beam calculation sheets. If I-joists are used, please have the lumber supplier provide this floor layout, along with any beam and I-joist calculation sheets that are required.

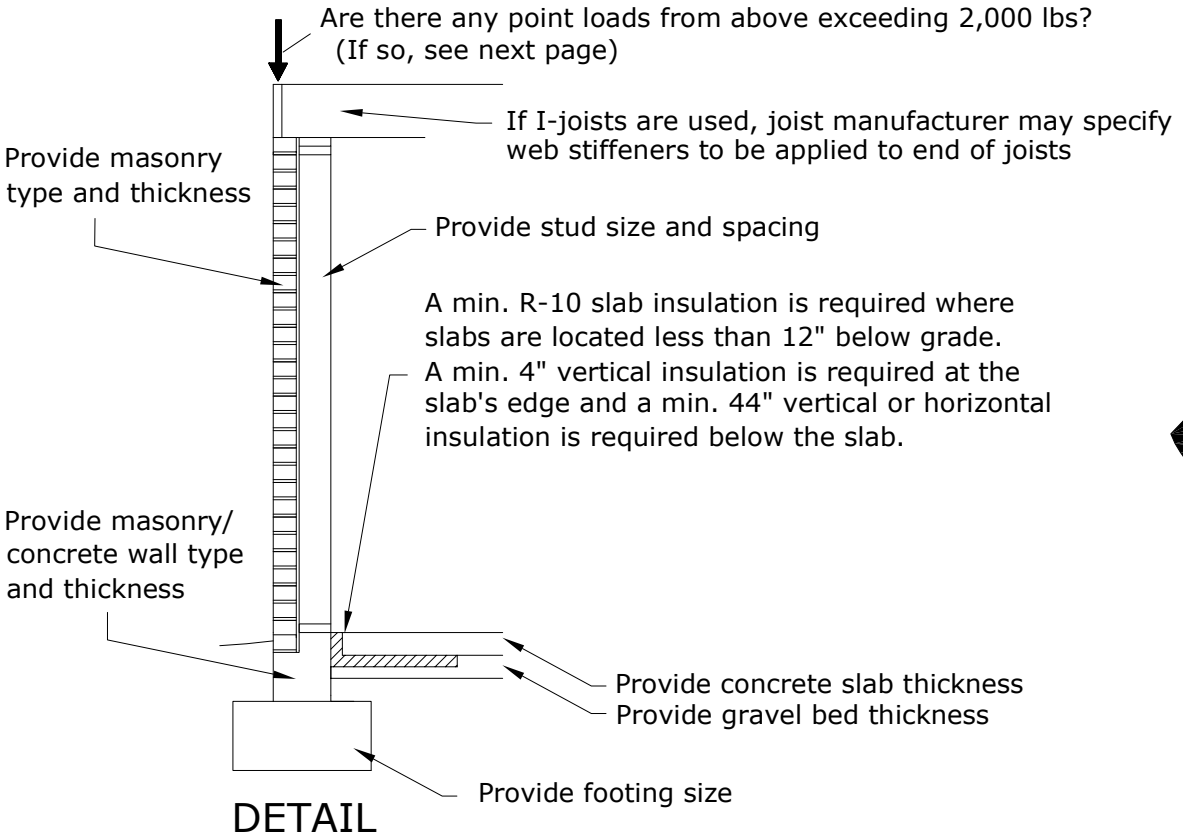
Walk-out Basement Wall Construction Using Stud Framing

Introduction

At the walk-out portion of a basement, stud wall framing is typically preferred since it can be used here. Often, a stud wall detail for this scenario is not shown on the plans. See DETAIL below and provide a similar wall section detail showing the required information on your plans.

If a brick veneer is to be used here as well, it can create a structural problem. The brick veneer cannot support other building loads. However, if there are no heavy point loads from the floor(s) and roof above, then the first floor joists can be considered as cantilevering 5" over the brick veneer and thus the joists are supporting the loads above.





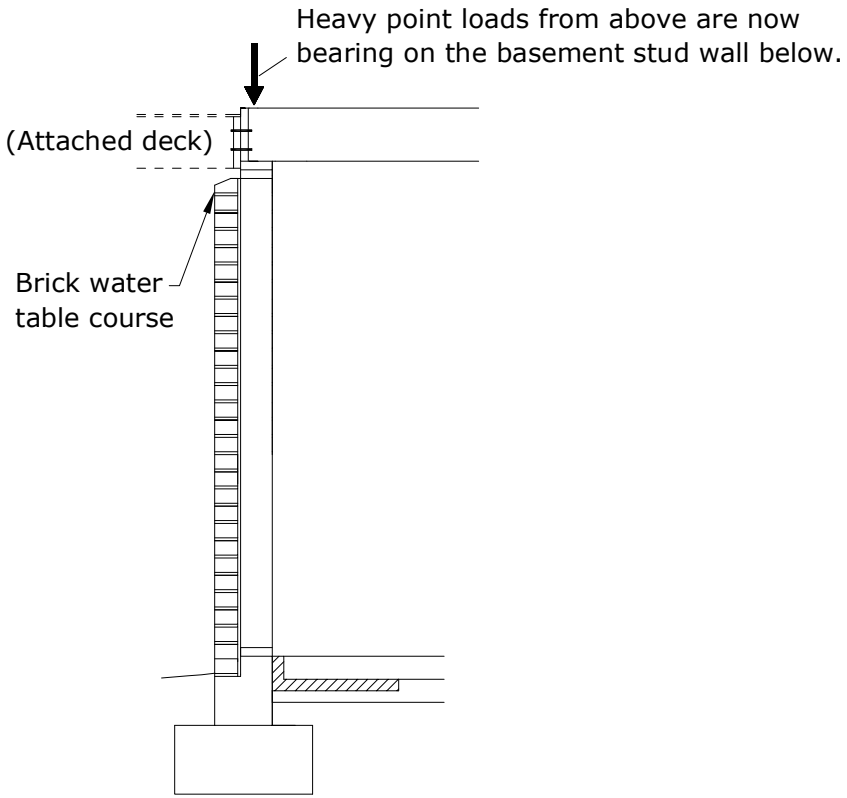
DETAIL

IF, however, there are any point loads from above that exceed 2,000 lbs., there are two options to support these loads. See next page.

Option #1 - Use a brick water table

One option is to realign your brick veneer and basement stud wall so that ALL of the building loads from above are now aligned with the basement stud wall below. The brick veneer would be topped off with a brick water table course.

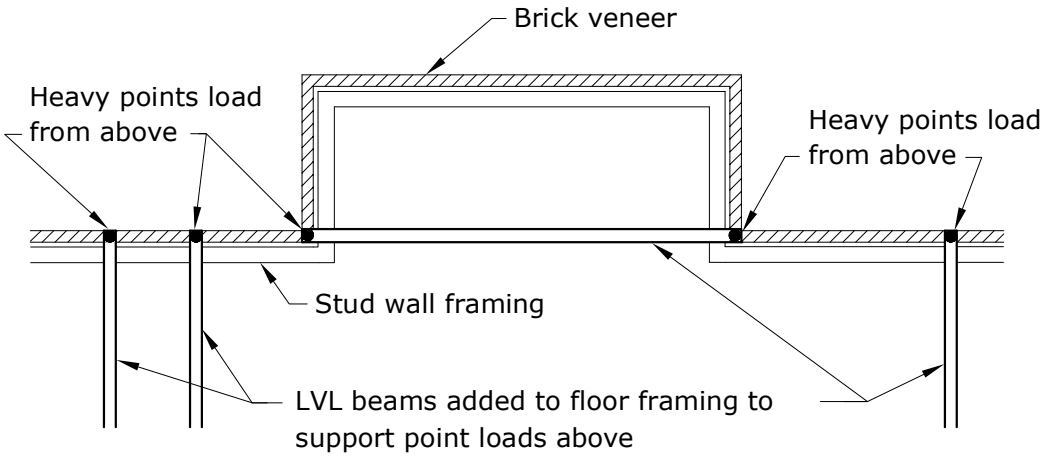
** IF YOU ALSO HAVE A DECK ATTACHED TO THE HOUSE, then Option # 1 is your ONLY solution.



Option # 1

Option #2 - Utilize LVL's in the floor

If the brick veneer must be tucked under your first floor framing (as shown on the previous page), then any heavy point loads from above can be supported by adding LVL beams to your first floor framing. An example is shown below. A lumber supplier will need to provide you with a floor framing plan and beam calculation sheets to demonstrate how and where these point loads are to be supported.



** IF YOU HAVE A DECK, the deck must be built free-standing. Attaching deck loads to a cantilevered floor system is NOT permitted, per R502.3.3.

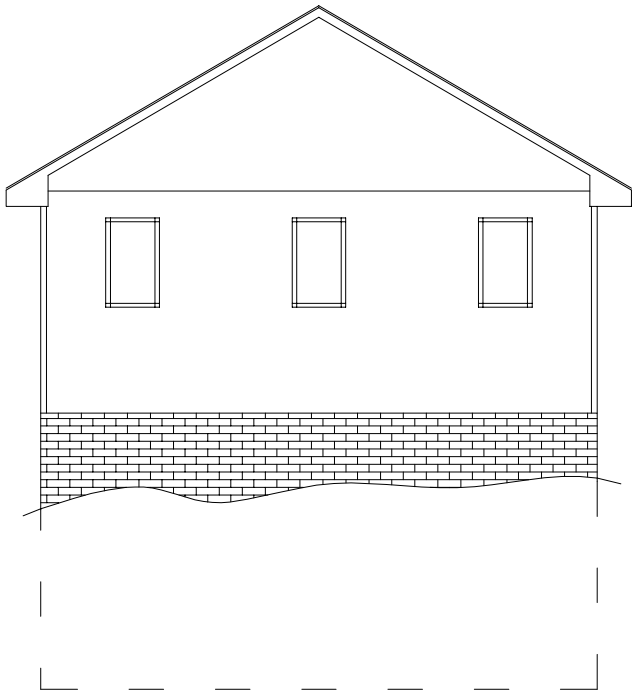
Option # 2

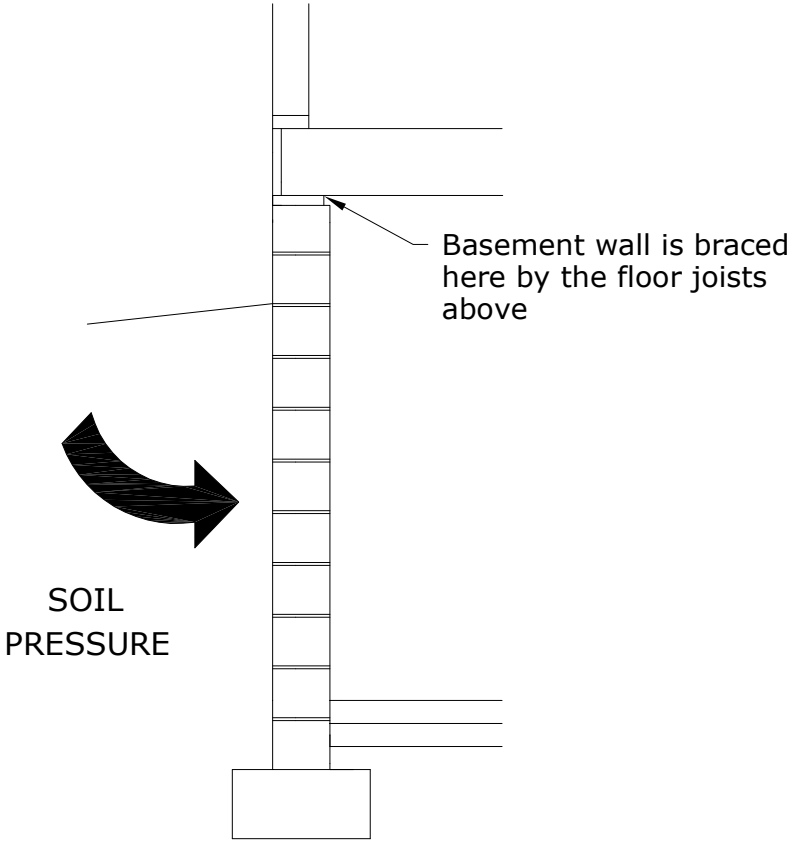
Gable End Blocking at First Floor Joists

Introduction

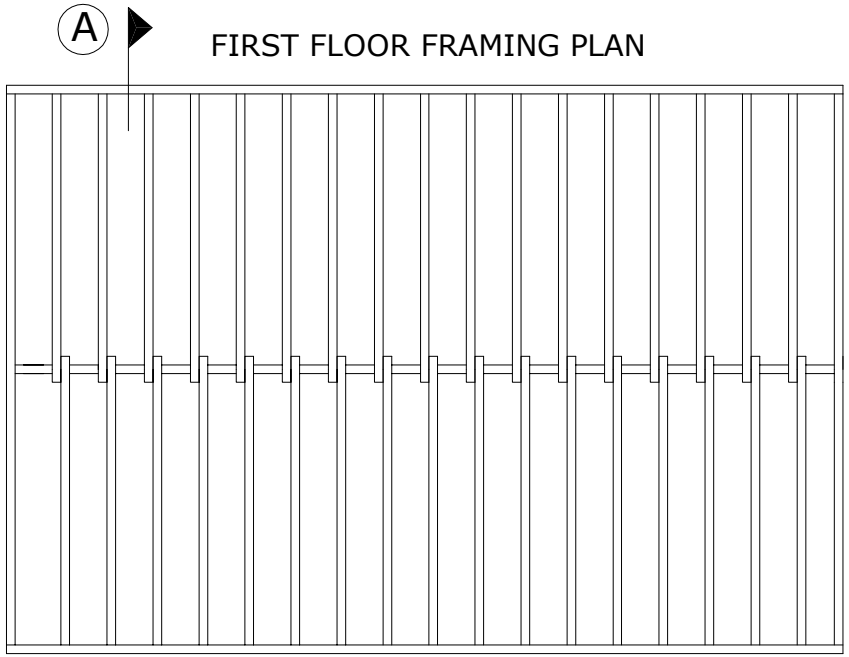
The soils that rest against basement walls can create lateral pressure that pushes against the wall due to various weather conditions.

Basement walls that are braced at the top by floor joists can withstand any lateral pressure caused by the surrounding soil. See Section A detail.

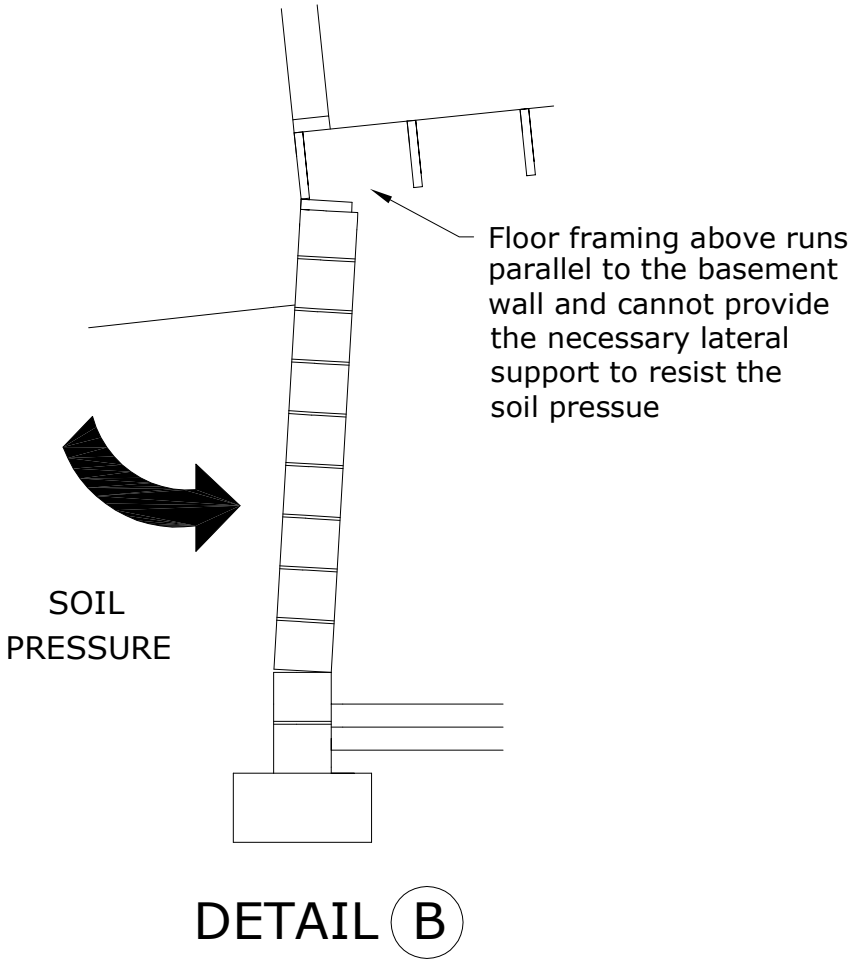




SECTION (A)



However, gable end walls typically lack perpendicular floor joists to brace the basement wall against soil pressure. See Section B detail below.



DETAIL (B)

The VRC does not permit this method of construction. Per section R404.1.1, any foundation wall that retains more than 48" of unbalanced backfill must have lateral support at the top and bottom of the wall. Lateral support can be achieved by providing blocking between the joists of gable end walls in the following manner:

Provide full depth joist blocking
2 joists deep @ 24" O.C.
OR
3 joists deep @ 48" O.C.

Please show the lateral blocking on your joist layout plan. If I-joists or floor trusses are used, please have the manufacturer show the blocking on their layout plan.

FIRST FLOOR FRAMING PLAN