

BRACING CONCRETE MASONRY WALLS UNDER CONSTRUCTION

TEK 3-4C
Construction (2014)

INTRODUCTION

Building codes typically place responsibility for providing a reasonable level of life safety for workers during construction on the erecting contractor. Various methods are employed to protect workers while newly constructed masonry walls are curing and/or until the roof or other structural supports are in place. This TEK provides guidelines for masonry wall stability to resist the lateral loading effects of wind during construction. It is based on principles set forth in the Council for Masonry Wall Bracing's *Standard Practice for Bracing Masonry Walls Under Construction* (ref. 1), but has been updated in accordance with the design provisions of the 2011 *Building Code Requirements for Masonry Structures* (MSJC, ref. 2). When other lateral loads such as impact, seismic, scaffolding, and lateral earth pressure are present, they need to be considered and evaluated separately. The *Walls Subject to Backfilling* section at the end of this TEK discusses bracing and support of basement walls during backfilling operations.

WALLS SUBJECT TO WIND LOADS

There are several strategies and considerations for protecting life safety on the jobsite. These include internal bracing, external bracing and evacuation zones. The combination of strategies appropriate for a particular job may depend on the type of masonry construction, masonry wall heights, the time elapsed since construction, and wind speeds at the site.

The industry term “internal bracing” is relatively new. Internal bracing refers to the stability of a masonry assembly

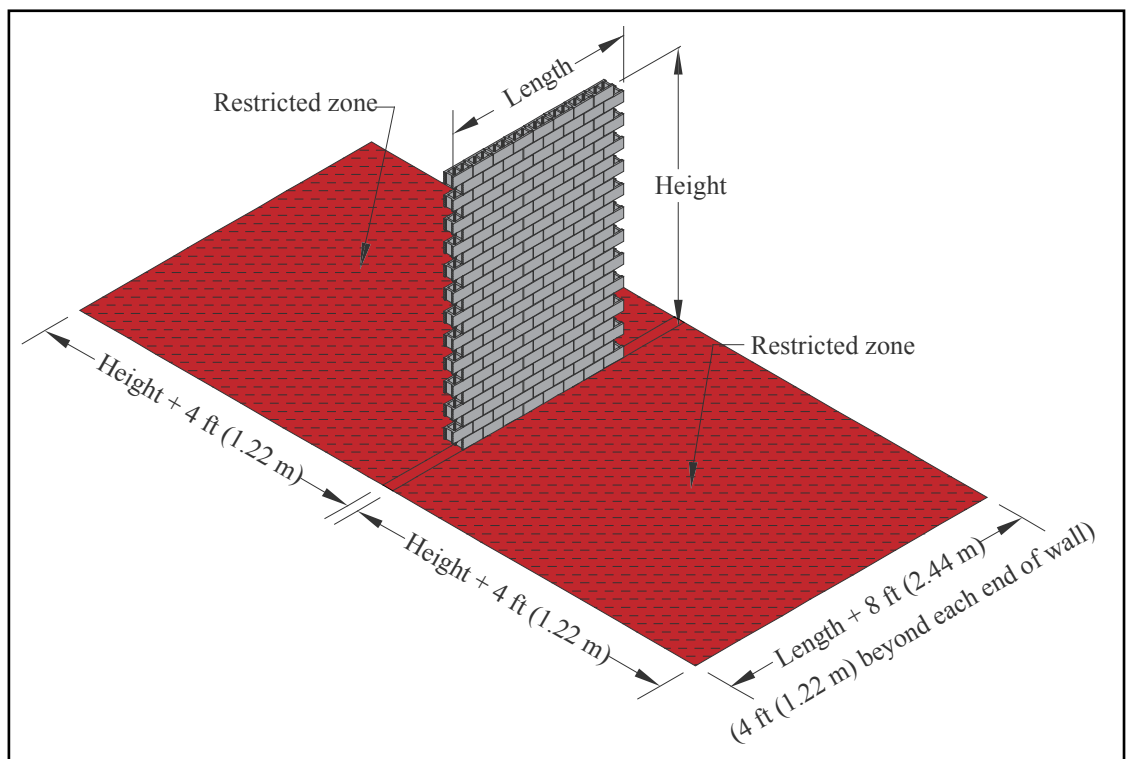


Figure 1—Restricted Zone for Masonry Walls

Related TEK:
14-4B, 14-7C

Keywords: backfilling, basement walls, bracing walls, construction loads, internal bracing, lateral loads, plain concrete masonry, restricted zone, unreinforced concrete masonry, wind loads

to resist wind loads through self-weight and allowable flexural stresses within the masonry.

The use of evacuation zones recognizes that it may be impractical to prevent the collapse of a masonry wall during construction when subjected to extreme loading conditions and that life safety is the primary concern. At prescribed wind speeds (taken as three-second gusts measured at the job site), the wall and the area around it is evacuated. The critical wind speed resulting in evacuation depends on the age of the wall being constructed and involves the three terms: “restricted zone,” “initial period,” and “intermediate period.”

Restricted Zone

The restricted zone is the area on each side of a wall subject to the effect of a masonry wall collapse. It is defined by a length equal to the height of the constructed wall plus 4 ft (1.22 m) on both sides of the wall, and a width equal to the wall length plus 4 ft (1.22 m) on both ends of the wall, as shown in Figure 1. When wind speeds exceed those allowed during the initial and intermediate periods, there is a chance that the masonry wall could fail, and the restricted zone must be evacuated in order to ensure life safety.

Initial Period

The initial period is the period of time, not to exceed 24 hours, during which the masonry is being laid above its base or highest line of bracing, and at the end of which required bracing is installed. During this period, the mortar is assumed to have no strength and wall stability is ac-

Table 1—Maximum Unbraced Height of UngROUTED Hollow Concrete Masonry Walls During the Initial Period, ft-in. (m)

Nominal wall thickness, in. (mm)	Density of masonry units, γ , lb/ft ³ (kg/m ³)		
	Lightweight units 95 < γ < 105 (1,522 < γ < 1,682)	Medium weight units 105 < γ < 125 (1,682 < γ < 2,002)	Normal weight units 125 < γ (2,002 < γ)
4 (102)	8'-0" (2.43)	8'-0" (2.43)	8'-0" (2.43)
6 (152)	8'-0" (2.43)	8'-0" (2.43)	8'-0" (2.43)
8 (203)	9'-4" (2.84)	10'-0" (3.05)	12'-0" (3.65)
10 (254)	13'-4" (4.05)	14'-8" (4.47)	17'-4" (5.27)
12 (305)	18'-0" (5.48)	20'-0" (6.09)	24'-0" (7.31)

Footnotes:

1. Height of walls above grade or highest line of lateral support
2. Based on 20 mph (8.9 m/s) evacuation wind speed.
3. Based on hollow units of lightest weight in the specified density category.

complished from the masonry self-weight only. Based on this assumption and a wind speed limit of 20 mph (8.9 m/s), walls can be built to the heights shown in Table 1 without bracing during the initial period. If wind speeds exceed 20 mph (8.9 m/s) during the initial period, work on the wall must cease and the restricted zone on both sides of the wall must be evacuated. Evacuation for walls up to 8 ft (2.44 m) above grade is not necessary until wind speeds reach 35 mph (15.6 m/s) in keeping with a long-standing OSHA requirement.

Intermediate Period

The intermediate period is the period of time following the initial period but before the wall is connected to the elements that provide its final lateral support. The design wind speed is 40 mph (17.9 m/s) 3-second gust for brace design. When the wind speed exceeds 35 mph (15.6 m/s), the restricted zone must be evacuated. The difference of 5 mph (2.2 m/s) is to allow workers time to evacuate the area.

During the intermediate period, the masonry is assumed to have one-half of its design compressive strength and plain masonry allowable flexural stresses are taken as two-thirds of the design value given in the 2011 MSJC (ref. 2). The masonry structural capacity then can be determined using these reduced values in accordance with the provisions of the Code (see ref. 3 for more information).

There are several methods of providing an acceptable level of life safety for masons and others working on the construction site. They are:

- 1) bracing to a design wind speed of 40 mph (17.9 m/s), 3-second gust and evacuating if the wind speed exceeds 35 mph (15.6 m/s), 3-second gust,
- 2) alternative bracing designs and methods approved, sealed, and signed by a registered professional engineer if supported by data representing field conditions, and
- 3) an early warning and evacuation program when the masonry is designed to resist a wind speed of 5 mph (2.2 m/s) greater than the designated evacuation wind speed. The wind speed measurement must be made by an instrument with a ± 2 mph (0.89 m/s) accuracy.

Traditionally, bracing and evacuation of the restricted zones has also been based on wind speeds lower than 35 mph (15.6 m/s). As such, Table 2 addresses evacuation wind speeds of 15 and 25 mph (6.7 and 11.2 m/s) in addition to the 35 mph (15.6 m/s) evacuation wind speed. Many jurisdictions will accept the lower wind speed criteria but users should first confirm acceptability with their local building official and/or OSHA representative before using them.

Table 2 lists maximum unbraced wall heights when early warning with an evacuation program is implemented. Design wind speeds for the heights in Table 2 are for 5 mph (2.2 m/s) greater than the evacuation speed to allow time for the

**Table 2—Intermediate Period Maximum Unbraced Heights, ft (m)^{A, B} (based on ref. 2)
Type M or S Mortar Only^L**

Support Condition	Evacuation Wind Speed:					
	15 mph (6.7 m/s)		25 mph (11.2 m/s)		35 mph (15.6 m/s)	
	PCL & MRC ^D	MC ^E	PCL & MRC ^D	MC ^E	PCL & MRC ^D	MC ^E
Unreinforced 8 in. (203 mm) wall						
Unbonded ^F	10'-0" (3.05)		4'-8" (1.42) ^G		2'-8" (0.81) ^G	
Bonded ^L :						
Above grade or line of support	23'-0" (7.01)	23'-0" (7.01)	17'-4" (5.28)	14'-4" (4.36)	12'-4" (3.75)	10'-0" (3.05)
Vertical spacing between braces	21'-4" (6.50)	18'-0" (5.48)	21'-0" (6.40)	17'-4" (5.28)	15'-0" (4.57)	12'-4" (3.75)
Above top brace	10'-8" (3.25)	9'-0" (2.74)	10'-4" (3.14)	8'-8" (2.64)	7'-4" (2.23)	6'-0" (1.82)
Unreinforced 12 in. (305 mm) wall						
Unbonded ^F	20'-0" (6.09)		9'-4" (2.84)		5'-4" (1.62) ^G	
Bonded ^L :						
Above grade or line of support	32'-0" (9.75)	32'-0" (9.75)	27'-0" (8.22)	21'-4" (6.50)	17'-4" (5.28)	14'-4" (4.36)
Vertical spacing between braces	32'-0" (9.75)	32'-0" (9.75)	30'-8" (9.34)	26'-0" (7.92)	21'-4" (6.50)	17'-4" (5.28)
Above top brace	16'-0" (4.87)	16'-0" (4.87)	15'-4" (4.67)	13'-0" (3.96)	10'-8" (3.25)	8'-8" (2.64)
Reinforced 8 in. (203 mm) wall ^{I, J}						
No. 5 at 10 ft o.c. (M#16 at 3.05 m) ^M						
Above grade or line of support	18'-0" (5.48)		18'-0" (5.48)		16'-0" (4.87)	
Vertical spacing between braces	21'-8" (6.60)		21'-8" (6.60)		19'-4" (5.89)	
Above top brace	10'-8" (3.25)		10'-8" (3.25)		9'-8" (2.94)	
No. 5 at 4 ft o.c. (M#16 at 1.22 m) ^M						
Above grade or line of support	23'-4" (7.11)		23'-4" (7.11)		23'-4" (7.11)	
Vertical spacing between braces	28'-0" (8.53)		28'-0" (8.53)		28'-0" (8.53)	
Above top brace	14'-0" (4.26)		14'-0" (4.26)		14'-0" (4.26)	
Reinforced 12 in. (305 mm) wall ^{I, J}						
No. 5 at 10 ft o.c. (M#16 at 3.05 m) ^M						
Above grade or line of support	25'-4" (7.72)		25'-4" (7.72)		24'-0" (7.31)	
Vertical spacing between braces	30'-0" (9.14)		30'-0" (9.14)		28'-8" (8.73)	
Above top brace	15'-0" (4.57)		15'-0" (4.57)		14'-4" (4.36)	
No. 5 at 4 ft o.c. (M#16 at 1.22 m) ^M						
Above grade or line of support	29'-4" (8.93)		29'-4" (8.93)		29'-4" (8.93)	
Vertical spacing between braces	35'-0" (10.66)		35'-0" (10.66)		35'-0" (10.66)	
Above top brace	17'-4" (5.28)		17'-4" (5.28)		17'-4" (5.28)	

^A Maximum height above highest line of lateral support permitted without bracing at wind speed indicated.

^B These values can be applied to all hollow concrete masonry of 95 lb/ft³ (1522 kg/m³) and greater density and all solid CMU.

^C Wall design wind speed is 5 mph (2.2 m/s) greater than evacuation wind speed.

^D PCL indicates portland cement/lime. MRC indicates mortar cement.

^E MC indicates masonry cement mortar.

^F Assumes an unbonded condition between the wall and foundation such as at flashing.

^G Exception: walls may extend up to a height of 8 ft (2.44 m) above the ground without bracing.

^H Assumes continuity of masonry at the base (i.e. no flashing).

^I Reinforced walls shall be considered unreinforced until grout is in place 12 hrs.

^J Reinforcement indicated is minimum vertical required and must be continuous into the foundation. Minimum lap splice for grout between 12 and 24 hrs. old is 40 in. (1,016 mm) or 30 in. (762 mm) splice length for grout 24 hrs. old and over.

^K For reinforced walls not requiring bracing, check adequacy of foundation to prevent overturning.

^L Table values are for Type M or S mortars only. Reduce unreinforced table values by 25% for portland cement /lime or mortar cement and 25% for masonry cement Type N mortars.

^M Table values are for Type M or S mortars only. Reduce reinforced table values by 5% for Type N mortars.

masons to get off the scaffolding and evacuate the restricted zone.

Figure 2 shows a wood brace detail for support heights up to 14'-4" (4.37 m) maximum. Proprietary pipe bracing systems and cable systems are also available for all heights shown in Table 2—see manufacturer's recommendations for details.

Research has shown that properly designed and constructed reinforcement splices can achieve up to 75% of the specified yield stress of the reinforcing steel at 12 hours and 100% at 24 hours (ref. 1). Therefore, the full capacity of splices may be used after grout has been in place 24 hours. Alternatively, the full splice capacity can be used after only 12 hours if the design lap length is increased by one-third. Splice criteria is as follows for Grade 60 reinforcement:

- 48 bar diameters for grout that has been in place 24 hours or more,
- 64 bar diameters for grout that has been in place 12 hours or more but less than 24 hours.

Connections to masonry can be designed using the previously described reduced masonry strengths and design formulas. As an alternate, restricted working loads for post-drilled anchors as reported in the manufacturer's literature may be used.

Design Example

Determine the bracing requirements for a 22 ft (6.71 m) tall wall constructed with 8 in. (203 mm) concrete masonry having a density of 110 lb/ft³ (1762 kg/m³) and reinforced with No. 5 bars at 32 in. (M#16 at 813 mm) o.c. using 30 in. (762 mm) splice lengths (i.e., 48 bar diameters). Mortar is masonry cement Type S, control joints are spaced at 24'-8" (7.52 m), and flashing is at the base of the wall only (unbonded condition).

Initial Period

From Table 1:

Maximum unsupported height = 10'-0" (3.05 m).

(These initial period provisions apply to all of the options that follow.)

Intermediate Period—Unbraced Option

From Table 2:

Alternate 1: Evacuation wind speed of 15 mph (6.7 m/s).

NOTE: Although this type of option has historically been accepted, the designer should verify acceptance with the local building official and/or OSHA representative.

Unreinforced wall:

Maximum height above grade, unbonded = 10'-0" (3.05 m)

Maximum height above grade or line of support, bonded = 23'-0" (7.01 m)

Reinforced wall:

Maximum height, bonded or unbonded = 23'-4" (7.11 m) for No. 5 at 48 in. (M#16 at 1.22 m)

This is conservative, because the wall in this example has reinforcement spaced closer than 48 in. (1.22 m).

Strategy:

Build the wall to a height of 10'-0" (3.05 m) the first day (initial period).

The maximum height for an unbonded condition during the intermediate period is 10'-0" (3.05 m) for this wind speed, therefore neither bracing nor grouting is required for the 10'-0" (3.05 m) height during the intermediate period.

If the wall is reinforced and grouted, it can support a total height of 23'-4" (7.11 m). Therefore, if the first 10'-0" (3.05 m) is reinforced and grouted, another 10'-0" (3.05 m) (initial period limit) could be built 24 hours after grout placement if the standard 30 in. (1,016 mm) reinforcement splice is used (or after 12 hours with a 40 in. (762 mm) splice). The 10'-0" (3.05 m) height is less than the 23'-0" (7.01 m) unbraced limit for the bonded unreinforced intermediate period and the total 20'-0" (6.10 m) of constructed wall height is less than the reinforced limit of 23'-4" (7.11 m).

The next day, the top 2 ft (0.61 m) of masonry can be added, because the initial period limit of 10'-0" (3.05 m) is met, the maximum unreinforced bonded limit of 23'-0" (7.01 m) is met, and the reinforced limit of 23'-4" (7.11 m) is met. Therefore, the wall can be built in this manner without external bracing.

NOTE: This option requires early warning and evacuation when wind speeds reach 15 mph (6.7 m/s) 3-second gust. This may not be practical in all areas.

Alternate 2: Design for an evacuation wind speed of 35 mph (15.6 m/s).

Unreinforced wall:

Maximum height above grade, unbonded = 8'-0" (2.44 m) at ground level (see Table 2 note G), 2'-8" (0.81 m) otherwise, Maximum height above grade or line of support, bonded = 10'-0" (3.05 m)

Maximum vertical spacing between braces, bonded = 12'-4" (3.75 m)

Maximum vertical height above brace, bonded = 6'-0" (1.82 m)

Reinforced wall:

Maximum height above grade or line of support, bonded = 23'-4" (7.11 m)

Maximum vertical spacing between braces, bonded = 28'-0" (8.53 m)

Maximum vertical height above brace, bonded = 14'-0" (4.26 m)

Strategy:

Build the wall to a height of 10 ft (3.05 m) the first day (Table 1: initial period limit is 10'-0" (3.05 m)). Grout that lift the same day, which after the curing period (12 or 24 hours depending on the splice length used) can support a cantilever height of 23'-4" (7.11 m).

Then, build an additional section of wall of 6'-0" (1.82 m) high, grout it and brace it at no lower than the 8'-0" (2.43 m) level, because only 14'-0" (4.26 m) of the reinforced 22 ft (6.71 m) wall can extend above the brace.

The next or following days, finish the rest of the wall and grout that portion the same day. (Note the first two sections each could have been done in 8'-0" (2.44 m) heights as well.)

The brace will need to stay in place until the permanent support (roof or floor) is in place. Note that when counting reinforced internal bracing, the wall must be grouted the same day and the restricted zone vacated for the next 12 or 24 hours, depending on the splice length used.

NOTE: Refer to the International Masonry Institute's *Internal Bracing Design Guide for Masonry Walls Under Construction* (ref. 4) for an example of how to use NCMA's *Structural Masonry Design System Software* (ref. 5) to determine wall bracing requirements. That document also demonstrates how to effectively use low-lift grouting for internal bracing, as each lift that is grouted can be considered reinforced and able to withstand higher loadings at the bottom of the wall where stresses are highest.

WALLS SUBJECT TO BACKFILLING

Unless concrete masonry basement walls are designed and built to resist lateral earth pressure as cantilever walls, they should not be backfilled until the first floor construction is in place and anchored to the wall or until the walls are adequately braced. Figure 3 illustrates one type of temporary lateral bracing being used in the construction of concrete masonry basement walls. Heavy equipment, such as bulldozers or cranes, should not be operated over the backfill during construction unless the basement walls are appropriately designed for the higher resulting loads.

Ordinarily, earth pressures assumed in the design of basement walls are selected on the assumption that the backfill material will be in a reasonably dry condition when placed. Because lateral earth pressures increase as the moisture content of the earth increases, basement walls should not be backfilled with saturated materials nor should backfill be placed when any appreciable amount of water is standing in the excavation. Similarly, water jetting or soaking should never be used to expedite consolidation of the backfill.

Care should be taken to avoid subjecting the walls to impact loads, as would be imparted by earth sliding down a steep slope and hitting the wall. This could also damage waterproofing, dampproofing, or insulation applied to the walls. Also, if needed, a concrete masonry unit can be left out at the bottom of a wall to prevent an unbalanced accumulation of water. The unit can be replaced before backfilling.

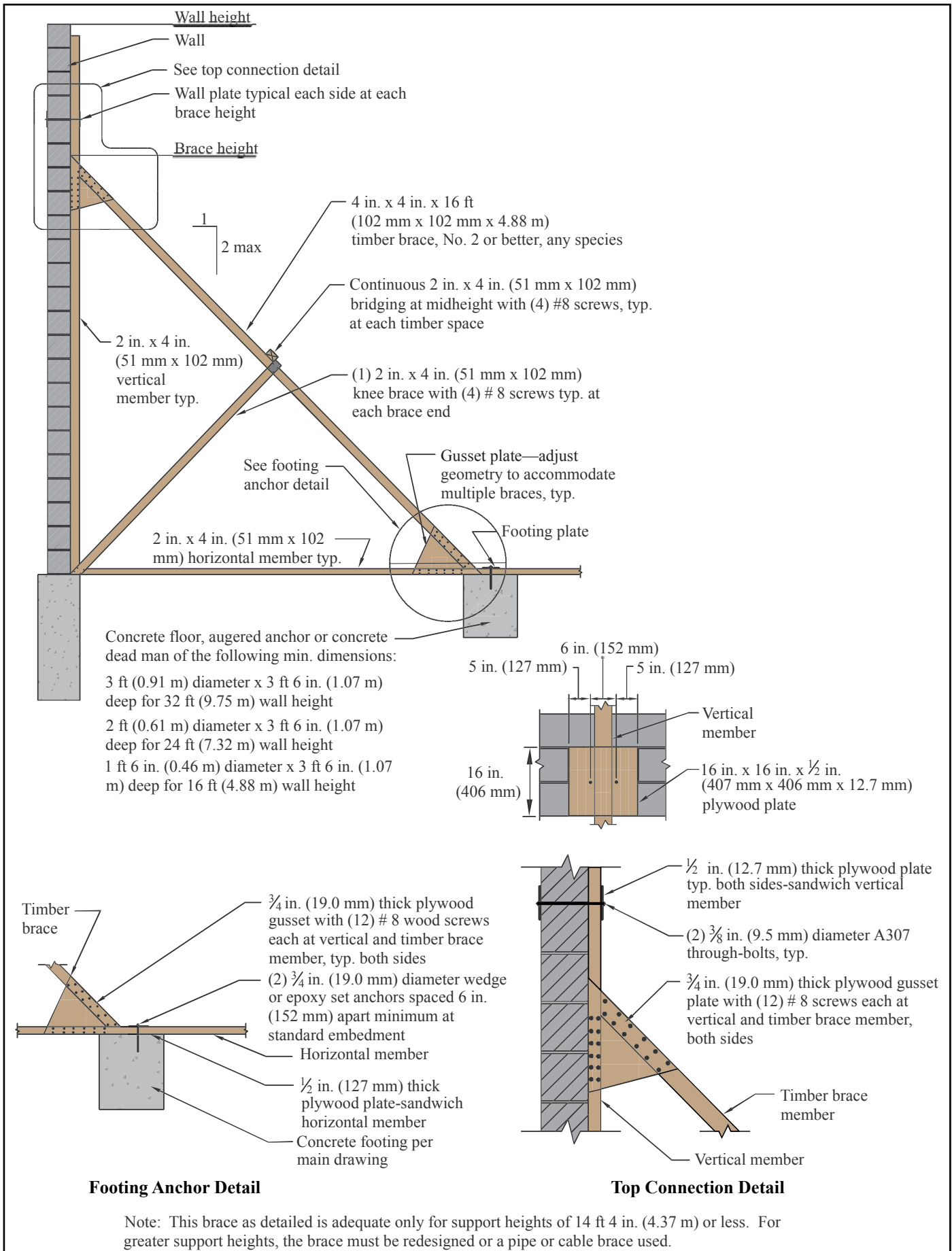


Figure 2—Wood Brace Detail

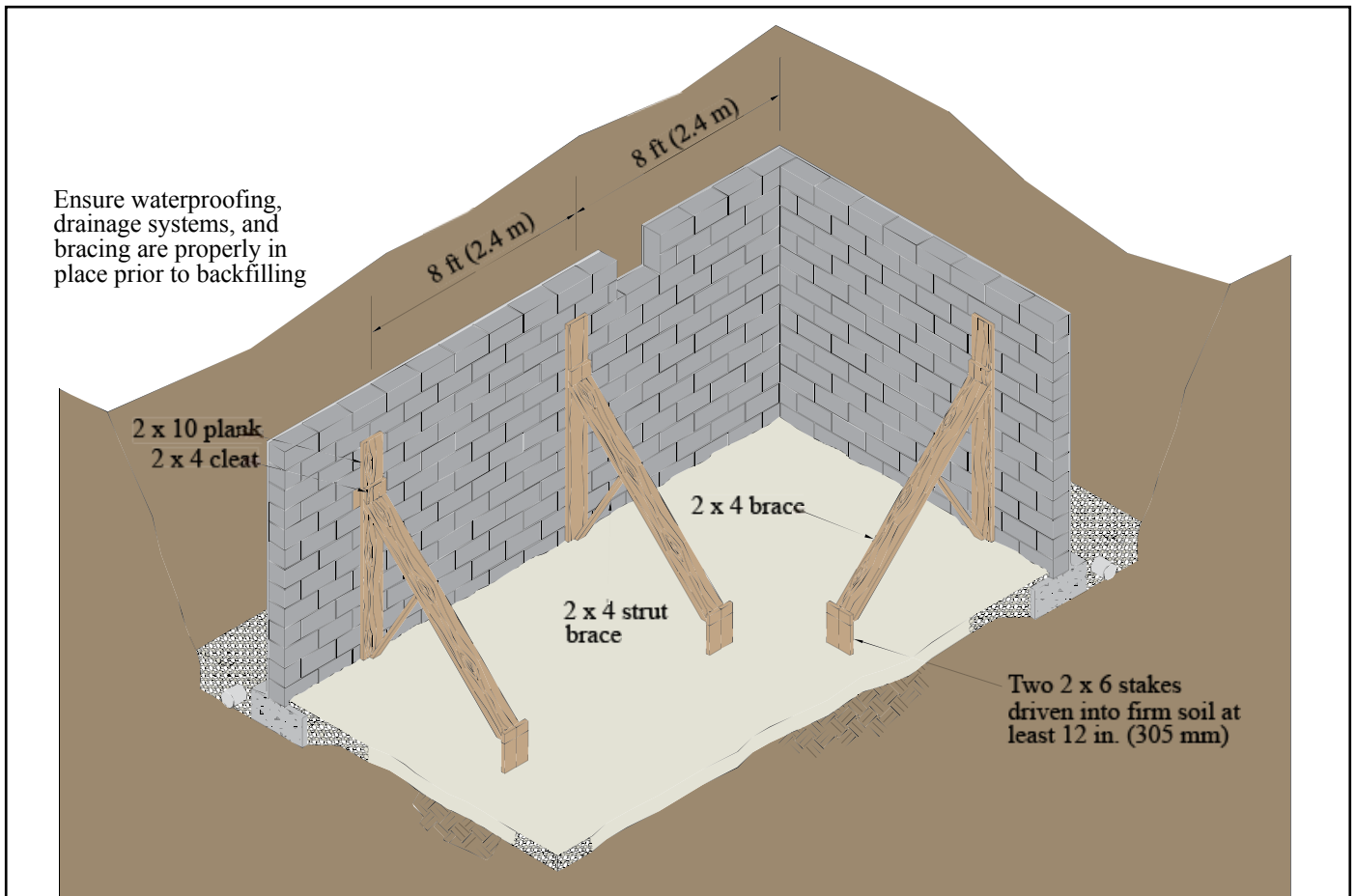


Figure 3—Typical Temporary Bracing for Concrete Masonry Basement Walls (ref. 6)

REFERENCES

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13750 Sunrise Valley Drive, Herndon, Virginia 20171
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