

National Concrete Masonry Association
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BRACING CONCRETE MASONRY WALLS DURING CONSTRUCTION

TEK 3-4B
Construction (2005)

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INTRODUCTION

Various codes and regulations relating to buildings and structures place responsibility on the erecting contractor for providing a reasonable level of life safety for workers during construction. Until the recent development of the *Standard Practice for Bracing Masonry Walls During Construction* (ref. 3) by the Council for Masonry Wall Bracing, there were no uniform guidelines for masonry wall stability. The Standard only addresses strategies to resist the lateral loading effects of wind during construction. When other lateral loads such as impact, seismic, scaffolding, and lateral earth pressure are present, they need to be considered and evaluated separately. A section is provided at the end of this TEK regarding bracing and support of basement walls during backfilling operations.

WALLS SUBJECT TO WIND FORCES

Recognizing that it may be impracticable to prevent the collapse of a masonry wall during construction when subjected to extreme loading conditions and that life safety is the primary concern, the Standard includes a procedure whereby the wall and the area around it is evacuated at prescribed wind speeds. Wind speeds as defined in the Standard are five-second gusts measured at the job site. The critical wind speed resulting in evacuation is dependent on the age of the wall being constructed and involves three new terms. They are “Restricted Zone,” “Initial Period,” and “Intermediate Period.”

Restricted Zone

The Restricted Zone is the area on each side of a wall equal to the length of the wall and extending a distance perpendicular to the wall equal to the height of the constructed wall plus 4 ft. (1.22 m), as shown in

Figure 1. When the 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 time frame during which the masonry is being laid above its base or highest line of bracing, limited to a maximum of one working day. During this period, the mortar is assumed to have no strength and wall stability is accomplished from its self weight only. Based on this assumption and a wind speed limit of 20 mph (32.2 km/hr), walls can be built to the height shown in Table 1 without bracing during the Initial Period. If wind speeds exceed 20 mph (32.2 km/hr) during the Initial Period, work on the wall must cease

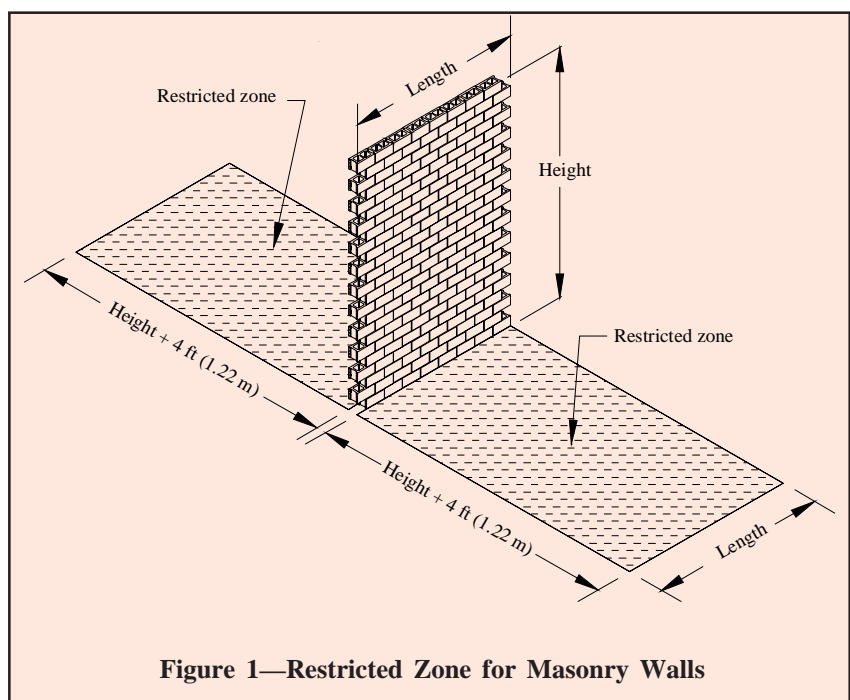


Figure 1—Restricted Zone for Masonry Walls

Table 1—Maximum Unbraced Height¹ of Ungrouted Hollow Concrete Masonry Walls During the Initial Period², ft (m)

Nominal wall thickness, in (mm)	Density of Masonry Units, γ , lb/ft ³ (kg/m ³)			
	Lightweight Units $95 \leq \gamma < 105$ (1522 $\leq\gamma$ <1682)	Medium Weight Units ³ $105 \leq \gamma < 115$ (1682 $\leq\gamma$ <1842) $115 \leq \gamma < 125$ (1842 $\leq\gamma$ <2002)		Normal Weight Units $125 \leq \gamma$ (2002 $\leq\gamma$)
4 (102)	8.0(2.44)	8.0(2.44)	8.0(2.44)	8.0(2.44)
6 (152)	8.0(2.44)	8.0(2.44)	8.0(2.44)	8.1(2.47)
8 (203)	10.8(3.29)	12.0(3.66)	13.1(3.99)	14.2(4.33)
10 (254)	17.0(5.18)	18.8(5.73)	20.0(6.10)	22.0(6.71)
12 (305)	23.2(7.07)	25.7(7.84)	28.1(8.56)	30.6(9.33)

Footnotes:
 1. Height of walls above grade or highest line of lateral support
 2. Adapted from ref. 3.
 3. For medium weight units, use $105 \leq \gamma < 115$ ($1682 \leq \gamma < 1842$) category unless it is known that units are $115 \leq \gamma < 125$ ($1842 \leq \gamma < 2002$).

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 (56.3 km/hr) in keeping with a long-standing OSHA requirement.

Intermediate Period

The Intermediate Period is the time following the Initial Period but before the wall is connected to the elements that provide its final lateral stability. The design wind speed is 40 mph (64.4 km/hr) 5 second gust for brace design. When the wind speed exceeds 35 mph (56.3 km/hr), the Restricted Zone must be evacuated. The difference of 5 mph (8.0 km/hr) 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 Masonry Standards Joint Committee's *Building Code Requirements for Masonry Structures* (ref. 1). The masonry structural capacity then can be designed using these reduced values in accordance with the provisions of the Code.

The Standard allows for several methods of providing an acceptable level of life safety for masons and others working on the construction site. They are: 1) an early warning and evacuation program, 2) bracing to a design wind speed of 40 mph (64.4 kph), 5 second gust and evacuating if the wind speed exceeds 35 mph (56.3 kph), 5 second gust, and 3) alternative bracing designs and methods approved by a registered professional engineer if supported by data representing field conditions.

Table 2 lists maximum unbraced wall heights when early warning with an evacuation program is implemented. Maximum allowable heights are provided for evacuation for 5 second gust wind speeds of 15 mph (24.1 kph), 25 mph (40.2 kph), and 35 mph (56.3 kph). The Standard also provides additional tables for 20 and 30 mph (32.2 and 48.3 kph) which are not presented in this TEK. Design wind speeds for the unbraced heights in Table 2 are 5 mph greater than the evacuation speed to allow time for the masons to get off the

scaffolding and evacuate the restricted zone.

Table 3 lists bracing points determined by the bracing method previously described and 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 3 and are detailed in the Standard. Provisions also are included in the Standard for strength design methods.

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. 3). Therefore, the Standard allows the full capacity of splices 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 1/3 (to 40 in. (1016 mm) for No. 5 (No. 16M) bars).

Connections to masonry can be designed using the previously quantified reduced masonry strengths and design formulas included in the Standard. 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 24 ft (7.32 m) tall wall constructed with 8 in. (203 mm) concrete masonry having a density of 110 lb/ft³ (1762 kg/m³) and reinforcement of No. 5 at 32 in. (No. 16M at 813 mm) on center using 30 in. (762 mm) splice lengths. 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.

Initial Period

From Table 1:

Maximum unsupported height = 12'-0" (3.66 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 (24.1 kph)

Unreinforced wall:

Maximum height, unbonded = 12'-8" (3.86 m)

Maximum height, bonded = 13'-4" (4.06 m)

Reinforced wall:

Maximum height, bonded or unbonded = 26'-0" (7.92 m)

Strategy:

Since reinforcement is No. 5 at 32 in. (No. 16M at 813 mm) o.c., the table values for No. 5 at 48 in. (16M at 1.22 m) o.c. can conservatively be used. Build the wall to a height of 12'-0" (3.66 m) the first day (Initial Period). The maximum unbonded height during the Intermediate

Table 2—Intermediate Period Maximum Unbraced Heights, ft (m)^{1,2}(adapted from ref. 3)

Bracing Condition	Evacuation Wind Speed ³											
	15 mph (24.1 kph)				25 mph (40.2 kph)				35 mph (56.3 kph)			
	PCL & MRC ⁴		MC ⁵		PCL & MRC ⁴		MC ⁵		PCL & MRC ⁴		MC ⁵	
	M/S	N	M/S	N	M/S	N	M/S	N	M/S	N	M/S	N
Unreinforced 8 in. (203 mm) wall												
Unbonded ⁶	12'-8" (3.66)				6'-0" (1.83) ⁷				3'-4" (1.02) ⁷			
Bonded ⁸	16'-0" (4.88)	14'-8" (4.47)	13'-4" (4.06)	12'-0" (3.66)	10'-0" (3.05)	8'-8" (2.64)	8'-0" (2.44)	6'-8" (2.03)	6'-8" (2.03)	6'-0" (1.83)	5'-4" (1.63)	4'-8" (1.42)
Unreinforced 12 in. (305 mm) wall												
Unbonded ⁶	28'-0" (8.53)				12'-8" (3.86)				7'-4" (2.24) ⁷			
Bonded ⁸	27'-4" (8.33)	25'-4" (7.72)	23'-8" (7.21)	22'-0" (6.71)	15'-4" (4.67)	14'-0" (4.27)	12'-8" (3.86)	11'-4" (3.45)	10'-8" (3.25)	10'-0" (3.05)	8'-8" (2.64)	8'-0" (2.44)
Reinforced 8 in. (203 mm) wall ^{9,10}												
Unbonded or bonded - No. 5 at 10 ft (16M at 3.05 m) o.c. ¹¹	20'-8" (6.30)				16'-8" (5.08)				12'-0" (3.66)			
Unbonded or bonded - No. 5 at 4 ft (16M at 1.22 m) o.c. ¹¹	26'-0" (7.92)				25'-4" (7.72)				19'-4" (5.89)			
Reinforced 12 in. (305 mm) wall ^{9,10}												
Unbonded or bonded - No. 5 at 10 ft (16M at 3.05 m) o.c. ¹¹	28'-8" (8.74)				23'-4" (7.11)				20'-0" (6.10)			
Unbonded or bonded - No. 5 at 6 ft (16M at 1.22 m) o.c. ¹¹	33'-4" (10.2)				33'-4" (10.2)				24'-0" (7.32)			
Footnotes:												
1. Maximum height above highest line of lateral support permitted without bracing at windspeed indicated.												
2. These values can be applied to all hollow concrete masonry of 95 lb/ft ³ (1522 kg/m ³) and greater density and all solid concrete masonry.												
3. Wall design wind speed is 5 mph (8.05 kph) greater than evacuation wind speed.												
4. PCL indicates portland cement/lime. MRC indicates mortar cement.												
5. MC indicates masonry cement mortar.												
6. Assumes an unbonded condition between the wall and foundation such as at flashing.												
7. Exception: Walls may extend up to a height of 8 ft (2.44 m) above the ground without bracing.												
8. Assumes continuity of masonry at the base (i.e. no flashing).												
9. Reinforced walls shall be considered unreinforced until grout is in place 12 hrs.												
10. Reinforcement indicated is minimum vertical required and shall be continuous into the foundation. Minimum lap splice for grout between 12 and 24 hrs. old is 40 in. (1016 mm) or 30 in. (762 mm) splice length for grout 24 hrs. old and over.												
11. For reinforced walls not requiring bracing, check adequacy of foundation to prevent overturning.												

Period is 12'-8" (3.86 m) for this wind speed, therefore neither bracing nor grouting needs be done for the 12 ft (3.86 m) height for the intermediate period. If the wall is reinforced and grouted, it can support a total height of 26 ft (7.92 m), the top 13'-4" (4.06 m) of which can be unreinforced, bonded masonry. Therefore if the first 12 ft (3.86 m) is reinforced and grouted, the remaining 12 ft (3.86 m) could be built after 24 hours of placing the grout if the standard 30 in. (1016 mm) reinforcement splice is

used (or 12 hours with a 40 in. (762 mm) splice). The total height of 24'-0" (7.32 m) is less than the maximum of 26'-0" (7.92 m) that the reinforced section can support and the top 12'-0" (3.66 m) is less than 13'-4" maximum that unreinforced bonded masonry can support. Therefore the wall can be built in this manner without bracing. Note: This option requires early warning and evacuation when wind speeds reach 15 mph (24.1 kph) 5 second gust. This may not be practical in all areas.

Alternate 2: Design for an evacuation wind speed of 25 mph (40.2 kph).

Unreinforced wall:

Maximum height, unbonded = 8'0" (2.44 m) at ground level, 6'-0" (1.83 m) otherwise

Maximum height, bonded = 8'0" (2.44 m)

Reinforced wall:

Maximum height, bonded or unbonded = 25'-4" (7.92 m)

Strategy:

Again, build the wall to a height of 12'-0" (3.66 m) the first day (Initial Period). Since the maximum unbonded height above grade during the Intermediate Period is 8'-0" (2.44 m) for this wind speed, grouting must be done the first day. The restricted zone must then be vacated for the first 24 hours after placing the grout when using the standard 30 in. (762 mm) reinforcement splice (or 12 hours for 40 in. (1016 mm) splices). After that continue building the wall up to the height of 24'-0" (7.32 m) which is less than the maximum of 25'-4"

(7.72 m). The top 12'-0" (3.66 m) of this is bonded unreinforced masonry which is more than 6'-0" (1.83 m) maximum. Therefore, it must also be grouted the same day and the restricted zone vacated for the next 12 or 24 hours depending on the splice length used.

Intermediate Period - Braced Option

From Table 3 (for 35 mph, 56.3 kph):

Unreinforced wall:

Maximum unsupported height = 3'-4" (1.02 m)

Maximum height above top brace = 5'-4" (1.63 m)

Maximum vertical spacing of braces = 11'-4" (3.45

m) Reinforced wall:

Maximum height above top brace = 10'-8" (3.25 m)

Maximum vertical spacing of braces = 21'-4" (6.50

m)

Strategy:

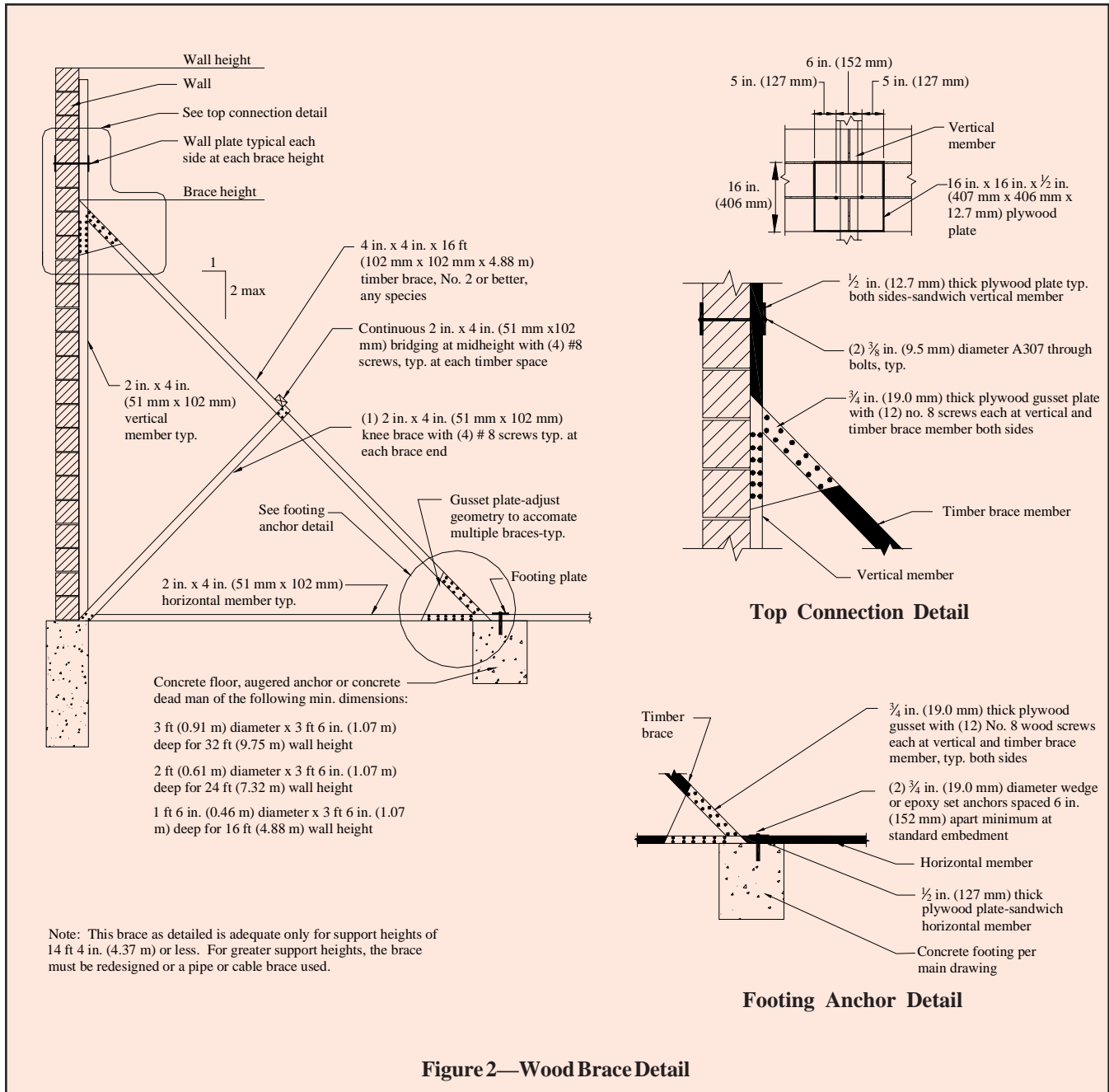
Build the wall to a height of 12'-0" (3.66 m) the first day (Initial Period) and brace at a height of 11'-4" (3.45 m) by the end of

Table 3—Intermediate Period Brace Locations, ft-in. (m)^{1,2}
35 mph (56.3 kph) Evacuation Wind Speed, 40 mph (64.4 kph) Design Wind Speed
Hollow Concrete Masonry, 95 lb/ft³ (1522 kg/m³) Density, (adapted from ref. 3)

Bracing Condition	PCL & MRC ³		MC ⁴	
	M/S	N	M/S	N
Unreinforced 8" (203 mm) wall				
Maximum unbraced height, unbonded condition ⁵ (i.e. at flashing) ⁵	3'-4" ⁶ (1.02)			
Maximum height above top brace ⁷	6'-8"(2.03)	6'-0"(1.83)	5'-4"(1.62)	4'-8"(1.42)
Maximum vertical spacing between braces ⁷	14'-0"(4.26)	12'-8"(3.85)	11'-4"(3.45)	10'-0"(3.04)
Unreinforced 12" (305 mm) wall				
Maximum unbraced height, unbonded condition ⁵ (i.e. at flashing) ⁵	7'-4" ⁶ (2.24)			
Maximum height above top brace ⁷	10'-8"(3.25)	10'-0"(3.04)	8'-8"(2.64)	8'-0"(2.44)
Maximum vertical spacing between braces ⁷	21'-4"(6.50)	19'-4"(5.89)	17'-4"(5.28)	16'-0"(4.88)
Reinforced 8" (203 mm) wall^{8,9}				
Maximum unbraced height, unbonded condition ⁵ and height above top brace ^{7,11}	10'-8"(3.25)			
Maximum vertical spacing between braces	21'-4"(6.50)			
Reinforced 12" (305 mm) wall^{8,10}				
Maximum unbraced height, unbonded condition ⁵ and height above top brace ^{7,11}	19'-4"(5.89)			
Maximum vertical spacing between braces	30'-0"(9.14)			

Footnotes:

- Applies to panels up to 25' (7.62 m) wide with a brace located at 0.2 times the panel width from each end.
- These values can be applied to all concrete masonry units of 95 lb/ft³ (1522 kg/m³) density and greater and all solid concrete masonry.
- PCL indicates portland cement/lime. MRC indicates mortar cement mortar.
- MC indicates masonry cement mortar.
- Assumes an unbonded condition between the wall and foundation such as at flashing - affects only unreinforced walls.
- Exception: Walls 8' (2.44 m) tall and less above the ground do not need to be braced.
- Assumes continuity of masonry other than at the base (i.e. no flashing other than at base).
- Reinforced walls shall be considered unreinforced until grout is in place 12 hours.
- Minimum reinforcement for 8" (203 mm) reinforced walls is No. 5 (No. 16M) vertical bars at 48" (1219 mm) on center and 40" (1016 mm) minimum lap splice for grout between 12 and 24 hours old or 30 inch (762 mm) splice length for grout 24 hours and over.
- Minimum reinforcement for 12" (305 mm) reinforced walls is No. 5 (No. 16M) vertical bars at 72" (1829 mm) on center and 40" (1016 mm) minimum lap splice for grout between 12 and 24 hours old or 30 inch (762 mm) splice length for grout 24 hours and over.
- For reinforced walls not requiring bracing, check adequacy of foundation to prevent overturning.
- Cantilevered retaining walls must meet the bonded condition.



the first working day. This leaves an extension of 8 in. (203 mm) above the top brace which is less than the 5'-4" (1.63 m) allowed (OK). The next level of masonry could be built to a height of 11'-4" + 12'-0" = 23'-4" (3.45 m + 3.66 m = 7.11 m). At the end of that working day, place the second brace at 24'-0" - 5'-4" = 18'-8" (7.32 m - 1.63 m = 5.69 m). Check the vertical spacing between the braces: 18'-8" - 11'-4" = 7'-4" < 21'-4" (5.69 m - 3.45 m = 2.24 m < 6.50 m) (OK).

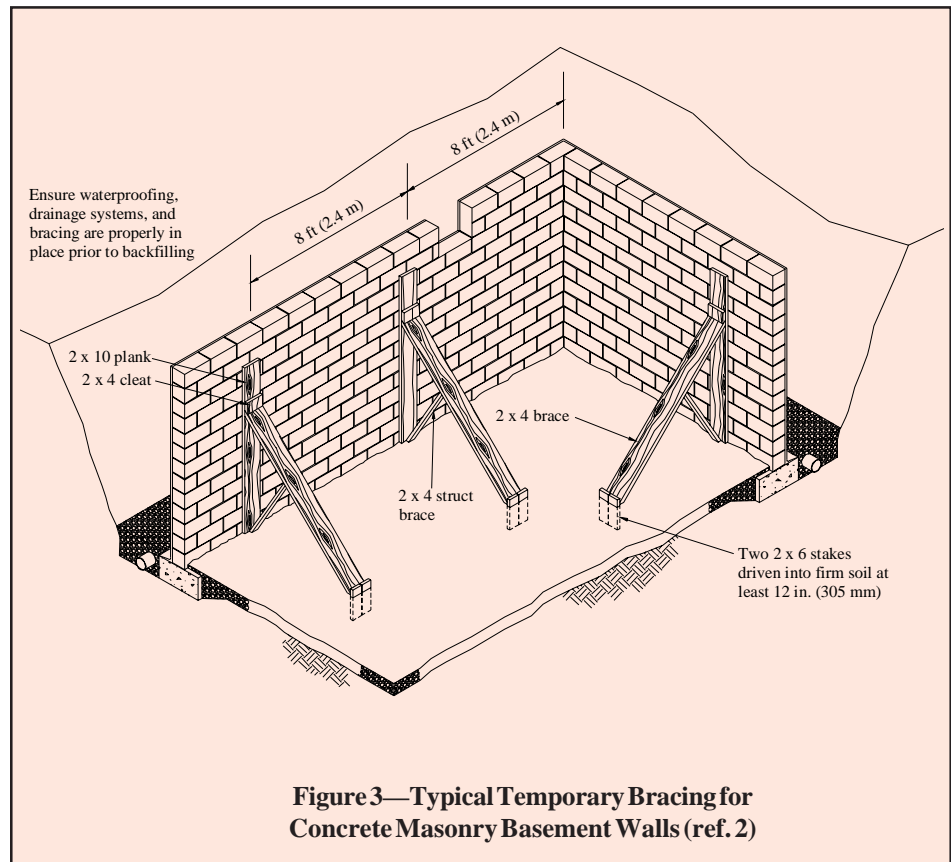
Then after installing the brace, place the remaining final course for the total height of 24'-0" (7.32 m). Note: The bottom brace could be removed after the 12 or 24 hour curing period (depending on the splice length) as the reinforced wall section can span 21'-4" (6.50 m) vertically and the height of the top brace is only at 18'-8" (5.69 m).

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. Since lateral earth pressures will increase as the moisture content of the earth is increased, 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 unit can be left out at the bottom of a wall to prevent an unbalanced accumulation of water and replace before backfilling.



REFERENCES

1. *Building Code Requirements for Masonry Structures*, ACI 530-02/ASCE 5-02/TMS 402-02. Reported by the Masonry Standards Joint Committee, 2002.
2. *NCMA Guide for Home Builders on Residential Concrete Masonry Walls*, TR-134, National Concrete Masonry Association, 1994.
3. *Standard Practice for Bracing Masonry Walls Under Construction*, Council for Masonry Wall Bracing, July 2001.

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