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NCMA TEK

National Concrete Masonry Association
an information series from the national authority on concrete masonry technology

REINFORCED EIGHT INCH BASEMENT WALLS

TEK 15-3
Structural (1996)

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INTRODUCTION

Rising costs of residential construction are rapidly exceeding the ability of first time and middle income home buyers to purchase affordable housing. Concrete masonry basements are one of the best floor space values for home buyers and are helping to hold the line on increasing costs. The cost of converting a residential foundation wall to a concrete masonry basement wall, when distributed over the additional living space, results in significant savings over the cost per square foot of above grade floor space. Concrete masonry basements offer quality living space with features including natural lighting, thermal comfort, quiet space, and a variety of wall finishes.

Concrete masonry is a versatile construction system. Modular by design, concrete masonry basement walls can economically accommodate irregular floor plans, windows, doors, skylight alcoves, and can support fireplaces on both above and below grade levels. Design changes or adjustments in the field can be readily accommodated.

The earth's mass surrounding basement walls moderates exterior temperature swings, thus reducing both heating and cooling costs while helping to maintain comfort. Concrete masonry's mass also moderates inside temperatures. In colder climates, basement walls can be insulated by placing insulation within the cells of concrete masonry units, by insulating the exterior, or by insulating and finishing the interior.

Natural lighting greatly enhances below grade living space. Natural light can be introduced through skylight covered alcoves and windows around the exterior perimeter. Windows and doors opening to subterranean gardens and patios provide alternative natural lighting sources.

Regardless of how the basement is used, whether for living space, sleeping rooms, storage, utility rooms or workshop areas, all basement walls must resist lateral earth pressure, keep the basement dry, and provide lasting durability.

STRUCTURAL DESIGN CONSIDERATIONS

The structural function of basement walls is to resist the lateral pressure of soil and to vertically support the structure. These loading conditions result in flexural tension, flexural compression, axial compression and shear in basement walls. Design of concrete masonry to resist these conditions is based on building code requirements (refs. 1,2,3,4,5) which include three alternative design methods: (1) empirical design, (2) allowable stress design, and (3) strength design.

This TEK is based on the allowable stress engineered design method in which reinforcement is designed to resist all flexural tension; therefore, the flexural tensile strength of masonry units, mortar, and grout is neglected.

Basement walls illustrated in this TEK are laterally supported along the base of the wall by the basement slab and are laterally supported along the top of the wall by the first floor diaphragm. The wall is designed to span vertically between the top and bottom lateral supports. Vertical reinforcing bars are designed to resist flexural tension resulting from the lateral soil pressure. These basement walls are designed to distribute lateral soil loads horizontally between vertical reinforcing bars. Horizontal joint reinforcement is designed to resist flexural tension in the horizontal span between vertical bars.

Vertical loads acting on basement walls tend to counteract flexural tension caused by lateral soil pressure. However, these loads are typically small. Lateral pressure due to soil is determined by an equivalent fluid pressure model (Figure 5) in which the equivalent fluid weight of free draining soil is taken to be 30 pcf (4.7 kN/m^3)(ref. 1).

Masonry materials include loadbearing concrete masonry units (ref. 6) having a minimum net area compressive strength of 1900 psi (13.1 MPa); Type S portland cement lime mortar (ref. 7); grout (ref. 8); Grade 60 reinforcing bars; joint reinforcement; bar positioners to secure vertical reinforcement in place; and anchor bolts to attach the sill plate to the top of the wall.

CONSTRUCTION

Basement construction begins with excavation, casting the footings against undisturbed soil, and laying out the first course of masonry. The first course of units is bonded directly to the top of the footing with a full bed of mortar. Subsequent courses are typically laid with face shell mortar bedding.

Cleanout openings are provided in the first course of masonry in cells to be grouted and reinforced, or alternative methods are used to maintain a clean grout space.

Cross webs adjacent to grouted cells are mortared to confine the fluid grout. In the bed joint above the first course,

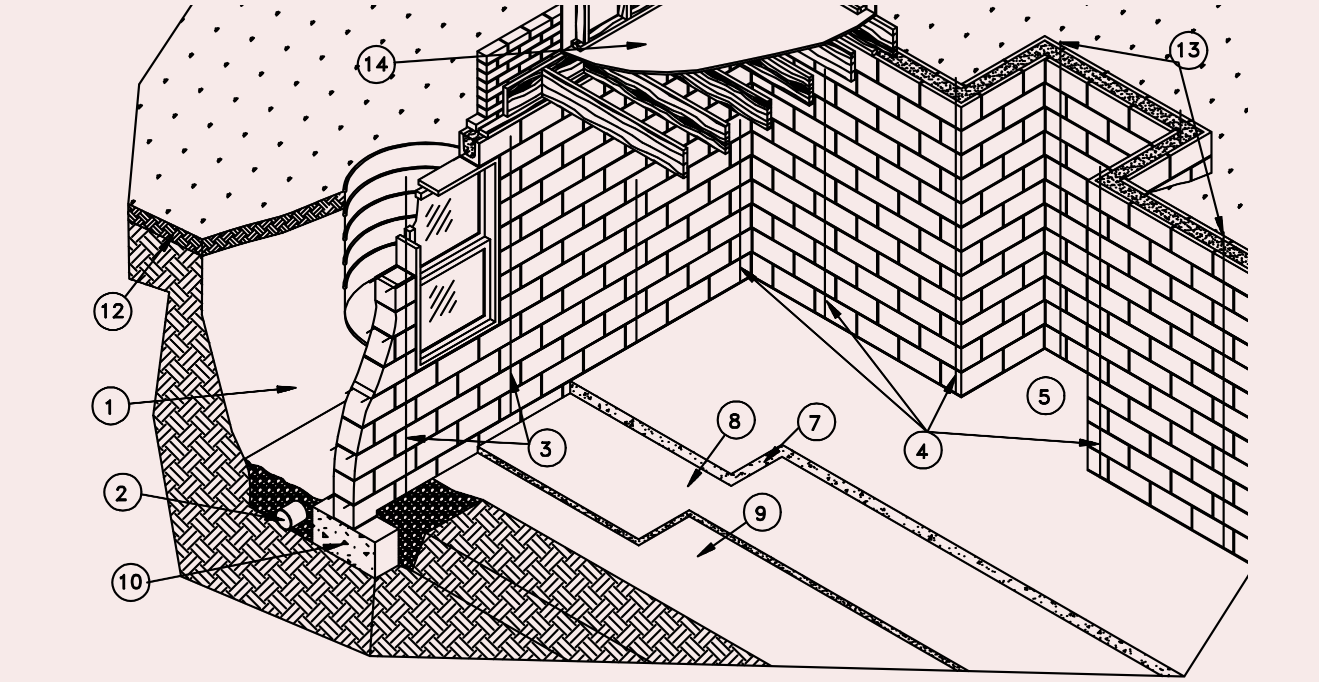


Figure 1—Reinforced Eight Inch Concrete Masonry Basement Construction

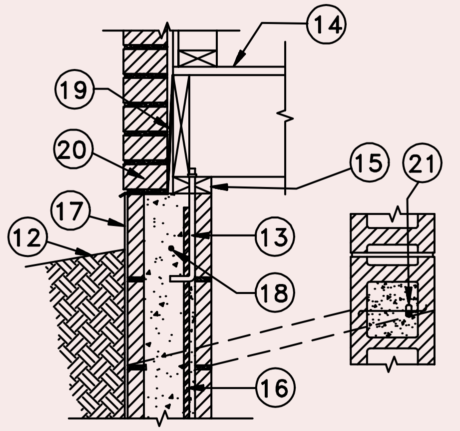


Figure 2—Basement Wall Connection to Floor Diaphragm

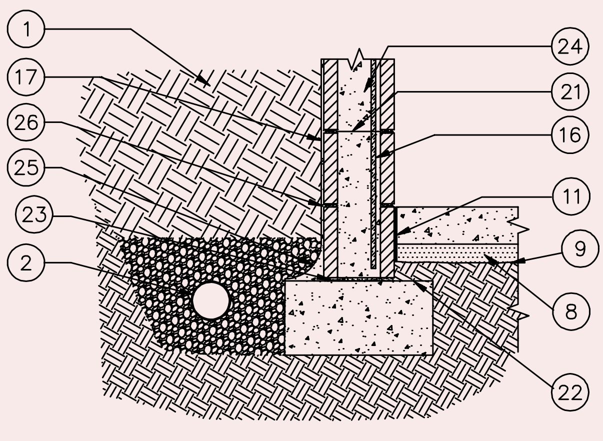


Figure 3—Basement Wall Footing Detail

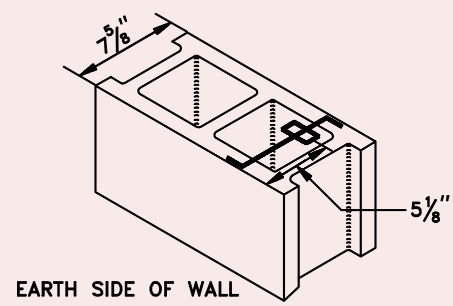


Figure 4—Reinforcing Bar Positioner

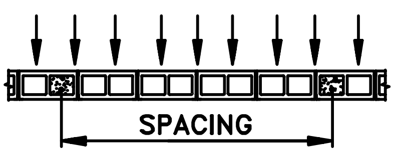
a bar positioner is placed in cells containing vertical reinforcement to position the bar away from the earth side of the wall (see Figure 2, *d* = 5 in., 127 mm). Another bar positioner is placed in the twelfth joint (see Table 1). The top course of masonry is constructed with bond beam units which have depressed webs to allow placement of a No. 4 bar horizontally. Solid-bottom bond beam units can be used to prevent grout from flowing into cells which are not intended to be grouted. As an alternative, a grout stop can be installed below the first course of masonry. Open-bottom bond beam units are used where vertical cells are to be reinforced. Vertical reinforcement is inserted into the cells and through the bar positioners prior to grouting. After the vertical reinforcement is positioned, grout is poured into the designated cells to a height of 4 ft (1.2 m) and consolidated by the use of a vibrator.

A second lift of grout fills the remainder of the cell and fills the bond beam course. The grout in the second lift is then consolidated and the previous grout lift is reconsolidated. After initial water loss, the second lift of grout is reconsolidated. Anchor bolts are inserted in the fluid grout adjacent to each vertical reinforcing bar (Figure 2) and centered under the to-be-installed sill plate.

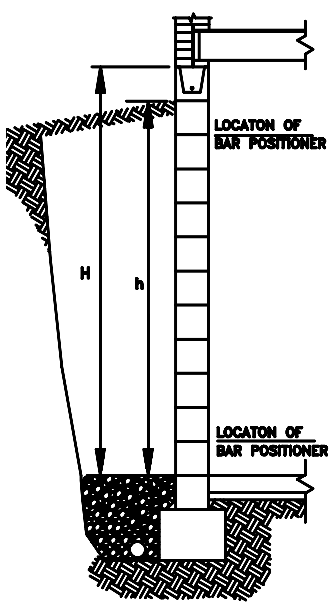
LEGEND TO FIGURES 1, 2, AND 3

1. Free draining backfill.
2. 4 in. (102 mm) perforated pipe perimeter drain with 12 in. (305 mm) of cover.
3. Vertical reinforcing bars in cells adjacent to openings (bar size selected from Table 1). Reinforcement held in place by bar positioners.
4. Vertical reinforcing bars in cells at all corners and at maximum spacing specified in Table 1. Reinforcement held in place by bar positioners.
5. Skylight alcove for increased natural lighting in living space. Top to be enclosed by skylight.
6. 8 in. (203 mm) hollow concrete masonry, partially grouted at cells containing vertical reinforcement.
7. 4 in. (102 mm) concrete floor slab reinforced with 10 x 10 #10 welded wire mesh. Minimum f'_c of concrete is 2500 psi (17.2 MPa).
8. 2 in. (51 mm) sand or gravel levelling bed.
9. Waterproof membrane below slab.
10. Minimum 6 in. (152 mm) thick footing cast against undisturbed soil on levelling bed of sand or gravel.
11. Edge of concrete floor slab cast against waterstop material turned up from beneath slab.
12. Top soil, compacted and sloped to drain water away from the basement wall.
13. Typically, 7 in. (178 mm) long, 1/2 in. (13 mm) diameter anchor bolts are used to to secure sill plate to wall. Bolts are to be located at corners; at a maximum of 6 ft (1.8 m) o. c.
14. Floor diaphragm, including joists and subfloor, to provide lateral support to top of wall.
15. Treated wood sill plate, 2 x 4 in. (51 x 102 mm) nominal, bolted to top of wall.
16. See notes 3 and 4. Vertical bars held in position at top and bottom with bar positioners.
17. Dampproofing or waterproofing, as required.
18. No. 4 bar in bond beam at top of wall. Alternately, a solid unit cap can be installed to seal the top of the wall.
19. Flashing.
20. Weep holes in head joints, spaced 32 in. (813 mm) o. c.
21. Vertical bar positioner in mortar bed joint one course below bond beam and 2 courses above footing. Bar location to be 5 in. (127 mm) from earth side of wall.
22. Top of footing within ±1/2 in. (13 mm) of specified elevation. Footing thickness shall be a minimum of 6 in. (152 mm) and the width shall be 8 in. (203 mm) plus twice the thickness.
23. First block course to be set in full mortar bed using Type S portland cement/lime mortar.
24. Cells containing vertical reinforcing bars to be grouted. Grout proportions to be 1 part portland cement, 2 1/4 to 3 parts sand, plus (optional) 1 to 2 parts gravel. Grout to be consolidated by puddling, if the lift is less than 12 in. (305 mm) or by vibrating.
25. Mold cove in parging to direct water away from wall and toward drain.
26. 3/8 in. (10 mm) mortar joint using Type S mortar. Faceshell mortar bedding, except at cells containing grout. Mortar to confine grout.

Table 1—Basement Wall Reinforcement



	Vertical reinforcement bar size and maximum bar spacing				
Backfill height, *h*, ft (m)	8 (2.4)	7 (2.4)	6 (1.8)	5 (1.5)[a]	4 (1.2)[a]
Bar size	#6	#6	#5	#5	#4
Spacing, in. (mm)	48	64	64	72	72



Mortar joint:	Bar positioner:	Horizontal joint reinforcement size and location for height of backfill, *h*, ft (m): 8 (2.4)[b]	7 (2.4)	6 (1.8)	5 (1.5)	4 (1.2)
13		-	-	-	-	-
12	(bar positioner)	-	-	-	-	-
11		W2.1	W1.7	W1.7	W1.7	W1.7
10		-	-	-	-	-
9		W2.1	W1.7	W1.7	W1.7	-
8		-	-	-	-	W1.7
7		W2.1	W1.7	W1.7	W1.7	-
6		-	-	-	-	W1.7
5		W2.1	W1.7	W1.7	W1.7	-
4		-	W1.7	W1.7	W1.7	W1.7
3	(bar positioner)	W2.1	W1.7	W1.7	W1.7	W1.7
2		-	-	-	-	-
1		-	-	-	-	-

[a] The empirical design method of *Building Code Requirements for Masonry Structures* (ref. 1), Chapter 9 allows up to 5 ft (1.5 m) of backfill on an 8 in. (203 mm) unreinforced concrete masonry wall.

[b] As an alternate, 9 gage joint reinforcement placed in joints no. 3, 4, 5, 7, 9, and 11 may be used.

The waterproof or dampproof system, as specified, is then installed for protection against water penetration.

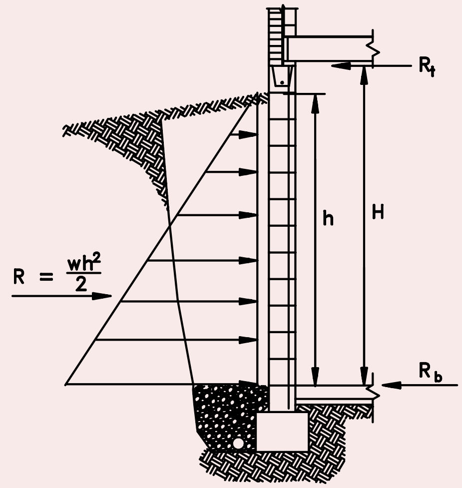
4 in. (102 mm) perforated drain pipe is installed around the perimeter and surrounded with at least 6 in. (152 mm) of gravel. The drain pipe is taken to daylight or, if this is not possible, directed to a sump or dry well.

The first floor level diaphragm is installed prior to backfilling with free draining fill or walls must be temporarily braced until the first floor is in place.

A water stop membrane is installed over the basement floor area and adhered to the face of the wall along the base course (Figure 1). If needed, a sand levelling bed is spread over the waterstop membrane prior to casting the slab. Final grading adjacent to the basement should direct water away from the wall.

REFERENCES

1. *Building Code Requirements for Masonry Structures*, ACI 530-95/ASCE 5-95/TMS 402-95. Reported by the Masonry Standards Joint Committee, 1995.
2. *BOCA National Building Code.* Country Club Hills, IL: Building Officials and Code Administrators International, Inc. (BOCA), 1993.
3. *CABO One and Two Family Dwelling Code.* Falls Church, VA: The Council of American Building Officials, 1995.
4. *Standard Building Code*. Birmingham, AL: Southern Building Code Congress International, Inc. (SBCCI), 1994.
5. *Standard Specification for Loadbearing Concrete Masonry Units*, ASTM C 90-95. American Society for Testing and Materials, 1995.
6. *Standard Specification for Grout for Masonry*, ASTM C 476-91. American Society for Testing and Materials, 1991.
7. *Standard Specification for Mortar for Unit Masonry*, ASTM C 270-95. American Society for Testing and Materials, 1995.
8. *Uniform Building Code*. Whittier, CA: International Conference of Building Officials (ICBO), 1994.



$$M_{\max} = \frac{wh^3}{6H}\left(H + \frac{2h}{3}\sqrt{\frac{h}{3H}} - h\right)$$

$$R_b = \frac{wh^2}{2} - \frac{wh^3}{6H} \qquad R_t = \frac{wh^3}{6H}$$

H = Wall height, ft (m)
h = Backfill height, ft (m)
R = Resultant lateral force, lb/ft (N/m)
W = Equivalent fluid weight of soil, pcf (N/m^3)
M_{max} = Maximum moment due to lateral soil pressure, ft-lb/ft (N·m/m)
R_t = Reaction at top of wall, lb/ft (N/m)
R_B = Reaction at bottom of wall, lb/ft (N/m)

Figure 5—Equivalent Lateral Forces on Basement Walls Due to Soil Pressure