HANDOUT

REINFORCED CONCRETE
A Fundamental Approach - Fifth Edition

RETAINING WALLS

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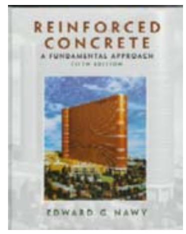

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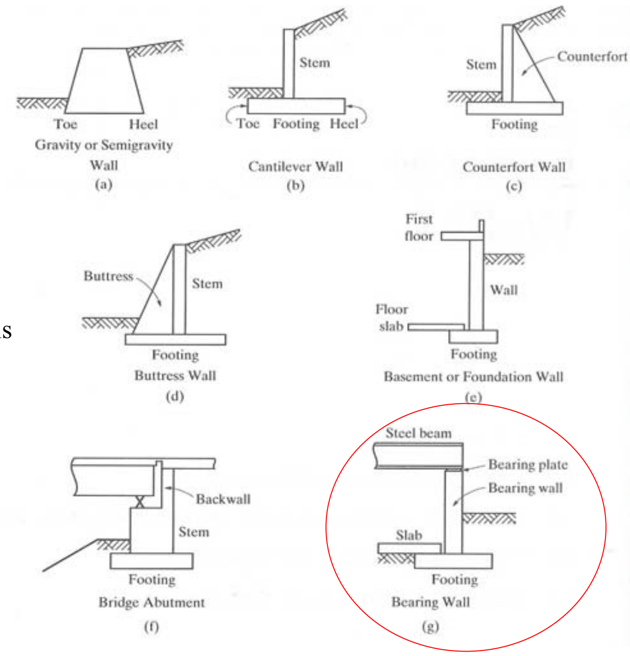
Design Considerations for Bearing Walls

- Bearing walls (see Figure 1g) are those walls that carry vertical load in addition to their own weight.
- Recommendations for the empirical design of such walls are presented in Chapter 14 of the ACI Code and apply primarily to relatively short walls spanning vertically and subject to vertical loads only, such those resulting from reactions of floor or roof systems supported on walls.

Figure 1
Common Types of Walls



Design Considerations for Bearing Walls

- Walls, other than short walls carrying "reasonably concentric" loads, should be designed as compression members for axial load and flexure in accordance with ACI Code, Chapter 10.
- "Reasonably concentric" implies that the resultant factored load falls within the middle third of the cross section.

Design Considerations for Bearing Walls

- Design Axial Load Strength

The design axial load strength or capacity of such a wall will be

$$\phi P_{nw} = 0.55 \phi f'_c A_g \left[1 - \left(\frac{k l_c}{32h} \right)^2 \right] \qquad (8)$$

ϕ = 0.70
h = thickness of wall (in.)
l_c = vertical distance between supports (in.)
A_g = gross area of section (in^2)
k = effective length factor

Design Considerations for Bearing Walls

- The effective length factor k shall be
  1. For walls braced top and bottom against lateral translation and
     a. Restrained against rotation at one or both ends (top and/or bottom) 0.8
     b. Unrestrained against rotation at both ends 1.0
  2. For walls not braced against lateral translation 2.0

Design Considerations for Bearing Walls

- Where the wall is subject to concentrated loads, the effective length of the wall for each concentration must not exceed the center-to-center distance between loads nor exceed the width of bearing plus four times the wall thickness.

Design Considerations for Bearing Walls

- The following requirements applicable to bearing walls are prescribed by ACI Code:
  1. Reinforced concrete bearing walls must have a thickness of at least 1/25 of the unsupported height or width, whichever is shorter, and less than 4 in.
  2. Thickness of nonbearing walls shall not be less than 4 in. nor less than 1/30 times the least distance between members that provide lateral support.

Design Considerations for Bearing Walls

3. The area of horizontal reinforcement must be at least 0.0025 times the area of the wall (0.0025bh per foot) and the area of vertical reinforcement not less than 0.0015 times the area of the wall (0.0015bh per foot), where b = 12 in. and h is the wall thickness. These values may be reduced to 0.0020 and 0.0012, respectively, if the reinforcement is not larger than 5/8 in. in diameter and consists of either welded wire fabric or deformed bars with f_y = 60,000 psi or greater.

Design Considerations for Bearing Walls

4. Exterior basement walls and foundation walls must not be less than 7 ½ in. thick.
5. Reinforced concrete walls must be anchored to floors and roofs or to columns, pilasters, buttresses, and intersecting walls.
6. Walls more than 10 in. thick, except for basement walls, must have reinforcement in each direction for each face. The exterior surface shall have a minimum of one-half and a maximum of two-thirds of the total

Design Considerations for Bearing Walls

steel required, with the interior surface having the balance of the reinforcement.

7. Vertical reinforcement must be enclosed by lateral ties if in excess of 0.01 times the gross concrete area or when it is required as compression reinforcement.

Design Considerations for Bearing Walls

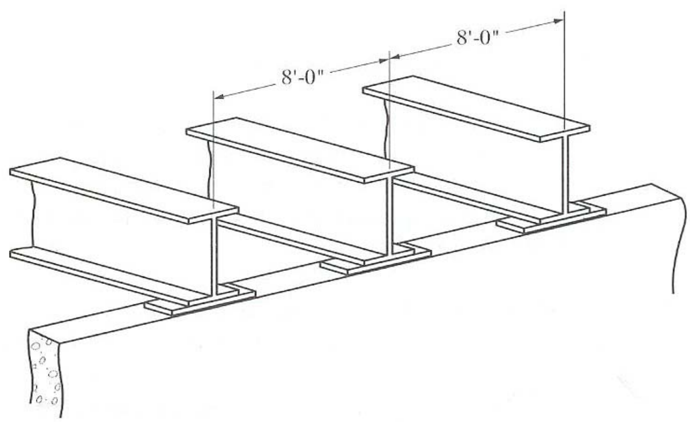
- Example 5

Design a reinforced concrete bearing wall to support a series of steel wide-flange beams at 8 ft-0 in. o.c. Each beam rests on a bearing plate 6 in. × 12 in. The wall is braced top and bottom against lateral translation. Assume the bottom end fixed against rotation. The wall height is 15 ft and the design (factored) load P_u from each beam is 125 kips. Use f'_c = 3000 psi and f_y = 60,000 psi.

To be discussed and solved in class.

Design Considerations for Bearing Walls

- Example 5 (cont'd)



Design Considerations for Bearing Walls

- Example 5 (cont'd)
  1) Assume an 8-in.-thick wall with full concentric bearing.
  2) According to the ACI Code, Section 10.17.1, the bearing strength of the concrete under the bearing plate is

$$\phi(0.85 f_c' A_1) = 0.70(0.85)(300)(6\times 12) = 128{,}520 \text{ lb}$$

$$\text{Factored Load } P_u = 125{,}000 \text{ lb}$$

$$125{,}000 < 128{,}520$$

O.K.

Design Considerations for Bearing Walls

- Example 5 (cont'd)
  3) The effective length of the wall (ACI Code, Section 14.2.4) must not exceed the center-to-center distance between loads nor the width of bearing plus four times the wall thickness. Beam spacing = 96 in., Thus

$$12 + 4(8) = 44 \text{ in.}$$

Therefore use 44 in.

Design Considerations for Bearing Walls

- Example 5 (cont'd)
  4) The minimum thickness required is 1/25 times the shorter of the unsupported height or width. Assume in this case the width does not control, then

$$h_{\min} = \frac{l_c}{25} = \frac{15 \times 12}{25} = 7.2 \text{ in.}$$

Also $h_{\min} = 4$ in., therefore the 8-in. wall is satisfactory.

Design Considerations for Bearing Walls

- Example 5 (cont'd)

5) The capacity of the wall, using Eq. 5, is

$$\phi P_{nw} = 0.55\phi f'_c A_g \left[1 - \left(\frac{kl_c}{32h}\right)^2\right]$$

$$= 0.55(0.70)(3)(44\times 8)\left[1 - \left(\frac{0.8(15)(12)}{32(8)}\right)^2\right] = 278 \text{ kips}$$

$$\phi P_{nw} > (P_u = 125 \text{ kips})$$

O.K.

Design Considerations for Bearing Walls

- Example 5 (cont'd)

6) The reinforcing steel (ACI Code, Section 14.3), assuming No. 5 bars or smaller, can be found.

For the vertical reinforcement per foot of wall length:

$$\text{req'd } A_s = 0.0012bh = 0.0012(12)(8) = 0.12 \text{ in}^2$$

For the horizontal reinforcement per foot of wall height:

$$\text{req'd } A_s = 0.002bh = 0.002(12)(8) = 0.19 \text{ in}^2$$

Design Considerations for Bearing Walls

- Example 5 (cont'd)

The maximum spacing of reinforcement must not exceed three times the wall thickness nor 18 in. (ACI Code, Section 14.3.5). Therefore

$$3(8) = 24\text{ in.}$$

Since 24 in. exceeds the Code limit value of 18 in, thus

$$\text{Use } 18\text{ in.}$$

Design Considerations for Bearing Walls

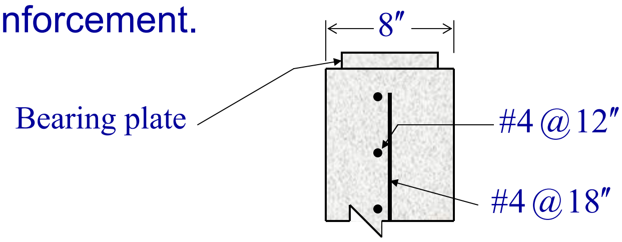
- Example 5 (cont'd)

Selection of reinforcing bars:

$$\text{vertical steel: Use No. 4 bars at 18 in. } (A_s = 0.13\text{ in}^2)$$

$$\text{horizontal steel: Use No. 4 bars at 12 in. } (A_s = 0.20\text{ in}^2)$$

The following figure shows the details of the reinforcement.



Design Considerations for Basement Walls

- A basement wall is a type of retaining wall in which there is lateral support assumed to be provided at bottom and top by the basement floor slab and first floor construction, respectively.
- As previously mentioned, the wall would be designed as a simply supported member with a loading diagram and moment diagram as shown in Figure 7.

Design Considerations for Basement Walls

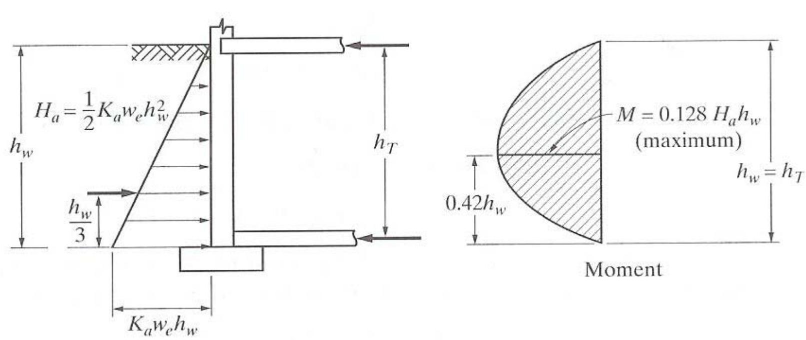


Figure 7. Basement wall with full height backfill: forces and moment diagram

Design Considerations for Basement Walls

- If the wall is part of a bearing wall, the vertical load will relieve some of the tension in the vertical reinforcement.
- This may be neglected since its effect may be small compared with the uncertainties in the assumption of loads.
- If the vertical load is of a permanent nature and of significant magnitude, its effect should be considered in the design.

Design Considerations for Basement Walls

- When a part of the basement wall is above ground, the lateral bending moment may be small and may be computed as shown in Figure 8.
- This assumes that the wall is spanning in a vertical direction.
- Depending on the type of construction, the basement wall may also span in a horizontal direction and behaves as a slab

Design Considerations for Basement Walls

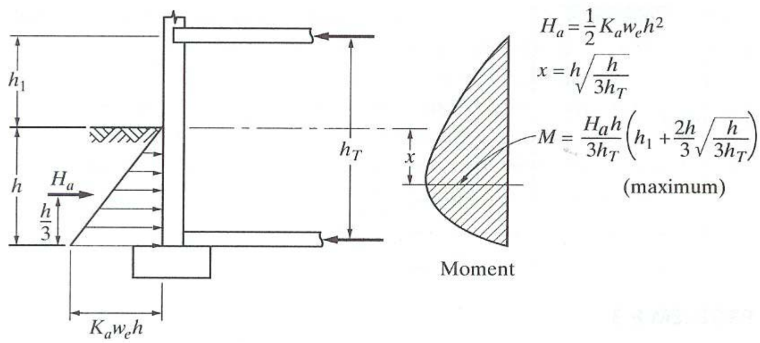


Figure 8. Basement wall with partial backfill: forces and moment diagram

Design Considerations for Basement Walls

reinforced in either one or two directions.

- If the wall design assumes two horizontal reactions, as shown in the figure, caution must be exercised that the two supports are in place prior to backfilling behind the wall.