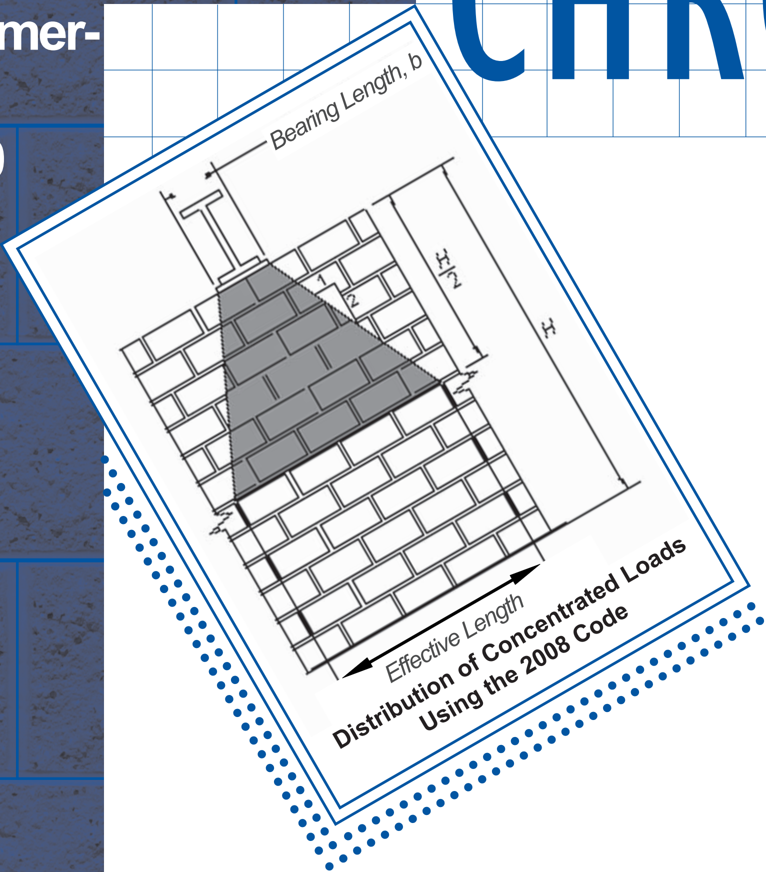
Engineering Notes For Design With Concrete Block Masonry

MASONRY CHRONICLES

Summer-Fall 2010



Distribution of Concentrated Loads Using the 2008 Code

CONCENTRATED LOADS ON MASONRY WALLS

Introduction

The 2009 International Building Code (IBC) [1] is scheduled to replace the 2006 IBC [2] as the basis for the California Building Code on January 1, 2010. (The 2009 IBC is currently being used in Nevada). For masonry design, the new code refers to the latest edition of Building Code Requirements for Masonry Structures (TMS 402-08) [3], which was published in 2008. The current masonry code replaces the 2005 MSJC edition that was refered to by the 2006 IBC.

One of the major differences between the current edition of the code and the previous edition is the manner in which concentrated loads are distributed on supporting elements. The 2005 code stipulated that concentrated loads should be distributed over a length no greater than the width of the bearing width plus four times the thickness of the supporting wall. The requirements for distributing loads in the 2005 code are illustrated in Figure 1. On the other hand, Section 1.9.7 of TMS 402-08 states that concentrated loads shall not be distributed over a length greater than the bearing width plus the length determined by assuming that the load is dispersed at a slope of 2 vertical to 1 horizontal, as shown in Figure 2. The dispersion of the concentrated load must stop at the wall mid-height. In addition, concentrated loads cannot be dispersed across movement joints, openings, or beyond the end of a wall. The length over which concentrated loads are distributed should also not exceed the center-to-center distance between concentrated loads. For walls that are not laid in running bond, concentrated loads cannot be dispersed beyond head joints unless a bond beam is used to distribute the loads. This means that loads can typically be dispersed across head joints in solid-grouted walls that are laid in stack bond if there is sufficient reinforcement. This is usually the case for buildings assigned to Seismic Design Categories D, E and F, since the minimum reinforcement requirements for masonry walls provide enough reinforcement to distribute concentrated loads across head joints in stack bond construction.

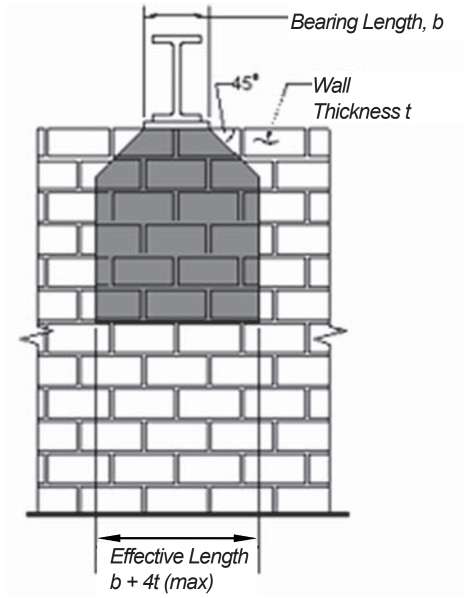


Figure 1 – Distribution of Concentrated Loads Using the 2005 Code

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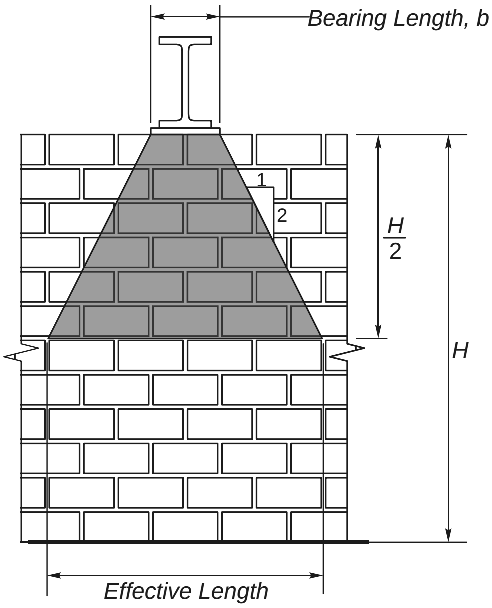

Figure 2 – Distribution of Concentrated Loads Using the 2008 Code

The code requirements for distributing concentrated loads requires that when designing a wall to resist out-of-plane loading, the portion of the wall directly beneath concentrated loads must be designed using different axial loads than the rest of the wall, as shown in Figure 3. Pilasters are sometimes required to resist the additional axial loads.

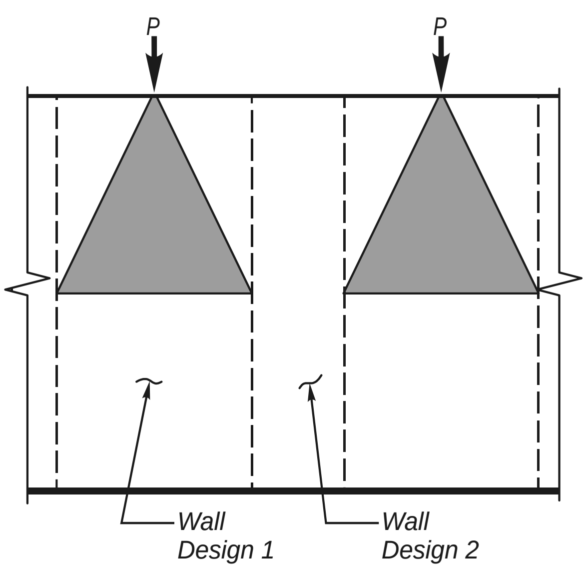

Figure 3 – Different Regions for Design to Resist Out-of-Plane Loading Due to Concentrated Loads

In addition to designing walls to resist the distributed concentrated loads, the bearing on the masonry must also be checked. Bearing stresses are calculated using the bearing area, A_{br}, which is equal to the smaller of the areas obtained from the following equations:

$$A_{br} = A_1\sqrt{\frac{A_2}{A_1}} \tag{1}$$

$$A_{br} = 2A_1 \tag{2}$$

Where A_1 is the loaded area and A_2 is the area of the base of the frustum of a pyramid or cone with the loaded area at the top and sides that slope at 45 degrees that is wholly contained within the masonry. The bearing areas are shown in Figure 4.

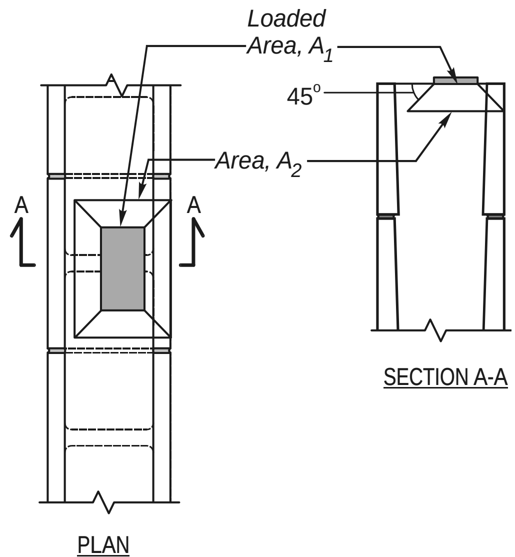

Figure 4 –Areas for Calculating Bearing Loads

When using allowable stress design, the allowable bearing stress is given by:

$$F_{br} = 0.25f'_m \tag{3}$$

Where f'_m is the specified compressive strength of the masonry.

When designing using strength design, the bearing capacity is equal to:

$$\phi P_{br} = \phi 0.6f'_m A_{br} \tag{4}$$

where the capacity reduction factor ϕ in bearing is equal to 0.6.

Example

Determine if the fully-grouted masonry wall has sufficient bearing capacity to support the load shown in Figure 5. Determine the axial load at wall mid-height that should be used for design of the wall to resist out-of-plane loads. Wall mid-height is 13 feet below the bottom of the bearing plate. The masonry has a specified compressive strength of 1500 psi.

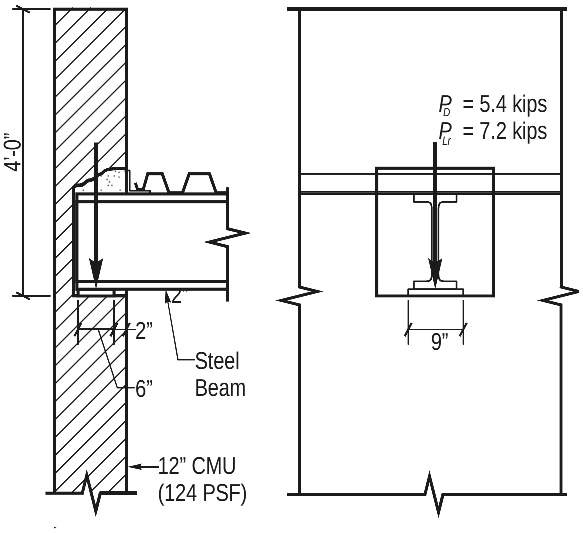

Figure 5 – Concentrated Loads on Masonry Wall

Solution

The bearing areas are calculated as follows:

$$A_1 = 6 \times 9 = 54 \text{ in}^2$$

$$A_2 = (6+4) \times (9+4) = 130 \text{ in}^2$$

$$A_{br} = A_1\sqrt{\frac{A_2}{A_1}} = 54\sqrt{\frac{130}{54}} = 83.8 \text{ in}^2 \quad \leftarrow \text{ Governs}$$

$$A_{br} = 2A_1 = 2 \times 54 = 108 \text{ in}^2$$

Therefore, when using allowable stress design, the bearing stress on the masonry is equal to:

$$f_{br} = \frac{P}{A_{br}} = \frac{(5.4+7.2)1000}{83.8} == 150.4 \text{ psi}$$

And the allowable bearing stress is given by:

$$F_{br} = 0.25f'_m = 0.25(1500) = 375 \text{ psi } > f_{br} \ldots\text{OK}$$

When using strength design, the governing load combination is 1.2*D* + 1.6*Lr*. Therefore the factored bearing load is given by:

$$P_u = 1.2(5.4) + 1.6(7.2) = 18 \text{ kips}$$

And the bearing strength is equal to:

$$\phi P_{br} = \phi 0.6 f'_m A_{br}$$

$$= \frac{0.6(0.6)1500(83.8)}{1000}$$

$$= 45.3 \text{ kips} > P_u \quad \text{...OK}$$

When designing the wall to resist the combination of axial and out of-plane loads, the length over which the concentrated load should be distributed is equal to:

$$9 + 13 \times 12 = 165 \text{ in}$$

The axial load at wall mid-height due to the self-weight of the wall is equal to:

$$P_w = 124(13+4) = 2108 \text{ lbs/ft}$$

The axial load due to roof dead load is given by:

$$P_{fD} = \frac{5.4(1000)(12)}{165} = 393 \text{ lbs/ft}$$

And the axial load due to roof live load is given by:

$$P_{fLr} = \frac{7.2(1000)(12)}{165} = 524 \text{ lbs/ft}$$

Thus, the 165-inch length of the wall directly beneath the beam should be designed for the following loads:

$$P_D = 2108 + 393 = 2501 \text{ lbs/ft}$$

$$P_{Lr} = 524 \text{ lbs/ft}$$

The length of wall between the concentrated loads should be designed for the following loads:

$$P_D = 2108 \text{ lbs/ft}$$

$$P_{Lr} = 0 \text{ lbs/ft}$$

References

1. ICC, 2006 International Building Code (2006 IBC), International Code Council (ICC), Inc., Country Club Hills, Illinois, 2005.

2. ICC, 2009 International Building Code, (2009 IBC), International Code Council (ICC), Inc., Country Club Hills, Illinois, 2008.

3. MSJC, Building Code Requirements for Masonry Structures (ACI 530-05/ASCE 5-05/TMS 402-05), Reported by the Masonry Standards Joints Committee (MSJC), American Concrete Institute, Farmington Hills, Michigan, 2005.

4. MSJC, Building Code Requirements for Masonry Structures (TMS 402-08/ACI 530-08/ASCE 5-08/), Reported by the Masonry Standards Joints Committee (MSJC), The Masonry Society, Boulder, Colorado, 2008.

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