MASONRY INSIGHTS

written in conjunction with International Masonry Institute

Lintels for Masonry Walls

Masonry lintel design is a critical part of an efficient structural masonry solution. The design of masonry lintels can add significant structural capacity to a wall that contractors and owners will welcome for crack prevention. In the past, we have made assumptions to simplify the analysis of masonry lintels that has been a detriment to its engineering and architectural design. This article will take a closer look at masonry vs. steel lintel options, with tables to compare equivalent sizes. We will also discuss the impact of arching action, and how to increase the capacity and efficiency of masonry lintels.

<u>Steel vs. Masonry Lintels</u>

In recent years, there has been a renewed interest in using reinforced masonry lintels instead of steel lintels. There are several reasons to consider masonry lintels:

A) Previously it was thought the only way to reduce shoring was to specify a steel lintel. This is no longer true due to:

   1) New and innovative methods for shoring to build in-place masonry lintels.

   2) Availability of pre-fabricated masonry lintels.

   3) Precast concrete lintels that allows better integration with masonry.

Figure 1: Prefabricated Masonry Lintel

B) Steel lintels are not performing as well over time due to:

   1) Differential movement from dissimilar materials creating serviceability issues and potential cracking.

   2) Steel lintels are often detailed to slide at one end, however in some cases the bearing is rusting and binding, preventing the steel from sliding which results in issues at the bearing.

   3) Large bearing plates are being specified which result in aesthetic and constructibility issues.

   4) Challenging interface details of vertical masonry reinforcement, steel bearing, and control joint.

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C) Steel lintels require additional and costly reinforcement. The required U-bar in Figure 2 is difficult and expensive to place, but is essential to prevent cracking. The vertical jamb reinforcement must be shifted away from the opening, which requires the jamb to be designed for more tributary width, resulting in a larger jamb. This condition also requires additional grout under the steel bearing. See Figure 2 below. An alternative to this detail is to have the jamb reinforcement go through the steel lintel. This is an expensive option that is difficult to construct and creates more potential problems than it resolves.

D) Masonry lintels create an integral joint with vertical jamb reinforcement. This leads to a more robust design with many design benefits, schedule reduction, and proves to be less expensive. See Figure 3 below.

E) Fixed ends can be considered with masonry lintels with top and bottom reinforcement. Negative moment can then develop that is resisted by top bars, resulting in less positive bending moment and more efficient distribution of loads through the wall. Steel lintels cannot be detailed with fixed ends with bottom flanges bearing on a plate and top flanges unrestrained. Instead, steel lintels are considered simply spanning with pinned ends, resulting in higher positive moment than fixed masonry lintels.

F) Perhaps the most compelling reason to use masonry or specialty precast lintels is due to the ability to use arching action, which allows the design load to be much smaller. Arching action, discussed later in this article, requires the lintel to be built integrally with the jamb with no control joints (CJ) at the openings. Steel lintels often require CJs at the end of the lintel due to differential movement, which prevents arching action and therefore requires much more load for the design.

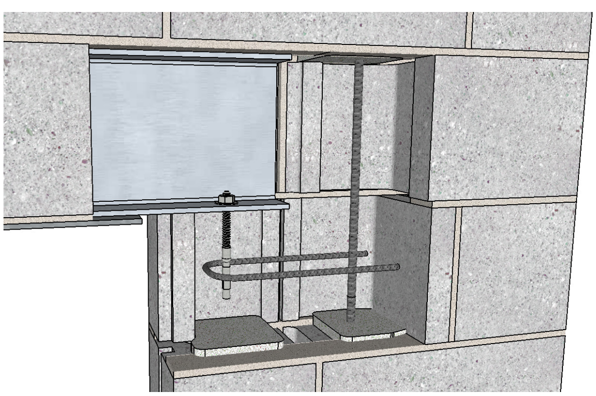

Figure 2: Steel lintel at bearing

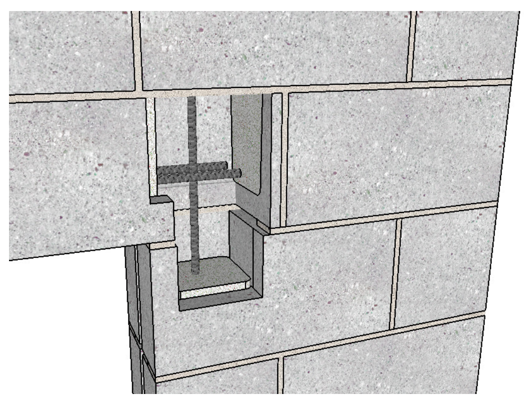

Figure 3: Masonry lintel intersection masonry jamb

Below are tables comparing equivalent masonry lintels to steel lintels. The masonry lintels are designed in the first two tables without considering arching action, and simply designed for the maximum load that the steel member could support. The lintels were checked as a beam with fixed ends (as it is built integrally with the rest of the wall) and the specified loads applied directly to the lintel.

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Lintel design criteria for all tables below:

- Masonry design is based on f'm = 2500 psi, strength design, and is designed using NCMA software-SMDS for fix-fix designs, and RISA3D for finite element analysis.
- Based on strength design code, with the deflection limit set to L/600 to get the maximum uniform load for the steel lintel, which is then used to determine masonry design. Equivalent service loads were: 8'-0 span - W8x10 (1.10 klf), W8x24 (3.76 klf), W16x26 (13.7 klf); 12'-0 span -W8x10 (0.34 klf), W8x24 (1.15 klf), W16x26 (4.19 klf).

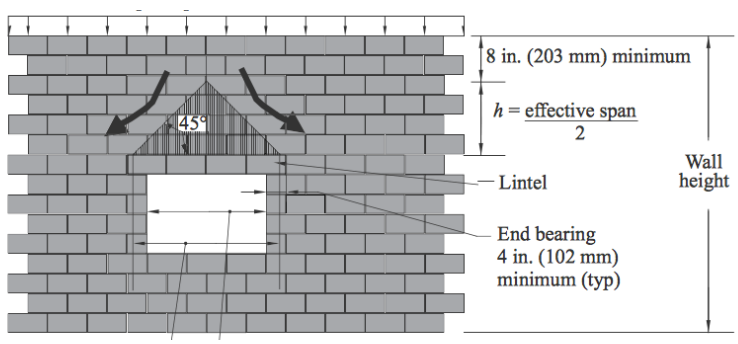

Figure 4: Arching Action Diagram from NCMA TEK

Table 1: 8" Masonry Wall Lintels, fixed ends, not considering arching action

length	8 feet[1]	12 feet[1]
to replace steel W8x10	16" deep (1) #4 top& bot	--
to replace steel W8x24	32" deep (1) #5 top& bot	16" deep (1) #6 top& bot
to replace steel W16x26	--	40" deep (1) #6 top& bot

Table 2: 12" Masonry Wall Lintels, fixed ends, not considering arching action

length	8 feet[1]	12 feet[1]
to replace steel W8x10	16" deep (1) #4 top& bot	--
to replace steel W8x24	24" deep (1) #5 top& bot	16" deep (1) #6 top& bot
to replace steel W16x26	--	32" deep (1) #7 top& bot

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In Table 3 below, arching action will be used to distribute all the load above the "arch" such as wall load, floor loads, or roof loads, and the only loads remaining for the masonry lintel will be the wall load below the arch. When considering arching action, only the load from the wall below the arch is considered to load the lintel. If point loads are on the wall above the opening, they need to be considered on the lintel as well. In these examples, we will assume all the loads on the wall are uniform loads.

Table 3: Both 8" and 12" Masonry Wall Lintels, considering arching action

length	4 feet	8 feet	12 feet
to replace steel W8x10, steel W8x24, steel W16x26	8" deep, (1) #4 top& bot	8" deep, (1) #4 top& bot	16" deep, (1) #4 top& bot

Finally, consider the design of the masonry lintels using finite element analysis (FEA). Finite element analysis is able to look at the entire wall panel as a unit and take advantage of the integral construction, and therefore yields a much more efficient design than looking at the lintel/beam individually. In FEA, masonry plate elements distribute the load based on the stiffness of the support elements below. The analysis from FEA resembles the analysis considering arching action with fixed-fixed support conditions.

High Strength Lintel

Multi-Course Masonry Lintels

In the design of masonry lintels, adding additional strength is easy to accomplish. Higher strength lintels are as simple as adding additional courses of solid grouted masonry to increase both shear and bending moment capacity of the lintel. In some cases, bottom reinforcement and several courses of masonry are sufficient to transfer high shear and positive bending moment. Other times, top and bottom reinforcement are required to resist positive and negative bending moment for the lintel.

There is typically no need for stirrups when additional courses can be used to increase lintel depth and resist shear loads. In situations where there is limited height above the opening, stirrups can be used, particularly in 12-inch or wider masonry walls. But, when the additional height is available, it is more cost-effective to create multi-course masonry lintels.

Multi-course masonry lintels with top and bottom steel are easy to build in the field or prefabricate. For example, a three course (or more) deep masonry lintel with horizontal rebar in the first and third course would be built with a typical masonry bond beam unit (U-block) as the bottom course, a regular stretcher unit as the middle course(s), and a masonry flow-through unit as the top course.

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Efficient Masonry Lintels

Below is a summary of ways to increase the efficiency and capacity of Masonry Lintels:

1. Use correct f'm, go to www.forsei.com/cmudata to get block strength in many areas of the country
2. Construction joints are to be placed away from openings; this will allow arching action to be considered in the analysis
3. Consider Finite Element Analysis (FEA) for a more accurate analysis of masonry lintels which generally leads to more efficient designs
4. If using a simple analysis, consider fixed end lintels; which reduces the maximum moment, has negative and positive moment, and requires top and bottom reinforcement

To increase Moment capacity:

5. Add more depth; simplest way to add more moment capacity
6. Add more reinforcement in single or double layers where necessary. More reinforcement with additional smaller bars is preferred over one large bar.

To increase Shear capacity:

7. Add more depth; generally the easiest and most cost effective is to add more courses and grout solid
8. If more depth is not possible, consider adding stirrups; this should be the last option, and only use single leg stirrups in 8" walls, double leg can be used in thicker walls

Alternate approach:

- Consider the full depth of the masonry above the opening and design lintels as deep beams. See current TMS code for more information on design and detailing of Deep Beam lintels.

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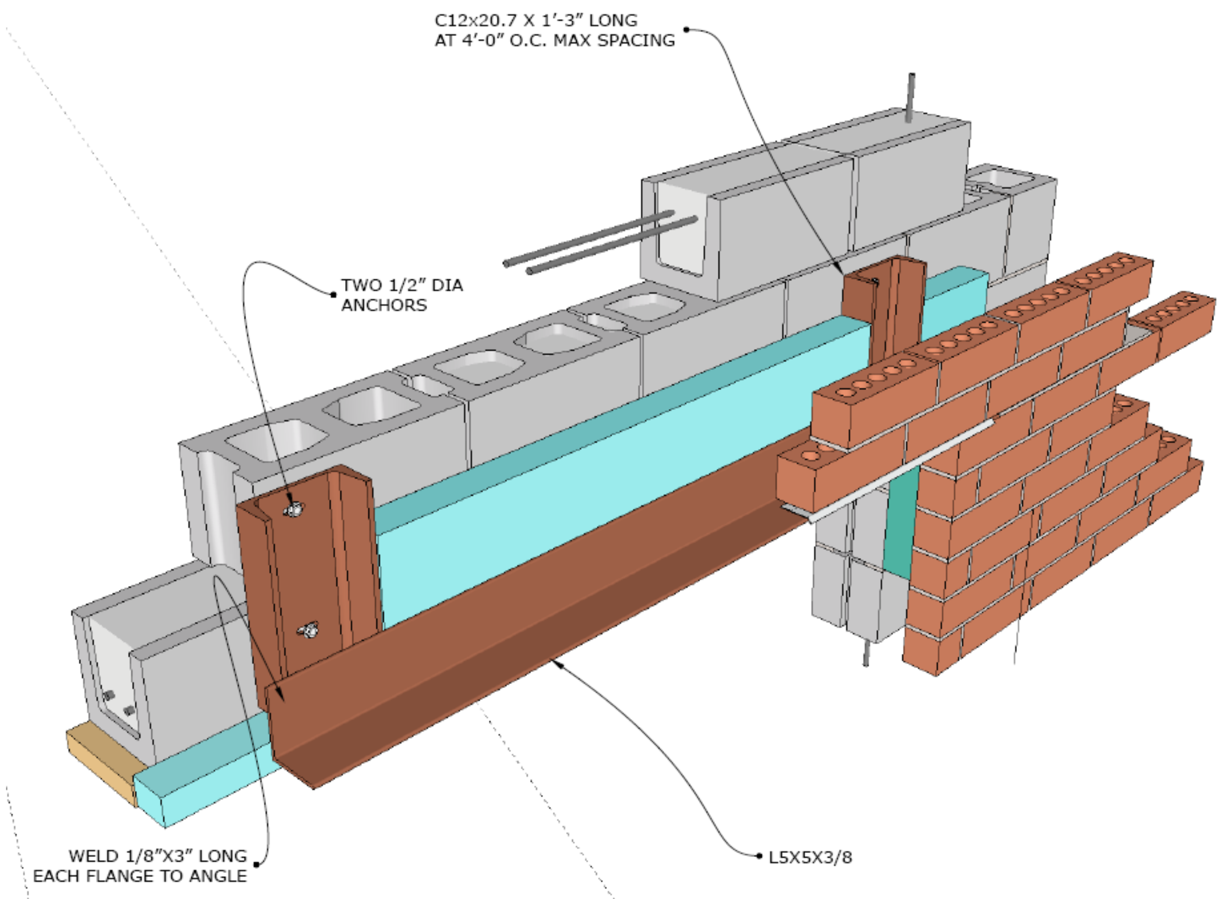

Figure 5: Option to support brick veneer from a masonry lintel using standoff channels to minimize thermal transfer

Lintels at Exterior Walls

One of the reasons often cited for using steel lintels at wide exterior wall openings is the ease of extending a beam bottom plate to pick up the load of the veneer. Although this strategy seems straight-forward from an engineer's perspective, this could negatively impact the architectural concerns of thermal transfer through the beam bottom plate and condensation or interior finish deterioration at the interior window head.

One strategy to create a more durable and energy efficient window head detail at wide exterior openings is to use a single-course or multi-course masonry lintel in the support wall with a steel lintel in the veneer. If the veneer lintel needs support, it can be bolted to the masonry lintel as shown above.

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Detailing the Top of an Opening in an Exterior Wall

An additional architectural consideration is how to best detail around the support of veneer wall over an opening. Where we have a masonry lintel and brick veneer spanning over the opening, there is typically a gap between the exterior face of the masonry lintel and interior face of the brick veneer wall (i.e. the wall cavity). Whether the brick veneer has a self-supporting brick lintel or there are steel angles attached to the backup wall, it is necessary to close this gap between the two walls.

With a masonry lintel and brick veneer, it is necessary to close the gap to:

1. Comply with fire codes
2. Cover insulation
3. Keep moisture, etc. out
4. Aesthetic reasons

This gap is typically closed off at the jambs by brick returns, window/door frames, or metal jamb extensions. The gap is closed off at sills by the window sill.

There are a number of ways to close the gap at the head of an opening:

1. Depending on the detail, the window or door frame covers the gap
2. Metal window/door frame extension
3. Back-to-back angles - this is also a great way to extend the length of loose veneer lintels
4. Longer horizontal leg at veneer angle - this is used when veneer lintel is fixed to structural wall

In summary, lintel design in masonry walls can impact the efficiency not just of the lintel, but of the entire wall panel. Choosing masonry over steel lintels results in a more integrated, robust wall solution with less long-term cracking issues over the life of the wall. Arching action can be achieved with masonry lintels and locating control joints away from the openings. Allowing for arching action to occur is key in efficiently engaging the lintel and the full wall panel to resist structural loading. This combined with increased f'm, fixed end boundary conditions, and multi-course depths, masonry lintels are an effective solution in spanning wall openings.

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