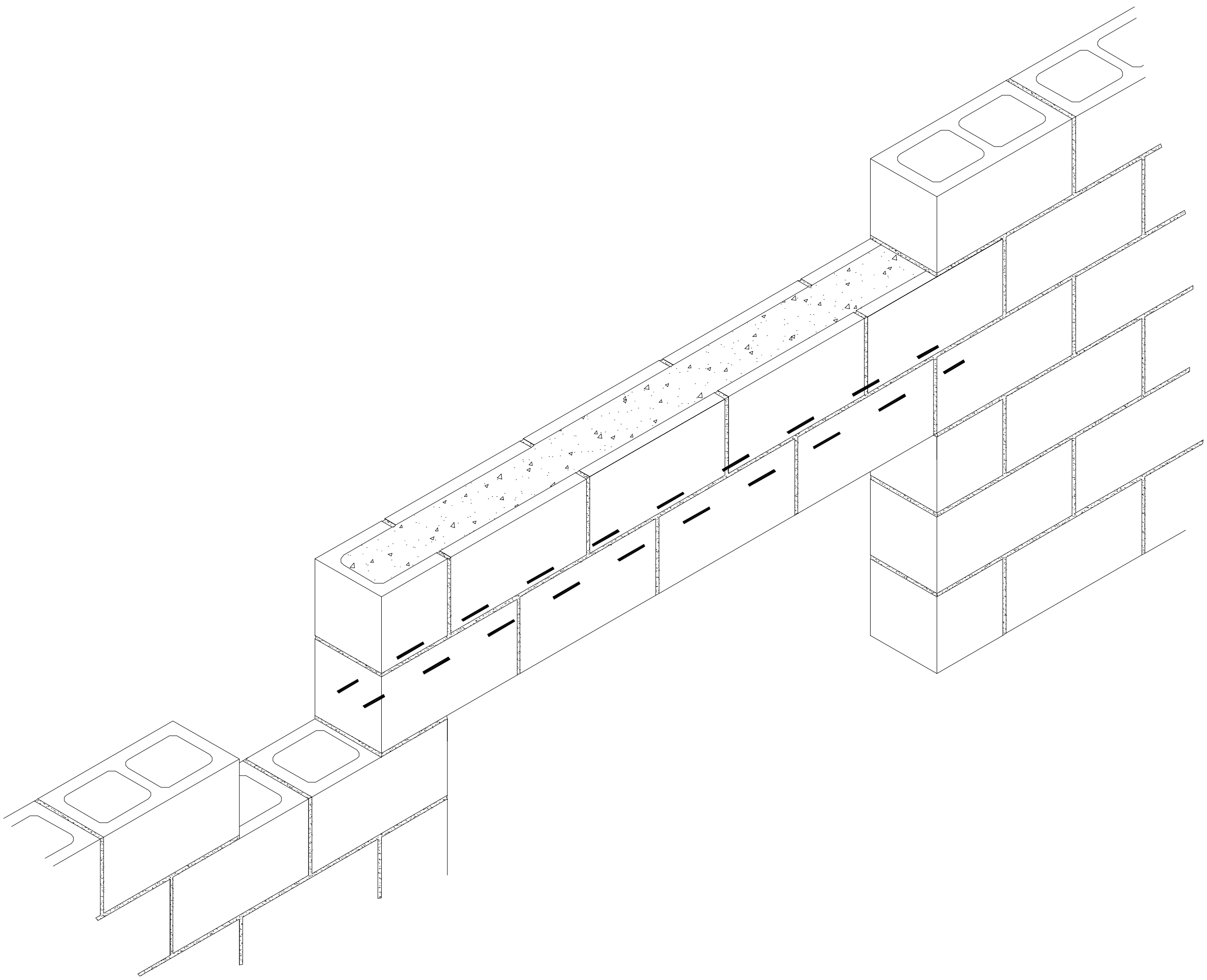
Lintel Design Manual

Design and Analysis of Concrete Masonry and Precast Concrete Lintels



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Design and Analysis of Concrete Masonry and Precast Lintels

NATIONAL CONCRETE MASONRY ASSOCIATION

The National Concrete Masonry Association (NCMA) is a not-for-profit organization whose mission is to support and advance the common interests of its members in the manufacture, marketing, research, and application of concrete masonry products. The Association is an industry leader in providing technical assistance and education, marketing, research and development, and product and system innovation to its members and to the industry.

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DISCLAIMER

NCMA promotes the use of concrete masonry through the development and dissemination of technical information. This manual was compiled to assist the designer, builder, or owner in the preparation of constructing with concrete masonry. The discussion, design tables, and design philosophies are intended to assist architects and engineers in the design of concrete masonry and precast concrete lintels and to acquaint builders and contractors with recommended construction methods and details.

The material presented does not cover all possible situations but is intended to represent some of the more widely used concrete masonry design and construction details and other pertinent information. Factors such as construction practices and building code requirements can vary significantly, even in the same locality. For this reason, the information contained in the handbook is necessarily of a general nature when illustrating typical design conditions, assumptions, and procedures. The actual design of lintels, preparation of working drawings, and similar services are best accomplished by a qualified architect or engineer familiar with local conditions and code requirements.

Care has been taken to ensure that the information included in this manual is as accurate as possible. However, NCMA does not assume responsibility for errors or omissions resulting from the use of this manual or in its use when preparing plans or specifications.

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LIST OF NOTATIONS

a	=	depth of an equivalent compression zone at nominal strength, in.
A_n	=	net cross-sectional area of masonry, in^2.
A_s	=	effective cross-sectional area of steel, in^2.
A_v	=	cross-sectional area of shear reinforcement, in^2.
b	=	effective width of section, in.
c	=	clear distance of cell where reinforcement is placed, in.
d	=	distance from extreme compression fiber to centroid of tension reinforcement, in.
d_b	=	diameter of reinforcing bar, in.
d_c	=	clear distance between horizontal bars, in.
d_v	=	actual depth of masonry in direction of shear considered, in.
D	=	dead load.
E_c	=	modulus of elasticity of concrete, psi.
E_m	=	modulus of elasticity of masonry, psi.
E_s	=	modulus of elasticity of steel, psi.
f'_c	=	specified compressive of concrete, psi.
f'_m	=	specified compressive strength of masonry, psi.
F_b	=	allowable compressive stress of masonry due to flexure only, psi.
F_s	=	allowable tensile stress in reinforcing steel, psi.
F_v	=	allowable shear stress in masonry, psi.
f_v	=	computed shear stress due to design load, psi.
f_y	=	specified yield strength of steel for reinforcement, psi.
h	=	height to apex of triangle for arching action, in.
h_m	=	height of masonry above lintel, in.
h_w	=	wall height, in.
j	=	ratio of distance between centroid of flexural compressive forces and centroid of tensile forces to depth, d.
k	=	ratio of the distance between compression face and neutral axis to the effective depth, d.
l	=	effective span length, ft.
L	=	live load.
L_r	=	roof live load.
M_m	=	resisting moment of masonry, in-lb.
M_n	=	nominal moment strength of a cross-section before application of strength reduction factor, in.-lb.
M_r	=	resisting moment of lintel, in-lb.
M_s	=	resisting moment of reinforcing steel, in-lb.
n	=	ratio of modulus of elasticity of reinforcement to modulus of elasticity of masonry.
P	=	concentrated load, lb.
pcf	=	pounds per cubic foot.
psf	=	pounds per square foot.
q	=	steel index.
R	=	rain load or seismic response modification factor as appropriate.
s	=	spacing of reinforcement, in.
S	=	snow load.
S_L	=	load spacing, ft.

LIST OF NOTATIONS — continued

t = thickness, in.
V_c = nominal shear strength provided by concrete, lb.
V_m = shear strength provided by masory masonry, lb.
V_n = nominal shear strength of a cross-section before application of strength reduction factor, lb.
V_r = resisting shear of lintel, lb.
V_s = shear strength provided by shear reinforcement, lb.
w = load per unit length, lb/ft.
α = tension reinforcement yield strain factor.
ε_y = yield strain of reinforcement.
ε_{mu} = maximum usable compressive strain of masonry.
ϕ = strength reduction factor.
ρ = reinforcement ratio.

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INTRODUCTION

Openings in concrete masonry walls are typically spanned by horizontal structural members known as lintels. Depending upon regional nomenclature, the terms lintel and beam are often interchanged. Regardless of the terminology used, the design approach and philosophy are identical for both elements. The purpose of these members is to support the weight of the wall above the opening, as well as any additional imposed loads. Lintels can be constructed from a variety of materials. The focus of this manual is on reinforced concrete masonry lintels and precast reinforced concrete lintels. Reinforced concrete masonry lintels may have an advantage in that the bond pattern and surface texture of the surrounding masonry is not interrupted.

Primarily designed as simply supported beams, lintels are sometimes constructed as a portion of a continuous bond beam course. This type of installation offers several distinct advantages, especially when the lintel is part of the top course of masonry walls.

All reinforced concrete masonry structural members can be designed by one of two methods–allowable stress design and strength design–in accordance with the 2002 *Building Code Requirements for Masonry Structures* (ACI 530/ASCE 5/TMS 402) [1], henceforth referred to as the MSJC Code (for the Masonry Standards Joint Committee which oversees its development). Its companion document, *Specification for Masonry Structures* (ACI 503.1/ASCE 6/TMS 602) [2], referred to as the MSJC Specification, covers the material and construction requirements for masonry.

In accordance with the allowable stress design provisions of the MSJC Code, structural elements are proportioned such that the stresses resulting from applied service loads do not exceed code prescribed maximum allowable stresses, which are some fraction of the strength level stress of the element. In contrast, when using the strength design method of the MSJC Code, the anticipated service loads are scaled up or down based upon the variability and predictability of the load under consideration. Simultaneously, the nominal strength of the element (the strength at which failure is initiated) is reduced by an appropriate strength reduction factor to account for design issues such as material variability.

Design of precast concrete lintels is governed by the *1999 Building Code Requirements for Structural Concrete* (ACI 318) [3]. ACI 318 uses the strength design method in the design of precast concrete lintels.

The remainder of this design guide is divided into five sections. First, a discussion on the materials commonly used for lintel construction is presented. Next, a detailed discussion on design loads presents lintel loading conditions and discusses arching action of masonry walls. The aspects and parameters of lintel design are presented followed by design examples. Finally, lintel design tables are presented.

MATERIALS

Materials used for reinforced precast and masonry lintels include cement, aggregates, concrete masonry units, mortar, grout, and steel reinforcement. These materials must meet the applicable specifications published by ASTM International. Applicable specifications for these materials are listed in **Table 2.1**.

Units. Concrete masonry units suitable for lintel construction come in a variety of shapes and sizes. Some typical shapes are shown in **Figure 2-1**. Lintel units are often U-shaped and available in various depths. Solid bottom units confine the grout in the lintel. Attention should be given to the bottom thickness and the shape of the lintel as they may limit the number of reinforcing bars that can be placed effectively. Where open bottom bond beam units are used to construct lintels, the bottom is blocked to confine the grout. Lintel units are specified to comply with ASTM C 90.

Mortar. Mortar is required to comply with ASTM C 270 and is governed by either of two specifications: (1) the proportion specification, which pre-

Table 2.1: Standard Material Specifications

Cement
ASTM C 150 Portland Cement

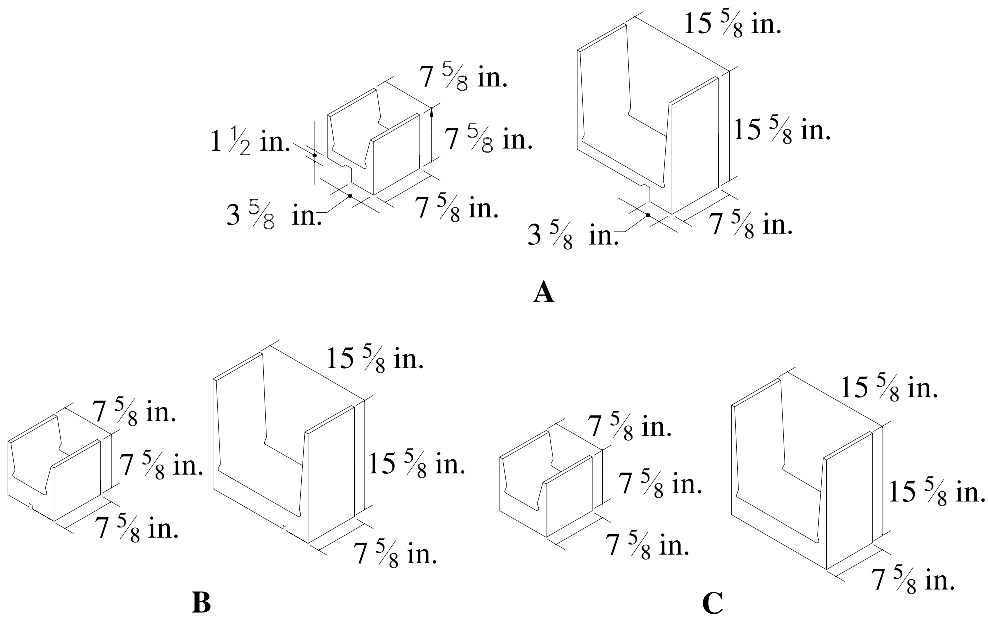
Concrete Masonry Units
ASTM C 90 Loadbearing Concrete Masonry Units

Mortar
ASTM C 270 Mortar for Unit Masonry

Grout
ASTM C 476 Grout for Masonry

Aggregates
ASTM C 33 Concrete Aggregates
ASTM C 144 Aggregate for Masonry Mortar
ASTM C 404 Aggregates for Masonry Grout

Reinforcement
ASTM A 615 Deformed and Plain Billet-Steel Bars for Concrete Reinforcement
ASTM A 706 Low-Alloy Steel Deformed Bars for Concrete Reinforcement
ASTM A 767 Zinc-Coated (Galvanized) Steel Bars for Concrete Reinforcement
ASTM A 775 Epoxy-Coated Reinforcing Steel Bars
ASTM A 951 Standard Specification for Masonry Joint Reinforcement



A. For metal or wood sash installed after wall is erected. These units make an efficient and weather tight joint.
B. For metal sash only installed as wall is erected.
C. For finished masonry openings, or metal and wood sash.

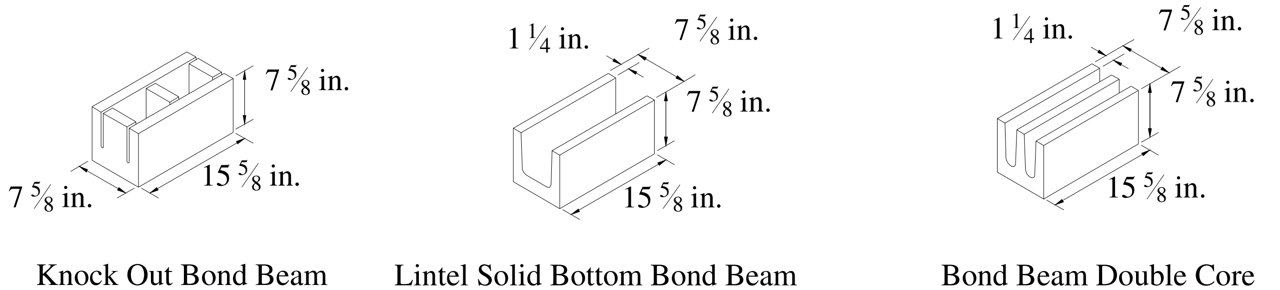


Figure 2-1: Lintel and Bond Beam Units

scribes the parts by volume of each constituent material required to provide a specific mortar type, or (2) the property specification, which allows approved materials to be mixed in controlled percentages as long as the resultant laboratory prepared mortar meets prescribed compressive strength, water retention, and air content requirements. Mortar types M, S, and N are permitted for construction of reinforced concrete masonry lintels. Although, Type N mortar is prohibited in seismically active areas.

Grout. Ingredients for grout used in masonry construction include cementitious materials and aggregates either course or fine. ASTM C 476 contains requirements for proportions for each of these ingredients. However, it is typical practice to specify compressive strength based on design requirements rather than specifying proportions of each ingredient. The minimum compressive strength of grout in accordance with ASTM C 476 is 2,000 psi or f'_m whichever is greater.

Reinforcement. Deformed steel bars must comply with the applicable ASTM standards listed in **Table 2.1**. Grade 60 reinforcement is commonly used although Grades 40 and 50 are permitted.

DESIGN LOADS

For all designs, the designer must determine the anticipated loads, and the manner in which they act upon the lintel based upon the analysis of the structure under consideration. Vertical loads carried by lintels typically include: (1) distributed loads from the dead weight of the lintel and the masonry above the lintel, and any floor and roof dead and live loads supported by the masonry, and (2) concentrated loads from floor beams, roof joists, and other beams framing into the wall.

Typical loads acting upon a lintel can be separated into four types illustrated in **Figure 3-1**: (1) uniform load acting over the effective span, (2) a triangular load, with apex at mid-span, acting over the effective span, (3) concentrated loads, and (4) uniform load acting over a portion of the effective span. The principle of superposition will allow the designer to calculate the effects of these individually and then combine them to determine the overall effect.

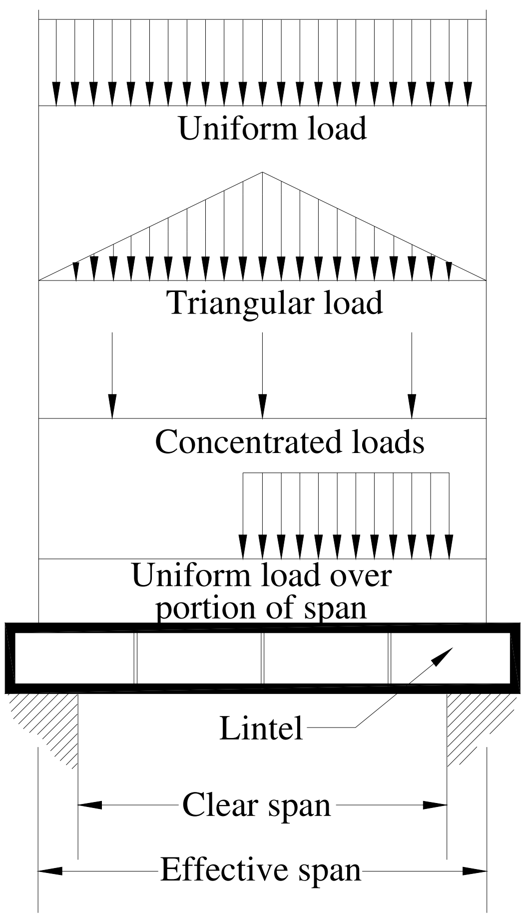


Figure 3-1: Typical Load Components

3.1 Determination of Loads

Lintels are required to carry gravity loads. Gravity loads are generally of two types: dead and live. Dead loads are generally permanent in nature, and can be divided into structure self-weight and superimposed loads. Superimposed loads may include the weight of the walls, floors, roofs, ceilings, partitions, and other similarly incorporated architectural and structural items.

Live loads are produced by the use and occupancy of the building and represent the assumed weight of building occupants, furnishings, equipment, etc. that are distributed to lintels by floor joists that bear on the wall above. Additionally, loads are produced by snow and rain that act on the lintel through the roof trusses or joists. Minimum live loads are mandated by the governing building code or by the American Society of Civil Engineers' *Minimum Design Loads for Buildings and Other Structures* [4] (ASCE-7). ASCE-7 contains minimum live loads for other loads such as different occupancies and procedures to calculate snow and rain loads.

3.2 Load Combinations

Building codes require design loads to be applied on structural members in various combinations. These load combinations are intended to account for the combined affects of several loadings occurring simultaneously. Accordingly, load combinations, such as dead plus live loads, must be considered since these loadings will most likely occur at the same time. Common load combinations for lintels are presented in **Table 3.1**. These are based on the provisions of ASCE-7 and are shown for both allowable stress design and strength design methods.

3.3 Arching Action

In some instances, the masonry will distribute loads so that they do not act on the lintel. This is called arching action of masonry [5] and is based on the amount of masonry that is around the lintel. Arching action can be assumed if the following criteria are met:

- masonry wall is laid in running bond
- sufficient wall height above the lintel to form a 45 degree triangle
- wall height above the arch height is at least 8 inches
- minimum end bearing is maintained
- there is sufficient masonry on either side of the opening to resist the induced horizontal thrust
- control joints or other discontinuities are not located adjacent to the opening

Figure 3-2 shows the relationships of these distances.

Table 3.1: Load Combinations

Allowable Stress Design Load Combinations[a]	Strength Design Load Combinations[b,c]
1. D 2. $D + L + (L_r$ or S or $R)$	1. $1.4D$ 2. $1.2D + 1.6L + 0.5(L_r$ or S or $R)$ 3. $1.2D + 0.5L + 1.6(L_r$ or S or $R)$

a. Based on ASCE 7 [4] section 2.4.1
b. Based on ASCE 7 [4] section 2.3.2
c. The load factor on L in combination 3 shall equal 1.0 for garages, areas occupied as places of public assembly, and all areas where the live load is greater than 100 psf.

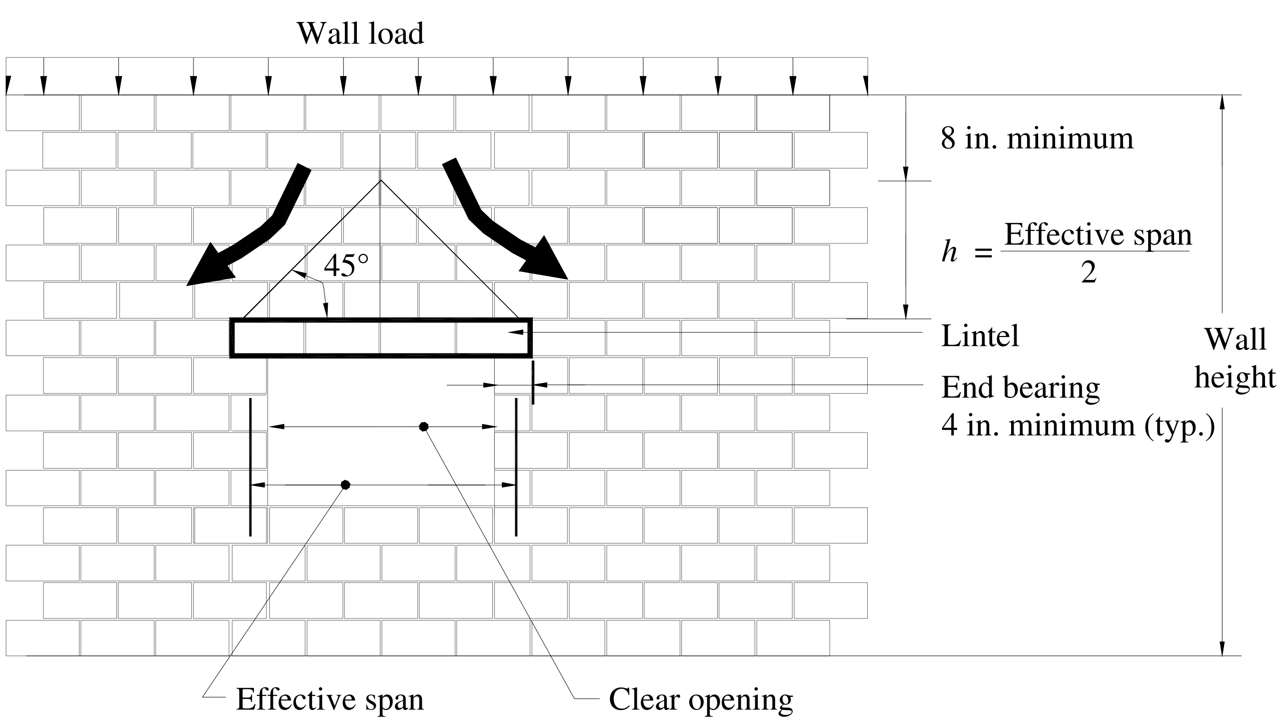


Figure 3-2: Arching Action

The design loads applied to a lintel depend on whether arching action is present or not. The types of loads for lintel design are shown in the flow chart of **Figure 3-3**. If arching is present, the self weight of the lintel, the weight of the wall below the arched portion taken as a triangular load, and concentrated loads are considered. Otherwise, the self weight, the weight of the wall above the lintel as a uniform load, roof and floor loads, and concentrated loads are considered.

Self Weight. Self weight is a uniform load computed based upon the weight of the lintel itself. Usually, the unit weights of masonry units, concrete, mortar, grout, and reinforcing are combined into a single estimate.

Wall Weight. Because of arching action, only the wall weight within the triangular area below the apex need be considered. The triangular load has a base equal to the effective span length and apex height equal to one -half of the effective span as shown in **Figure 3-2**. The magnitude will vary as shown in **Figure 3-1**.

Concentrated Loads. Concentrated loads applied to walls constructed of running bond masonry are as-

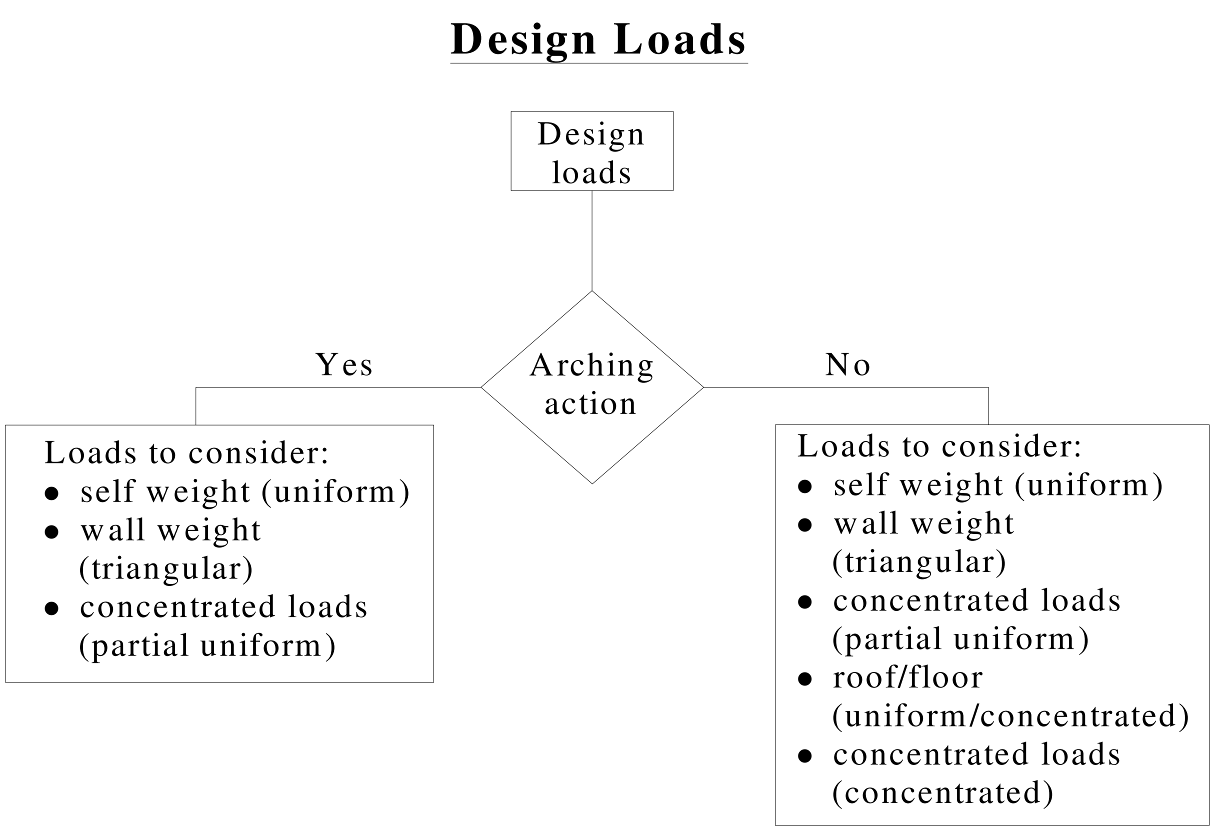


Figure 3-3: Lintel Design Loads

sumed to be distributed downwards at an angle of thirty degrees from the vertical on each side of bearing, as shown in **Figure 3-4** [5]. This is then resolved onto the lintel as a uniform load with maximum length equal to 4 times the thickness of the wall + width of bearing. The magnitude of the load per unit of length is computed from the concentrated load divided by this length. In most cases, this results in a uniform load acting over a portion of the lintel span.

In some cases, a series of concentrated loads may be considered uniform to resolve onto the lintel. The criteria, based on load spacing is described in Section 3.4 on roof/floor loads. If this criteria is met and the loads are considered uniform, the loading on the lintel would be neglected if the previously specified conditions for arching action were met. Otherwise, each concentrated load would be resolved by the method above.

3.4 No Arching Action

If the criteria described in Section 3.3 are not met, the masonry wall will not act as an arch. The loading conditions on the lintel are presented below.

Self Weight. Self weight must be considered and is computed as described previously.

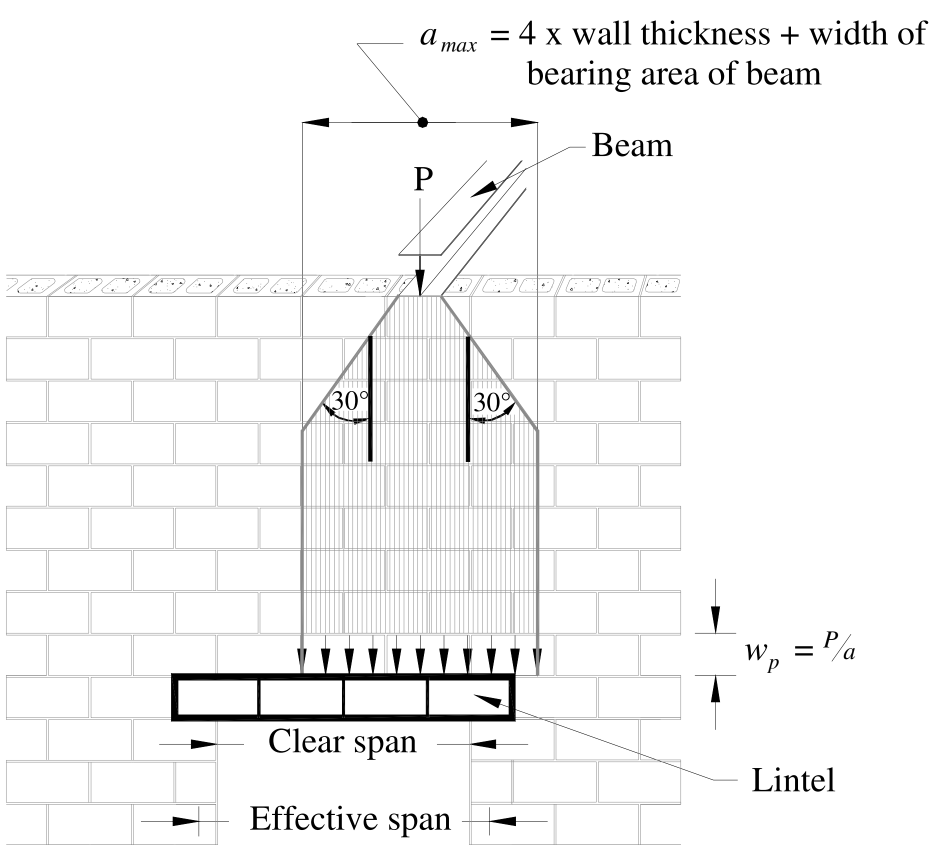


Figure 3-4: Distribution of Concentrated Load Over Running Bond

Wall Weight. In this case wall loads are assumed to act directly on the lintel. The wall thickness and grout spacing are necessary to estimate the wall weight, usually in terms of wall weight per square foot of wall area. The load on the lintel is computed from this weight multiplied by the height of the wall above the lintel.

Roof/Floor Loads. In some instances, a series of concentrated loads on walls laid in running bond may be considered as uniform loads. Relatively light loads spaced closely together, such as floor joists and rafters in residential construction, may be considered uniformly distributed as shown in **Figure 3-5**. Historically, these loads have been considered uniformly distributed if the total height of the masonry between bearing and the top of the lintel is equal to or greater than one-third the center to center spacing of the loads.

Wider spaced loads, that may be encountered in industrial and commercial building, are de-

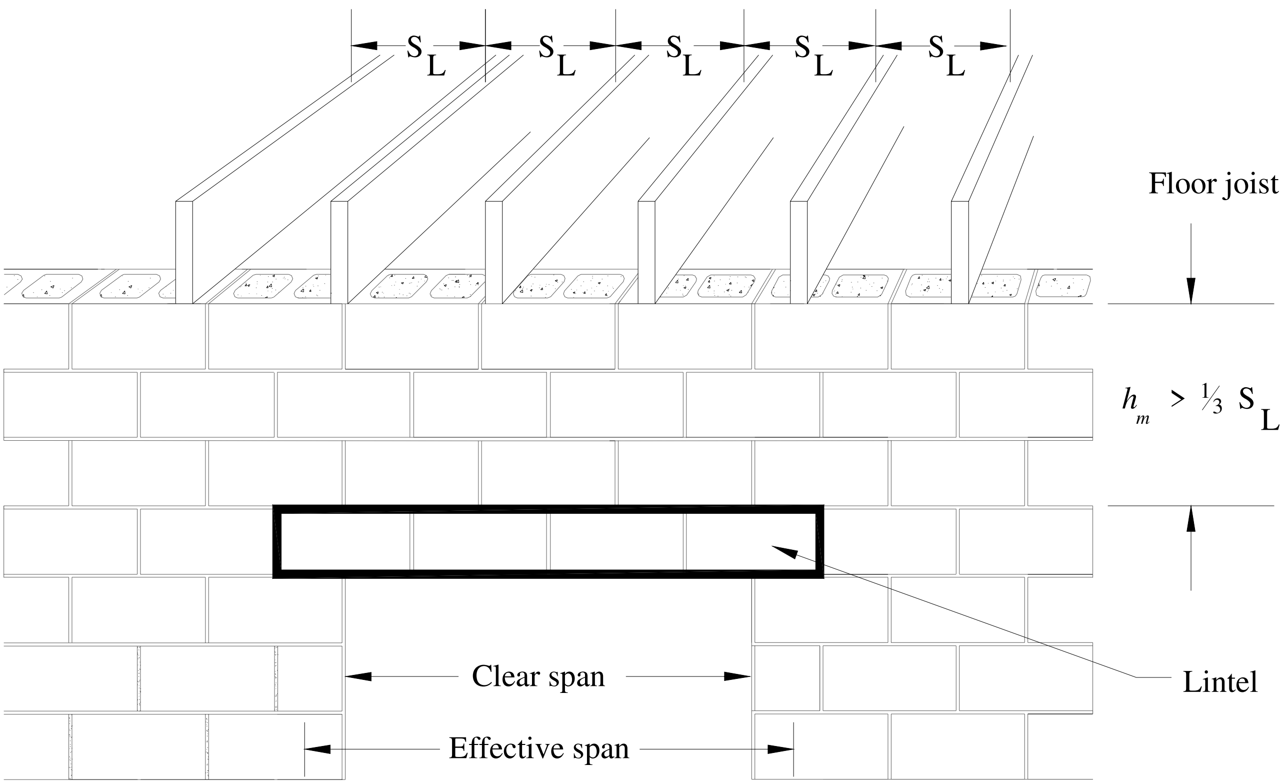


Figure 3-5: Light Roof/Floor Loads

picted in **Figure 3-6**. In this case, uniform loading is often assumed whenever the load spacing is less than 4 feet and the wall height above the lintel is greater than half the load spacing.

Loads spaced more than 4 feet apart should generally be considered individual concentrated loads and distributed to the lintel as described in the section on arching action.

Concentrated Loads. Concentrated loads over stack bond masonry are not transferred or distributed across vertical joints. This is shown in **Figure 3-7**. Loads should not be assumed to be transmitted across vertical joints even if joint reinforcement is used in the wall construction. Concentrated loads applied to running bond construction are resolved as described in **Figure 3-4**.

3.5 Maximum Loads

The loading on a lintel, as described above, can get quite complicated. For example, a lintel under arching action can carry its self weight (uniform), wall weight (triangular), and partial uniform loads from concentrated loads. In this case, the maximum moment or shear may not be at mid-span and the lintel ends, respectively. Complicated loading cases may

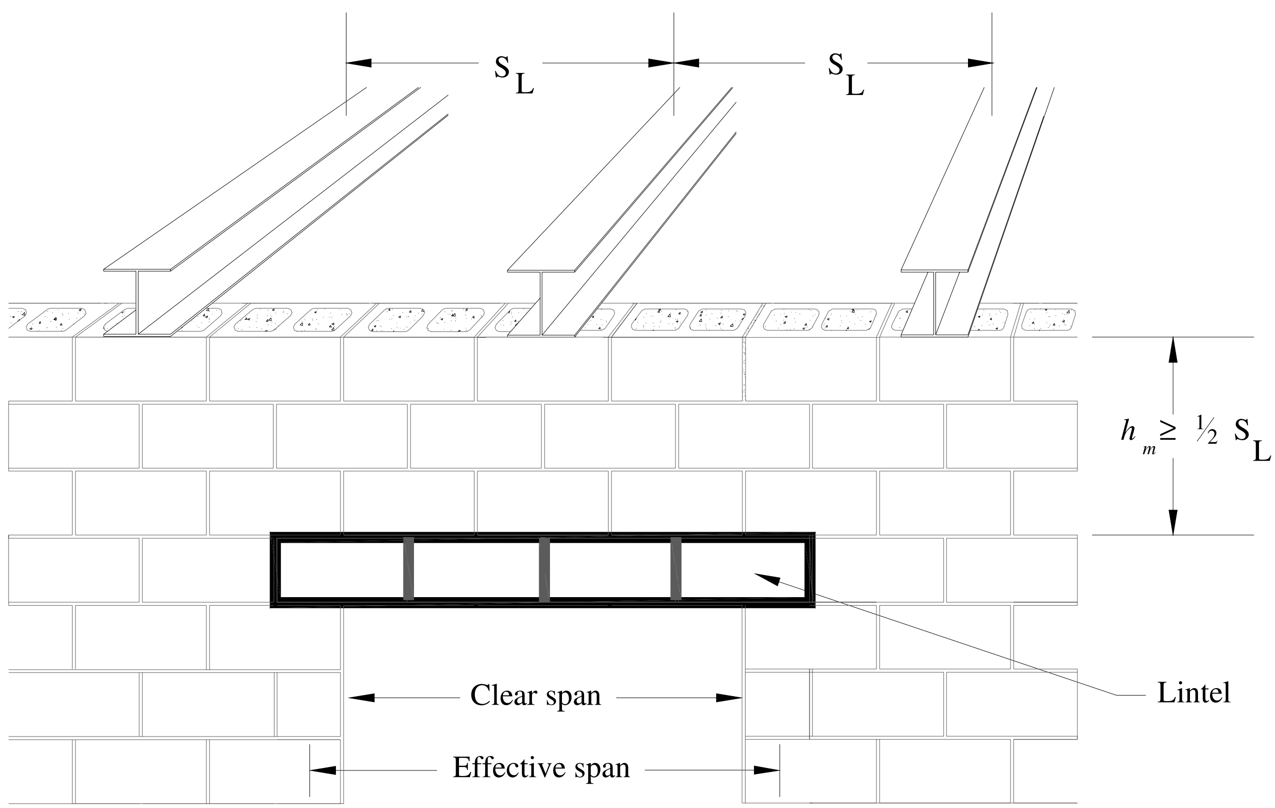


Figure 3-6: Heavy Roof/Floor Loads

arise from lintels not subject to arching action. The support conditions are also a factor. Supports may be either simple or continuous. Continuous supports, while not typical, can often be modeled with fixed end supports.

Lintels are modeled as beams. Appendix A shows a few simple load cases for simple and continuous supported beams. In some of the loading cases listed, the maximum moments and shears are either mid-span or at the ends. Consequently, where these loading cases act at the same time, the moment or shear is the addition of the individual components. For example, for a simply supported lintel under uniform and triangular loads, the maximum moment and shear are :

Maximum moment

$$wl^2/8 + wl^2/12$$

Maximum shear

$$wl/2 + wl/4$$

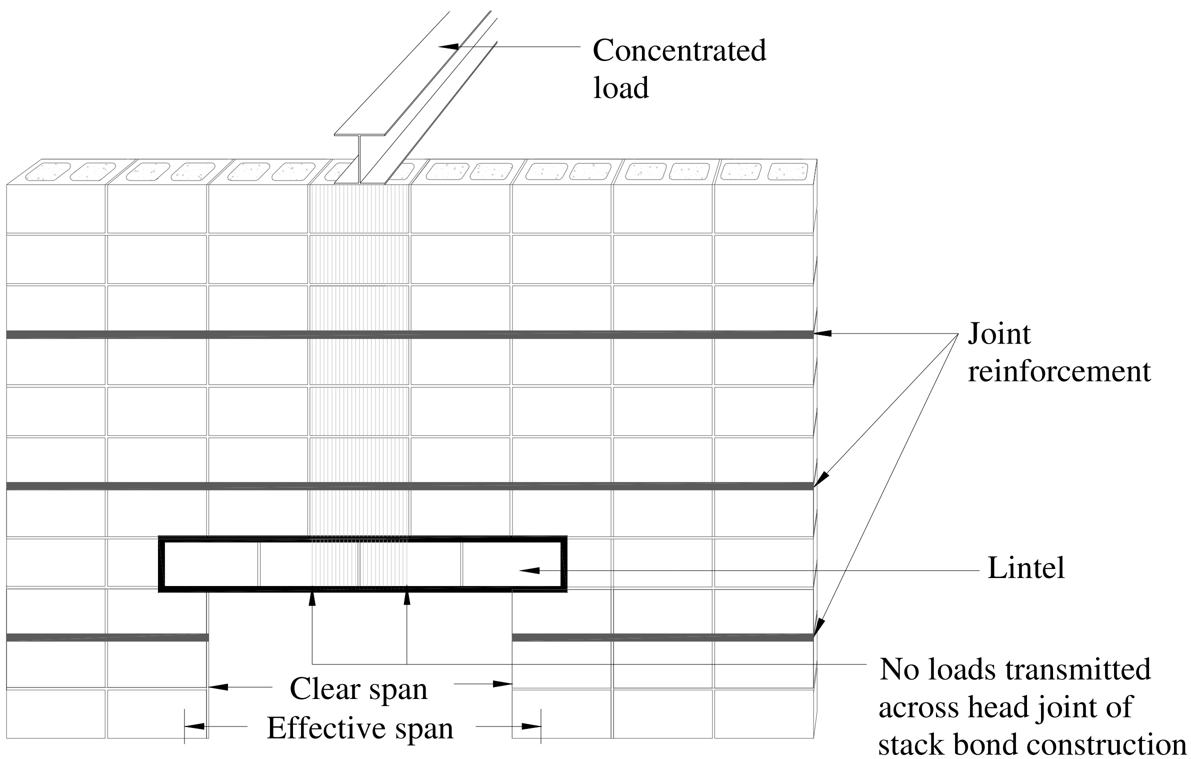


Figure 3-7: Distribution of Concentrated Load Over Stack Bond

LINTEL DESIGN

This section presents the design methods and parameters governing lintels. The allowable stress design method is presented first, followed by the strength design method. Concrete masonry lintels can be designed by either allowable stress (Section 4.1) or strength design (Section 4.2). Precast concrete lintels are designed by strength design methods (Section 4.2.2). Section 4.3, on design parameters, lists the material properties and design assumptions that are used to compute the expected or design lintel strength, for allowable stress and strength design, respectively.

4.1 Allowable Stress Design of Concrete Masonry Lintels

The allowable stress design method compares design stresses produced in a member by the applied loads to allowable stresses. The allowable stresses are prescribed by the applicable building code, and are determined by reducing the expected strengths by appropriate factors of safety. The allowable stress values from the MSJC Code are presented in the section 4.4, Design Parameters.

Flexural compressive and tensile stresses in lintels are determined in accordance with accepted allowable stress design principles. The masonry is assumed to resist the compressive forces. Conversely tensile strength of masonry units, concrete, mortar, and grout is neglected and all tensile stresses are assumed to be carried by the reinforcing steel. Flexural members are proportioned such that the maximum tensile and compressive stresses are within the allowable stress limits discussed above.

Flexural members are also designed to resist shear. The member is proportioned such that the maximum applied shear stress is less than or equal to the allowable shear strength of the masonry or, alternatively shear reinforcement can be provided increase shear strength. When required, shear reinforcement is provided parallel to the direction of the shear force and distributed over a distance based on the effective depth of the member.

The equations governing allowable stress design are listed below:

$$n = E_s/E_m$$

$$\rho = \frac{A_s}{bd}$$

$$k = \sqrt{2n\rho + (n\rho)^2} - n\rho$$

$$j = 1 - (k/3)$$

$$M_m = \tfrac{1}{2} F_b bd^2 jk$$

$$M_s = A_s F_s jd$$

M_r = the lesser of M_m and M_s

$$V_m = F_v bd$$

$$V_s = \frac{A_v F_s d}{s}$$

V_r = the lesser of V_m and V_s

4.2 Strength Design

4.2.1 Concrete Masonry Lintels

The strength design method compares factored loads to design strengths of the member. It allows the load that produces failure to be predicted and it allows the failure mode to be controlled so that ductile failure can occur. Based on acceptable strength design principles, the nominal strength of the member is determined and then reduced by strength reduction factors, called phi (ϕ) factors. These factors account for any variability in materials and construction practices. The resulting reduced capacity called the design strength of the member, is then compared to the factored loads (see **Table 2.1**) to ensure the member has adequate capacity.

Flexural compression, tension, and shear are determined in accordance with accepted strength design principles. The tensile strength of masonry is neglected and the nominal strengths are computed.

For fully grouted masonry elements, the nominal flexural strength, M_n, is calculated as follows:

$$M_n = (A_s f_y)\left(d - \frac{a}{2}\right)$$

$$a = \frac{A_s f_y}{0.80 f'_m b}$$

To provide for a prescribed level of ductility in the event of failure, the amount of reinforcement permitted in reinforced masonry construction is limited. The maximum reinforcement ratio, ρ_{max}, is limited in accordance with the equation below. When the actual reinforcement ratio exceeds this maximum, the cross section must be increased to accommodate the selected reinforcement bar or bars.

$$\rho_{\max} = \frac{0.64 f'_m\left(\frac{\varepsilon_{mu}}{\varepsilon_{mu} + \alpha\varepsilon_y}\right)}{1.25 f_y}$$

Where the tension reinforcement yield strain factor, α, is as follows:

α = 5.0 for walls subjected to in-plane forces, for columns and for beams designed using an R value greater than 1.5.

Shear acting on reinforced masonry members is resisted by the masonry and shear reinforcement, if provided, in accordance with the following:

$$V_n = V_m + V_s$$

The nominal shear strength provided by the masonry, V_m is determined in accordance with the following:

$$V_m = 2.25 A_n \sqrt{f'_m}$$

When shear reinforcement is incorporated into reinforced masonry construction, the shear strength provided by the reinforcement is calculated in accordance with the following.

$$V_s = 0.5(A_v/s) f_y d_v$$

4.2.2 Precast Concrete Lintels

Nominal flexural strength, M_n, is calculated per ACI 318 [3]:

$$M_n = A_s f_y \left(d - \frac{a}{2}\right)$$

$$a = \frac{A_s f_y}{0.85 f'_c b}$$

The amount of reinforcement is also needed to provide for ductility in the event of failure. For precast concrete lintels, the reinforcement, ρ, is limited to:

$$\rho < 0.75 \rho_b$$

where:

$$\rho_b = \frac{0.85 f'_c}{f_y} \beta_1 \left(\frac{87{,}000}{87{,}000 + f_y}\right)$$

and

$$\beta_1 = 0.85 \text{ for } f'_c \le 4{,}000 \text{ psi}$$

$$\beta_1 = 0.85 - 0.05\left(\frac{f'_c - 4{,}000}{4{,}000}\right) \text{for } f'_c > 4{,}000 \text{ psi}$$

For precast concrete lintels, nominal shear is similar as presented in Section 4.2.1,

$$V_n = V_c + V_s$$

The normal shear strength provided by the concrete, V_c, is determined in accordance to:

$$V_c = 2 A_v \sqrt{f'_c}$$

Where shear reinforcement is incorporated, V_s, is determined by:

$$V_s = \frac{A_v f_y d}{s}$$

4.3 Design Parameters

Compressive strength of concrete. The requirements for compressive strength of concrete, designated f_c', are found in Chapter 5 of ACI 318. Unless otherwise specified, f_c', is the specified compressive strength of concrete based on 28 day strengths.

Compressive strength of masonry. The requirements for complying with the specified compressive strength of masonry, designated f_m', are found in the MSJC Specification. Either of two methods are used to verify compliance with f_m': the unit strength method or the prism test method.

Allowable stresses. The allowable flexural stress for lintels, F_b is equal to one-third of f_m' (MSJC-2.3.3). Allowable shear stress for lintels is equal to the square root of f_m' (MSJC-2.3.5). The allowable tensile stress for grade 60 reinforcing steel is 24,000 psi (MSJC-2.3.2). To summarize, the allowable stresses are:

$$F_b = {}^1/_3\ f_m'$$

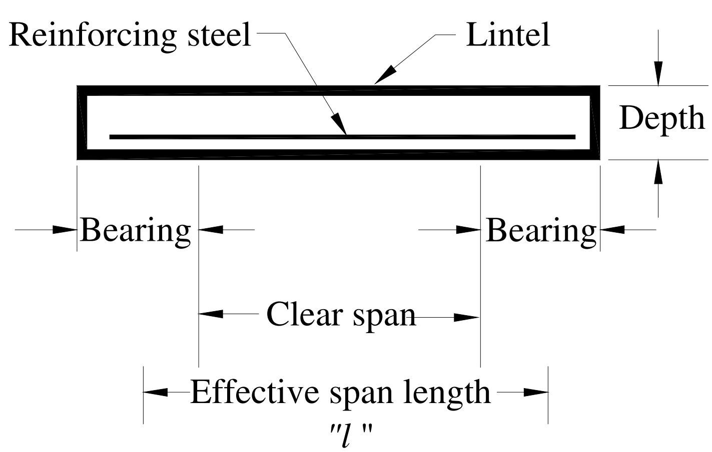
$$F_v = \sqrt{f_m'}$$

$$F_s = 24{,}000 \text{ psi}$$

Modulus of Elasticity. The modulus of elasticity for concrete masonry is taken as, $E_m = 900 f_m'$. For steel, the modulus of elasticity is taken as 29,000,000 psi (MSJC-1.8). The modulus of elasticity of concrete used is 57,000 $\sqrt{f_c'}$ per ACI 318, Section 8.5-1.

Strength reduction factors. Reinforced concrete masonry strength reduction factors for flexure and shear are based on Section 3.1.4 of the MSJC Code. For flexure $\phi = 0.9$; for shear $\phi = 0.8$. Precast concrete strength reduction factors are based on Section 9-3 of ACI 318. For flexure $\phi = 0.9$; for shear $\phi = 0.75$.

Effective span. The effective span length of a lintel should be the clear span plus the depth of the member, but not be greater than the distance between the support centers (MSJC-2.3.3.4.1). Furthermore, the end bearing should not be less than 4 inches (MSJC-2.3.3.4.3). **Figure 4-1** shows the relationship of effective span, end bearing, and clear span.



l = Clear span + depth

l_{max} = Distance between centers of support

Figure 4-1: Effective Span Length

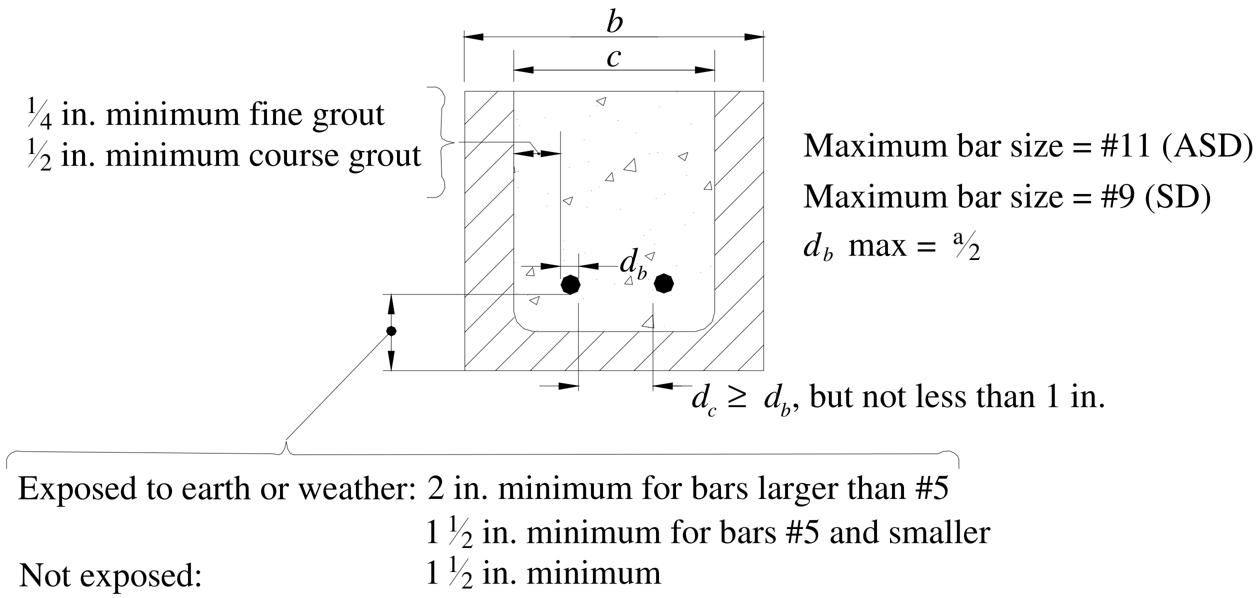


Figure 4-2: Detailing Limitations of Reinforcing Bars

Effective width and depth. The effective compressive width, *b*, of a lintel is taken as: the nominal width minus $^3/_8$ inch. The effective depth, *d*, to the tension reinforcement is taken as: nominal depth minus $^3/_8$ inch minus cover depth minus half the diameter of the reinforcing bar.

Limitations on detailing reinforcing bars within lintels. Reinforcing bar size, placement, and protection are limited by the requirements contained in Section 1.12 of the MSJC for masonry and Chapter 7 of ACI 318 for concrete, respectively. **Figure 4-2** summarizes these requirements.

Lateral support. As an integral part of the wall, lintels are typically considered laterally supported. Lateral support of the compression face of masonry beams is required along the length of the beam at a maximum spacing of 32 times the thickness of the beam (MSJC-2.3.3.4.4).

Embedment of flexural reinforcement. For a concrete masonry lintel to perform properly under service loads, stress transfer between steel and masonry must occur. The MSJC Code requires that the reinforcing steel be fully developed. This ensures that the mode of failure (if unanticipated overload occurs) would be ductile yielding rather than a non-ductile pullout.

Deflection. Lintel deflection is limited to the effective span length divided by 600 or 0.3 inches (MSJC-1.10.1) when used to support unreinforced masonry. This requirement limits excessive deflection which may damage the supported masonry.

Weight Tables. **Table 4.1** gives estimates of lintel weights per foot of length for lintels of 4, 6, 8, 10, and 12 inch thicknesses. The values are for three depths, 8, 16, and 24 inches, and for both lightweight and normal weight concrete masonry units. Precast concrete lintels are assumed to weigh 150 pcf. **Tables 4.2**, **4.3**, **4.4**, and **4.5** list wall weights for four wall thickness and various grout spacings.

Typical Details. **Figures 4-3**, **4-4** and **4-5** show typical lintel construction for simple and continuous support conditions, respectively.

Table 4.1: Lintel Weights

Lintel Height (inches-nominal)	Lintel Weights in Pounds per Lineal Foot — Wall Thickness (inches-nominal)			
	6	8	10	12
	Lightweight Concrete Masonry Units			
8	39	53	67	81
16	78	106	134	162
24	116	158	200	242
	Normal Weight Concrete Masonry Units			
8	44	59	74	90
16	87	118	148	179
24	130	176	222	268

based on: Unit weight of grout and reinforcing bars:145 pcf.
Unit weight of masonry units—lightweight: 100 pcf
—normal weight: 135 pcf

Table 4.2: Wall Weights for 6 Inch Single Wythe Walls

Units	Vertical Grout Spacing, in.	Mortar Bedding	Wall Weights (lb/ft^2) for Concrete Unit Densities (pcf) of: 85	95	105	115	125	135
Hollow	No grout	Face shell	20	22	24	26	28	30
Hollow	No grout	Full	20	22	24	26	28	31
Solid	No grout	Full	42	46	50	55	59	63
Hollow	8	Full	53	56	58	60	62	64
Hollow	16	Face shell	37	39	41	43	45	47
Hollow	24	Face shell	31	33	35	37	39	41
Hollow	32	Face shell	28	30	32	34	37	39
Hollow	40	Face shell	26	29	31	33	35	37
Hollow	48	Face shell	25	27	30	32	34	36
Hollow	56	Face shell	25	27	29	31	33	35
Hollow	64	Face shell	24	26	28	30	32	34
Hollow	72	Face shell	23	26	28	30	32	34
Hollow	80	Face shell	23	25	27	29	31	34
Hollow	88	Face shell	23	25	27	29	31	33
Hollow	96	Face shell	23	25	27	29	31	33
Hollow	104	Face shell	22	24	27	29	31	33
Hollow	112	Face shell	22	24	26	28	30	33
Hollow	120	Face shell	22	24	26	28	30	32

Table 4.3: Wall Weights for 8 Inch Single Wythe Walls

Units	Vertical Grout Spacing, in.	Mortar Bedding	Wall Weights (lb/ft^2) for Concrete Unit Densities (pcf) of: 85	95	105	115	125	135
Hollow	No grout	Face shell	25	28	31	33	36	39
Hollow	No grout	Full	26	28	31	34	37	39
Solid	No grout	Full	56	62	68	74	80	86
Hollow	8	Full	73	76	78	81	84	86
Hollow	16	Face shell	49	52	55	57	60	63
Hollow	24	Face shell	41	44	47	49	52	55
Hollow	32	Face shell	37	40	43	45	48	51
Hollow	40	Face shell	35	38	40	43	46	48
Hollow	48	Face shell	33	36	39	41	44	47
Hollow	56	Face shell	32	35	38	40	43	46
Hollow	64	Face shell	31	34	37	39	42	45
Hollow	72	Face shell	31	33	36	39	41	44
Hollow	80	Face shell	30	33	35	38	41	44
Hollow	88	Face shell	30	32	35	38	40	43
Hollow	96	Face shell	29	32	35	37	40	43
Hollow	104	Face shell	29	32	34	37	40	42
Hollow	112	Face shell	29	31	34	37	39	42
Hollow	120	Face shell	28	31	34	37	39	42

Table 4.4: Wall Weights for 10 Inch Single Wythe Walls

Units	Vertical Grout Spacing, in.	Mortar Bedding	Wall Weights (lb/ft^2) for Concrete Unit Densities (pcf) of: 85	95	105	115	125	135
Hollow	No grout	Face shell	30	34	37	40	44	47
Hollow	No grout	Full	31	34	38	41	44	48
Solid	No grout	Full	71	78	86	93	101	108
Hollow	8	Full	93	96	99	102	106	109
Hollow	16	Face shell	62	65	68	71	75	78
Hollow	24	Face shell	51	54	58	61	64	68
Hollow	32	Face shell	46	49	53	56	59	62
Hollow	40	Face shell	43	46	49	53	56	59
Hollow	48	Face shell	41	44	47	51	54	57
Hollow	56	Face shell	39	43	46	49	52	56
Hollow	64	Face shell	38	41	45	48	51	55
Hollow	72	Face shell	37	41	44	47	50	54
Hollow	80	Face shell	37	40	43	46	50	53
Hollow	88	Face shell	36	39	43	46	49	52
Hollow	96	Face shell	36	39	42	45	49	52
Hollow	104	Face shell	35	38	42	45	48	52
Hollow	112	Face shell	35	38	41	45	48	51
Hollow	120	Face shell	35	38	41	44	48	51

Table 4.5: Wall Weights for 12 Inch Single Wythe Walls

Units	Vertical Grout Spacing, in.	Mortar Bedding	Wall Weights (lb/ft^2) for Concrete Unit Densities (pcf) of: 85	95	105	115	125	135
Hollow	No grout	Face shell	35	38	42	46	50	54
Hollow	No grout	Full	36	39	43	47	51	54
Solid	No grout	Full	86	95	104	113	122	131
Hollow	8	Full	113	116	120	124	128	132
Hollow	16	Face shell	74	78	81	85	89	93
Hollow	24	Face shell	61	65	68	72	76	80
Hollow	32	Face shell	54	58	62	66	69	73
Hollow	40	Face shell	50	54	58	62	65	69
Hollow	48	Face shell	48	52	55	59	63	67
Hollow	56	Face shell	46	50	53	57	61	65
Hollow	64	Face shell	45	48	52	56	60	63
Hollow	72	Face shell	43	47	51	55	59	62
Hollow	80	Face shell	43	46	50	54	58	61
Hollow	88	Face shell	42	46	49	53	57	61
Hollow	96	Face shell	41	45	49	53	56	60
Hollow	104	Face shell	41	45	48	52	56	60
Hollow	112	Face shell	40	44	48	52	55	59
Hollow	120	Face shell	40	44	47	51	55	59

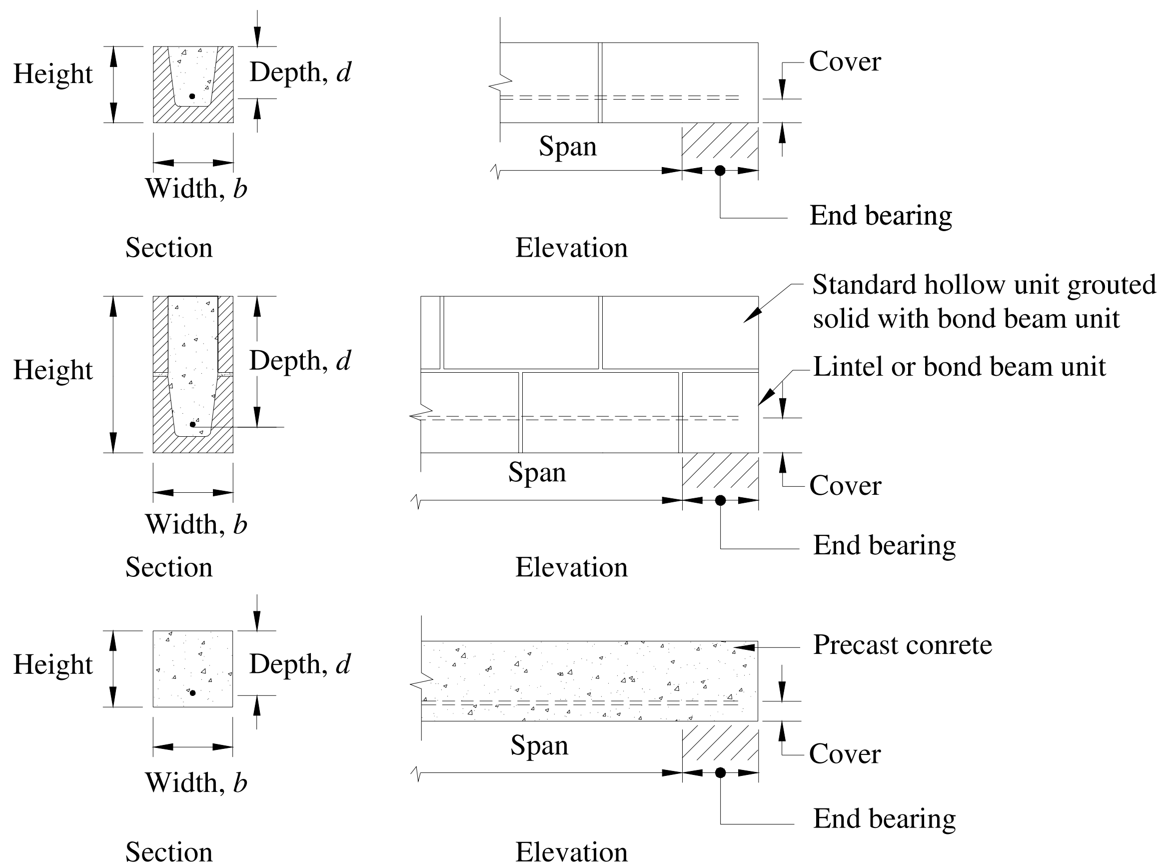


Figure 4-3: Construction Details, Simple Supports

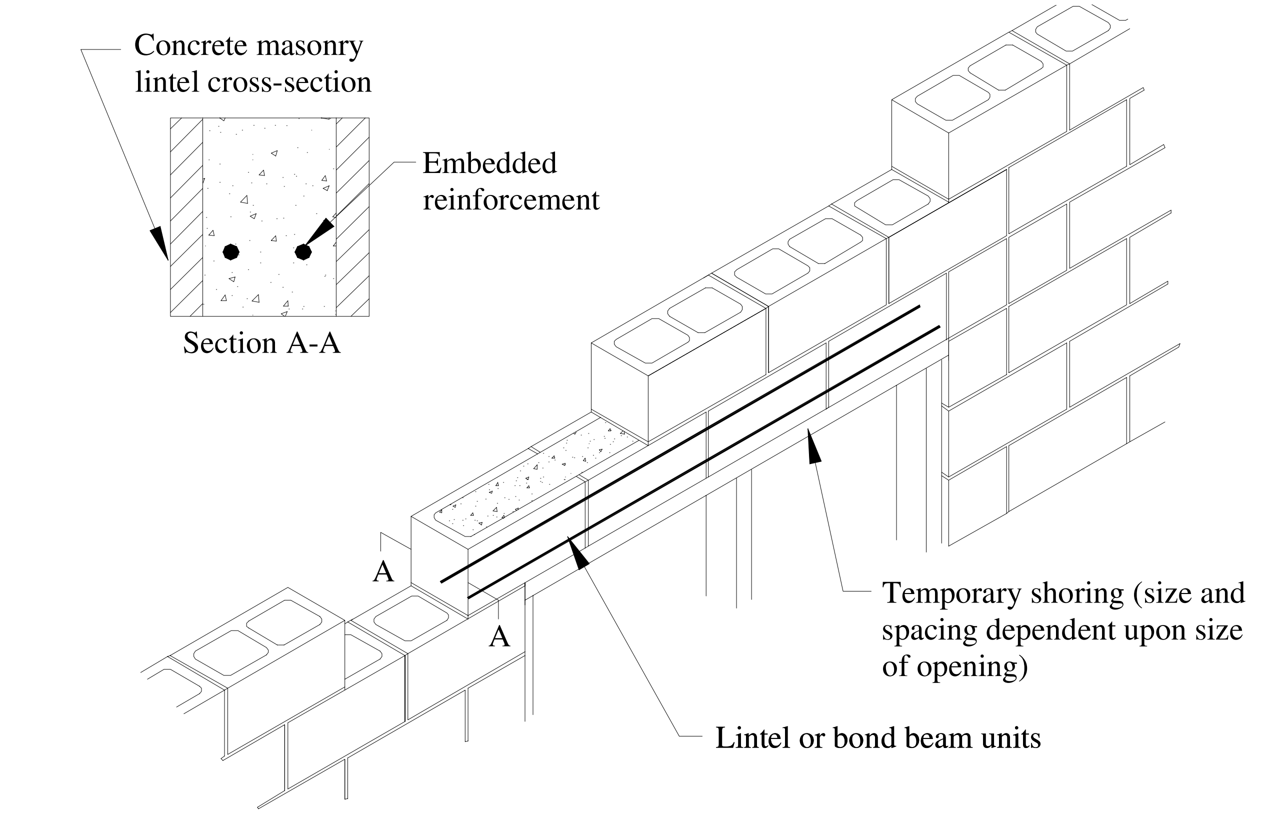


Figure 4-4: Concrete Masonry Lintel Assembly

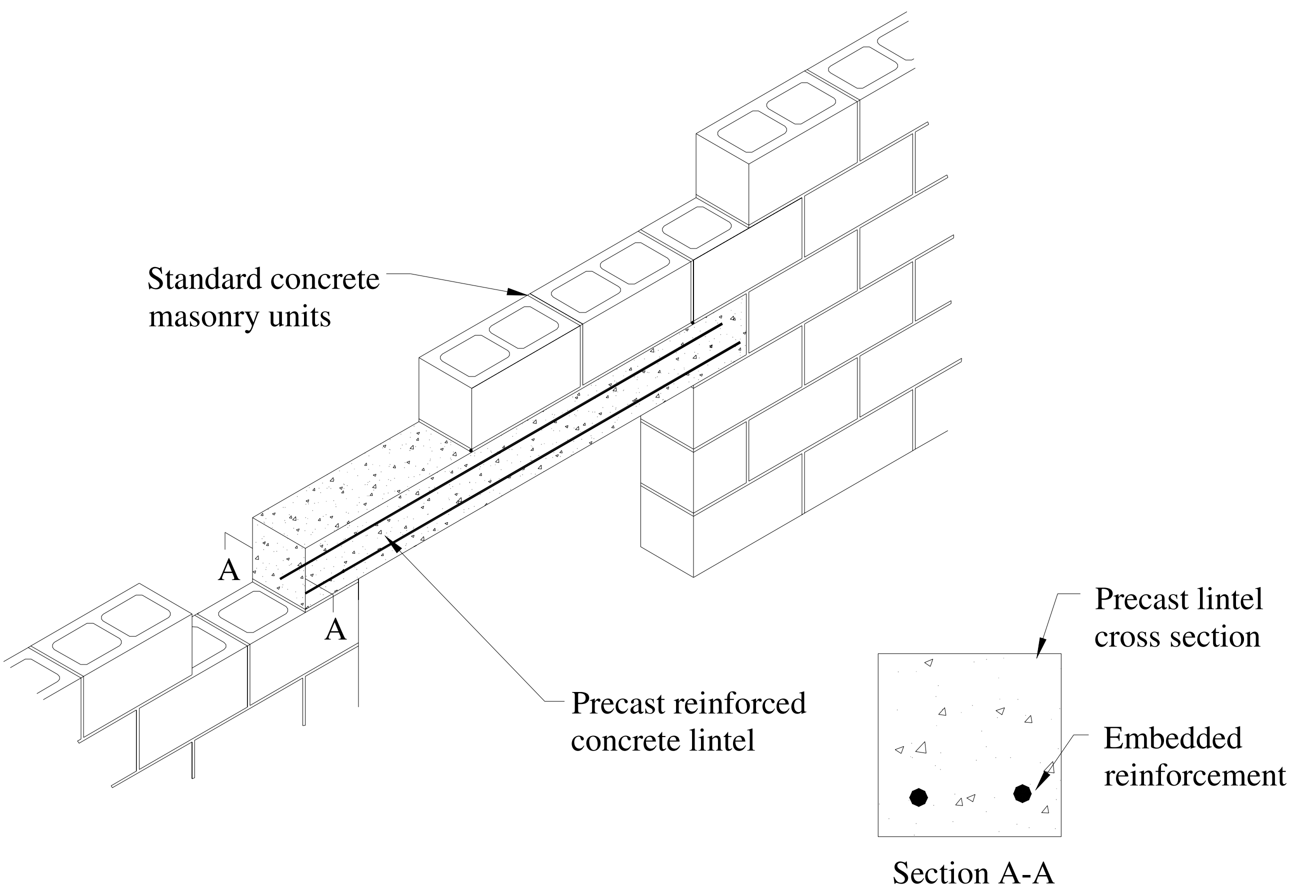


Figure 4-5: Precast Concrete Lintel Assembly

DESIGN EXAMPLES

EXAMPLE 1

The 18 foot tall wall shown in Figure 5-1 contains an opening that measures 64 inches in length and 48 inches in height. The bottom of the opening is located 40 inches from the base of the wall. The overall length of the wall is sufficient to resist any horizontal thrust induced due to arching action. The specified compressive strength of the assembly is 1,500 psi.

The wall is constructed of 12 inch normal weight concrete masonry units laid in running bond. The lintel is to have 8 inches of bearing on each side of the opening and is assumed to be simply supported at each end.

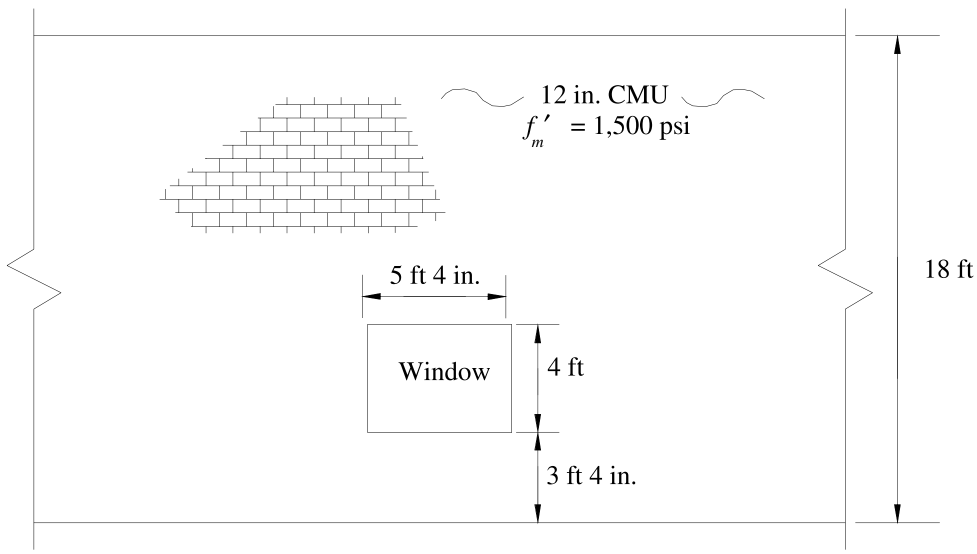


Figure 5-1: Masonry Wall Configuration

Joists are framed into the top of the wall. The distance between joists is 16 inches. Each joist applies a load of 250 pounds dead load and 500 pounds live load.

<u>Check for arching action</u>. Prior to calculating the loads applied to the lintel, the height of masonry required for arching action is determined. The effective span of the lintel is taken as the clear span of the opening plus the depth of the beam – not to exceed the center-to-center distance between supports. Since the depth of the lintel is not known, it can be conservatively assumed that the effective span is the center-to-center distance between supports.

l = clear span + one-half bearing length + one-half bearing length
= 64 in. + (8/2) in. + (8/2) in. = 72 inches

The height of masonry above the opening is:

$$H = (18\text{ ft})(12\text{ in./ft}) - 40\text{ in.} - 48\text{ inches}$$
$$= 128\text{ inches}$$

The height of masonry required above the lintel for arching action to occur is (refer to Figure 3-2):

$$h = (\text{effective span}/2) + 8\text{ inches}$$
$$= (72/2)\text{ inches} + 8\text{ inches} = 44\text{ inches}$$

Therefore, as long as the height of the lintel does not exceed 128 inches – 44 inches = 84 inches arching action may be assumed for this condition.

With arching action, the uniformly applied superimposed loads from the joists are neglected in the design of the lintel.

Concrete masonry lintel – allowable stress design. Assuming arching action will occur, the loads to be considered in this design consist of the self weight of the lintel and the dead load of the wall under the arched portion taken as a triangular load. Further, since arching is assumed, the size (depth) of the lintel will likely be relatively small. Therefore, attempt a design using a 12 in. by 8 in. (width by height) nominal lintel.

From **Table 4.1**, the self weight of a 12 in. by 8 in. lintel constructed with normal weight units is:

$$D_{lintel} = 90\text{ lb/ft}$$

From **Table 4.5**, the dead load of a 12 in. face shell bedded 125 pcf wall is:

$$\text{Wall self weight} = 50\text{ lb/ft}^2$$

For the wall weight, only the triangular portion with height equal to one-half the effective span (3 ft) is considered. The maximum load applied on the lintel from the wall at the apex of the triangle is:

$$D_{wall} = (50\text{ lb/ft}^2)(3\text{ ft}) = 150\text{ lb/ft}$$

Maximum moment and shear forces are computed using the beam diagrams in Appendix A. The maximum moment and shear due to the self weight of the lintel is determined using Figure A-3 as follows:

$$M_{lintel} = wl^2/8 = (D_{lintel})(l^2)/8 = (90\text{ lb/ft})(72/12\text{ ft})^2/8 = 405\text{ ft-lb}$$

$$V_{lintel} = wl/2 = (D_{lintel})(l^2)/2 = (90\text{ lb/ft})(72/12\text{ ft})/2 = 270\text{ lb}$$

The maximum moment and shear due to the wall weight is determined using Figure A-5 as follows:

$$M_{wall} = wl^2/12 = (D_{wall})(l^2)/12 = (150\text{ lb/ft})(72/12\text{ ft})^2/12 = 450\text{ ft-lb}$$

$$V_{wall} = wl/4 = (D_{wall})(l^2)/4 = (150\text{ lb/ft})(72/12\text{ ft})/4 = 225\text{ lb}$$

Since the loading from the self weight of the lintel and wall are both symmetrically applied to the lintel, the maximum moment and maximum shear will occur at the same location along the length of the beam and therefore can be added together to obtain the design moment and shear:

M_{max} (at the center of the lintel) = $M_{lintel} + M_{wall}$ = 405 ft-lb + 450 ft-lb = 855 ft-lb
= 10,260 in-lb

V_{max} (at the support of the lintel) = $V_{lintel} + V_{wall}$ = 270 lb + 225 lb = 495 lb

From **Table 6.10**, a 12 by 8 inch lintel with one No. 4 bar having a bottom cover of up to 3 inches has sufficient strength to carry the applied design loads.

$M_{provided}$ = 16560 in-lb

$V_{provided}$ = 1969 lb

<u>Check lintel deflection.</u> Because this lintel is supporting unreinforced masonry, the code requires that the deflection of the lintel be limited to l/600 or 0.3 in., whichever is less.

$E = (900)(1{,}500) = 1{,}350{,}000$ psi

$I = (1/12)(11.625 \text{ in.})(7.625 \text{ in.})^3 = 429.5 \text{ in.}^4$

From **Figure A-3**, the maximum deflection due to the lintel self weight is:

$Delta_{lintel} = 5wl^4/[384EI] = (5)(90/12)(72)^4/[(384)(1{,}350{,}000)(429.5)] = 0.00453$ in.

From **Figure A-5**, the maximum deflection due to the wall self weight is:

$Delta_{wall} = wl^4/[240EI] = (150/12)(72)^4/[(240)(1{,}350{,}000)(429.5)] = 0.00241$ in.

Again, since the loading from the self weight of the lintel and wall are both symmetrically applied to the lintel, the deflection from each load will occur at the same location (at the center of the beam) and therefore can be added together to obtain the maximum deflection:

$Delta_{max} = 0.00453 \text{ in.} + 0.00241 \text{ in.} = 0.00694$ in.

Since $l/600 = 72/600 = 0.12$ in., not to exceed 0.3 in. this lintel design is sufficient.

Note: Deflections based on cracked sections can be greater and are more difficult to calculate. The deflection calculation above is based on uncracked moment of inertia, *I*. To determine deflection of crack sections see various testbooks such as [5].

EXAMPLE 2

An interior partition has a 20 foot opening in an 8 inch hollow masonry wall laid in running bond. The lintel will carry only its self-weight and the weight of the wall. The design of the lintel is governed by strength design. The wall configuration is shown in **Figure 5-2**.

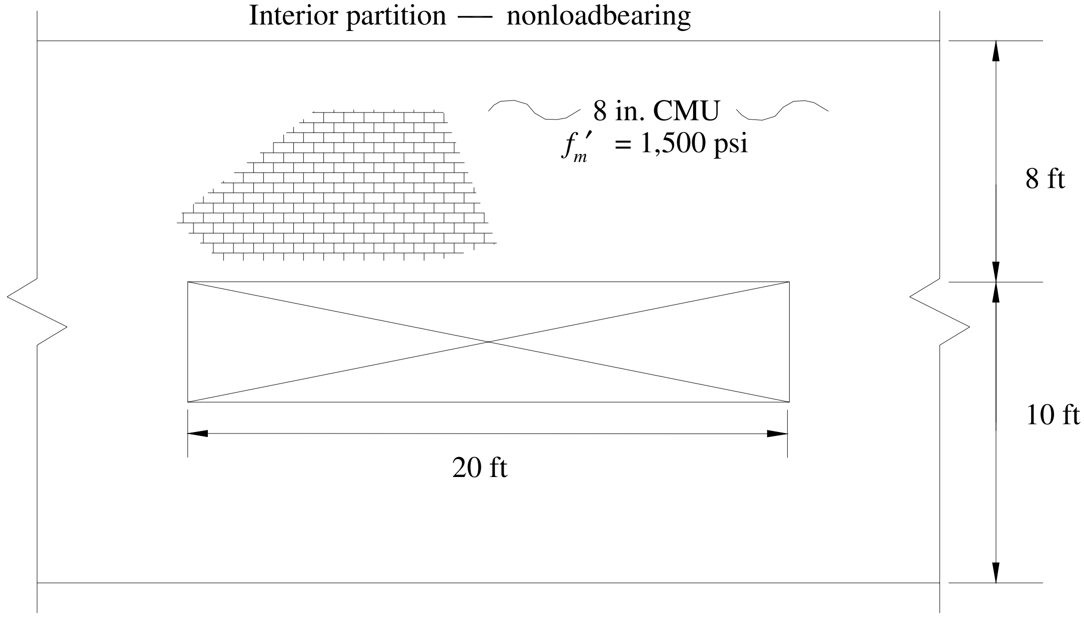


Figure 5-2: Interior Partition

Check for arching action. Prior to calculating the loads applied to the lintel, the height of masonry required for arching action is determined. The effective span of the lintel is taken as the clear span of the opening plus the depth of the beam – not to exceed the center-to-center distance between supports. Since the depth of the lintel is not known, it can be conservatively assumed that the effective span is the center-to-center distance between supports.

l = clear span + one-half bearing length + one-half bearing length
= 240 in. + (8/2) in. + (8/2) in. = 248 inches

The height of masonry above the opening is:

H = (8 ft)(12 in./ft)
= 96 inches

The height of masonry required above the lintel for arching action to occur is (refer to Figure 3-2):

h = (effective span/2) + 8 inches
= (248/2) inches + 8 inches = 132 inches

Given that the actual height above the lintel is less than h, arching action is not present. Consequently, the wall load is considered a uniform load as opposed to a triangular load.

<u>**Concrete masonry lintel – strength design.**</u> The partition carries only the lintel self-weight and the wall above. These dead loads are increased by a factor 1.4 as required by strength design (see **Table 3.1**). Therefore, the loads are,

$$D_{lintel} = 1.4(176) = 247 \text{ lb/ft (assuming a 24 in. lintel—Table 4.1)}$$

$$D_{wall} = 1.4(36)(8\text{-}2) = 303 \text{ lb/ft (assuming 125 pcf 8 in. block—Table 4.3)}$$

Both loads are uniform over the lintel, so the maximum moment and shear are,

$$M_{max} = \text{(at the center of the lintel) } wl^2/8 = (247 + 303)(20.67)^2/8 = 29{,}373 \text{ ft-lb} = 352{,}480 \text{ in.-lb}$$

$$V_{max} = wl/2 = (247 + 303)(20.67)/2 = 5{,}684 \text{ lb}$$

Using strength design **Table 6.42**, a 8 x 24 lintel with 1 No. 5 reinforcing bar with bottom cover 2.5 inches or less is adequate to support the design load.

$$M_{provided} = 354{,}932 \text{ in.-lb}$$
$$V_{provided} = 16{,}898 \text{ lb}$$

<u>**Check lintel deflection.**</u> Because this lintel may be supporting unreinforced masonry, the code requires that the deflection of the lintel be limited to *l*/600 or 0.3 in., whichever is less. Further service loads (unfactored loads) are use for deflection checks.

$$E = (900)(1{,}500) = 1{,}350{,}000 \text{ psi}$$

$$I = (1/12)(7.625 \text{ in.})(23.625 \text{ in.})^3 = 8378.7 \text{ in.}^4$$

From **Figure A-3**, the maximum deflection due to the lintel self weight is:

$$Delta_{lintel} = 5wl^4/384EI = (5)(176/12)(248)^4/[(384)(1{,}350{,}000)(8378.7)] = 0.06387 \text{ in.}$$

From **Figure A-3** again, the maximum deflection due to the wall self weight is:

$$Delta_{wall} = 5wl^4/384EI = (5)(303/12)(248)^4/[(384)(1{,}350{,}000)(8378.7)] = 0.10995 \text{ in.}$$

Again, since the loading from the self weight of the lintel and wall are both symmetrically applied to the lintel, the deflection from each load will occur at the same location (at the center of the beam) and therefore can be added together to obtain the maximum deflection:

$$Delta_{max} = 0.06387 \text{ in.} + 0.10995 \text{ in.} = 0.17382 \text{ in.}$$

Since *l*/600 = 248/600 = 0.41in., the deflection limit not to exceed 0.3 in. controls. Since the actual calculated value is less than this, the lintel design is adequate.

EXAMPLE 3

A residential basement needs a lintel to support an opening for an exit door. The wall supports a floor similar to that shown in **Figure 3-5.** **Figure 5-3** shows the arrangement of the basement wall. It was determined that the floor live load is 400 lbs/joist and the floor dead load is 100 lbs/joist. A concrete masonry lintel and a precast concrete lintel will be designed. A concrete masonry lintel and a precast concrete lintel will be designed.

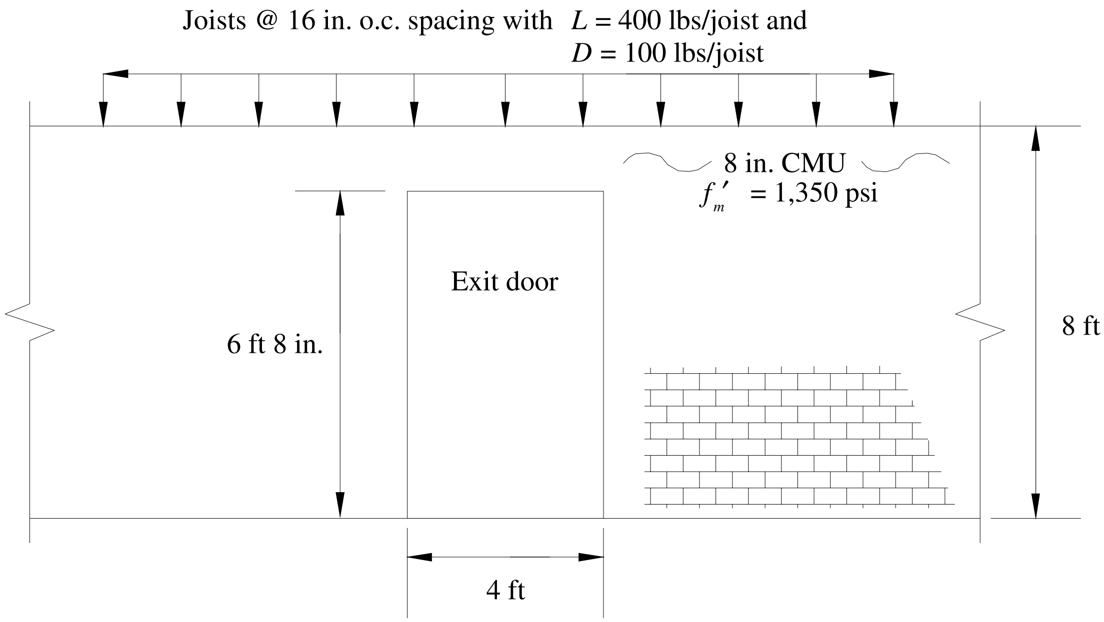


Figure 5-3: Residential Basement

<u>**Check for arching action.**</u> Assuming 8 in. end bearing, $l = 4$ ft 8 in. and $h = 2$ ft 4 in. Arching action cannot be assumed, because there is not enough masonry above the door.

<u>**Floor loading.**</u> First, the floor load spacing is checked. Recall, that if the height of masonry above the lintel is at least $^1/_3$ the center-to center load spacing, the loading is resolved onto the lintel as uniformly distributed. Assuming an 8 inch lintel, the height of masonry above the lintel is,

$$h_m = (8 \text{ ft } 0 \text{ in.} - 6 \text{ ft } 8 \text{ in.}) - 8 \text{ in.} = 8 \text{ in.}$$

There is sufficient masonry above the lintel so that the floor load is considered uniform. Given that, the uniform load acting on the lintel is,

$$w = {}^{12}/_{16}\, P$$

<u>**Design loads.**</u> Using the above equation, the design live load is,

$$w_L = {}^{12}/_{16}\,(400) = 300 \text{ lb/ft}$$

The dead loads on the lintel include the floor weight, lintel self-weight, and the wall weight. Note that the wall weight is considered uniform instead of triangular because arching action is not present. The dead loads are,

$$D_{floor} = \left(\frac{12}{16}\right)(100) = 75 \text{ lb/ ft}$$

D_{lintel} = 59 lb/ft (assuming 8in. normal weight units – Table 4.1)

D_{wall} = 36(8/12) = 24 lb/ft (assuming 125 pcf block – Table 4.3)

Concrete masonry lintel – allowable stress design. All the loads are uniformly distributed, so the maximum moment and shear are,

$$M_{max} = (300 + 75 + 59 + 24)(4.67)^2/8 = 1{,}249 \text{ ft-lb} = 14{,}983 \text{ in.-lb}$$

$$V_{max} = (300 + 75 + 59 + 24)(4.67)/2 = 1{,}069 \text{ lb}$$

Using **Table 6.4**, an 8 x 8 lintel with 1 No. 4 reinforcing bar and 2.5 inches cover or less has adequate capacity.

(V_{all} = 1,439 lb, M_{all} = 14,997 in.-lb)

Concrete masonry lintel – strength design. The maximum moment and shear are:

$$M_{max} = [1.6 (300) + 1.2 (75 + 59 + 24)](4.67)^2/8 = 1{,}825 \text{ ft-lb} = 21{,}905 \text{ in-lb}$$

$$V_{max} = [1.6 (300) + 1.2 (75 + 59 + 24)](4.67)^2/2 = 1{,}564 \text{ lb}$$

From **Table 6.29**, an 8 x 16 in. lintel with 1 No. 4 reinforcing bar and 3 inches cover or less is adequate.

$M_{provided}$ = 126,568 in-lb

$V_{provided}$ = 8,305 lb

By inspection the additional weight of a 16 inch lintel vs. the 8 inch lintel assumed will not exceed provided capacity.

Precast concrete lintel design. M_{max} and V_{max} are essentially the same as calculated for masonry strength design above (except for a slight increase in the dead load of the lintel due to a higher density of the concrete which by inspection will not exceed provided capacity).

From **Table 6.51** and assuming the strength of concrete equal to 3000 psi, a 8 by 8 inch precast concrete lintel with one No. 4 bar having a bottom cover of up to 3 inches has sufficient strength to carry the applied design loads.

$M_{provided}$ = 60,117 in-lb

$V_{provided}$ = 4,171 lb

Note: If this lintel is supporting unreinforced masonry a deflection check should be made for all three designs similar to Examples 1 and 2.

EXAMPLE 4

An industrial warehouse has a garage door that spans 12 feet. The one story warehouse supports a roof and the loading on the wall was determined to be 4,500 lb concentrated loads at 5 ft o.c. (3,000 live load and 1,500 dead load). Strength design will be used and **Figure 5-4** shows the wall configuration. The wall is constructed of 12 in. concrete masonry laid in stack bond with No. 6 reinforcing bars spaced 48 inches on-center. Recall that with stack bond, masonry arching action is not present. Additionally, with stack bond masonry the roof loads are concentrated loads acting on the lintel (see **Figure 3-7**). Design a concrete masonry lintel using strength design.

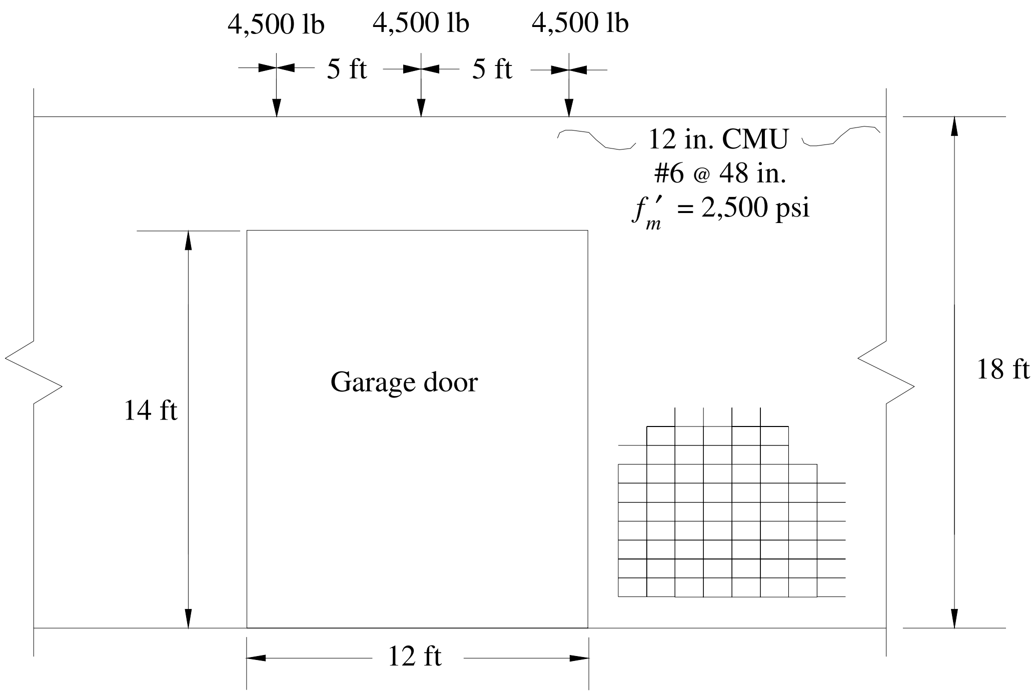


Figure 5-4: Warehouse Wall

Design loads. The lintel will be loaded with a combination of uniform and concentrated loads as shown in **Figure 5-5.** The lintel is assumed 24 inches high and carries 2 feet of wall above. The loads shown in the figure are increased by load factors from **Table 3-1:** 1.2 for dead loads and 1.6 for live loads.

Since the loads are symmetrical, the maximum moment will be at the center of the span and will be the sum of the individual moments at that point.

Concrete masonry lintel – strength deisgn.

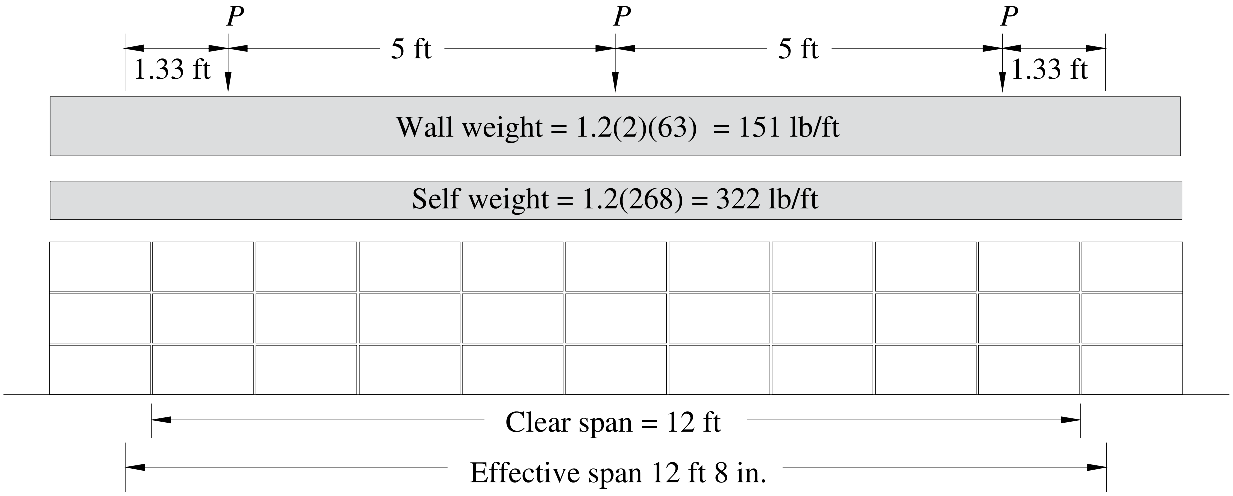
Moments:

Left *P* (Figure A-2)

M = 6,600 (1.33) [1-(6.33/12.67)] = 4,389 ft-lb

Middle *P* (Figure A-1)

M = 6,600 (12.67)/4 = 20,906 ft-lb



P = 1.2(1,500) + 1.6(3,000) = 6,600 lb

Figure 5-5: Lintel Loading

Right *P* (same as left *P* by symmetry)	=	4,389	ft-lb
Uniform load (Figure A-3)			
$M = (151 + 322)(12.67)^2/8$	=	9,491	ft-lb
M_{max}	=	39,175	ft-lb
	=	470,100	in.-lb

Shear:

By inspection, the loads are symmetrical. Maximum shear is at each support and equal to 1/2 total vertical load. (Alternatively, the shear per each load could be determined at each support and then summed similar to the moment calculation.)

V_{max} = [3(6,600) + 12.67(151 + 322)]/2 = 12,896 lb

Table 6.36 shows that a 12 x 24 lintel with 1 No. 6 bar will support the load as long as a 2 inch cover depth is maintained.

$M_{provided}$ = 479,530 in-lb

$V_{provided}$ = 24,717 lb

<u>Deflection check</u>. A deflection check is not necessary here since the masonry being supported is reinforced unless serviceability requirements dictate otherwise.

LINTEL DESIGN TABLES

The design tables contained herein list the allowable - for allowable stress design–and design–for strength design - shear and moments for reinforced concrete masonry lintels. **Table 6.1** to **Table 6.24** are based on allowable stress design, while **Table 6.25** to **Table 6.48** are based on strength design. The tables are by lintel width and height and list shear and moment for a certain reinforcing bar size and specified cover depth. The nominal lintel widths and heights are: 6, 8, 10,12 inches and 8, 16, 24 inches, respectively.

Following the masonry lintel tables, design tables for reinforced concrete lintels are presented. These tables, **6.49 to 6.52**, list design shear and moment strengths using the strength design provisions of ACI 318 [3]. The tables include values for 4 x 8 in., 6 x 8 in., and 8 x 8 in. and 8 x 16 in. nominal lintels and 3 concrete compressive strengths.

Table 6.1: Allowable Shear and Moment for Nominal 6 x 8 in. Concrete Masonry Lintels [a,b]

Steel Size (No.)	No. of Bars	Bottom Cover (in.) 1.5		2		2.5		3	
		V_{all} lb	M_{all} in.-lb	V_{all} lb	M_{all} in.-lb	V_{all} lb	M_{all} in.-lb	V_{all} lb	M_{all} in.-lb
4	1	1,279	16,691	1,170	14,369	1,062	12,182	953	10,136
5	1	1,266	18,709	1,157	16,028	1,048	13,511	939	11,168
6	1	1,252[c]	20,435[c]	1,143	17,203	1,034	14,426	925	11,849
4	2	1,279	20,435	1,170	17,504	1,062	14,756	953	12,200
5	2	1,266	22,313	1,157	19,010	1,048	15,929	939	13,076

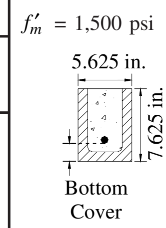


Table 6.2: Allowable Shear and Moment for Nominal 6 x 16 in. Concrete Masonry Lintels [a,b]

Steel Size (No.)	No. of Bars	Bottom Cover (in.) 1.5		2		2.5		3	
		V_{all} lb	M_{all} in.-lb	V_{all} lb	M_{all} in.-lb	V_{all} lb	M_{all} in.-lb	V_{all} lb	M_{all} in.-lb
4	1	3,022	60,355	2,913	58,087	2,804	55,821	2,695	53,558
5	1	3,009	80,278	2,900	75,531	2,791	70,892	2,682	66,364
6	1	2,995[c]	89,629[c]	2,886	84,228	2,777	78,956	2,668	73,814
4	2	3,022	88,199	2,913	82,955	2,804	77,833	2,695	72,835
5	2	3,009	100,484	2,900	94,367	2,791	88,399	2,682	82,583

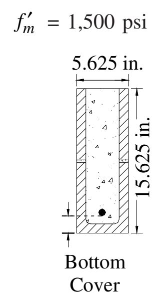
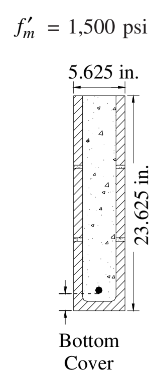


Table 6.3: Allowable Shear and Moment for Nominal 6 x 24 in. Concrete Masonry Lintels [a,b]

Steel Size (No.)	No. of Bars	Bottom Cover (in.) 1.5		2		2.5		3	
		V_{all} lb	M_{all} in.-lb	V_{all} lb	M_{all} in.-lb	V_{all} lb	M_{all} in.-lb	V_{all} lb	M_{all} in.-lb
4	1	4,765	96,892	4,656	94,598	4,547	92,304	4,438	90,012
5	1	4,751	147,158	4,643	143,640	4,534	140,125	4,425	136,613
6	1	4,738[c]	191,919[c]	4,629	184,711	4,520	177,606	4,411	170,604
4	2	4,765	187,235	4,656	180,269	4,547	173,401	4,438	166,632
5	2	4,751	216,957	4,643	208,723	4,534	200,608	4,425	192,615



a. Tables based on allowable stress design method [1].

b. Moment and shear capacity based on f'_m = 1,500 psi and grade 60 reinforcement.

c. Not permitted for masonry exposed to earth or weather (Figure 4-2).

Table 6.4: Allowable Shear and Moment for Nominal 8 x 8 in. Concrete Masonry Lintels [a,b]

Steel Size (No.)	No. of Bars	Bottom Cover (in.)							
		1.5		2		2.5		3	
		V_{all} lb	M_{all} in.-lb	V_{all} lb	M_{all} in.-lb	V_{all} lb	M_{all} in.-lb	V_{all} lb	M_{all} in.-lb
4	1	1,734	20,464	1,587	17,651	1,439	14,997	1,292	12,509
5	1	1,716	23,176	1,568	19,898	1,421	16,816	1,273	13,938
6	1	1,698[c]	25,219[c]	1,550	21,557	1,402	18,125	1,255	14,933
4	2	1,734	25,468	1,587	21,866	1,439	18,481	1,292	15,323
5	2	1,716	28,142	1,568	24,036	1,421	20,194	1,273	16,628
6	2	1,698[c]	29,973[c]	1,550	25,478	1,402	21,289	1,255	17,418

f'_m = 1,500 psi

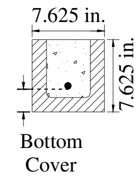


Table 6.5: Allowable Shear and Moment for Nominal 8 x 16 in. Concrete Masonry Lintels [a,b]

Steel Size (No.)	No. of Bars	Bottom Cover (in.)							
		1.5		2		2.5		3	
		V_{all} lb	M_{all} in.-lb	V_{all} lb	M_{all} in.-lb	V_{all} lb	M_{all} in.-lb	V_{all} lb	M_{all} in.-lb
4	1	4,097	61,110	3,949	58,824	3,802	56,540	3,654	54,258
5	1	4,079	92,558	3,931	89,057	3,783	85,560	3,636	80,862
6	1	4,060[c]	109,743[c]	3,912	103,212	3,765	96,832	3,617	90,604
4	2	4,097	107,759	3,949	101,428	3,802	95,241	3,654	89,200
5	2	4,079	123,963	3,931	116,517	3,783	109,247	3,636	102,156
6	2	4,060[c]	137,015[c]	3,912	128,617	3,765	120,426	3,617	112,446

f'_m = 1,500 psi

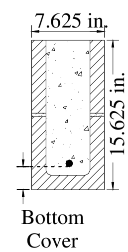
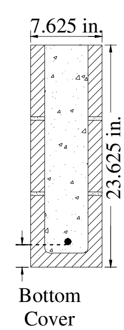


Table 6.6: Allowable Shear and Moment for Nominal 8 x 24 in. Concrete Masonry Lintels [a,b]

Steel Size (No.)	No. of Bars	Bottom Cover (in.)							
		1.5		2		2.5		3	
		V_{all} lb	M_{all} in.-lb	V_{all} lb	M_{all} in.-lb	V_{all} lb	M_{all} in.-lb	V_{all} lb	M_{all} in.-lb
4	1	6,460	97,906	6,312	95,597	6,164	93,289	6,017	90,981
5	1	6,441	148,990	6,293	145,445	6,146	141,902	5,998	138,360
6	1	6,423[c]	207,829[c]	6,275	202,844	6,127	197,862	5,980	192,883
4	2	6,460	190,849	6,312	186,304	6,164	181,762	6,017	177,223
5	2	6,441	264,994	6,293	255,057	6,146	245,261	5,998	235,608
6	2	6,423[c]	297,175[c]	6,275	276,119	6,127	269,265	5,980	262,417

f'_m = 1,500 psi



a. Tables based on allowable stress design method [1].

b. Moment and shear capacity based on f'_m = 1,500 psi and grade 60 reinforcement.

c. Not permitted for masonry exposed to earth or weather (Figure 4-2).

Table 6.7: Allowable Shear and Moment for Nominal 10 x 8 in. Concrete Masonry Lintels [a,b]

Steel Size (No.)	No. of Bars	Bottom Cover (in.)							
		1.5		2		2.5		3	
		V_{all} lb	M_{all} in.-lb	V_{all} lb	M_{all} in.-lb	V_{all} lb	M_{all} in.-lb	V_{all} lb	M_{all} in.-lb
4	1	2,190	23,818	2,003	20,572	1,817	17,506	1,630	14,628
5	1	2,166	27,172	1,980	23,366	1,793	19,782	1,607	16,430
6	1	2,143[c]	29,763[c]	1,957	25,486	1,770	21,470	1,584	17,728
7	1	2,120[c]	31,912[c]	1,933	27,210	1,747	22,810	1,560	18,724
4	2	2,190	29,991	2,003	25,792	1,817	21,840	1,630	18,147
5	2	2,166	33,430	1,980	28,605	1,793	24,082	1,607	19,875
6	2	2,143[c]	35,872[c]	1,957	30,551	1,770	25,582	1,584	20,980
7	2	2,120[c]	37,723[c]	1,933	31,982	1,747	26,641	1,560	21,715

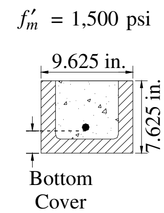


Table 6.8: Allowable Shear and Moment for Nominal 10 x 16 in. Concrete Masonry Lintels [a,b]

Steel Size (No.)	No. of Bars	Bottom Cover (in.)							
		1.5		2		2.5		3	
		V_{all} lb	M_{all} in.-lb	V_{all} lb	M_{all} in.-lb	V_{all} lb	M_{all} in.-lb	V_{all} lb	M_{all} in.-lb
4	1	5,172	61,637	4,985	59,339	4,799	57,042	4,613	54,748
5	1	5,148	93,503	4,962	89,979	4,776	86,458	4,589	82,941
6	1	5,125[c]	127,612[c]	4,939	120,084	4,752	112,726	4,566	105,541
7	1	5,102	141,167[c]	4,915	122,529	4,729	117,640	4,543	112,758
4	2	5,172	119,875	4,985	115,360	4,799	110,701	4,613	103,740
5	2	5,148	144,915	4,962	136,294	4,776	127,872	4,589	119,653
6	2	5,125[c]	161,164[c]	4,939	151,389	4,752	141,848	4,566	132,547
7	2	5,102[c]	175,507[c]	4,915	164,660	4,729	154,085	4,543	143,785

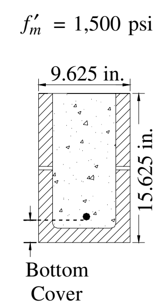
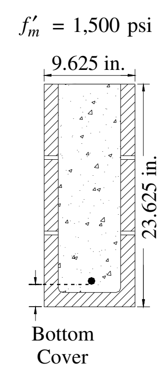


Table 6.9: Allowable Shear and Moment for Nominal 10 x 24 in. Concrete Masonry Lintels [a,b]

Steel Size (No.)	No. of Bars	Bottom Cover (in.)							
		1.5		2		2.5		3	
		V_{all} lb	M_{all} in.-lb	V_{all} lb	M_{all} in.-lb	V_{all} lb	M_{all} in.-lb	V_{all} lb	M_{all} in.-lb
4	1	8,154	98,607	7,968	96,288	7,781	93,970	7,595	91,653
5	1	8,131	150,268	7,944	146,704	7,758	143,141	7,571	139,581
6	1	8,107[c]	209,872[c]	7,921	204,855	7,735	199,841	7,548	194,830
7	1	8,084[c]	281,585[c]	7,898	201,522	7,711	196,551	7,525	191,585
4	2	8,154	192,655	7,968	188,082	7,781	183,512	7,595	178,945
5	2	8,131	292,290	7,944	285,287	7,758	278,289	7,571	271,297
6	2	8,107[c]	346,815[c]	7,921	*333,712*	7,735	*320,797*	7,548	*308,073*
7	2	8,084[c]	382,833[c]	7,898	*368,712*	7,711	*353,665*	7,525	*339,411*



a. Tables based on allowable stress design method [1].

b. Moment and shear capacity based on f'_m = 1,500 psi and grade 60 reinforcement.

c. Not permitted for masonry exposed to earth or weather (Figure 4-2).

Table 6.10: Allowable Shear and Moment for Nominal 12 x 8 in. Concrete Masonry Lintels [a,b]

Steel Size (No.)	No. of Bars	Bottom Cover (in.) 1.5		2		2.5		3	
		V_{all} lb	M_{all} in.-lb	V_{all} lb	M_{all} in.-lb	V_{all} lb	M_{all} in.-lb	V_{all} lb	M_{all} in.-lb
4	1	2,645	25,405	2,420	23,147	2,194	19,792	1,969	16,560
5	1	2,616	30,823	2,391	26,538	2,166	22,498	1,941	18,714
6	1	[3]	[3]	2,363	29,095	2,138	24,548	1,913	20,304
7	1	[3]	[3]	2,335	31,219	2,110	26,213	1,885	21,558
4	2	2,645	34,135	2,420	29,392	2,194	24,925	1,969	20,744
5	2	2,616	38,306	2,391	32,824	2,166	27,679	1,941	22,884
6	2	[3]	[3]	2,363	35,268	2,138	29,582	1,913	24,307
7	2	[3]	[3]	2,335	37,124	2,110	30,978	1,885	25,299

f'_m = 1,500 psi

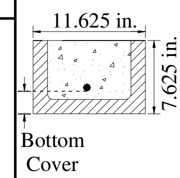


Table 6.11: Allowable Shear and Capacity for Nominal 12 x 16 in. Concrete Masonry Lintels [a,b]

Steel Size (No.)	No. of Bars	Bottom Cover (in.) 1.5		2		2.5		3	
		V_{all} lb	M_{all} in.-lb	V_{all} lb	M_{all} in.-lb	V_{all} lb	M_{all} in.-lb	V_{all} lb	M_{all} in.-lb
4	1	6,247	62,033	6,021	59,725	5,796	57,420	5,571	55,116
5	1	6,218	94,218	5,993	90,676	5,768	87,138	5,543	83,603
6	1	[3]	[3]	5,965	126,194	5,740	121,220	5,515	116,253
7	1	[3]	[3]	5,937	123,731	5,712	118,808	5,487	113,892
4	2	6,247	120,880	6,021	116,340	5,796	111,805	5,571	107,275
5	2	6,218	164,018	5,993	154,332	5,768	144,867	5,543	135,626
6	2	[3]	[3]	5,965	*172,243*	5,740	161,477	5,515	150,975
7	2	[3]	[3]	5,937	*188,213*	5,712	*176,229*	5,487	*164,551*

f'_m = 1,500 psi

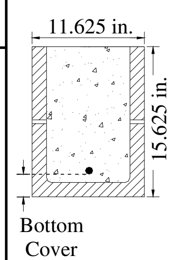
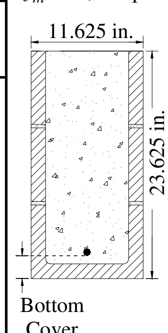


Table 6.12: Allowable Shear and Moment for Nominal 12 x 24 in. Concrete Masonry Lintels [a,b]

Steel Size (No.)	No. of Bars	Bottom Cover (in.) 1.5		2		2.5		3	
		V_{all} lb	M_{all} in.-lb	V_{all} lb	M_{all} in.-lb	V_{all} lb	M_{all} in.-lb	V_{all} lb	M_{all} in.-lb
4	1	9,848	99,130	9,623	96,804	9,398	94,478	9,173	92,154
5	1	9,820	151,226	9,595	147,648	9,370	144,072	9,145	140,497
6	1	[3]	[3]	9,567	206,373	9,342	201,335	9,117	196,301
7	1	[3]	[3]	9,539	203,201	9,314	198,204	9,089	193,210
4	2	9,848	194,014	9,623	189,422	9,398	184,832	9,173	180,244
5	2	9,820	294,729	9,595	287,688	9,370	280,652	9,145	273,620
6	2	[3]	[3]	9,567	*377,327*	9,342	*362,830*	9,117	*348,544*
7	2	[3]	[3]	9,539	*417,933*	9,314	*401,630*	9,089	*385,572*

f'_m = 1,500 psi



a. Tables based on allowable stress design method [1].

b. Moment and shear capacity based on f'_m = 1,500 psi and grade 60 reinforcement.

c. Not permitted for masonry exposed to earth or weather (Figure 4-2).

Table 6.13: Allowable Shear and Moment for Nominal 6 x 8 in. Concrete Masonry Lintels [a,b]

Steel Size (No.)	No. of Bars	Bottom Cover (in.) 1.5		2		2.5		3	
		V_{all} lb	M_{all} in.-lb	V_{all} lb	M_{all} in.-lb	V_{all} lb	M_{all} in.-lb	V_{all} lb	M_{all} in.-lb
4	1	1,652	23,417	1,511	20,223	1,371	17,206	1,230	14,374
5	1	1,634	26,694	1,494	22,951	1,353	19,426	1,212	16,131
6	1	1,617[c]	29,218[c]	1,476	25,014	1,335	21,068	1,195	17,392
4	2	1,652	29,449	1,511	25,320	1,371	21,436	1,230	17,807
5	2	1,634	32,794	1,494	28,055	1,353	23,613	1,212	19,483

f'_m = 2,500 psi

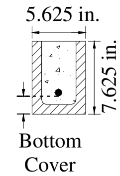


Table 6.14: Allowable Shear and Moment for Nominal 6 x 16 in. Concrete Masonry Lintels [a,b]

Steel Size (No.)	No. of Bars	Bottom Cover (in.) 1.5		2		2.5		3	
		V_{all} lb	M_{all} in.-lb	V_{all} lb	M_{all} in.-lb	V_{all} lb	M_{all} in.-lb	V_{all} lb	M_{all} in.-lb
4	1	3,902	61,580	3,761	59,283	3,621	56,988	3,480	54,695
5	1	3,884	93,400	3,744	89,878	3,603	86,360	3,462	82,845
6	1	3,867[c]	125,477[c]	3,726	118,068	3,585	110,826	3,445	103,756
4	2	3,902	119,730	3,761	115,218	3,621	108,854	3,480	102,002
5	2	3,884	142,408	3,744	133,927	3,603	125,642	3,462	117,558

f'_m = 2,500 psi

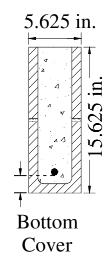
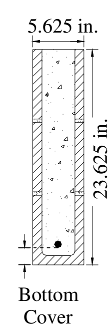


Table 6.15: Allowable Shear and Moment for Nominal 6 x 24 in. Concrete Masonry Lintels[a,b]

Steel Size (No.)	No. of Bars	Bottom Cover (in.) 1.5		2		2.5		3	
		V_{all} lb	M_{all} in.-lb	V_{all} lb	M_{all} in.-lb	V_{all} lb	M_{all} in.-lb	V_{all} lb	M_{all} in.-lb
4	1	6,152	98,531	6,011	96,213	5,871	93,896	5,730	91,580
5	1	6,134	150,129	5,994	146,567	5,853	143,006	5,712	139,448
6	1	6,117[c]	209,649[c]	5,976	204,635	5,835	199,625	5,695	194,617
4	2	6,152	192,458	6,011	187,888	5,871	183,321	5,730	178,757
5	2	6,134	291,938	5,994	284,941	5,853	277,949	5,712	269,220

f'_m = 2,500 psi



a. Tables based on allowable stress design method [1].

b. Moment and shear capacity based on f'_m = 2,500 psi and grade 60 reinforcement.

c. Not permitted for masonry exposed to earth or weather (Figure 4-2).

Table 6.16: Allowable Shear and Moment for Nominal 8 x 8 in. Concrete Masonry Lintels[a,b]

Steel Size (No.)	No. of Bars	Bottom Cover (in.)							
		1.5		2		2.5		3	
		V_{all} lb	M_{all} in.-lb	V_{all} lb	M_{all} in.-lb	V_{all} lb	M_{all} in.-lb	V_{all} lb	M_{all} in.-lb
4	1	2,239	25,506	2,049	23,243	1,858	20,956	1,667	17,545
5	1	2,216	32,684	2,025	28,156	1,834	23,884	1,644	19,882
6	1	2,192[c]	36,064[c]	2,001	30,942	1,810	26,124	1,620	21,625
4	2	2,239	36,251	2,049	31,233	1,858	26,503	1,667	22,074
5	2	2,216	40,807	2,025	34,990	1,834	29,527	1,644	24,433
6	2	2,192[c]	44,166[c]	2,001	37,699	1,810	31,647	1,620	26,026

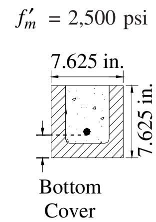


Table 6.17: Allowable Shear and Moment for Nominal 8 x 16 in. Concrete Masonry Lintels[a,b]

Steel Size (No.)	No. of Bars	Bottom Cover (in.)							
		1.5		2		2.5		3	
		V_{all} lb	M_{all} in.-lb	V_{all} lb	M_{all} in.-lb	V_{all} lb	M_{all} in.-lb	V_{all} lb	M_{all} in.-lb
4	1	5,289	62,210	5,099	59,899	4,908	57,589	4,717	55,281
5	1	5,266	94,539	5,075	90,990	4,884	87,444	4,694	83,901
6	1	5,242[c]	131,684[c]	5,051	126,693	4,860	121,706	4,670	116,725
4	2	5,289	121,334	5,099	116,783	4,908	112,237	4,717	107,695
5	2	5,266	173,749	5,075	163,523	4,884	153,528	4,694	143,767
6	2	5,242[c]	194,556[c]	5,051	182,894	4,860	171,504	4,670	160,392

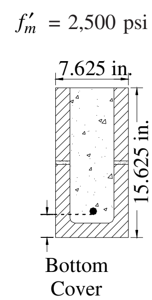
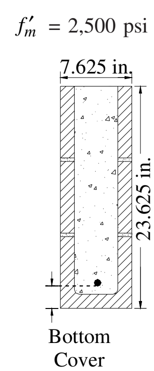


Table 6.18: Allowable Shear and Moment for Nominal 8 x 24 in. Concrete Masonry Lintels[a,b]

Steel Size (No.)	No. of Bars	Bottom Cover (in.)							
		1.5		2		2.5		3	
		V_{all} lb	M_{all} in.-lb	V_{all} lb	M_{all} in.-lb	V_{all} lb	M_{all} in.-lb	V_{all} lb	M_{all} in.-lb
4	1	8,339	99,363	8,149	97,034	7,958	94,705	7,767	92,377
5	1	8,316	151,656	8,125	148,072	7,934	144,489	7,744	140,908
6	1	8,292[c]	212,105[c]	8,101	207,055	7,910	202,007	7,720	196,962
4	2	8,339	194,625	8,149	190,023	7,958	185,424	7,767	180,827
5	2	8,316	295,830	8,125	288,772	7,934	281,718	7,744	274,669
6	2	8,292[c]	412,241[c]	8,101	399,533	7,910	384,234	7,720	369,156



a. Tables based on allowable stress design method [1].

b. Moment and shear capacity based on f'_m = 2,500 psi and grade 60 reinforcement.

c. Not permitted for masonry exposed to earth or weather (Figure 4-2).

Table 6.19: Allowable Shear and Moment for Nominal 10 x 8 in. Concrete Masonry Lintels [a,b]

Steel Size (No.)	No. of Bars	Bottom Cover (in.)							
		1.5		2		2.5		3	
		V_{all} lb	M_{all} in.-lb	V_{all} lb	M_{all} in.-lb	V_{all} lb	M_{all} in.-lb	V_{all} lb	M_{all} in.-lb
4	1	2,827	25,758	2,586	23,480	2,346	21,207	2,105	18,941
5	1	2,797	38,006	2,556	32,785	2,316	27,853	2,075	23,227
6	1	2,767[c]	42,175[c]	2,526	36,241	2,285	30,651	2,045	25,423
7	1	2,767[c]	45,799[c]	2,496	39,200	2,255	33,002	2,015	27,224
4	2	2,827	42,313	2,586	36,509	2,346	31,030	2,105	25,893
5	2	2,797	47,999	2,556	41,225	2,316	34,853	2,075	28,901
6	2	2,767[c]	52,308[c]	2,526	44,730	2,285	37,624	2,045	31,013
7	2	2,737[c]	55,809[c]	2,496	47,517	2,255	39,768	2,015	32,584

f'_m = 2,500 psi

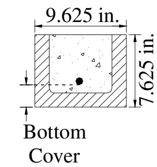


Table 6.20: Allowable Shear and Moment for Nominal 10 x 16 in. Concrete Masonry Lintels [a,b]

Steel Size (No.)	No. of Bars	Bottom Cover (in.)							
		1.5		2		2.5		3	
		V_{all} lb	M_{all} in.-lb	V_{all} lb	M_{all} in.-lb	V_{all} lb	M_{all} in.-lb	V_{all} lb	M_{all} in.-lb
4	1	6,677	62,645	6,436	60,324	6,196	58,004	5,955	55,686
5	1	6,647	95,333	6,406	91,765	6,166	88,200	5,925	84,638
6	1	6,617[c]	132,953[c]	6,376	127,931	6,135	122,913	5,895	117,900
7	1	6,587[c]	178,117[c]	6,346	171,326	6,105	164,542	5,865	157,767
4	2	6,677	122,458	6,436	117,880	6,196	113,306	5,955	108,737
5	2	6,647	185,539	6,406	178,527	6,166	171,522	5,925	164,525
6	2	6,617[c]	226,867[c]	6,376	213,392	6,135	200,227	5,895	187,376
7	2	6,587[c]	250,008[c]	6,346	234,902	6,105	220,155	5,865	205,772

f'_m = 2,500 psi

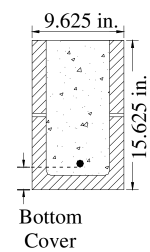
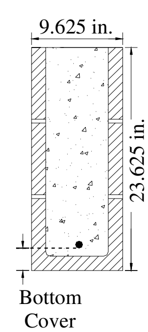


Table 6.21: Allowable Shear and Moment for Nominal 10 x 24 in. Concrete Masonry Lintels [a,b]

Steel Size (No.)	No. of Bars	Bottom Cover (in.)							
		1.5		2		2.5		3	
		V_{all} lb	M_{all} in.-lb	V_{all} lb	M_{all} in.-lb	V_{all} lb	M_{all} in.-lb	V_{all} lb	M_{all} in.-lb
4	1	10,527	99,934	10,286	97,597	10,046	95,261	9,805	92,925
5	1	10,497	152,710	10,256	149,111	10,016	145,514	9,775	141,918
6	1	10,467[c]	213,813[c]	10,226	208,737	9,985	203,664	9,745	198,594
7	1	10,437[c]	287,559[c]	10,196	280,684	9,955	273,813	9,715	195,761
4	2	10,527	196,128	10,286	191,505	10,046	186,884	9,805	182,265
5	2	10,497	298,554	10,256	291,455	10,016	284,360	9,775	277,269
6	2	10,467[c]	416,573[c]	10,226	406,588	9,985	396,610	9,745	386,638
7	2	10,437[c]	536,145[c]	10,196	515,984	9,955	496,109	9,715	476,523

f'_m = 2,500 psi



a. Tables based on allowable stress design method [1].

b. Moment and shear capacity based on f'_m = 2,500 psi and grade 60 reinforcement.

c. Not permitted for masonry exposed to earth or weather (Figure 4-2).

Table 6.22: Allowable Shear and Moment for Nominal 12 x 8 in. Concrete Masonry Lintels[a,b]

Steel Size (No.)	No. of Bars	Bottom Cover (in.)							
		1.5		2		2.5		3	
		V_{all} lb	M_{all} in.-lb	V_{all} lb	M_{all} in.-lb	V_{all} lb	M_{all} in.-lb	V_{all} lb	M_{all} in.-lb
4	1	3,414	25,947	3,124	23,659	2,833	21,375	2,542	19,098
5	1	3,378	39,067	3,087	35,562	2,797	31,468	2,506	26,276
6	1	3,342[c]	47,749[c]	3,051	41,078	2,760	34,788	2,470	28,898
7	1	3,305[c]	52,072[c]	3,015	44,628	2,724	37,627	2,433	31,091
4	2	3,414	47,836	3,124	41,319	2,833	35,162	2,542	29,382
5	2	3,378	54,583	3,087	46,940	2,797	39,741	2,506	33,009
6	2	3,342[c]	59,798[c]	3,051	51,207	2,760	43,141	2,470	35,623
7	2	3,305[c]	64,126[c]	3,015	54,680	2,724	45,840	2,433	37,631

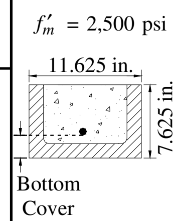


Table 6.23: Allowable Shear and Moment for Nominal 12 x 16 in. Concrete Masonry Lintels[a,b]

Steel Size (No.)	No. of Bars	Bottom Cover (in.)							
		1.5		2		2.5		3	
		V_{all} lb	M_{all} in.-lb	V_{all} lb	M_{all} in.-lb	V_{all} lb	M_{all} in.-lb	V_{all} lb	M_{all} in.-lb
4	1	8,064	62,969	7,774	60,641	7,483	58,315	7,192	55,989
5	1	8,028	95,928	7,737	92,346	7,447	88,768	7,156	85,192
6	1	7,992[c]	133,910[c]	7,701	128,865	7,410	123,823	7,120	118,787
7	1	7,955[c]	131,678[c]	7,665	126,672	7,374	121,671	7,083	116,675
4	2	8,064	123,303	7,774	118,706	7,483	114,112	7,192	109,522
5	2	8,028	187,058	7,737	180,007	7,447	172,965	7,156	165,929
6	2	7,992[c]	*256,284*[c]	7,701	*241,169*	7,410	*226,396*	7,120	*211,969*
7	2	7,955[c]	*283,543*[c]	7,665	*266,543*	7,374	*249,939*	7,083	*233,738*

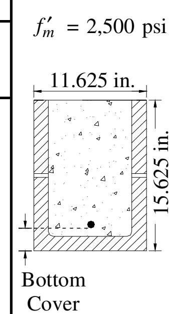
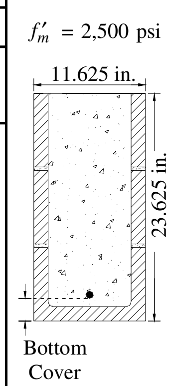


Table 6.24: Allowable Shear and Moment for Nominal 12 x 24 in. Concrete Masonry Lintels[a,b]

Steel Size (No.)	No. of Bars	Bottom Cover (in.)							
		1.5		2		2.5		3	
		V_{all} lb	M_{all} in.-lb	V_{all} lb	M_{all} in.-lb	V_{all} lb	M_{all} in.-lb	V_{all} lb	M_{all} in.-lb
4	1	12,714	100,358	12,424	98,015	12,133	95,673	11,842	93,332
5	1	12,678	153,496	12,387	149,886	12,097	146,278	11,806	142,671
6	1	12,642[c]	215,091[c]	12,351	209,997	12,060	204,906	11,770	199,817
7	1	12,605[c]	212,309[c]	12,315	207,246	12,024	202,186	11,733	197,129
4	2	12,714	197,252	12,424	192,613	12,133	187,976	11,842	183,341
5	2	12,678	300,604	12,387	293,475	12,097	286,349	11,806	279,227
6	2	12,642[c]	*419,853*[c]	12,351	*409,817*	12,060	*399,788*	11,770	*389,764*
7	2	12,605[c]	*563,334*[c]	12,315	*549,767*	12,024	*536,209*	11,733	*522,662*



a. Tables based on allowable stress design method [1].

b. Moment and shear capacity based on f'_m = 2,500 psi and grade 60 reinforcement.

c. Not permitted for masonry exposed to earth or weather (Figure 4-2).

Table 6.25: Design Shear and Moment Capacity for Nominal 6 x 8 in. Concrete Masonry Lintels [a,b]

Steel Size (No.)	No. of Bars	Bottom Cover (in.)							
		1.5		2		2.5		3	
		ϕV_n (lb)	ϕM_n (in.-lb)	ϕV_n (lb)	ϕM_n (in.-lb)	ϕV_n (lb)	ϕM_n (in.-lb)	ϕV_n (lb)	ϕM_n (in.-lb)
4	1	2,990	53,850	2,990	48,450	2,990	43,050	2,990	37,650
5	1	2,990	74,237	2,990	65,867	2,990	57,497	2,990	49,127
6	1	2,990[c]	90,156[c]	2,990	78,276	2,990	66,396	2,990	54,516
4	2	2,990	88,500	2,990	77,700	2,990	66,900	2,990	56,100
5	2	2,990	102,346	2,990	85,606	2,990	68,866	2,990	52,126

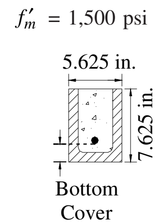


Table 6.26: Design Shear and Moment Capacity for Nominal 6 x 16 in. Concrete Masonry Lintels [a,b]

Steel Size (No.)	No. of Bars	Bottom Cover (in.)							
		1.5		2		2.5		3	
		ϕV_n (lb)	ϕM_n (in.-lb)	ϕV_n (lb)	ϕM_n (in.-lb)	ϕV_n (lb)	ϕM_n (in.-lb)	ϕV_n (lb)	ϕM_n (in.-lb)
4	1	6,127	140,250	6,127	134,850	6,127	129,450	6,127	124,050
5	1	6,127	208,157	6,127	199,787	6,127	191,417	6,127	183,047
6	1	6,127[c]	280,236[c]	6,127	268,356	6,127	256,476	6,127	244,596
4	2	6,127	261,300	6,127	250,500	6,127	239,700	6,127	228,900
5	2	6,127	370,186	6,127	353,446	6,127	336,706	6,127	319,966

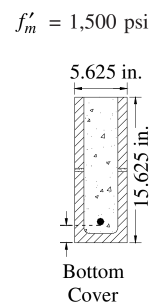
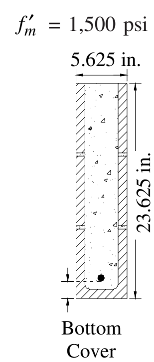


Table 6.27: Design Shear and Moment Capacity for Nominal 6 x 24 in. Concrete Masonry Lintels [a,b]

Steel Size (No.)	No. of Bars	Bottom Cover (in.)							
		1.5		2		2.5		3	
		ϕV_n (lb)	ϕM_n (in.-lb)	ϕV_n (lb)	ϕM_n (in.-lb)	ϕV_n (lb)	ϕM_n (in.-lb)	ϕV_n (lb)	ϕM_n (in.-lb)
4	1	9,264	226,650	9,264	221,250	9,264	215,850	9,264	210,450
5	1	9,264	342,077	9,264	333,707	9,264	325,337	9,264	316,967
6	1	9,264[c]	470,316[c]	9,264	458,436	9,264	446,556	9,264	434,676
4	2	9,264	434,100	9,264	423,300	9,264	412,500	9,264	401,700
5	2	9,264	638,026	9,264	621,286	9,264	604,546	9,264	587,806



a. Tables based strength design.
b. Moment and shear capacity based on f'_m = 1,500 psi and grade 60 reinforcement, strength reduction factors taken as $\phi = 0.9$ for moment and $\phi = 0.8$ for shear.
c. Not permitted for masonry exposed to earth or weather (Figure 4-2).
d. Shading indicates lintel section exceeds maximum reinforcement ratio in Section 4.2.2.

Table 6.28: Design Shear and Moment Capacity for Nominal 8 x 8 in. Concrete Masonry Lintels [a,b]

Steel Size (No.)	No. of Bars	Bottom Cover (in.)							
		1.5		2		2.5		3	
		ϕV_n (lb)	ϕM_n (in.-lb)	ϕV_n (lb)	ϕM_n (in.-lb)	ϕV_n (lb)	ϕM_n (in.-lb)	ϕV_n (lb)	ϕM_n (in.-lb)
4	1	4,053	56,368	4,053	50,968	4,053	45,568	4,053	40,168
5	1	4,053	80,286	4,053	71,916	4,053	63,546	4,053	55,176
6	1	4,053[c]	102,343[c]	4,053	90,463	4,053	78,583	4,053	66,703
4	2	4,053	98,572	4,053	87,772	4,053	76,972	4,053	66,172
5	2	4,053	126,544	4,053	109,804	4,053	93,064	4,053	76,324
6	2	4,053[c]	136,133[c]	4,053	112,373	4,053	88,613	4,053	64,853

f'_m = 1,500 psi

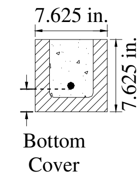


Table 6.29: Design Shear and Moment Capacity for Nominal 8 x 16 in. Concrete Masonry Lintels [a,b]

Steel Size (No.)	No. of Bars	Bottom Cover (in.)							
		1.5		2		2.5		3	
		ϕV_n (lb)	ϕM_n (in.-lb)	ϕV_n (lb)	ϕM_n (in.-lb)	ϕV_n (lb)	ϕM_n (in.-lb)	ϕV_n (lb)	ϕM_n (in.-lb)
4	1	8,305	142,768	8,305	137,368	8,305	131,968	8,305	126,568
5	1	8,305	214,206	8,305	205,836	8,305	197,466	8,305	189,096
6	1	8,305[c]	292,423[c]	8,305	280,543	8,305	268,663	8,305	256,783
4	2	8,305	271,372	8,305	260,572	8,305	249,772	8,305	238,972
5	2	8,305	394,384	8,305	377,644	8,305	360,904	8,305	344,164
6	2	8,305[c]	516,293[c]	8,305	492,533	8,305	468,773	8,305	445,013

f'_m = 1,500 psi

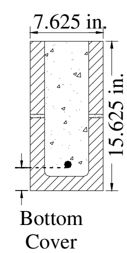
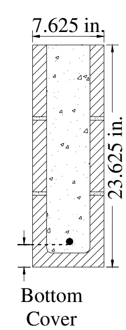


Table 6.30: Design Shear and Moment Capacity for Nominal 8 x 24 in. Concrete Masonry Lintels [a,b]

Steel Size (No.)	No. of Bars	Bottom Cover (in.)							
		1.5		2		2.5		3	
		ϕV_n (lb)	ϕM_n (in.-lb)	ϕV_n (lb)	ϕM_n (in.-lb)	ϕV_n (lb)	ϕM_n (in.-lb)	ϕV_n (lb)	ϕM_n (in.-lb)
4	1	12,558	229,168	12,558	223,768	12,558	218,368	12,558	212,968
5	1	12,558	348,126	12,558	339,756	12,558	331,386	12,558	323,016
6	1	12,558[c]	482,503[c]	12,558	470,623	12,558	458,743	12,558	446,863
4	2	12,558	444,172	12,558	433,372	12,558	422,572	12,558	411,772
5	2	12,558	662,224	12,558	645,484	12,558	628,744	12,558	612,004
6	2	12,558[c]	896,453[c]	12,558	872,693	12,558	848,933	12,558	825,173

f'_m = 1,500 psi



a. Tables based strength design.

b. Moment and shear capacity based on f'_m = 1,500 psi and grade 60 reinforcement, strength reduction factors taken as $\phi = 0.9$ for moment and $\phi = 0.8$ for shear.

c. Not permitted for masonry exposed to earth or weather (Figure 4-2).

d. Shading indicates lintel section exceeds maximum reinforcement ratio in Section 4.2.2.

Table 6.31: Design Shear and Moment Capacity for Nominal 10 x 8 in. Concrete Masonry Lintels [a,b]

Steel Size (No.)	No. of Bars	Bottom Cover (in.) 1.5		2		2.5		3	
		ϕV_n (lb)	ϕM_n (in.-lb)	ϕV_n (lb)	ϕM_n (in.-lb)	ϕV_n (lb)	ϕM_n (in.-lb)	ϕV_n (lb)	ϕM_n (in.-lb)
4	1	5,116	57,839	5,116	52,439	5,116	47,039	5,116	41,639
5	1	5,116	83,822	5,116	75,452	5,116	67,082	5,116	58,712
6	1	5,116[c]	109,465[c]	5,116	97,585	5,116	85,705	5,116	73,825
7	1	5,116[c]	133,781[c]	5,116	117,581	5,116	101,381	5,116	85,181
4	1	5,116	104,458	5,116	93,658	5,116	82,858	5,116	72,058
5	2	5,116	140,686	5,116	123,946	5,116	107,206	5,116	90,466
6	2	5,116[c]	164,622[c]	5,116	140,862	5,116	117,102	5,116	93,342
7	2	5,116[c]	166,575[c]	5,116	134,175	5,116	101,775	5,116	69,375

f'_m = 1,500 psi

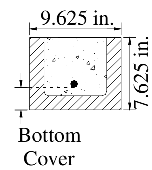


Table 6.32: Design Shear and Moment Capacity for Nominal 10 x 16 in. Concrete Masonry Lintels [a,b]

Size (No.)	of Bars	Bottom Cover (in.) 1.5		2		2.5		3	
		ϕV_n (lb)	ϕM_n (in.-lb)	ϕV_n (lb)	ϕM_n (in.-lb)	ϕV_n (lb)	ϕM_n (in.-lb)	ϕV_n (lb)	ϕM_n (in.-lb)
4	1	10,484	144,239	10,484	138,839	10,484	133,439	10,484	128,039
5	1	10,484	217,742	10,484	209,372	10,484	201,002	10,484	192,632
6	1	10,484[c]	299,545[c]	10,484	287,665	10,484	275,785	10,484	263,905
7	1	10,484[c]	392,981[c]	10,484	376,781	10,484	360,581	10,484	344,381
4	2	10,484	277,258	10,484	266,458	10,484	255,658	10,484	244,858
5	2	10,484	408,526	10,484	391,786	10,484	375,046	10,484	358,306
6	2	10,484[c]	544,782[c]	10,484	521,022	10,484	497,262	10,484	473,502
7	2	10,484[c]	684,975[c]	10,484	652,575	10,484	620,175	10,484	587,775

f'_m = 1,500 psi

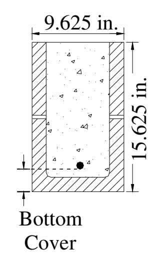
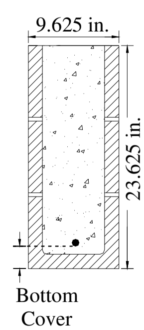


Table 6.33: Design Shear and Moment Capacity for Nominal 10 x 24 in. Concrete Masonry Lintels [a,b]

Steel Size (No.)	No. of Bars	Bottom Cover (in.) 1.5		2		2.5		3	
		ϕV_n (lb)	ϕM_n (in.-lb)	ϕV_n (lb)	ϕM_n (in.-lb)	ϕV_n (lb)	ϕM_n (in.-lb)	ϕV_n (lb)	ϕM_n (in.-lb)
4	1	15,852	230,639	15,852	225,239	15,852	219,839	15,852	214,439
5	1	15,852	351,662	15,852	343,292	15,852	334,922	15,852	326,552
6	1	15,852[c]	489,625[c]	15,852	477,745	15,852	465,865	15,852	453,985
7	1	15,852[c]	652,181[c]	15,852	635,981	15,852	619,781	15,852	603,581
4	2	15,852	450,058	15,852	439,258	15,852	428,458	15,852	417,658
5	2	15,852	676,366	15,852	659,626	15,852	642,886	15,852	626,146
6	2	15,852[c]	924,942[c]	15,852	901,182	15,852	877,422	15,852	853,662
7	2	15,852[c]	1,203,375[c]	15,852	1,170,975	15,852	1,138,575	15,852	1,106,175

f'_m = 1,500 psi



a. Tables based strength design.

b. Moment and shear capacity based on f'_m = 1,500 psi and grade 60 reinforcement, strength reduction factors taken as $\phi = 0.9$ for moment and $\phi = 0.8$ for shear.

c. Not permitted for masonry exposed to earth or weather (Figure 4-2).

d. Shading indicates lintel section exceeds maximum reinforcement ratio in Section 4.2.2.

Table 6.34: Design Shear and Moment Capacity for Nominal 12 x 8 in. Concrete Masonry Lintels [a,b]

Steel Size (No.)	No. of Bars	Bottom Cover (in.) 1.5 ϕV_n (lb)	1.5 ϕM_n (in.-lb)	2 ϕV_n (lb)	2 ϕM_n (in.-lb)	2.5 ϕV_n (lb)	2.5 ϕM_n (in.-lb)	3 ϕV_n (lb)	3 ϕM_n (in.-lb)
4	1	6,179	58,804	6,179	53,404	6,179	48,004	6,179	42,604
5	1	6,179	86,141	6,179	77,771	6,179	69,401	6,179	61,031
6	1	6,179[c]	114,137[c]	6,179	102,257	6,179	90,377	6,179	78,497
7	1	6,179[c]	142,468[c]	6,179	126,268	6,179	110,068	6,179	93,868
4	2	6,179	108,319	6,179	97,519	6,179	86,719	6,179	75,919
5	2	6,179	149,962	6,179	133,222	6,179	116,482	6,179	99,742
6	2	6,179[c]	183,309[c]	6,179	159,549	6,179	135,789	6,179	112,029
7	2	6,179[c]	201,324[c]	6,179	168,924	6,179	136,524	6,179	104,124

f'_m = 1,500 psi

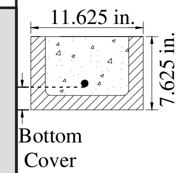


Table 6.35: Design Shear and Moment Capacity for Nominal 12 x 16 in. Concrete Masonry Lintels [a,b]

Steel Size (No.)	No. of Bars	Bottom Cover (in.) 1.5 ϕV_n (lb)	1.5 ϕM_n (in.-lb)	2 ϕV_n (lb)	2 ϕM_n (in.-lb)	2.5 ϕV_n (lb)	2.5 ϕM_n (in.-lb)	3 ϕV_n (lb)	3 ϕM_n (in.-lb)
4	1	12,662	145,204	12,662	139,804	12,662	134,404	12,662	129,004
5	1	12,662	220,061	12,662	211,691	12,662	203,321	12,662	194,951
6	1	12,662[c]	304,217[c]	12,662	292,337	12,662	280,457	12,662	268,577
7	1	12,662[c]	401,668[c]	12,662	385,468	12,662	369,268	12,662	353,068
4	2	12,662	281,119	12,662	270,319	12,662	259,519	12,662	248,719
5	2	12,662	417,802	12,662	401,062	12,662	384,322	12,662	367,582
6	2	12,662[c]	563,469[c]	12,662	539,709	12,662	515,949	12,662	492,189
7	2	12,662[c]	719,724[c]	12,662	687,324	12,662	654,924	12,662	622,524

f'_m = 1,500 psi

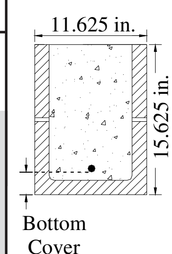
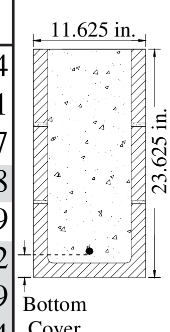


Table 6.36: Design Shear and Moment Capacity for Nominal 12 x 24 in. Concrete Masonry Lintels [a,b]

Steel Size (No.)	No. of Bars	Bottom Cover (in.) 1.5 ϕV_n (lb)	1.5 ϕM_n (in.-lb)	2 ϕV_n (lb)	2 ϕM_n (in.-lb)	2.5 ϕV_n (lb)	2.5 ϕM_n (in.-lb)	3 ϕV_n (lb)	3 ϕM_n (in.-lb)
4	1	19,146	231,604	19,146	226,204	19,146	220,804	19,146	215,404
5	1	19,146	353,981	19,146	345,611	19,146	337,241	19,146	328,871
6	1	19,146[c]	494,297[c]	19,146	482,417	19,146	470,537	19,146	458,657
7	1	19,146[c]	660,868[c]	19,146	644,668	19,146	628,468	19,146	612,268
4	2	19,146	453,919	19,146	443,119	19,146	432,319	19,146	421,519
5	2	19,146	685,642	19,146	668,902	19,146	652,162	19,146	635,422
6	2	19,146[c]	943,629[c]	19,146	919,869	19,146	896,109	19,146	872,349
7	2	19,146[c]	1,238,124[c]	19,146	1,205,724	19,146	1,173,324	19,146	1,140,924

f'_m = 1,500 psi



a. Tables based strength design.
b. Moment and shear capacity based on f'_m = 1,500 psi and grade 60 reinforcement, strength reduction factors taken as $\phi = 0.9$ for moment and $\phi = 0.8$ for shear.
c. Not permitted for masonry exposed to earth or weather (Figure 4-2).
d. Shading indicates lintel section exceeds maximum reinforcement ratio in Section 4.2.2.

Table 6.37: Design Shear and Moment Capacity Nominal for 6 x 8 in. Concrete Masonry Lintels [a,b]

Steel Size (No.)	No. of Bars	Bottom Cover (in.)							
		1.5		2		2.5		3	
		ϕV_n (lb)	ϕM_n (in.-lb)	ϕV_n (lb)	ϕM_n (in.-lb)	ϕV_n (lb)	ϕM_n (in.-lb)	ϕV_n (lb)	ϕM_n (in.-lb)
4	1	3,860	57,690	3,860	52,290	3,860	46,890	3,860	41,490
5	1	3,860	83,462	3,860	75,092	3,860	66,722	3,860	58,352
6	1	3,860[c]	108,741[c]	3,860	96,861	3,860	84,981	3,860	73,101
4	2	3,860	103,860	3,860	93,060	3,860	82,260	3,860	71,460
5	2	3,860	139,248	3,860	122,508	3,860	105,768	3,860	89,028

f'_m = 2,500 psi

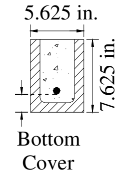


Table 6.38: Design Shear and Moment Capacity Nominal for 6 x 16 in. Concrete Masonry Lintels [a,b]

Steel Size (No.)	No. of Bars	Bottom Cover (in.)							
		1.5		2		2.5		3	
		ϕV_n (lb)	ϕM_n (in.-lb)	ϕV_n (lb)	ϕM_n (in.-lb)	ϕV_n (lb)	ϕM_n (in.-lb)	ϕV_n (lb)	ϕM_n (in.-lb)
4	1	7,910	144,090	7,910	138,690	7,910	133,290	7,910	127,890
5	1	7,910	217,382	7,910	209,012	7,910	200,642	7,910	192,272
6	1	7,910[c]	298,821[c]	7,910	286,941	7,910	275,061	7,910	263,181
4	2	7,910	276,660	7,910	265,860	7,910	255,060	7,910	244,260
5	2	7,910	407,088	7,910	390,348	7,910	373,608	7,910	356,868

f'_m = 2,500 psi

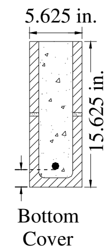
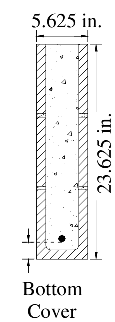


Table 6.39: Design Shear and Moment Capacity Nominal for 6 x 24 in. Concrete Masonry Lintels [a,b]

Steel Size (No.)	No. of Bars	Bottom Cover (in.)							
		1.5		2		2.5		3	
		ϕV_n (lb)	ϕM_n (in.-lb)	ϕV_n (lb)	ϕM_n (in.-lb)	ϕV_n (lb)	ϕM_n (in.-lb)	ϕV_n (lb)	ϕM_n (in.-lb)
4	1	11,960	230,490	11,960	225,090	11,960	219,690	11,960	214,290
5	1	11,960	351,302	11,960	342,932	11,960	334,562	11,960	326,192
6	1	11,960[c]	488,901[c]	11,960	477,021	11,960	465,141	11,960	453,261
4	2	11,960	449,460	11,960	438,660	11,960	427,860	11,960	417,060
5	2	11,960	674,928	11,960	658,188	11,960	641,448	11,960	624,708

f'_m = 2,500 psi



a. Tables based strength design.
b. Moment and shear capacity based on f'_m = 2,500 psi and grade 60 reinforcement, strength reduction factors taken as $\phi = 0.9$ for moment and $\phi = 0.8$ for shear.
c. Not permitted for masonry exposed to earth or weather (Figure 4-2).
d. Shading indicates lintel section exceeds maximum reinforcement ratio in Section 4.2.2.

Table 6.40: Design Nominal Shear and Moment Capacity for 8 x 8 in. Concrete Masonry Lintels [a,b]

Steel Size (No.)	No. of Bars	Bottom Cover (in.)							
		1.5		2		2.5		3	
		ϕV_n (lb)	ϕM_n (in.-lb)	ϕV_n (lb)	ϕM_n (in.-lb)	ϕV_n (lb)	ϕM_n (in.-lb)	ϕV_n (lb)	ϕM_n (in.-lb)
4	1	5,232	59,200	5,232	53,800	5,232	48,400	5,232	43,000
5	1	5,232	87,092	5,232	78,722	5,232	70,352	5,232	61,982
6	1	5,232[c]	116,053[c]	5,232	104,173	5,232	92,293	5,232	80,413
4	2	5,232	109,903	5,232	99,103	5,232	88,303	5,232	77,503
5	2	5,232	153,767	5,232	137,027	5,232	120,287	5,232	103,547
6	2	5,232[c]	190,975[c]	5,232	167,215	5,232	143,455	5,232	119,695

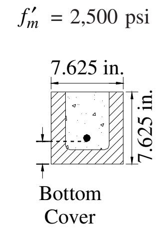


Table 6.41: Design Nominal Shear and Moment Capacity for 8 x 16 in. Concrete Masonry Lintels [a,b]

Steel Size (No.)	No. of Bars	Bottom Cover (in.)							
		1.5		2		2.5		3	
		ϕV_n (lb)	ϕM_n (in.-lb)	ϕV_n (lb)	ϕM_n (in.-lb)	ϕV_n (lb)	ϕM_n (in.-lb)	ϕV_n (lb)	ϕM_n (in.-lb)
4	1	10,722	145,600	10,722	140,200	10,722	134,800	10,722	129,400
5	1	10,722	221,012	10,722	212,642	10,722	204,272	10,722	195,902
6	1	10,722[c]	306,133[c]	10,722	294,253	10,722	282,373	10,722	270,493
4	2	10,722	282,703	10,722	271,903	10,722	261,103	10,722	250,303
5	2	10,722	421,607	10,722	404,867	10,722	388,127	10,722	371,387
6	2	10,722[c]	571,135[c]	10,722	547,375	10,722	523,615	10,722	499,855

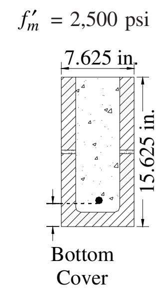
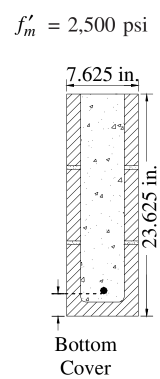


Table 6.42: Design Shear and Moment Capacity for Nominal 8 x 24 in. Concrete Masonry Lintels [a,b]

Steel Size (No.)	No. of Bars	Bottom Cover (in.)							
		1.5		2		2.5		3	
		ϕV_n (lb)	ϕM_n (in.-lb)	ϕV_n (lb)	ϕM_n (in.-lb)	ϕV_n (lb)	ϕM_n (in.-lb)	ϕV_n (lb)	ϕM_n (in.-lb)
4	1	16,898	242,800	16,898	237,400	16,898	232,000	16,898	226,600
5	1	16,898	371,672	16,898	363,302	16,898	354,932	16,898	346,562
6	1	16,898[c]	519,973[c]	16,898	508,093	16,898	496,213	16,898	484,333
4	2	16,898	477,103	16,898	466,303	16,898	455,503	16,898	444,703
5	2	16,898	722,927	16,898	706,187	16,898	689,447	16,898	672,707
6	2	16,898[c]	998,815[c]	16,898	975,055	16,898	951,295	16,898	927,535



a. Tables based strength design.

b. Moment and shear capacity based on $f'_m = 2{,}500$ psi and grade 60 reinforcement, strength reduction factors taken as $\phi = 0.9$ for moment and $\phi = 0.8$ for shear.

c. Not permitted for masonry exposed to earth or weather (Figure 4-2).

d. Shading indicates lintel section exceeds maximum reinforcement ratio in Section 4.2.2.

Table 6.43: Design Shear and Moment Capacity for Nominal 10 x 8 in. Concrete Masonry Lintels [a,b]

Steel Size (No.)	No. of Bars	Bottom Cover (in.) 1.5 ϕV_n (lb)	1.5 ϕM_n (in.-lb)	2 ϕV_n (lb)	2 ϕM_n (in.-lb)	2.5 ϕV_n (lb)	2.5 ϕM_n (in.-lb)	3 ϕV_n (lb)	3 ϕM_n (in.-lb)
4	1	6,605	60,083	6,605	54,683	6,605	49,283	6,605	43,883
5	1	6,605	89,213	6,605	80,843	6,605	72,473	6,605	64,103
6	1	6,605[c]	120,327[c]	6,605	108,447	6,605	96,567	6,605	84,687
7	1	6,605[c]	153,978[c]	6,605	137,778	6,605	121,578	6,605	105,378
4	1	6,605	113,435	6,605	102,635	6,605	91,835	6,605	81,035
5	2	6,605	162,252	6,605	145,512	6,605	128,772	6,605	112,032
6	2	6,605[c]	208,069[c]	6,605	184,309	6,605	160,549	6,605	136,789
7	2	6,605[c]	247,365[c]	6,605	214,965	6,605	182,565	6,605	150,165

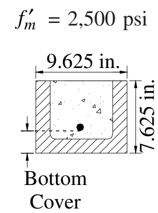


Table 6.44: Design Shear and Moment Capacity for Nominal 10 x 16 in. Concrete Masonry Lintels [a,b]

Steel Size (No.)	No. of Bars	Bottom Cover (in.) 1.5 ϕV_n (lb)	1.5 ϕM_n (in.-lb)	2 ϕV_n (lb)	2 ϕM_n (in.-lb)	2.5 ϕV_n (lb)	2.5 ϕM_n (in.-lb)	3 ϕV_n (lb)	3 ϕM_n (in.-lb)
4	1	13,535	146,483	13,535	141,083	13,535	135,683	13,535	130,283
5	1	13,535	223,133	13,535	214,763	13,535	206,393	13,535	198,023
6	1	13,535[c]	310,407[c]	13,535	298,527	13,535	286,647	13,535	274,767
7	1	13,535[c]	413,178[c]	13,535	396,978	13,535	380,778	13,535	364,578
4	2	13,535	286,235	13,535	275,435	13,535	264,635	13,535	253,835
5	2	13,535	430,092	13,535	413,352	13,535	396,612	13,535	379,872
6	2	13,535[c]	588,229[c]	13,535	564,469	13,535	540,709	13,535	516,949
7	2	13,535[c]	765,765[c]	13,535	733,365	13,535	700,965	13,535	668,565

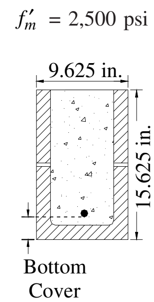
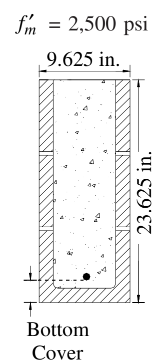


Table 6.45: Design Shear and Moment Capacity for Nominal 10 x 24 in. Concrete Masonry Lintels [a,b]

Steel Size (No.)	No. of Bars	Bottom Cover (in.) 1.5 ϕV_n (lb)	1.5 ϕM_n (in.-lb)	2 ϕV_n (lb)	2 ϕM_n (in.-lb)	2.5 ϕV_n (lb)	2.5 ϕM_n (in.-lb)	3 ϕV_n (lb)	3 ϕM_n (in.-lb)
4	1	20,465	232,883	20,465	227,483	20,465	222,083	20,465	216,683
5	1	20,465	357,053	20,465	348,683	20,465	340,313	20,465	331,943
6	1	20,465[c]	500,487[c]	20,465	488,607	20,465	476,727	20,465	464,847
7	1	20,465[c]	672,378[c]	20,465	656,178	20,465	639,978	20,465	623,778
4	2	20,465	459,035	20,465	448,235	20,465	437,435	20,465	426,635
5	2	20,465	697,932	20,465	681,192	20,465	664,452	20,465	647,712
6	2	20,465[c]	968,389[c]	20,465	944,629	20,465	920,869	20,465	897,109
7	2	20,465[c]	1,284,165[c]	20,465	1,251,765	20,465	1,219,365	20,465	1,186,965



a. Tables based strength design.

b. Moment and shear capacity based on $f'_m = 2{,}500$ psi and grade 60 reinforcement, strength reduction factors taken as $\phi = 0.9$ for moment and $\phi = 0.8$ for shear.

c. Not permitted for masonry exposed to earth or weather (Figure 4-2).

d. Shading indicates lintel section exceeds maximum reinforcement ratio in Section 4.2.2.

Table 6.46: Design Shear and Moment Capacity for Nominal 12 x 8 in. Concrete Masonry Lintels [a,b]

Steel Size (No.)	No. of Bars	Bottom Cover (in.) 1.5		2		2.5		3	
		ϕV_n (lb)	ϕM_n (in.-lb)	ϕV_n (lb)	ϕM_n (in.-lb)	ϕV_n (lb)	ϕM_n (in.-lb)	ϕV_n (lb)	ϕM_n (in.-lb)
4	1	7,977	60,662	7,977	55,262	7,977	49,862	7,977	44,462
5	1	7,977	90,605	7,977	82,235	7,977	73,865	7,977	65,495
6	1	7,977[c]	123,130[c]	7,977	111,250	7,977	99,370	7,977	87,490
7	1	7,977[c]	159,191[c]	7,977	142,991	7,977	126,791	7,977	110,591
4	2	7,977	115,751	7,977	104,951	7,977	94,151	7,977	83,351
5	2	7,977	167,818	7,977	151,078	7,977	134,338	7,977	117,598
6	2	7,977[c]	219,281[c]	7,977	195,521	7,977	171,761	7,977	148,001
7	2	7,977[c]	268,214[c]	7,977	235,814	7,977	203,414	7,977	171,014

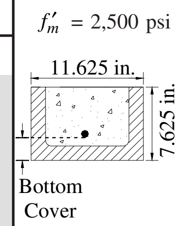


Table 6.47: Design Shear and Moment Capacity for Nominal 12 x 16 in. Concrete Masonry Lintels [a,b]

Steel Size (No.)	No. of Bars	Bottom Cover (in.) 1.5		2		2.5		3	
		ϕV_n (lb)	ϕM_n (in.-lb)	ϕV_n (lb)	ϕM_n (in.-lb)	ϕV_n (lb)	ϕM_n (in.-lb)	ϕV_n (lb)	ϕM_n (in.-lb)
4	1	16,347	147,062	16,347	141,662	16,347	136,262	16,347	130,862
5	1	16,347	224,525	16,347	216,155	16,347	207,785	16,347	199,415
6	1	16,347[c]	313,210[c]	16,347	301,330	16,347	289,450	16,347	277,570
7	1	16,347[c]	418,391[c]	16,347	402,191	16,347	385,991	16,347	369,791
4	2	16,347	288,551	16,347	277,751	16,347	266,951	16,347	256,151
5	2	16,347	435,658	16,347	418,918	16,347	402,178	16,347	385,438
6	2	16,347[c]	599,441[c]	16,347	575,681	16,347	551,921	16,347	528,161
7	2	16,347[c]	786,614[c]	16,347	754,214	16,347	721,814	16,347	689,414

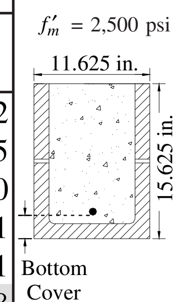
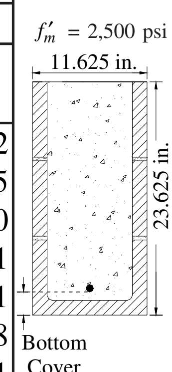


Table 6.48: Design Shear and Moment Capacity for Nominal 12 x 24 in. Concrete Masonry Lintels [a,b]

Steel Size (No.)	No. of Bars	Bottom Cover (in.) 1.5		2		2.5		3	
		ϕV_n (lb)	ϕM_n (in.-lb)	ϕV_n (lb)	ϕM_n (in.-lb)	ϕV_n (lb)	ϕM_n (in.-lb)	ϕV_n (lb)	ϕM_n (in.-lb)
4	1	24,717	233,462	24,717	228,062	24,717	222,662	24,717	217,262
5	1	24,717	358,445	24,717	350,075	24,717	341,705	24,717	333,335
6	1	24,717[c]	503,290[c]	24,717	491,410	24,717	479,530	24,717	467,650
7	1	24,717[c]	677,591[c]	24,717	661,391	24,717	645,191	24,717	628,991
4	2	24,717	461,351	24,717	450,551	24,717	439,751	24,717	428,951
5	2	24,717	703,498	24,717	686,758	24,717	670,018	24,717	653,278
6	2	24,717	979,601	24,717	955,841	24,717	932,081	24,717	908,321
7	2	24,717[c]	1,305,014[c]	24,717	1,272,614	24,717	1,240,214	24,717	1,207,814



a. Tables based strength design.

b. Moment and shear capacity based on f'_m = 2,500 psi and grade 60 reinforcement, strength reduction factors taken as $\phi = 0.9$ for moment and $\phi = 0.8$ for shear.

c. Not permitted for masonry exposed to earth or weather (Figure 4-2).

d. Shading indicates lintel section exceeds maximum reinforcement ratio in Section 4.2.2.

Table 6.49: Shear and Moment Capacity for Nominal 4 x 8 in. Reinforced Concrete Lintels [1,2]

Steel Size (No.)	No. of Bars	f'_c (psi) 3,000 ϕV_n (lb)	3,000 ϕM_n (in.-lb)	3,500 ϕV_n (lb)	3,500 ϕM_n (in.-lb)	4,000 ϕV_n (lb)	4,000 ϕM_n (in.-lb)
3	1	2,004	33,148	2,169	33,451	2,314	33,678
4	1	1,983	56,440	2,143	57,441	2,290	58,192
5	1	1,962	80,459	2,119	82,869	2,269	84,670

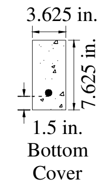


Table 6.50: Shear and Moment Capacity for Nominal 6 x 8 in. Reinforced Concrete Lintels [1,2]

Steel Size (No.)	No. of Bars	f'_c (psi) 3,000 ϕV_n (lb)	3,000 ϕM_n (in.-lb)	3,500 ϕV_n (lb)	3,500 ϕM_n (in.-lb)	4,000 ϕV_n (lb)	4,000 ϕM_n (in.-lb)
3	1	3,110	33,902	3,359	34,097	3,591	34,244
4	1	3,077	58,932	3,324	59,578	3,553	60,062
5	1	3,044	86,448	3,288	87,998	3,515	89,161
3	2	3,110	65,071	3,359	65,852	3,591	66,438
4	2	3,077	108,829	3,324	111,411	3,553	113,347
5	2	c	c	c	c	3,515	162,042

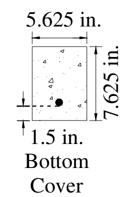
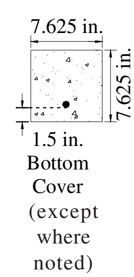


Table 6.51: Shear and Moment Capacity for Nominal 8 x 8 in. Reinforced Concrete Lintels [1,2]

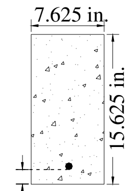
Steel Size (No.)	No. of Bars	f'_c (psi) 3,000 ϕV_n (lb)	3,000 ϕM_n (in.-lb)	3,500 ϕV_n (lb)	3,500 ϕM_n (in.-lb)	4,000 ϕV_n (lb)	4,000 ϕM_n (in.-lb)
4	1	4,171	60,117	4,505	60,593	4,816	60,950
5	1	4,127	89,294	4,457	90,438	4,765	91,296
6[d]	1	4,082	120,490	4,410	122,794	4,714	124,522
6[e]	1	3,727	108,610	4,026	110,914	4,304	112,742
4	2	4,171	113,569	4,505	115,474	4,816	116,902
5	2	4,127	162,575	4,457	167,151	4,765	170,582
6[d]	2	c	c	c	c	4,714	224,847
6[e]	2	c	c	c	c	c	c



a. Tables based strength design method – ACI 318. Moment and shear capacity based on grade 60 reinforcement, strength reduction factors taken as $\phi = 0.9$ for moment and $\phi = 0.85$ for shear.
b. Concrete cover of 1.5 inches.
c. Reinforcement at listed effective depth exceeds maximum reinforcing ratio of 0.75 ρ_b.
d. 1.5 inch cover – not permitted for lintel exposed to earth or weather for larger than No. 5(Figure 4-2).
e. 2 inch cover – permitted for lintel exposed to earth or weather (Figure 4-2).

Table 6.52: Shear and Moment Capacity for Nominal 16 x 8 in. Reinforced Concrete Lintels [1,2]

Steel Size (No.)	No. of Bars	f'_c (psi)					
		3,000		3,500		4,000	
		ϕV_n (lb)	ϕM_n (in.-lb)	ϕV_n (lb)	ϕM_n (in.-lb)	ϕV_n (lb)	ϕM_n (in.-lb)
4	1	9,851	146,517	10,640	146,993	11,375	147,350
5	1	9,807	223,214	10,592	224,358	11,324	225,216
6[d]	1	9,762	310,570	10,544	312,874	11,273	314,602
6[e]	1	9,407	298,690	10,161	300,994	10,863	302,722
4	2	9,851	286,369	10,640	288,274	11,375	289,702
5	2	9,807	430,415	10,592	434,991	11,324	438,422
6[d]	2	9,762	588,879	10,544	598,096	11,273	605,009
6[e]	2	9,407	565,119	10,161	574,336	10,863	581,249



a. Tables based strength design method – ACI 318. Moment and shear capacity based on grade 60 reinforcement, strength reduction factors taken as $\phi = 0.9$ for moment and $\phi = 0.85$ for shear.
b. Concrete cover of 1.5 inches.
c. Reinforcement at listed effective depth exceeds maximum reinforcing ratio of 0.75 ρ_b.
d. 1.5 inch cover – not permitted for lintel exposed to earth or weather for larger than No. 5(Figure 4-2).
e. 2 inch cover – permitted for lintel exposed to earth or weather (Figure 4-2).

REFERENCES

[1] *Building Code Requirements for Masonry Structures*, ACI 530/ASCE 5/TMS 402, Reported by the Masonry Standards Joint Committee, 2002.

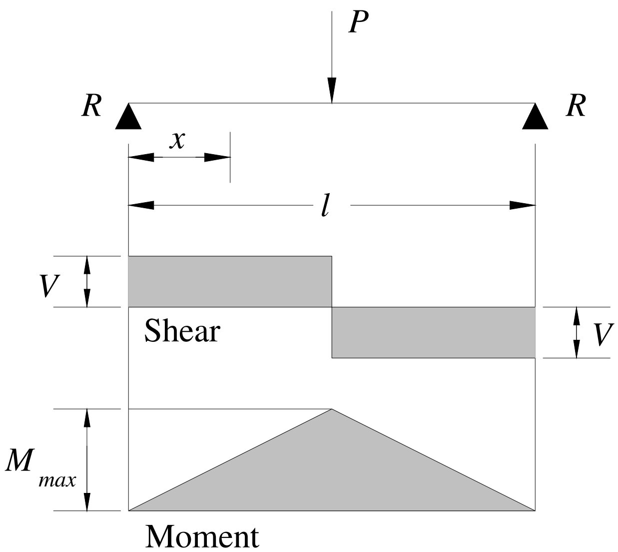
[2] *Specifications for Masonry Structures*, ACI 530.1/ASCE 6/TMS 602, Reported by the Masonry Standards Joint Committee, 2002.

[3] *Building Code Requirements for Structural Concrete*, ACI 318, Reported by ACI Committee 318, 1999.

[4] *Minimum Design for Buildings and Other Structures*, American Society of Civil Engineers, ASCE-7, 1998.

[5] *Masonry Structures Behavior and Design*, Drysdale, R.G., Hamid, A.A., Baker, L.R., Prentice Hall, Englewood Cliffs, NJ, 1999.

BEAM DIAGRAMS AND FORMULAS



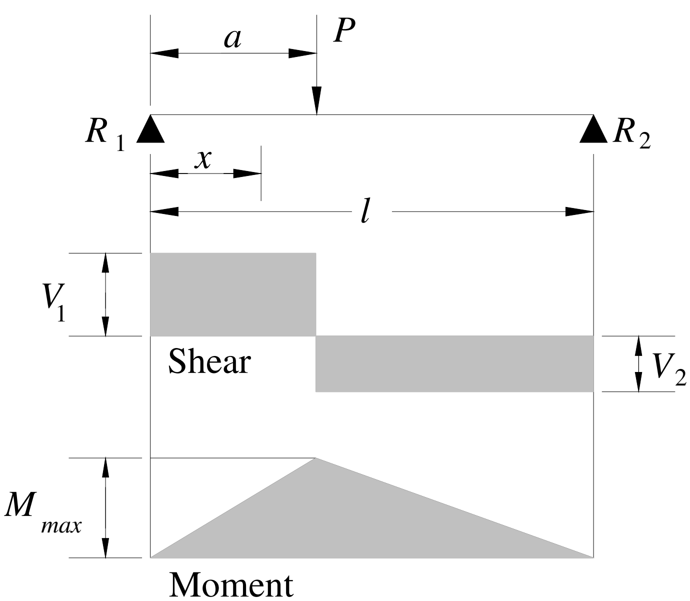
$$R = V = \frac{P}{2}$$

$$M_{\max}\,(\text{center}) = \frac{Pl}{4}$$

$$Mx\left(x < \frac{l}{2}\right) = \frac{Px}{l}$$

$$\text{Max deflection} = \frac{Pl^3}{4BEI}$$

Figure A-1: Simple Beam—Concentrated Load at Center



$$R_1 = V_1 = \frac{Pl(l-a)}{l}$$

$$R_2 = V_2 = \frac{Pa}{l}$$

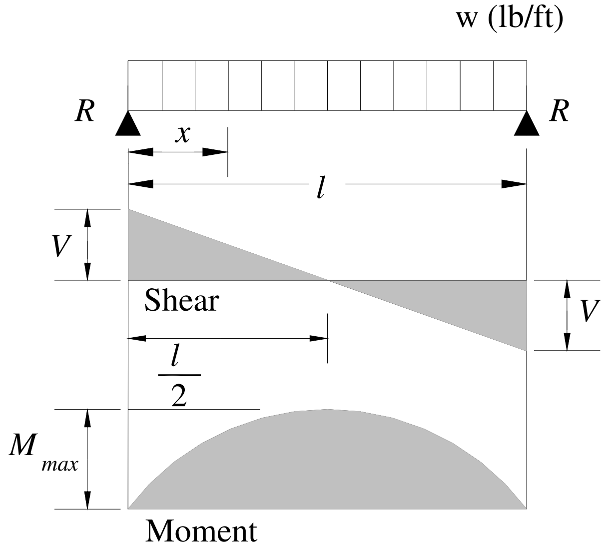
$$M_{\max}\,(\text{at load}) = \frac{Pa(l-a)}{l}$$

$$Mx\,(x < a) = \frac{Px(l-a)}{l}$$

$$Mx\,(x > a) = Pa\left(1 - \frac{x}{l}\right)$$

$$\text{Max deflection} = \frac{Pa^2(l-a)}{3EIl}$$

Figure A-2: Simple Beam—Concentrated Load at Any Point



$$R = V = \frac{wl}{2}$$

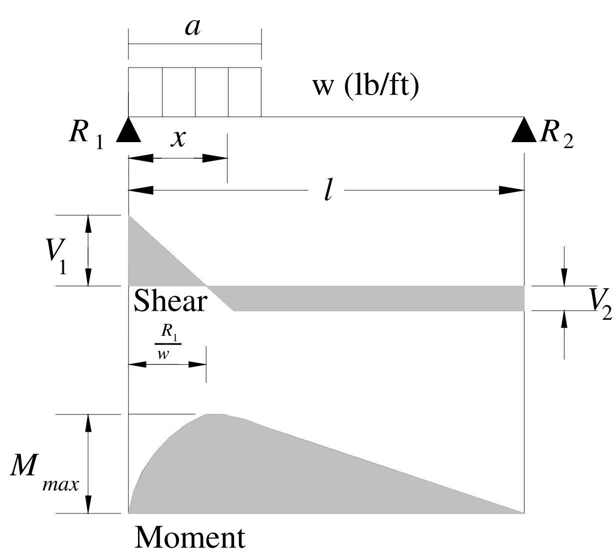
$$Vx = w\left(\frac{l}{2} - x\right)$$

$$M_{\max}\,(\text{center}) = \frac{wl^2}{8}$$

$$Mx = \frac{wx}{2}\,(l - x)$$

$$\underset{(\text{center})}{\text{Max deflection}} = \frac{5wl^4}{384EI}$$

Figure A-3: Simple Beam—Uniformly Distributed Load



$$R_1 = V_1 = \frac{wa}{2l}\,(2l - a)$$

$$R_2 = V_2 = \frac{wa}{2l}$$

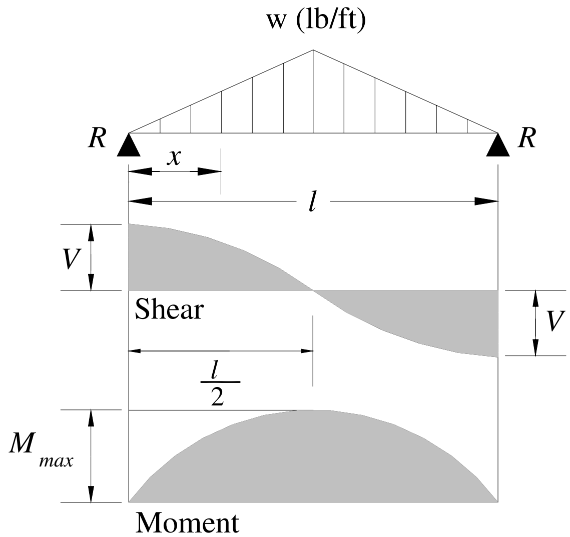
$$Vx\,(x < a) = R_1 - wx$$

$$M_{\max} = \frac{{R_1}^2}{2w}$$

$$Mx\,(x < a) = R_1\,x - \frac{wx^2}{2}$$

$$Mx\,(x > a) = R_2\,(l - x)$$

Figure A-4: Simple Beam—Uniform Load Partially Distributed at One End



$$R = V = \frac{wl}{4}$$

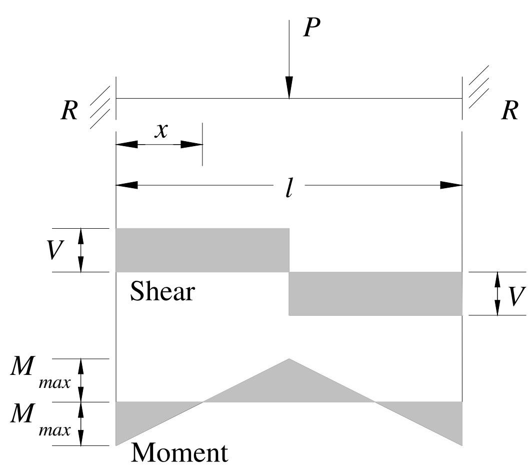
$$Vx = \left(x < \frac{l}{2} \right) = \frac{w}{4l}\left(l^2 - 4x^2\right)$$

$$M_{\max}\,(\text{center}) = \frac{wl^2}{12}$$

$$Mx\left(x < \frac{l}{2} \right) = \frac{wxl}{4}\left(\frac{1}{2} - \frac{2x^2}{3l^2} \right)$$

$$\underset{(\text{center})}{\text{Max deflection}} = \frac{wl^4}{240EI}$$

Figure A-5: Simple Beam—Triangular Load



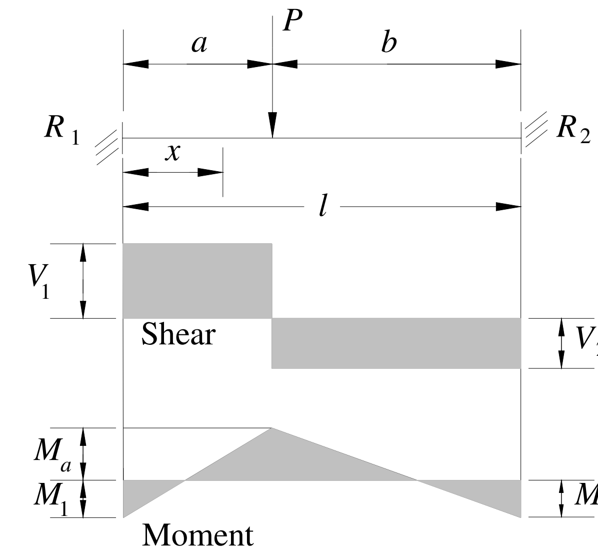
$$R = V = \frac{P}{2}$$

$$M_{\max}\,(\text{center}) = \frac{Pl}{8}$$

$$Mx\left(x < \frac{l}{2} \right) = \frac{P}{8}(4x - l)$$

$$\underset{(\text{center})}{\text{Max deflection}} = \frac{Pl^3}{192EI}$$

Figure A-6: Beam Fixed at Both Ends—Concentrated Load at Center



$$R_1 = V_1 = \frac{Pb^2}{l^3}(3a+b)$$

$$R_2 = V_2 = \frac{Pa^2}{l^3}(a+3b)$$

$$M_1 = \frac{Pab^2}{l^2}$$

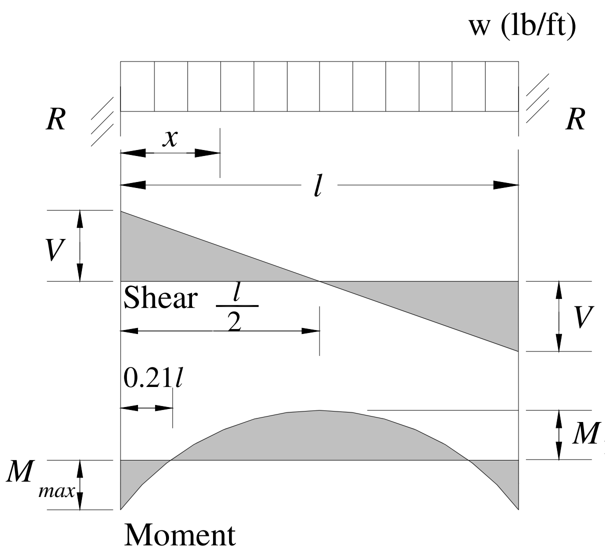
$$M_2 = \frac{Pa^2b}{l^2}$$

$$M_a = \frac{2Pa^2b^2}{l^3}$$

$$Mx\,(x<a) = M_1 + R_1\,x$$

$$Mx\,(x>a) = M_1 + R_1\,x - Pa$$

Figure A-7: Beam Fixed at Both Ends—Concentrated Load at Any Point



$$R = V = \frac{wl}{2}$$

$$Vx = w\left(\frac{l}{2} - x\right)$$

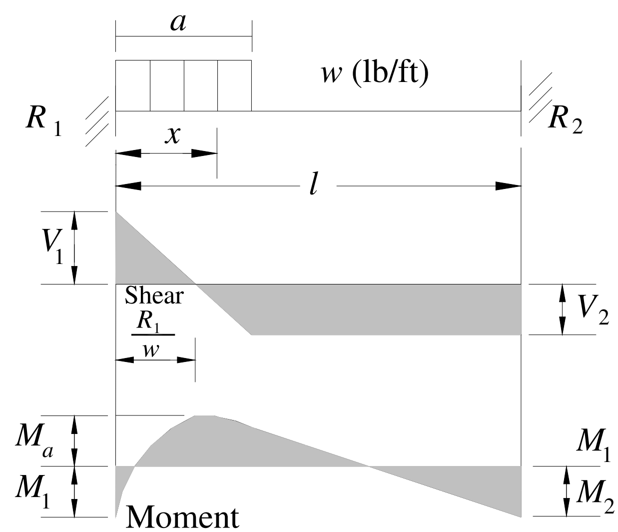
$$M_{\max}\,(\text{ends}) = \frac{wl^2}{12}$$

$$M_1\,(\text{center}) = \frac{wl^2}{24}$$

$$Mx\left(x < \frac{l}{2}\right) = \frac{w}{12}\left(6lx - l^2 - 6x^2\right)$$

$$\text{Max deflection (center)} = \frac{wl^2}{384EI}$$

Figure A-8: Beam Fixed at Both Ends—Uniform Load



$$R_1 = V_1 = \frac{wa}{2l^3}\left(2l^3 + 2a^2\, l + a^3\right)$$

$$R_2 = V_2 = \frac{wa^3}{2l^3}\left(2l - a\right)$$

$$Vx\left(x < a\right) = R_1 - wx$$

$$M_1 = \frac{wa^2}{12l^2}\left(6l^2 + 8al + 3a^2\right)$$

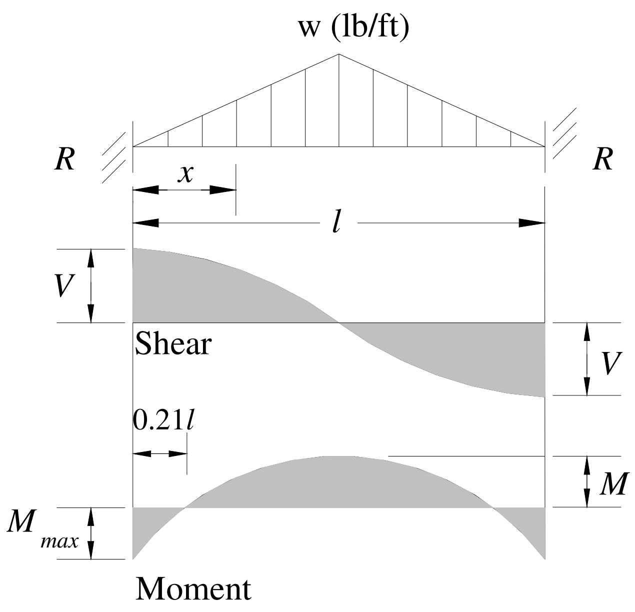
$$M_2 = \frac{wa^3}{12l^2}\left(4l - 3a\right)$$

$$M_a = \frac{R_1^2}{2w} M_1$$

$$Mx\left(x < a\right) = \frac{3wx^2}{2} R_1\, x - M_1$$

$$Mx\left(x > a\right) = \frac{wa^2}{2} - \left(M_1 + V_2\, x\right)$$

Figure A-9: Beam Fixed at Both Ends—Uniform Load Partially Distributed at One End



$$R = V\, \frac{wl}{4}$$

$$Vx = \left(x < \frac{l}{2}\right) = \frac{w}{4l}\left(4x^2 - l^2\right)$$

$$M_{\max} = \frac{5wl^2}{96}$$

$$M\left(x < \frac{l}{2}\right) = \frac{w}{12l}\left(\frac{5}{8}wl^3 - 4x^3 + 3xl^2\right)$$

$$\text{Max deflection (center)} = \frac{0.7\, wl^4}{384\, EI}$$

Figure A-10: Beam Fixed at Both Ends—Triangular Load

A-6

METRIC CONVERSIONS

Quantity	Inch-Pound Units	Metric Units	Multiply Inch-Pound Units by:
Length	mi	km	1.609344*
	ft	m	0.3048*
	ft	mm	304.8*
	in.	cm	2.54*
	in.	mm	25.4*
Area	yd^2	m^2	0.83612736*
	ft^2	m^2	0.09290304*
	$in.^2$	mm^2	645.16*
Volume	yd^3	m^3	0.7645549
	ft^3	m^3	0.0283168
	$in.^3$	mm^3	16,387.064*
Mass	ton	Mg	0.9071847
	lb	kg	0.4535924
Density	lb/ft^3	kg/m^3	16.01846
Force	lb	N	4.448222
Force/Unit Length	lb/ft	N/m	14.593904
	lb/in.	N/mm	0.1751269
Force/Unit Area	psf	Pa	47.88026
	psi	MPa	0.00689476
	psf	kPa	0.04788026
*Denotes exact conversion.			

TR 91B

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