NCMA TEK

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ALLOWABLE STRESS DESIGN OF CONCRETE MASONRY LINTELS

TEK 17-1B
Structural (2001)

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INTRODUCTION

Lintels and beams are horizontal structural members designed to carry loads above openings. Although lintels may be constructed of concrete masonry units, precast or cast-in-place concrete, or structural steel, this TEK addresses reinforced concrete masonry lintels only. Concrete masonry lintels have the advantages of easily maintaining the bond pattern, color, and surface texture of the surrounding masonry and being placed without need for special lifting equipment.

Concrete masonry lintels are sometimes constructed as a portion of a continuous bond beam. This construction provides several benefits: it is considered to be more advantageous in high seismic areas or areas where high winds may be expected to occur; control of wall movement due to shrinkage or temperature differentials is more easily accomplished; and lintel deflection may be substantially reduced.

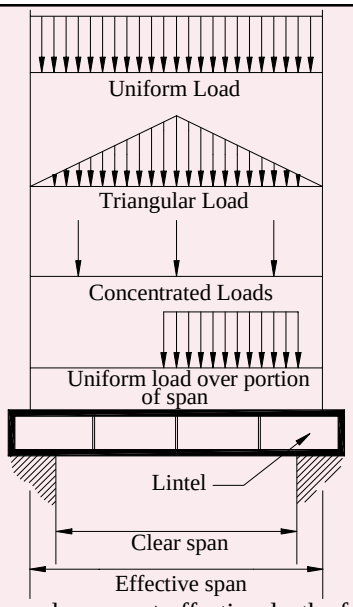
DESIGN LOADS

Vertical loads carried by lintels typically include: (1) distributed loads from the dead weight of the lintel, the dead weight of the masonry above, and any floor and roof loads, dead and live loads supported by the masonry; and (2) concentrated loads from floor beams, roof joists, or other beams framing into the wall. Axial load carried by lintels is negligible.

Most of these loads can be separated into the four types illustrated in Figure 1: uniform load acting over the effective span; triangular load with apex at mid-span acting over the effective span; concentrated load; and uniform load acting over a portion of the effective span. The designer calculates the effects of each individual load and then combines them using superposition to determine the overall effect, typically by assuming the lintel is a simply supported beam.

Arching Action

For some configurations, the masonry will distribute applied loads in such a manner that they do not act on the lintel. This is called arching action of masonry. Arching action can be assumed when the following conditions are met (see also Figure 2):



Effective span = clear span + effective depth of lintel, *d*, but need not exceed distance between centers of support (for simply supported)

Figure 1—Typical Lintel Load Components

- masonry wall laid in running bond,
- sufficient wall height above the lintel to form a 45° triangle,
- at least 8 in. (203 mm) of wall height above the apex of the 45° triangle,
- minimum end bearing (4 in. (102 mm) typ) is maintained,
- control joints are not located adjacent to the lintel, and
- sufficient masonry on each side of the opening to resist lateral thrust from the arching action. The designer should consider two cases. First, there should be a sufficient shear area of the masonry to resist the horizontal thrust, and second, there must be enough masonry to resist the in-plane overturning moment on the masonry adjacent to the opening. In unreinforced masonry, this means using vertical loads to offset overturning. In reinforced masonry, vertical steel can be used to resist overturning. As an alternative, the lintel could be a discrete length of a larger continuous bond beam to provide adequate restraint. For a series of wall openings, the designer should consider the offsetting effect of thrust from adjacent openings.

Lintel Loading

The loads supported by a lintel depend on whether arching action can occur or not. If arching occurs, only the self weight of the lintel, the weight of the wall below the arched portion, and concentrated loads are considered. Otherwise, the self weight, the weight of the wall above the lintel, roof and floor loads, and concentrated loads are considered. Self weight is a uniform load based on lintel weight (see Table 2).

When arching occurs, the wall weight supported by the lintel is taken as the wall weight within the triangular area below the apex (see Table 3). This triangular load has a base equal to the effective span length of the lintel and a height of half the effective span. Any superimposed roof and floor live and dead loads are neglected, since they are assumed to be distributed to the masonry on either side of the lintel. When arching is not present, the full weight of the wall section above the lintel is considered, as are superimposed loads.

Concentrated loads are assumed to be distributed as illustrated in Figure 3. The load is then resolved onto the lintel as a uniform load, with a magnitude determined by dividing the concentrated load by this length. In most cases, this results in a uniform load acting over a portion of the lintel span.

When a lintel or other beam supports unreinforced masonry, *Building Code Requirements for Masonry Structures* (ref. 1) limits lintel deflection to the clear lintel span divided by 600 or to 0.3 in. (7.6 mm) to limit damage to the supported masonry.

Table 2—Lintel Weights, lb/ft (kN/m)[a]

Nominal lintel height, in. (mm)	Nominal wall thickness, in. (mm) 8 (203)	10 (254)	12 (305)
	LIGHTWEIGHT CMU		
8 (203)	51 (0.75)	65 (0.95)	79 (1.2)
16 (406)	103 (1.5)	130 (1.9)	158 (2.3)
24 (610)	154 (2.3)	195 (2.9)	237 (3.5)
	NORMAL WEIGHT CMU		
8 (203)	58 (0.84)	73 (1.1)	88 (1.3)
16 (406)	116 (1.7)	146 (2.1)	176 (2.6)
24 (610)	174 (2.5)	219 (3.2)	264 (3.9)

[a] Face shell mortar bedding. Unit weights: grout = 140 pcf (2,242 kg/m^3); lightweight masonry units = 100 pcf (1602 kg/m^3); normal weight units = 135 pcf (2,162 kg/m^3).

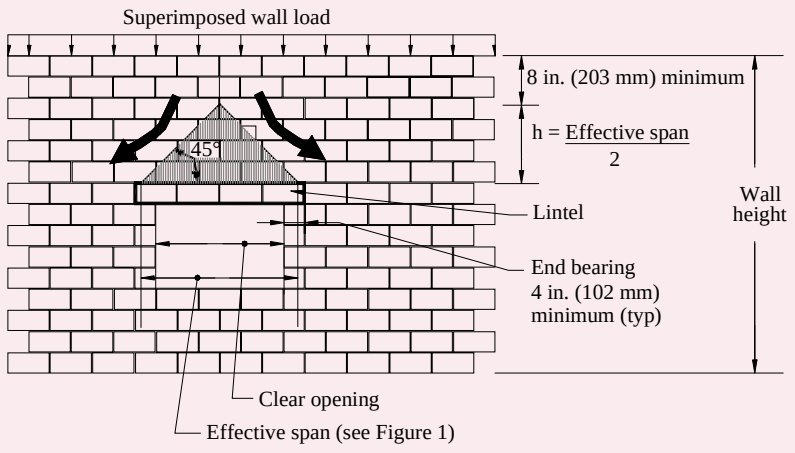


Figure 2—Arching Action

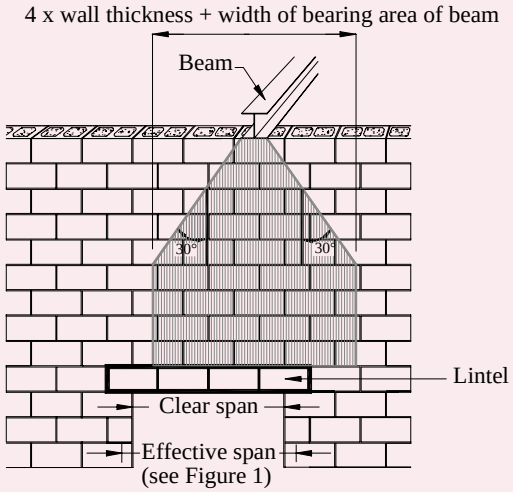


Figure 3—Distribution of Concentrated Load For Running Bond Construction

DESIGN EXAMPLE

Design a lintel for a 12 in. (305 mm) normal weight concrete masonry wall laid in running bond with vertical reinforcement at 48 in. (1.2 m) o.c. The wall configuration is shown in Figure 4.

Check for Arching Action. Determine the height of masonry required for arching action. Assuming the lintel has at least 4 in. (102 mm) bearing on each end, the effective span is: $L = 5.33 + 0.33 = 5.67$ ft (1.7 m).

The height of masonry above the lintel necessary for arching to occur in the wall (from Figure 2) is h + 8 in. (203 mm) = $L/2$ + 8 in. = 3.5 ft (1.1 m).

Because there is 18.0 - 7.33 = 10.67 ft (3.3 m) of masonry above the lintel, arching is assumed and the superimposed uniform load is neglected.

Design Loads. Because arching occurs, only the lintel and wall dead weights are considered. Lintel weight, from Table 2, for 12 in. (305 mm) normal weight concrete masonry units assuming an 8 in. (203 mm) height is,

D_{lintel} = 88 lb/ft (1.3 kN/m)

For wall weight, only the triangular portion with a height of 3.5 ft (1.1 m) is considered. From Table 3 wall dead load is,

D_{wall} = 68 lb/ft^2 (3.5 ft) = 238 lb/ft (3.5 kN/m) at the apex.

Maximum moment and shear are determined using simply supported beam relationships. The lintel dead weight is considered a uniform load, so the moment and shear are,

$M_{lintel} = wL^2/8 = (88)(5.7)^2/8 = 357$ ft-lb (0.48 kN-m)

$V_{lintel} = wL/2 = (88)(5.7)/2 = 251$ lb (1.1 kN)

For triangular wall load, moment and shear are,

$M_{wall} = wL^2/12 = (238)(5.7)^2/12 = 644$ ft-lb (0.87 kN-m)

$V_{wall} = wL/4 = (238)(5.7)/4 = 339$ lb (1.5 kN)

Since the maximum moments and shears for the two loading conditions occur in the same locations on the lintel, the moments and shears are superimposed by simple addition:

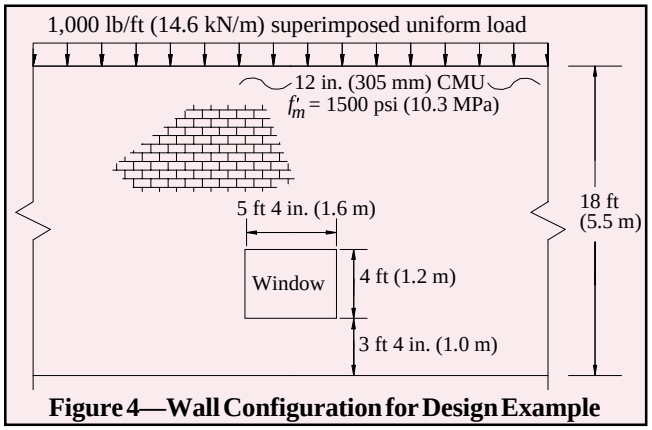


Figure 4—Wall Configuration for Design Example

M_{max} = 357 + 644 = 1,001 ft-lb = 12,012 in-lb (1.4 kN-m)
V_{max} = 251 + 339 = 590 lb (2.6 kN)

Lintel Design. From Table 4, a 12 x 8 lintel with one No. 4 (M 13) bar and 3 in. (76 mm) or less bottom cover has adequate strength. In this example, shear was conservatively computed at the end of the lintel. However, *Building Code Requirements for Masonry Structures* (ref. 1) allows maximum shear to be calculated using a distance *d*/2 from the face of the support.

Case 2, No Arching Action. Using the same example, recalculate assuming a 2 ft (0.6 m) height from the bottom of the lintel to the top of the wall. For ease of construction, the entire 2 ft (0.6 m) would be grouted solid, producing a 24 in. (610 mm) deep lintel.

Since the height of masonry above the lintel is less than 3.5 ft (1.1 m), arching cannot be assumed, and the superimposed load must be accounted for.

D_{lintel} = 264 lb/ft (3.9 kN/m), from Table 2. Because the lintel is 24 in. (610 mm) deep, there is no additional dead load due to masonry above the lintel.

D_{total} = 264 lb/ft + 1,000 lb/ft = 1,264 lb/ft (18.4 kN/m)
$M_{max} = wL^2/8 = (1{,}264)(5.7)^2/8 \times 12$ in./ft = 61,601 in.-lb (7.0 kN-m)
$V_{max} = wL/2 = (1{,}264)(5.7)/2 = 3{,}602$ lb (16.0 kN)

From Table 4, a 12 x 24 lintel with one No. 4 (M 13) reinforcing bar and 3 in. (76 mm) or less bottom cover is adequate.

REFERENCES

1. *Building Code Requirements for Masonry Structures*, ACI 530-99/ASCE 5-99/TMS 402-99. Reported by the Masonry Standards Joint Committee, 1999.

Table 3—Wall Weights [a]

Grouted cells	Wall weights (lb/ft²) for wall thicknesses, in. (mm), of: Lightweight units 4(102)	6(152)	8(203)	10(254)	12(305)	Normal weight units 4(102)	6(152)	8(203)	10(254)	12(305)
None	16	23	30	36	41	21	31	40	48	55
48 in. o.c.	19	29	38	46	54	24	36	48	58	68
40 in. o.c.	20	30	39	48	57	25	38	49	60	70
32 in. o.c.	21	32	42	52	61	26	39	52	63	74
24 in. o.c.	23	35	46	57	67	28	42	55	69	81
16 in. o.c.	26	40	54	67	80	31	48	63	79	94
Full grout	37	57	78	98	119	42	64	87	110	133

[a] Assumes face shell mortar bedding. Unit weights: grout = 140 pcf (2,242 kg/m³); lightweight masonry units = 100 pcf (1602 kg/m³); normal weight units = 135 pcf (2,162 kg/m³). kN/m² = lb/ft² x 0.04788

Table 4—Allowable Shear and Moment Capacities for Concrete Masonry Lintels (width x height) [a]

Steel size	No. of bars	Bottom cover, in. (mm): 1.5(38) V_{all} lb	1.5(38) M_{all} in.-lb	2(51) V_{all} lb	2(51) M_{all} in.-lb	2.5(64) V_{all} lb	2.5(64) M_{all} in.-lb	3(76) V_{all} lb	3(76) M_{all} in.-lb
8 x 8 lintels									
No. 4	1	1,730	20,460	1,580	17,650	1,440	14,990	1,290	12,510
No. 5	1	1,710	23,170	1,560	19,890	1,420	16,810	1,270	13,930
No. 6	1	1,690	25,220	1,550	21,550	1,400	18,120	1,250	14,930
No. 4	2[b]	1,730	25,460	1,580	21,860	1,440	18,480	1,290	15,320
No. 5	2[b]	1,710	28,140	1,560	24,030	1,420	20,190	1,270	16,620
10 x 8 lintels									
No. 4	1	2,190	23,810	2,000	20,570	1,810	17,500	1,630	14,620
No. 5	1	2,160	27,170	1,980	23,360	1,790	19,780	1,600	16,430
No. 6	1	2,140	29,760	1,950	25,480	1,770	21,470	1,580	17,720
No. 4	2	2,190	29,990	2,000	25,790	1,810	21,840	1,630	18,140
No. 5	2	2,160	33,430	1,980	28,600	1,790	24,080	1,600	19,870
12 x 8 lintels									
No. 4	1	2,640	25,400	2,420	23,140	2,190	19,790	1,970	16,560
No. 5	1	2,610	30,820	2,390	26,530	2,160	22,490	1,940	18,710
No. 6	1	2,580	33,930	2,360	29,090	2,130	24,540	1,910	20,300
No. 4	2	2,640	34,130	2,420	29,390	2,190	24,920	1,970	20,740
No. 5	2	2,610	38,300	2,390	32,820	2,160	27,670	1,940	22,880

Table 4—Allowable Shear and Moment Capacities for Concrete Masonry Lintels (width x height) (continued)[a]

Steel size	No. of bars	Bottom cover, in. (mm), of: 1.5 (38) V_{all} lb	1.5 (38) M_{all} in.-lb	2 (51) V_{all} lb	2 (51) M_{all} in.-lb	2.5 (64) V_{all} lb	2.5 (64) M_{all} in.-lb	3 (76) V_{all} lb	3 (76) M_{all} in.-lb
8 x 16 lintels									
No. 4	1	4,090	61,110	3,950	58,820	3,800	56,540	3,650	54,250
No. 5	1	4,070	92,550	3,930	89,050	3,780	85,560	3,630	80,860
No. 6	1	4,060	109,740	3,910	103,210	3,760	96,830	3,610	90,600
No. 4	2[b]	4,090	107,750	3,950	101,420	3,800	95,240	3,650	89,200
No. 5	2[b]	4,070	123,960	3,930	116,510	3,780	109,240	3,630	102,150
10 x 16 lintels									
No. 4	1	5,170	61,630	4,980	59,330	4,790	57,040	4,610	54,740
No. 5	1	5,140	93,500	4,960	89,970	4,770	86,450	4,590	82,940
No. 6	1	5,120	127,610	4,930	120,080	4,750	112,720	4,560	105,540
No. 4	2	5,170	119,870	4,980	115,360	4,790	110,700	4,610	103,740
No. 5	2	5,140	144,910	4,960	136,290	4,770	127,870	4,590	119,650
12 x 16 lintels									
No. 4	1	6,240	62,030	6,020	59,720	5,790	57,420	5,570	55,110
No. 5	1	6,210	94,210	5,990	90,670	5,760	87,130	5,540	83,600
No. 6	1	6,190	131,170	5,960	126,190	5,740	121,220	5,510	116,250
No. 4	2	6,240	120,880	6,020	116,340	5,790	111,800	5,570	107,270
No. 5	2	6,210	164,010	5,990	154,330	5,760	144,860	5,540	135,620
8 x 24 lintels									
No. 4	1	6,460	97,900	6,310	95,590	6,160	93,280	6,010	90,980
No. 5	1	6,440	148,990	6,290	145,440	6,140	141,900	5,990	138,360
No. 6	1	6,420	207,830	6,270	202,840	6,120	197,860	5,980	192,880
No. 4	2[b]	6,460	190,850	6,310	186,300	6,160	181,760	6,010	177,220
No. 5	2[b]	6,440	264,990	6,290	255,050	6,140	245,260	5,990	235,600
10 x 24 lintels									
No. 4	1	8,150	98,600	7,960	96,280	7,780	93,970	7,590	91,650
No. 5	1	8,130	150,260	7,940	146,700	7,750	143,140	7,570	139,580
No. 6	1	8,100	209,870	7,920	204,850	7,730	199,840	7,540	194,830
No. 4	2	8,150	192,650	7,960	188,080	7,780	183,510	7,590	178,940
No. 5	2	8,130	292,290	7,940	285,280	7,750	278,290	7,570	271,290
12 x 24 lintels									
No. 4	1	9,840	99,130	9,620	96,800	9,390	94,470	9,170	92,150
No. 5	1	9,820	151,220	9,590	147,640	9,370	144,070	9,140	140,490
No. 6	1	9,790	211,410	9,560	206,370	9,340	201,330	9,110	196,300
No. 4	2	9,840	194,010	9,620	189,420	9,390	184,830	9,170	180,240
No. 5	2	9,820	294,730	9,590	287,680	9,370	280,650	9,140	273,620

[a] Grade 60 reinforcement. Metric equivalents: f'_m = 1,500 psi (10.3 MPa); N = lb x 4.44822; N·m = in.-lb x 0.112985; No. 4 bar (M 13); No. 5 (M 16); No. 6 (M 19). Table values differ from TEK 17-1A due to change in E_m (ref. 1).

[b] For 8 in. (204 mm) lintels with two bars, low lift grouting is recommended for adjacent jambs to ensure proper grout flow and consolidation.