MASONRY INSIGHTS

written in conjunction with International Masonry Institute

Masonry Lap Lengths

Lap splice lengths for reinforcement on masonry projects are an important specification to consider on design drawings. When a project utilizes typical masonry closed-end masonry block, mason contractors will need to lift blocks over the vertical bar that projects above the bottom courses to lap with vertical bars above. The longer the lap, the more labor costs are incurred. However, designers must also ensure the proper transfer of stresses from one bar to another within the lap splice. This article hopes to clarify tips to consider while calculating lap splice (or development) lengths, and best practices for detailing lap lengths on design drawings.

According to the masonry code, **TMS 402 Building Code Requirements for Masonry Structures** (formerly MSJC), development length of reinforcement shall be the minimum of 12 inches or the length calculated by the following equation:

$$l_d = \frac{0.13 d_b^{\,2} f_y \gamma}{K\sqrt{f'_m}}$$

l_d = length of reinforcement development or splice length

d_b = diameter of reinforcement bar

f_y = reinforcement yield strength

γ = 1.0 for bars #3-#5 - 1.3 for bars #6-#7 - 1.5 for bars #8 and larger reinforcement

K = minimum (cover, clear spacing, 9 x d_b)

f'_m = masonry design strength

wall thickness, t_w:	**8 inches**	reinf. spacing:	**64 inches**
wall strength, f'_m:	**2500 psi**	reinf.position:	**centered**
reinf. Strength, f_y:	**60000 psi**		

Bar	Bar diameter, d_b	γ	K	development length, l_d
#3	0.375	1	3.375	12 inches
#4	0.5	1	3.5625	12 inches
#5	0.625	1	3.5	17 inches
#6	0.75	1.3	3.4375	33 inches
#7	0.875	1.3	3.375	46 inches
#8	1	1.5	3.3125	71 inches
#9	1.125	1.5	3.25	91 inches

Example 1: DEVELOPMENT LENGTH TABLE
Based on TMS 402 Equation 6-1

Note that for epoxy-coated bars, TMS 402 requires that development length shall be increased by a factor of 1.5. The International Building Code, IBC references the TMS code, and also provides a maximum development length or lap length of 72 times bar diameter, d_b. This maximum length parameter generally only affects the development/lap lengths for larger bars or bars at each face. Refer to Example 2.

thickness, t_w:	**8 inches**	reinf. spacing:	**48 inches**
strength, f'_m:	**2500 psi**	reinf.position:	**centered**
reinf., f_y:	**60000 psi**		

Bar	d_b	γ	K	development length, l_d	Maximum of 72 x d_b (from IBC)
#3	0.375	1	3.375	12 inches	27 inches
#4	0.5	1	3.5625	12 inches	36 inches
#5	0.625	1	3.5	17 inches	45 inches
#6	0.75	1.3	3.4375	33 inches	54 inches
#7	0.875	1.3	3.375	46 inches	63 inches
#8	1	1.5	3.3125	71 inches	72 inches
#9	1.125	1.5	3.25	81 inches	81 inches

Example 2: DEVELOPMENT LENGTH TABLE
Based on TMS 402 and IBC

The old method of determining reinforcement laps were based on a simple formula of 48 times d_b.

This old method is too simple. In most cases the development length/ splice length based on $48*d_b$ is too long (overly conservative) for smaller bars - see Example 3 below.

thickness, t_w:	**8 inches**	reinf. spacing:	**48 inches**
strength, f'_m:	**2500 psi**	reinf.position:	**centered**
reinf., f_y:	**60000 psi**		

Bar	d_b	γ	K	development length, l_d	48 * db	comment
#3	0.375	1	3.375	**12 inches**	~~18 inches~~	too long
#4	0.5	1	3.5625	**12 inches**	~~24 inches~~	too long
#5	0.625	1	3.5	**17 inches**	~~30 inches~~	too long
#6	0.75	1.3	3.4375	**33 inches**	~~36 inches~~	too long
#7	0.875	1.3	3.375	**46 inches**	~~42 inches~~	too short
#8	1	1.5	3.3125	**71 inches**	~~48 inches~~	too short
#9	1.125	1.5	3.25	**81 inches**	~~54 inches~~	too short

Example 3: OLD METHOD COMPARISON FOR DEVELOPMENT LENGTHS, BARS CENTERED

There are also times, especially with reinforcement at each face, when development length/ splice length based on $48*d_b$ is too short (un-conservative) - see Example 4 below.

thickness, t_w:	**12 inches**	reinf. spacing:	**48 inches**
strength, f'_m:	**2500 psi**	reinf.position:	**each face**
reinf., f_y:	**60000 psi**	reinf. cover:	**2.0 inches**

Bar	d_b	γ	K	development length, l_d	48 * db	comment
#3	0.375	1	2.0 inches	**12 inches**	~~18 inches~~	too long
#4	0.5	1	2.0 inches	**20 inches**	~~24 inches~~	too long
#5	0.625	1	2.0 inches	**30 inches**	~~30 inches~~	too short
#6	0.75	1.3	2.0 inches	**54 inches**	~~36 inches~~	too short
#7	0.875	1.3	2.0 inches	**63 inches**	~~42 inches~~	too short
#8	1	1.5	2.0 inches	**72 inches**	~~48 inches~~	too short
#9	1.125	1.5	2.0 inches	**81 inches**	~~54 inches~~	too short

Example 4: OLD METHOD COMPARISON FOR DEVELOPMENT LENGTHS, BARS EACH FACE

Finally, adding the lap splice length to the masonry wall schedule is a good way to communicate the required lap lengths for reinforcement within masonry walls. A wall schedule is often referred to while contractors build the walls, and it is a simple, clear, and easy way to identify the required lap length.

		VERTICAL REINFORCEMENT		
WALL TYPE	**THICKNESS**	**BAR(S) @ SPACING**	**LAP DISTANCE**	**NOTES**
W1	8”	1-#4 @ 64” O.C.	**12 inches**	
W2	8”	2-#4 @ 16” O.C.	**20 inches**	
W3	8”	1-#6 @ 48” O.C.	**33 inches**	
W4	8”	1-#7 @ 48” O.C.	**46 inches**	CONSIDER REINF COUPLER
W5	12”	2-#6 @ 16” O.C.	**54 inches**	CONSIDER REINF COUPLER
f'_m = 2500 PSI				

Example 5: MASONRY WALL SCHEDULE WITH LAP LENGTHS

Confinement of Reinforcement

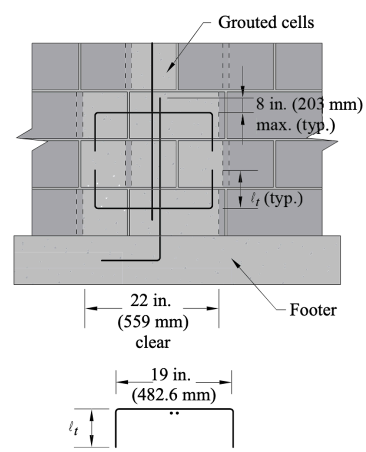
Lap splice lengths can be reduced if the lap splice is properly confined by transverse reinforcement per TMS 402. Providing a #3 or larger bar transverse to the lapped bars and within 8” from each end of the lap splice allows the lap splice length to be reduced by the confinement reinforcement factor per equation below. However, the lap splice length shall not be less than $36d_b$. The clear space between the transverse bars and lapped bars shall not exceed 1.5”, and the transverse must fully develop beyond the intersection with lapped bars in grouted masonry.

$$\xi = 1.0 - \frac{2.3A_{sc}}{{d_b}^{2.5}} \leq 1.0$$

A_{sc} = area of the transverse bar, not greater than 0.35 in^2

d_b = diameter of reinforcement bar

Figure 1 illustrates minimum requirements for confinement reinforcement per NCMA TEK 12-6a (2013).



If continuous horizontal reinforcement is not otherwise provided within the end 8 in. (203 mm) of each end of the splice, confinement requirements may be satisfied by providing hooked reinforcement as detailed here. See Tables 4a through 4d for l_t minimum length requirements. Hook extensions are permitted to overlap.

Figure 1: CONFINEMENT REINFORCEMENT AT LAP SPLICE PER NCMA TEK 12-6A

Additional Tips for Designers

Using a wall schedule is a good way to show that the same bar may have different lap lengths required in different situations, as is shown in WALL TYPE W1 and W2. Lap lengths do vary based on all the variables shown in the equation on page 1.

Lap lengths increase when:

- Using lower f'_m
- Increasing bar size, and/ or
- Decreasing reinforcement cover or spacing distance between reinforcement

Ways to avoid long lap lengths are to use the maximum allowed f'_m , use smaller bar diameters when possible, try to avoid tight bar spacings, and try to avoid small reinforcement covers (double reinforced walls) when possible.

When there is a situation where a larger lap distance is needed (larger bars are needed, small spacing, and/ or double reinforced walls are needed) as shown in WALL TYPE W4 and W5, it may be advisable to consider using a reinforcement coupler instead of lapping the reinforcement bars. Reinforcement couplers can be a threaded splice coupler or a mechanical sleeve coupler. Couplers must be selected carefully as masonry cells are confined spaces and may not have sufficient space for all types of couplers.

In conclusion, considering ways to reduce lap splice lengths (use of higher f'm, centering bars within cells where possible, selecting smaller bar diameters, confinement of laps, etc) will help towards constructability and labor costs, possibly offsetting any additional material costs. Implementing wall, lintel, or pier schedules specifying lap splice lengths specific to reinforcement conditions in lieu of more general statements in General Notes will also lead to more efficient masonry detailing.