What is a Masonry "Flush Pilaster"?

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Structural engineers have a peculiar vocabulary, when you think about it. What we call "stress" is not much like what psychologists call "stress". What we call "strain" is not what the spectators think about when watching a weight lifting match. And when we ask what the moment is, a confused general public thinks that in our own strange way we are asking what time it is.

What we call something must be understood within the context of what we are talking about; it must be clearly defined. This is particularly important when we get into the writing of a legally binding document. If we mean to mandate something, we need to be clear on what it is that we are mandating.

Masonry Pilaster Definition

In the latest version of The Masonry Society's 2013 MSJC *Provisions*, or the *Masonry Building Code* (TMS 402/602), there are certain provisions that apply specifically to the design of masonry pilasters. However, the writers of the code have not yet included a definition for pilaster. So, should we be allowed to impose our own (or Webster's) definition onto the code? It seems that would be wrong, since the writers of the code obviously had in mind structural members with certain characteristics that were intended to be governed by the specific pilaster provisions.

Although the original authors of the pilaster provisions did not include a definition, they did give us clues as to what characteristics they envisioned for pilasters. First we can look at the illustrations in the commentary. Note that in figure CC-5.4-1, titled "Typical pilasters", all of the illustrations show projections from either one or both faces of the wall. We can also look at the provisions to see what they require. The table of contents for Chapter 5 refers us to Section 5.4 for pilaster provisions. Section 5.4 points us to sections 5.1.1.2.1 through 5.1.1.2.5. Interestingly, section 5.1.1.2 is called "Design of wall intersections". So, we can assume that they intended that a pilaster would look something like that shown in the figures, and it would have similarities with the characteristics of intersecting walls. Reading the provisions of 5.1.1.2, we find references to a flange that is different than the web of the section. That is the similarity between intersecting walls and pilasters, and is shown by the projections in the illustrations. A pilaster has a web that projects from the flange(s).

Engineers on the west coast (the author included, although few would define Utah as "the west coast") often forget that the provisions of TMS 402/602 apply to both reinforced and unreinforced masonry. Section 5.4 is written to be generally applicable to both reinforced and unreinforced masonry. This clarifies the geometry even further. In unreinforced masonry, any geometry of a pilaster that did not have projections from the wall would be completely impossible to differentiate from a partially grouted wall.

Flush Pilasters

When confronted with this, many engineers may ask "But wait – what about those 'Flush Pilasters' I've been designing for years?" In fact, in the 2008 edition of TMS 402/602, the figure that illustrates pilasters actually included a sketch showing a "hidden" (or "flush") pilaster. Dr. Richard Bennett, current Chairman of the TMS 402/602 Committee and a member of the Committee when this was changed, shared some of the history as to why the figure was changed.

The illustration for the "Hidden Pilaster" was removed from TMS 402/602 in the 2011 edition. This was done in response to a public comment that correctly noted that a hidden pilaster and a partially grouted wall are essentially indistinguishable. Yet the code allowed for a different compression width to be utilized for a pilaster (even a hidden pilaster) than it allowed for bars in grouted cells of walls. This was obviously not appropriate. It was wrong for the code to provide different requirements applicable to the same element. Dr. Bennett shared the exact language from the rationale of the ballot item that deleted that illustration:

> *"In response to public comment 51a, the commentary is changed to remove references to hidden pilasters.* ***Note that this does not preclude the construction shown in Figure 2.1-5(c)****. Rather it just removes the problem with the conflict pointed out in the public comment relative to the compression width of the bar. This ballot item does not address adding a definition of pilasters to Section 1.6 (public comments 51a and 69). This non-life safety issue will be taken up as new business in the 2013 cycle."*

So, the response to those engineers who still want to design "Flush Pilasters" would be …

> You may call the strengthened portions of walls whatever you'd like; however, since the Pilaster provisions in the code are applicable to a member that doesn't have a Flush geometric profile, those members are not Pilasters within the language of TMS 402/602.

But, as was noted in the rationale of the ballot item quoted above, just because they are not technically "Pilasters" within the definition of TMS 402/602 does not, in any way, mean that they cannot be designed and constructed in accordance with this code. It must be clearly understood that those elements always could be and still can be designed and constructed in accordance with the code provisions.

Design Example

Take, for instance, the common occurrence of what might be termed "Flush Pilasters" in sound wall systems that are built along many roadways. To be technically accurate, call these Strengthened Sections. Typical construction might be a 12-inch thick CMU, with Strengthened Sections occurring between 12 feet and 24 feet apart. The Strengthened Section is likely16 inches wide, with reinforcing on each face (to get a maximum "d") and cantilevers from a concrete pier or grade beam. The portion of wall between these Strengthened Sections is supported vertically continuously, but spans horizontally between the Strengthened Sections to resist out-of-plane loads.

Below is one possible way to design these elements using the Allowable Stress Design Provisions. This solution utilizes a method found in the *Reinforced Masonry Engineering Handbook* published by MIA (The Masonry Institute of America). It is called the Universal Elastic Flexural Design Technique.

Given:

- Wind Pressure per ASCE 7-10 = 30 psf, Load Combination is 0.6W + D
- Construction: 12-inch CMU, 12 feet high, with 16-inch wide Strengthened Sections spaced every 12 feet.
- f'_m = 2000 psi, Medium Weight Block, and Grade 60 reinforcing, so F_s = 32000 psi
- Use bars each face, so "d" = 9 inches
- The modular ratio n = 29,000,000 / E_m = 16.1.

The Design Loads on the Strengthened Section for this load combination are:

- Dead Load (self weight of element only) = 165 plf x 12 feet = 2000 pounds
- Wind Load = 18 psf x 12-foot spacing = 216 plf

The design moment on the section is 216 x 12^2 / 2, or 15,550 lb-ft (187,000 lb-in). (Note: some engineers may wish to reduce this moment by the resisting moment provided by the dead load of the element. By choosing not to, the author is perhaps a bit conservative)

The allowable F_b in the masonry due to flexure is 0.45* f'_m, or 900 psi. This must be reduced by the axial compression stress due to the weight of the element, which is 11 psi. So, use F_b = 900 – 11 = 889 psi for flexural design (see code section 8.3.4.2.2).

The next question is this – What should be used for "b", the width of the compression flange? There are a few options. For illustration we will check it three different ways:

First, assume b = 16 inches, the width of the element. This is the minimum value that could be used. With b = 16 inches, 2/kj = 6.16 and npj = 0.0726. The masonry stress controls the design, with a corresponding np = 0.109. So, p = A_s/bd = 0.0067, and the required A_s = 0.97 square inches of steel.

Now, check it with b = 72 inches, the maximum value allowed in section 5.1.2. For this condition, 2/kj = 27.7 and npj = 0.016. Now steel stress controls the design, with np = 0.017. Thus, p = 0.00106, and A_s = 0.68 square inches of steel.

So, if we were very conservative we could use b = 16 inches. Masonry stress would control the design, and we would use (1) #9 or (2) #7 bars, each face. By not utilizing a larger b, I am not being as efficient with the steel.

If we use b = 72 inches, we are using the maximum b allowed in section 5.1.2. Steel stress governs the design, so the steel is being used to full efficiency. We would use (1) #8 or (2) #6 bars, each face.

Finally, if we use b = 20 inches, which is just 2 inches each side of the section, then np = 0.064, and A_s = 0.72 square inches. This is essentially the same answer as using b = 72 inches. The reason for this is that at b = 20 inches, steel stress now governs the design. Once this happens, using a larger value for "b" makes very little difference in the answer.

Some engineers might argue that if we use (2) bars in this "Strengthened Section", then section 5.1.2 would technically limit b to 16 inches (8 inches per bar), based on the "center-to-center bar spacing" requirement. The author would argue that, since we could have used just one bar and only used two bars because it makes construction simpler, we should be allowed to assume that, for this situation, the "center-to-center bar spacing" should be considered as the spacing of the Strengthened Sections. This is a case where engineering judgment must be allowed to be exercised.

In either case, the wall would then be designed to span horizontally between these elements, probably with (2) horizontal bars in bond beams at 48 inches on-center.

Whatever you want to call these, this construction always has been and continues to be allowed. These elements could also be designed using other design methodologies, based either on Allowable Stress Design or on Strength Design. Results would be similar, if not identical.

Prescriptive Provisions

Beyond section 5.4, the only other significant provisions related to pilaster design are found in 7.4.3.2.5., where additional requirements are imposed if the pilaster is supporting a discontinuous stiff element. Note that ties are required in pilasters only if: 1) the pilaster is supporting a discontinuous element as noted in 7.4.3.2.5, or if 2) the designer is relying on the steel to support compression loads (in which case the element essentially becomes a column), or if 3) the shear stress is so high that ties are needed to resist shear (which is theoretically possible but nearly impossible in practice).

There is a caveat to this entire discussion. It applies to pilasters and strengthened sections of walls in reinforced masonry walls that are laterally supported at floors and/or a roof. Regardless of whether or not such "pilasters" are projecting or are flush, the design engineer should recognize that the provisions of ASCE 7 section 12.11.2.2.7 must apply. In other words, although ASCE 7 does not include a definition for pilaster, common sense indicates that for reinforced masonry, whether or not the strengthened section is projecting from the face of the wall, it is, for the purposes of this section of ASCE 7, a pilaster.

It is possible that in the next edition of TMS 402/602, (anticipated to be the 2016 edition), additional definition will be given to clarify what a pilaster is and what it is not. If so, this will be simply a clarification, so that engineers do not have to wade through the provisions in order to determine if what they are designing is a "Pilaster". It will not change the fact that strengthened sections of reinforced walls can still be designed and constructed, no matter what they are called.

Finally, the next time you are trying to determine the limit on how much reinforcing you can put into that masonry wall you are designing, remember that ρ_{max} has a very different meaning to you than it does to a spectator at the Harvard-Yale Regatta.▪

Although Mr. Pierson is affiliated with TMS because of his position on the TMS 402/602 committee, this article represents only his opinions. This should not be construed as an official position statement from TMS.