Do Relieving Angles Really Relieve?

By Brian E. Trimble, P.E., LEED AP

I have presented a lot of seminars over the years to both engineers and architects about masonry. A beef of mine for a long time has been the misuse of the term "relieving angles" – those steel angles that are used to support brickwork at floor levels. I think that they are more appropriately called shelf angles. While you may think this is the same kind of semantic issue as concrete mixers vs. cement mixers, I think that it has confused a whole generation of designers.

Looking at their purpose in a structure will help us to understand more clearly what we are talking about. In multi-story buildings that are clad in brick veneer, an angle is often placed at the floor level to support the brickwork. Why is this angle supporting the brickwork? Can it not withstand its own weight? Does it need to relieve the weight of all the brick above it? Actually, the steel angle is put in place to create a horizontal break in the brick veneer so that the expansion of the brick can take place, as well as any shrinkage of the structural frame. A space is needed above the brick since it permanently expands over time. A steel angle placed in the wall cannot just sit on the brick below – that would defeat the purpose – so it must be bolted to the structure instead. These shelf angles do not "relieve" the weight of the brick – they actually just create a gap, so "relieving angles" is really the wrong term. While you could say that they relieve stresses in the brickwork that could otherwise build up, the brickwork really should not be receiving any stresses unless your horizontal expansion joint is not working properly.

I worry that young designers are being misled by the term "relieving angle" into thinking that these shelf angles somehow "relieve" extra weight from the brickwork. Did you know that you could build a brick wall almost 1,000 feet high before it would ever crush under its own weight? In an old book, I found a statement that works it out: "If we assume that the weight of brickwork is 120 pounds per cubic foot, and that it would commence to crush under 700 pounds per square inch, then a wall of uniform thickness would have to be 840 ft high before the bottom courses would commence to crush from the weight of the brickwork above." Of course, this does not take into account any lateral forces, but you can see that it is not a problem to stack a considerable amount of brick.

It is also important to differentiate between shelf angles and steel lintels above windows. Loose lintels bear on either side of the opening and are not bolted to the structure at all. Shelf angles, on the other hand, are bolted to the structure. You cannot use a loose lintel where a shelf angle is required. When we start talking about placement of vertical brick expansion joints, whether the angle is a loose lintel or a shelf angle will dictate how the area surrounding the bearing point is detailed.

Design Requirements

The design of shelf angles and loose lintels is covered in Brick Industry Association (BIA) Technical Notes 18A and 31B, respectively (**www.gobrick.com**). Requirements for these elements are also discussed in Chapter 6 of TMS 402/ACI 530/ASCE 5, *Building Code Requirements for Masonry Structures*. In Section 6.2.2.3, height limits are given for various backing systems. For steel stud backing, the maximum height before a shelf angle is needed is 30 feet from the foundation, or 38 feet if measuring to the top of a gable. There are no maximum height requirements when a concrete or concrete block backing is used. Model building codes can require additional limits based upon seismic issues. Therefore, consideration should be given to placing a shelf angle at the same locations as other backings unless analysis shows that it is not necessary.

The reason for this height limit is empirical. It is at this height that the accumulated movement can become great enough to cause concern. If you use a rule of thumb of 1 inch of expansion for each 100 feet of brickwork then, at 30 feet, the approximate growth of the brick is ⅓-inch. At these heights, brick anchors (ties) will have to be flexible enough to allow this amount of movement without disengaging. In addition, openings through the brick veneer and at the top of the wall must be designed to allow this movement to occur without putting stress on the brickwork. Certainly, brick veneer walls taller than 30 feet have been built without shelf angles, but a thorough analysis of movement of all wall elements is necessary to justify this.

Typical Shelf Angle in Brick Veneer Construction.

On multi-story buildings, it is very typical to place horizontal expansion joints (shelf angles) at every floor. This placement keeps the size of the horizontal expansion joint relatively small. Placing the horizontal expansion joint at every other floor can be done, as is often the case in high-rise construction to save money, but the size of the joint has to match the anticipated movements. For brick veneer and steel stud wall assemblies, BIA recommends that shelf angles be placed at every floor above 30 feet. This allows the brick above this level to span from floor to floor just like the steel stud, resulting in similar deflection patterns for both elements.

Various papers and design guides (*see references in online version*) provide information on the structural design of steel shelf angles. Two things to keep in mind are proper bearing of the brick on the steel angle, and providing enough space beneath the angle to take into account deflection or rotation of the steel angle, brick expansion, sealant compressibility, and tolerances. Proper bearing for brick veneer is always at least ⅔ the thickness of the brick. Many bricks made today are 3⅝ inches deep, although many other depths are available, so the maximum overhang in such cases is 1.21 inches. *Table 1* provides lengths of the horizontal leg depending on brick thickness and cavity width for a steel shelf angle.

BIA's details on horizontal expansion joints and shelf angles are found in Technical Notes 18 and 18A, and call for a

Table 1: Required Length of Horizontal Leg of Steel Angle, in.

Specified Brick Thickness, in.	Cavity Width, in.		
	2	3	4
3	4.00	5.00	6.00
3.5	4.33	5.33	6.33
3.625*	4.42	5.42	6.42
3.75	4.50	5.50	6.50

* most typical brick thickness used in commercial construction

minimum gap of ¼-inch below the angle (*Figure 1*). The gap should be larger if an analysis indicates greater movement or structure deflection.

Constructability Issues

Tolerances for concrete or steel frames to which shelf angles are attached can have an impact on design. Problems are often seen in the field when the steel structure meets the AISC tolerances, yet these may not come close to the tolerances required for masonry, which is a finish material. Design of the supporting elements should include provisions for adjustability. This could include the ability to move the slab edge in or out, the ability to change the location of the backing wall, or the use of slotted connections. Bolted connections provide for more adjustability than welded connections to deal with these tolerances. The designer should also call out any limitations on shimming that the masonry contractor may use in the field.

When designing shelf angles, consideration should be given to the horizontal location on the structure. Placing shelf angles at the level of the slab edge or spandrel beam is typically the most economical. If the desire is to place the shelf angle at the top of a window head, then hangers will be needed to pick up the weight of the veneer. The longer the hanger system, the more costly it will become.

Designers can develop just about any structural design to meet the requirements of the loading conditions. However, other items must be taken into account. These include placement of thermal, air and moisture barriers within the wall system and around structural supports. In addition, the sealant joint in front of the angle can become quite large based on the expected amount of movement. As is often mentioned, good communication between all design professionals, and between the design professionals and the contractors, is necessary to avoid issues that could otherwise slip through the cracks. Solutions are available for most of the typical conditions seen in the field, but thoughtful design can go a long way toward making possible the most efficient structure.

Conclusion

Shelf angles, often referred to incorrectly as "relieving angles", are used to create horizontal expansion joints. The movement (expansion) of the brick veneer, as well as the shrinkage of the frame, requires that some type of accommodation be made. Shelf angles are most often found at each floor of a multi-story structure, although for structures less than 30 feet tall, they can usually be avoided. Size and location of shelf angles is dictated not only by loading, but also by such things as tolerances and the desire to make the building economical.▪

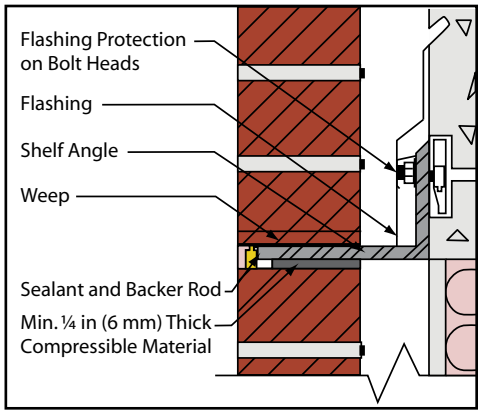

Figure 1: Typical Shelf Angle Detail. Courtesy of Brick Industry Association.

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