Design and Detailing of Masonry Veneer Lintels

Scott W. Walkowicz[i] and W. Mark McGinley[ii]

Abstract

Masonry veneer lintel design and detailing continues to be challenging for designers. Methods to economize loose lintel design have been previously studied and published but these methods have not been widely implemented. In addition, increasing cavity widths have created varying design solutions for masonry veneer openings and the design assumptions that designers must make regarding system behavior. Lintel designs may include heavy bolted angles or plated beam lintels that often lead to expensive detailing for both the lintel capacity requirements and cavity closures. This paper discusses how these systems typically behave and the range of design options that include reinforced and unreinforced brick veneer lintels. Detailed discussion of how to implement these system designs will be presented. Also presented will be options for providing cavity closure for commercial and residential window/door/louver assemblies when using veneer beam lintels.

Keywords
Veneer, loose lintel, brick lintel, reinforced, unreinforced, wide-cavity, cavity closure.

[i] Owner, Walkowicz Consulting Engineers, LLC, East Lansing, MI, USA, scott@walkowiczce.com
[ii] Professor and Endowed Chair for Infrastructure Research, Civil and Environmental Engineering, University of Louisville, KY, USA, m.mcginley@louisville.edu

INTRODUCTION

Masonry cavity wall construction (brick veneer and concrete block or other backup systems, with a purposeful cavity between them) has been commonly used since the 1970's and changes in design and detailing of this wall system continue to this day. Industry organizations such as the International Masonry Institute, the Concrete Masonry and Hardscapes Association and the Brick Industries Association all produce and update design guides and technical notes including several for veneer and lintel design and detailing [1][2][3]. Among the design and detailing aspects considered, is the support of the masonry veneer over openings and the envelope assembly. Common conditions include discrete, or 'punched', openings and continuous, or 'ribbon' openings. The openings are commonly required for windows while other functional features, such as louvers, may create similar demands for design and detailing.

This paper focuses on discrete wall openings and the requirements associated with their design and detailing. Continuous wall openings require different solutions and are not considered in this paper. Primary concerns for veneer lintel design and detailing over openings are the structural support of the veneer over the opening, the potential influence of that veneer support (and the resulting loading) on veneer adjacent to the lintel and/or the backing system, and the thermal and moisture management of the assembly above the opening.

Historical and current solutions utilize 'loose' steel angle lintels for small openings, generally limited to openings in the range of 1.2 m (4 ft), to as much as 1.8 m (6 ft). Openings wider than 1.8 m (6 ft) typically cannot rely on loose steel angle lintels due load eccentricity and poor torsional performance of common angles[1][1]. Wider openings, typically require a veneer support system that is bolted to the backing system or a more substantial structural lintel assembly, such as fabricated composite steel wide-flange beams, or hollow structural tubes, with plates and angles.

Conventional detailing for discrete openings in masonry walls where the veneer is supported by loose steel angle lintels, requires both moisture management, in the form of flashing and end dams, as well as thermal transmission management, typically through employing thermal breaks. Furthermore, designs for the evermore stringent energy codes [6] have led many designers to significantly increase in-cavity insulation, resulting in very wide cavities that contribute to challenges in providing cavity closure at the lintel. Even though this additional insulation is of questionable effectiveness [7][8][9], backing system design and the incorporation of window systems can lead to challenges in detailing for cavity closure and moisture management.

Clear understanding of veneer behavior, when designing the vertical support, can result in much more effective and economical designs [10] and innovative detailing solutions. Studies have shown that these free angles act mostly as temporary support of the veneer and, when combined with veneer joint reinforcement, can provide the required structural support while eliminating torsional and end restraint design. This approach also does not require a lintel system that engages the backing system, inducing torsion on the structural lintel. These aspects of structural behavior provide great flexibility in designing and detailing for moisture and thermal management in the wall at the lintel location.

SUMMARY OF HISTORICAL AND CURRENT VENEER LINTEL DESIGN

Typical Design and Detailing

Wall assemblies with solid backing systems, such as masonry and concrete, typically include commercial glazing systems that bridge between the veneer and backing, creating cavity closure, while including thermal breaks. Fig. 1 shows a typical punched opening detail with a loose steel angle lintel in the veneer and a structural CMU lintel over the backing wall opening along with a commercial style frame that bridges the cavity. Fig. 2 shows a similar condition, with a commercial style frame that is set back into a wood light-framed opening and uses break-formed metal for cavity closure. Wider cavities can create a closure issue when window frames can no longer bridge the cavity due to limits of frame widths and anchoring requirements. Architectural closure for such wide-cavity conditions has historically been detailed with break-formed metal with other designers using blocking as trim to 'picture frame' the opening and push the frame out closer to the back of the veneer.

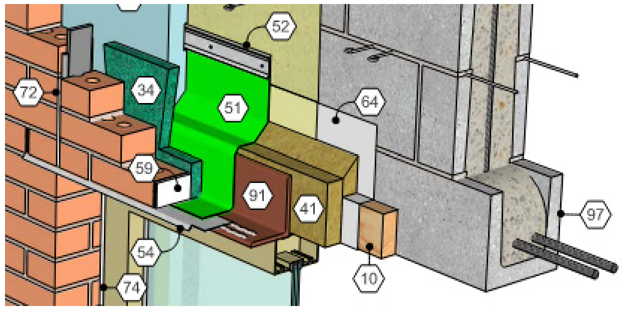

Figure 1: Loose Steel Angle Veneer Lintel (Figure Credit International Masonry Institute)

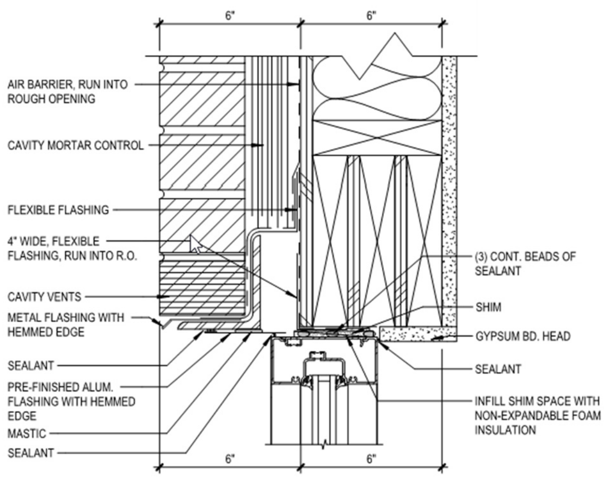

Figure 2: Loose Steel Angle Veneer Lintel in Wood Light-Framed Construction (Figure Credit ProgressiveAE)

When the opening gets wider, the steel angle is typically bolted to the structural lintel in the backing wall, and larger angles or bent steel plates are commonly used. Fig. 3 shows a typical punched opening, in a CMU wall with a structural CMU lintel, with a bolted steel veneer lintel. The bolted angle concept is commonly applied to wider openings which also result in structural CMU lintels using larger single bars or, as shown here, modest double bars with the depth selected to avoid the need for shear reinforcement (stirrups). Greater cavity widths require thicker angles and increase the torsion applied to the structural lintel while increasing the tension force in the fasteners that anchor the veneer lintel to the structural lintel. The structural lintel must be designed for bending (in and out-of-plane) and torsional loading. This can require the structural lintel design to utilize more significant masonry sections, or to use more substantial concrete or steel members. It should be noted that the current US masonry code does not address torsional loading and often results in engineers utilizing other structural systems for the lintel assembly, or to apply modified provisions from concrete for the design of torsionally loaded masonry structural lintels. A system that eliminates the eccentric veneer loading on the structural lintel assembly can greatly simplify the design and detailing process.

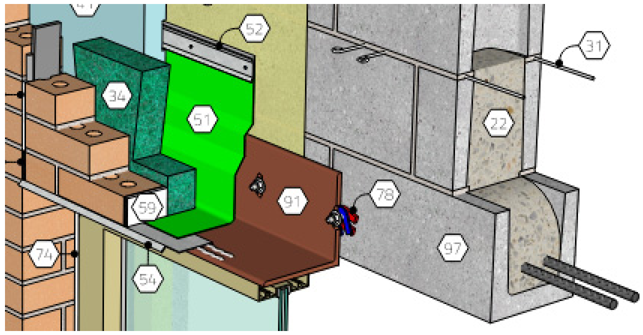

Figure 3: Bolted Steel Angle Lintel (Figure Credit International Masonry Institute)

Steel beams are also used as the structural lintel in the backing wall and carry backing wall loads over the opening, as well as the veneer loads. Fig. 4 shows a typical punched opening with a plated steel beam lintel. Note that structural steel beam lintel design should, also, consider proper end restraint for torsion due to the eccentric veneer loading along with in-plane release for differential thermal movement (slotted and bolted connections) and include discontinuities that allow thermal breaks. Greater cavity widths require thicker plates, larger beams and increase the torsion applied to structural lintel. Hollow structural steel tube lintels have been used to better address all facets of demand under these conditions.

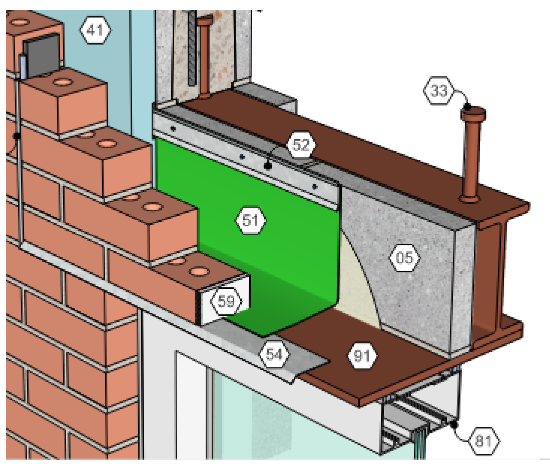

Figure 4: Plated Steel Beam Lintel (Figure Credit International Masonry Institute)

Light frame construction often includes flanged window frames that mount flush to the backing face (face of sheathing) and require cavity closure as part of, or in addition to, the veneer lintel. Fig. 5 shows a window head detail that incorporates the flange mounting to a sheathed, light frame wall system. The green, highlighted flange mounts flush to the sheathing face and, for this assembly, the frame extends 3.18 cm (1.25 in) beyond the flange face which may require additional closure detailing. Fig. 6 shows a similar condition with a flange style frame, set into wood light-frame construction, that does not include a frame extension while incorporating a break-formed metal cavity closure. Frame designs may, or may not, include frame extensions and frame extensions may vary by manufacturer or model line. Greater secondary closure requirements may exist with smaller frame extensions or when there is no frame extension.

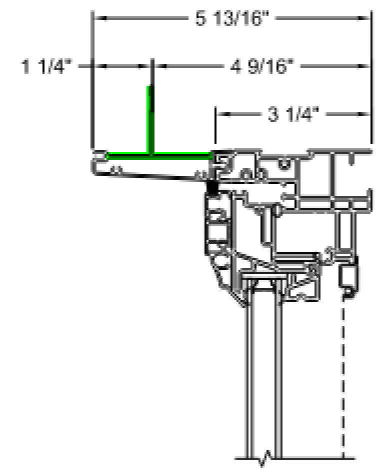

Figure 5: Flanged Window Head Detail for Light-Framed Construction (Figure Credit Jeld-Wen)

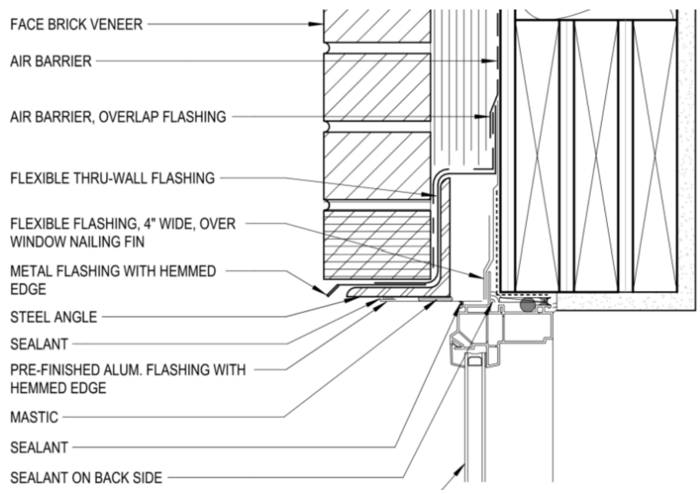

Figure 6: Flanged Window Head Detail for Light-Framed Construction (Figure Credit ProgresiveAE)

Because of the need for cavity closure, architects often prefer angle lintels to be mounted flush to the backing wall face so that the frame overlaps with the heel of the angle lintel or mounts in-plane and allows for simple sealant detailing. An outboard angle lintel location, combined with larger cavity and masonry veneer widths, requires wider horizontal angle legs to keep the angle flush with the backing wall face while still sufficiently supporting the veneer. This larger leg length increases weight eccentricity and drives the leg thickness up to resist flexural and torsional loading. Engineers, because of the eccentricity and torsional demands, typically prefer the angle to be located outboard – as close to the back of the brick as possible. Final design for envelope performance and appearance, including the need for closure, often leads to the lintel angles being located against the backing while their size and thickness increase significantly and often lead to angles bolted to the backing wall. Bolted angles, and their connections, can be very challenging when working with light-frame construction of wood or steel. A system that eliminates the eccentric veneer loading on the angle can result in smaller, thinner angles (saving weight and saving cost) and avoid the use of angles bolted to the backing wall.

Limits of Historical Design and Detailing

Loose angle lintels incorporated in the veneer are usually limited to small, or modest openings. Limits of up to 1.8 m (6.0 ft) are common, while some firms limit loose lintels to 1.2 m (4.0 ft). Common lintel angle sizes are L10x10 (L4x4) or L10x15 (L4x6) LLV when used in narrow cavities or when located at back face of the brick in wider cavities. In addition, McGinley, et – al, [10] showed that lintel spans for low to modest heights of veneer using loose steel angle lintels work well assuming simple support conditions, although some end restraint was observed during field testing, and this could be implemented for longer spans. That investigation also noted that torsional loading, due to the veneer weight loading on the angle being eccentric to its shear center near the angle heel, limited the spanning capacity of the angles and these effects must be carried by the veneer and backing system. McGinley [4][5], also, noted that simple steel angle beam models, do not consider the torsion induced in the angle and are not sufficient for design. Poor angle torsional behavior allows significant outward rotation of the angle and greatly reduces acceptable lintel spans. Placement of angles deeper into wider cavities, and longer loose angle lintel spans, create greater torsional demand on the loose angle lintels and require thicker angles and/or plated steel structural lintels. Greater thickness, of angles and plates, can require custom detailing such as lipped masonry units to hide the steel section and to reduce joint widths at the lintel bearing. These challenges have led to the desire for better veneer lintel systems and design methods.

Proposed Solution for Loose Lintel Design and Detailing

Given the limits for loose steel lintel angles supporting masonry veneer over openings described previously, a better approach is required. As described by McGinley et-al, [10] rather than using larger and thicker angles, or plated steel beam lintels, a combination of loose angles over openings with idealizing the veneer as a brick beam has been shown to be an effective alternative. This type of veneer support has been codified in US residential building codes [11], and used effectively for several decades. The brick beam above the angle can be developed as an unreinforced beam, or reinforced using joint reinforcement, to resist bending in the plane of the wall [10]. The resulting veneer beam can support the veneer weight over quite large openings, once the masonry has cured. Furthermore, sections other than angles, such as WT's, may be used as loose steel veneer lintels in place of the angle sections. In this type of lintel design, the loose steel veneer lintel simply acts as a temporary form and provides protection and partial closure for the veneer above the opening. As a temporary form, the loose steel veneer lintel may be shored for the construction of the brick veneer over the opening until the veneer is strong enough to support its own weight. The use and placement of the shoring would be dependent on the lintel span and the initial height of veneer to be constructed. Following curing, the shoring may be removed with negligible deflection. Reshoring may be installed, if needed, for construction of additional veneer over the veneer lintel beam. This form of veneer support resolves the structural concerns with using a bolted angle or a heavy lintel plate connected to a structural lintel, or a very heavy angle or other eccentric section, as well as any thermal bridging of the cavity. Fig. 7 shows a detail developed to illustrate both the reinforced veneer lintel and one approach cavity and closure detailing. The highlighted veneer section, over the loose lintel can be the 'veneer lintel' and the depth would be selected based on demand, detailing preferences, or construction sequencing expectations. The joint reinforcement may be hot dipped galvanized, or stainless steel as noted in this detail.

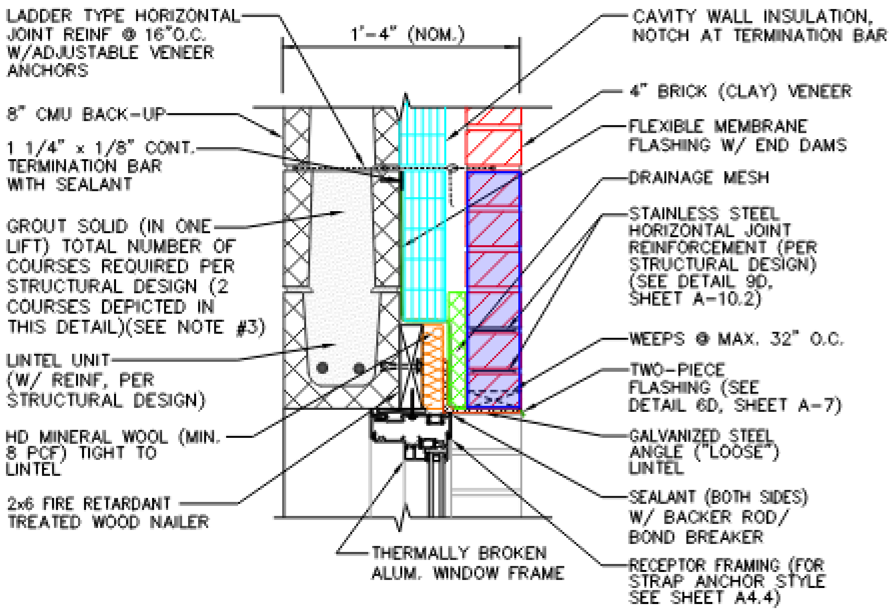

Figure 7: Reinforced Veneer Beam with CMU Backing (Figure Credit: Masonry Institute of Michigan)

Related to the challenges of veneer lintel design is the seemingly ever-increasing thickness of wall cavity insulation. It is important to consider limiting cavity insulation, and the resulting cavity widths, to reasonable dimensions. Analysis has shown that using greater than 5 cm (2 in) or 8 cm (3 in) of cavity insulation is an inefficient investment for improving thermal performance [7][8][9]. Furthermore, by limiting the cavity width, commercial glazing systems can typically span the cavity and provide thermal breaks and cavity closure with modest frame depth dimensions.

VENEER LINTEL DESIGN

Reinforced Veneer Lintel Design

A good alternative veneer lintel design approach to any veneer opening, is to provide a reinforced or unreinforced masonry veneer beam designed to span over the opening, with a loose steel veneer lintel providing temporary support (with shoring if needed) and cavity closure. This approach will provide sufficient capacity to carry the weight of the veneer, without introducing torsion into the loose steel veneer lintel, or requiring veneer anchorage design to transfer the torsion-inducing eccentric loading to the backing system. The loose angle can be designed to carry the veneer as it cures (with shores as needed). Once the veneer is cured sufficiently (consider 40-percent or 50-percent compressive strength), the veneer will carry its concentrically applied self-weight as a beam. An alternative would be to leave the shoring in place until after the full veneer height is constructed and to utilize the full section for even greater capacity. After curing, the angle, serves as a closure system for the cavity and provides a clean bottom to the veneer along with a surface to flash to and to fasten cavity closure elements to. Wider cavities may require supplemental trim elements for cavity closure.

Note that the US masonry code [12] requires prescriptive, distributed horizontal and vertical reinforcement for simple span beams whose effective span-to-depth ratio is less than 2. To avoid these, or similar, deep beam prescriptive requirements, veneer depths that are less than one-half of the effective span, the veneer beam element can be designed for the additional veneer weight from any veneer above one-half the span length above the beam section. As an alternative, the masonry veneer can be designed as a tied-arch when the effective span-to-depth ratio is less than 2. In this design approach, deep sections can often be shown to be adequate with minimal horizontal reinforcement placed near the section bottom to form the arch tie. This tie is often able to resist the low arch thrust forces while developing compression struts. The horizontal reinforcement in the tied-arch design should be extended past the arch supports to fully develop the reinforcing, on both sides.

Veneer beam lintels can use the commonly installed clay brick veneer units to carry load. Clay brick units are usually much stronger than the concrete masonry units (CMU's) with unit compression strengths approaching 140 MPa (20 ksi). These unit strengths, when combined with common veneer mortar (Type N in the USA), can provide masonry assembly strengths of 28 MPa (4 ksi). Two-wire joint reinforcement can be used for veneer beam reinforcement. Joint reinforcement wire typically has yield strengths of 480 MPa (70 ksi) to 620 MPa (90 ksi), providing an allowable tensile stress of 207 MPa (30 ksi) [12]. The higher strength of both the veneer units and the joint reinforcement results in an efficient section design for the veneer beam lintel. Note that joint reinforcement is commonly available in 3.25 m (10.67 ft) lengths, and that laps in the reinforcement will be required for openings wider than 3.0 m (10 ft).

McGinley, et al, [10] includes design solutions for various reinforced veneer (brick) beams. That study showed that a 0.30 m (12 in) height of veneer acting as a beam with one layer of 3.76 mm (9 GA / 0.017 in) double-wire joint reinforcement was capable of spanning 3.68 m (12.06 ft), while the same brick section with two layers of reinforcement can span up to 4.31 m (14.14 ft). For larger heights of brick veneer, a 1.52 m (5.00 ft) height of veneer with one layer of 3.76 mm (9 GA / 0.017 in) double-wire joint reinforcement was shown to be capable of spanning 4.18 m (13.70 ft) while the same section with two layers of reinforcement can span 5.72 m (18.75 ft). Designs of masonry veneers with heights of up to 9.14 m (30 ft) can span up to 5.02 m (16.47 ft). Note that these designs assume that the veneer is solid over the full height and shorter span lengths will allow for greater veneer heights to be supported. Furthermore, the designs assumed that there are no openings in the veneer beams, and that their sections are full height at the supports.

Unreinforced Veneer Lintel Design

For smaller openings, reinforcement may not be required for the veneer over an angle. This approach is similar to the reinforced veneer lintel, discussed above. It still uses a uses an angle for support of the masonry veneer as it is being laid while incorporating unreinforced masonry design methodology for the veneer lintel design. Once cured, the veneer above the opening is designed to limit the net flexural stresses in the masonry. Although there is no flexural tensile stress limit in the US code [12] for this stress direction, it is expected that these strengths are well above the listed values for stress normal to bend joints for unreinforced masonry. Very conservative limits of 34 kPa (5.0 psi) or 103 kPa (15 psi) had been proposed [10] as target levels for allowable flexural tensile stress (Allowable Stress Design) limits under the TMS 402 Code [12] while similar values could be developed for modulus of rupture limits (Strength Design). Veneer lintel capacity will be lower for the unreinforced veneer lintels, when compared to reinforced veneer beam lintels, and designers should expect lesser spans or greater depths when using this approach. McGinley, et al, [10] also included design solutions for various unreinforced veneer (brick) beams. A 0.30 m (12 in) height of veneer was shown to span up to 0.82 m (2.69 ft) or 1.42 m (4.66 ft) for 34 kPa (5.0 psi) and 103 kPa (15 psi) stress limits. Similarly, 0.91 m (3.0 ft) height of veneer had respective spans of 1.42 m (4.66 ft) and 2.46 m (8.08 ft) while a 1.52 m (5.0 ft) height of veneer was shown to span up to 1.84 m (6.02 ft) and 3.17 m (10.4 ft), respectively. Greater veneer heights, up to 9.14 m (30.0 ft) generated even greater allowable spans – up to 4.50 m (14.75 ft) and 7.77 m (25.5 ft), respectively.

It is important to note that masonry beams are required to be reinforced by the US code [12]. However, these provisions were developed to address load bearing conditions and are very conservative for veneers where only the self-weight of the veneer is being supported. Like other unreinforced masonry designs, we can limit the net flexural tensile stresses in the masonry to preclude cracking and provide safe designs. Furthermore, if the unreinforced masonry beam does crack, the presence of the angle will preclude collapse of veneer.

Steel Section Considerations and Design

When using reinforced, or unreinforced veneer lintels, as described above, loose steel veneer lintels need only to act as a form for the masonry as it is laid and reaches its design strength. Shoring is provided until the masonry is sufficiently cured to be able to carry its self-weight. Shoring is commonly provided by vertical dimensional lumber placed at broad spacings, often 1.2 m (4.0 ft) to 2.4 m (8.0 ft) on center, as required by analysis or by construction sequence and angle rotations. The loose steel veneer lintel should be sized for its self-weight plus the weight of the masonry to be erected prior to curing of the veneer lintel beam, and for the span conditions over shore supports, as discussed below.

When selecting loose steel veneer lintels, items for consideration include:

- The width of the horizontal segment of the section must provide sufficient width of support for the veneer, and to provide part or all the desired cavity closure.
- The thickness of the horizontal and vertical segments of the angles must have sufficient strength to carry its self-weight while fitting within the vertical and horizontal space for the lintel assembly.
- The location of the vertical leg relative to the width of the horizontal segment will impact the size and thickness of the steel angle.

Angles are the most common section used for loose steel veneer lintels. These shapes are commonly available in many sizes and thicknesses. In conventional loose steel veneer lintel design, it is ideal to keep the horizontal leg short, so that the vertical leg (and centroid) is as close to the veneer center as possible, and the angle thickness is minimized. When this practice is followed, the cavity may be left mostly open and will require a secondary closure. As an alternative, the designer can hold the angle back at, or very near to, the face of the backing wall. When this alternative is employed, the angle can provide cavity closure, however traditional design methods would require much greater angle thicknesses because the angle is required to carry all the eccentric veneer weight. Thicker angles weigh more, and thereby, increases cost. They also can create complication with regard to flashing detailing and joint thickness. As an alternative to angles, bent plates can provide greater flexibility in leg dimensions. They can be sized for specific veneer and cavity dimensions with their thickness based on detail dimensional and capacity requirements.

Another alternative would be WT sections. They are not as readily available as angle sections but often are available with less time and expense than custom fabricated shapes. They have the advantage of offering flange widths that can provide support and bottom coverage for the veneer while keeping the stem (web) closer to the back of the brick and still offering closure to the cavity by the back portion of the flange. WT, or similar shapes, can provide function similar to angles while potentially doubling the horizontal width without significantly increasing load eccentricity. WT flanges can be selected so that the outer flange provides the appropriate veneer bearing width and the inner flange can be used as-is or may be cut down to provide the required closure in narrower cavities. Conversely, the flange size could be selected such that the inner flange provides closure for cavities wider than the veneer thickness and the outer flange may be cut down to the proper width for veneer bearing.

The design of the loose steel veneer lintels can use plastic moment capacity to span between supports, including shores, under veneer weight for green masonry and for the full span of the opening under only their self-weight once the veneer is strong enough to be self supporting A simplified analysis can be conducted using only the capacity of the horizontal segment of the loose steel veneer lintel. Continuous beam behavior in the shored condition allows for the plate to carry the uncured veneer loads, with shoring locations and quantities selected to provide the desired capacity and deflection control. Simple span behavior should be used when analyzing the final conditions, unless partial fixity is considered in keeping with McGinley, et al, [10]. Similar checks can be conducted for other shapes while recognizing that symmetrical shapes can provide better capacity and deflection control for the final condition.

As an example, a loose steel veneer lintel with a flat bottom section measuring 10 cm (4.0 in) by 1.0 cm (0.38 in) where the 10 mm (0.38 in) thickness is selected to match the nominal mortar joint thickness within the veneer. Typical steel angles would have a yield strength of 248 MPa (36 ksi). The section's design moment would then be 515 Nm (4560 lb-in) and can be compared to various span and load conditions. For the shored condition, with continuous beam behavior, the limiting, negative moment can be found as $w*l^2/12$, and the moment limited spacing can be calculated as 2.3 m (7.58 ft) while carrying approximately 0.61 m (2.0 ft) of common brick veneer at 120 kg/m (80 plf). Partial fixity would likely not be developed during the shoring stage and end span moments would vary by fixity and may be as large as $w*l^2/8$, resulting in a moment limited span of 1.9 m (6.17 ft), when using the same loading. For the angle self-weight condition over the full opening span, the horizontal leg will control design while carrying its own weight with some end fixity present. The weight of the above noted flat section can be found to be 7.6 kg/m (5.1 plf) and the limiting simple span length can be found to be 7.4 m (24 ft). Deflections of the full angle section would require a much more sophisticated analysis, due to the low torsional resistance of the angle and this simplification is a conservative approximation.

Deflections of the angles are not considered a big issue as McGinley, et al, [10] noted only small deflections were observed for the lintel over a 4.9 m (16 ft) opening after partial masonry veneer construction and initial shoring removal. A 128 x 89 x 63 mm (5 x 3.5 x ¼ in) angle, with a 467 mm (18.5 in) deep veneer lintel beam constructed over it, was cured for 2.5 days and then the shores were removed. The loose steel veneer angle lintel developed only 0.600 mm (0.0235 in) of deflection, and the brick supported its own weight with no distress.

A great advantage of this simplified approach is that a wider angle section, possibly the full width from near the veneer face to the face of the backing wall, can be selected. The wider angle leg can then be placed with the vertical leg in contact, or very near to, the face of the backing wall to provide the desired architectural closure without the need for secondary closure installation such as break metal trim.

VENEER LINTEL DETAILING

Cavity Closure

Cavity closure is required to address the gap between the backing wall and the back of the veneer. The closure provides weather and pest protection for the cavity. Fig. 8 shows windows without, and with, secondary cavity closure at the head. Either the veneer lintel must provide the closure, or a secondary element must be added to cover and protect the bottom of the masonry units. Challenges related to secondary closure include fastening and sequencing of trades because the mason contractor will typically not install the secondary closure element, requiring an additional trade to install the closure later.

Figure 8: Residential Flanged Style Windows with Open Cavity and Cavity Closure (Figure Credits: ProgressiveAE)

Veneer Anchorage

Although the creation of a reinforced, or unreinforced, veneer beam lintel within the veneer over an opening adds a new function to the veneer, designers may still use traditional veneer anchorage schemes and components. Attention must be paid to the lowest veneer anchor location because they should clear the loose steel veneer lintel section as well as any flashing and flashing termination. Otherwise, the veneer anchorage should be detailed to penetrate only at the vertical leg of the flashing. The placement of anchors should also be coordinated to avoid placement in the same bed joints as the horizontal reinforcement in a reinforced veneer beam. The number of joint reinforcement courses used in a reinforced veneer lintel beam should be limited to two, or three, given the relatively large distance between bed joints and the rapidly decreasing effective depth of the tension-compression couple for a given section. Limiting the number of courses of reinforcement will, also, allow veneer anchors to be placed in reasonable proximity to the bottom of the masonry carried on the loose steel veneer lintel.

Veneer and Steel Section, Moisture and Thermal Management Detailing

The veneer detailing over the loose steel veneer lintel section is improved by allowing thinner steel sections to be used. Steel section thicknesses should be limited to between 6.4 mm (0.25 in) and 9.5 mm (0.38 in) to fit within standard mortar bed joint thicknesses. Use common flashing with a drip edge to hide the loose steel veneer lintel toe. Lipped brick, with the lip down over the toe of the steel section may still be desired based on aesthetics and/or fit within veneer bed joints at the bearing zones.

The combination of a masonry veneer beams and loose steel veneer lintels also allows for full continuity of insulation down to the cavity closure element. The cavity space may be conventionally detailed with continuous insulation or include partial wood blocking for fastening of frames and other components. The system creates a formal thermal break and eliminates direct thermal bridges found with bolted angles and lintel plates extended from structural steel lintels.

Summary, Conclusions and Recommendations

For design, detailing and construction, designing brick veneer to act as its own lintel has many advantages. The brick has sufficient strength and stiffness if designed properly, and the low torsional resistance of steel angles results in the brick wanting to carry its own weight anyway. Reinforced or unreinforced segments of masonry, working in conjunction with a loose steel veneer lintel, create easily calculatable elements that can span significant openings. Furthermore, architectural closure detailing is improved, with cost savings. The resulting assemblies eliminate the need for heavy steel angles or plates, that are often required when bolted angles or lintel plates and structural steel lintels are used.

For future work, conduct additional analytical and testing studies to further evaluate and present simplified methods for veneer beam and loose steel veneer lintel design.

ACKNOWLEDGEMENTS

The authors thank the designers at ProgressiveAE (Grand Rapids, MI, USA) for their inquiry that led to further consideration of veneer lintel options and for providing details and photos illustrating their challenges and past solutions. The authors, also, thank the International Masonry Institute for discussion and resourcing including their detailing series from which several details were used. Finally, the authors thank their industry peers for continued support, questioning and assisting in the development of better masonry design and detailing practices.

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