Online exclusive

Expanding Possibilities: Engineered Design of Masonry Veneer

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MASONRY VENEER IS a well-known and commonly used cladding system found in the built environment due to its aesthetic possibilities and durability. Historically, this "nonstructural" element has fallen under the architect's purview in the design process, but with increasing complexity in building performance and geometry, building enclosure consultants are frequently joining the design team for, or providing third-party design review of, masonry veneer construction.

When project demands require masonry to exceed the prescriptive design limitations, engineered design of masonry veneer is required. The 2022 edition of The Masonry Society's TMS 402/6021 includes engineered design methods, which allow for new design and construction possibilities for masonry veneer beyond prescriptive limitations.

A BRIEF USE AND CODE HISTORY OF MASONRY VENEER

ASTM International defines masonry as "the type of construction made of manufactured masonry units laid with mortar, grout, or other methods of joining,"[2] although colloquially, natural stone or "dimension stone" unit assemblies are regularly referred to as masonry veneer as well. Natural stone masonry structures, such as ancient Egyptian pyramids, have existed for millennia, so users of masonry as a building material have expectations that it will be durable. Subsequently, mass masonry structures used multiple layers, or wythes, of smaller masonry units to maintain the durability and aesthetics of the ancient structures with improved constructability. Nonetheless, mass masonry walls remained a labor-intensive construction method.

In modern construction, masonry veneer was the next evolution to decrease installation costs. The Masonry Society (TMS) defines masonry veneer as "a masonry wythe that provides the exterior finish of a wall system and transfers out-of-plane load directly to a backing but is not considered to add strength or stiffness to the wall system."[1]

Masonry veneer can be broken into two attachment categories: anchored veneer and adhered veneer. An anchored veneer assembly transfers out-of-plane load to the backing predominantly through veneer ties (Item 32 in **Fig. 1**).[3] An adhered masonry veneer assembly transfers out-of-plane load to the backing through either direct bond or mechanical fasteners and lath into the backing (Item 40 in **Fig. 2**).[4] Unlike mass masonry walls, masonry veneer typically contains a drainage cavity and associated accessory products to expel incidental water that penetrates the porous masonry units and mortar. The detailing to prevent bulk water infiltration and provide lateral attachment of the masonry veneer is critical to maintain the durability and safety of masonry cladding.

The code history for masonry veneer is relatively short, as summarized in **Table 1.** The masonry veneer standard referenced in the *2024 International Building Code*[5] is TMS 402/602-22.[1] As the numbering suggests, the document is split into two sections: the design code (TMS 402) and the construction specification (TMS 602). TMS 602 includes the minimum construction requirements that can be incorporated into design specifications and drawing notes by reference. TMS 402 includes the remaining design requirements that must be defined in either the design specifications or drawings to convey the intended masonry veneer design for a given project. To avoid misinterpretation of the design intent, TMS 402 cannot be incorporated into design documents by reference.

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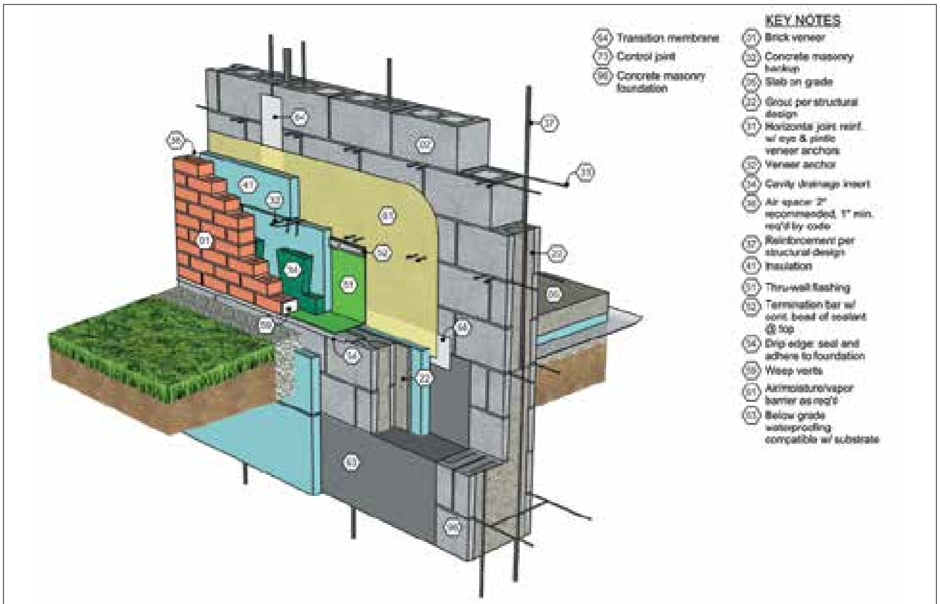

Figure 1. *Typical anchored brick veneer assembly at concrete masonry backing. Image reproduced from the International Masonry Institute (2019).*

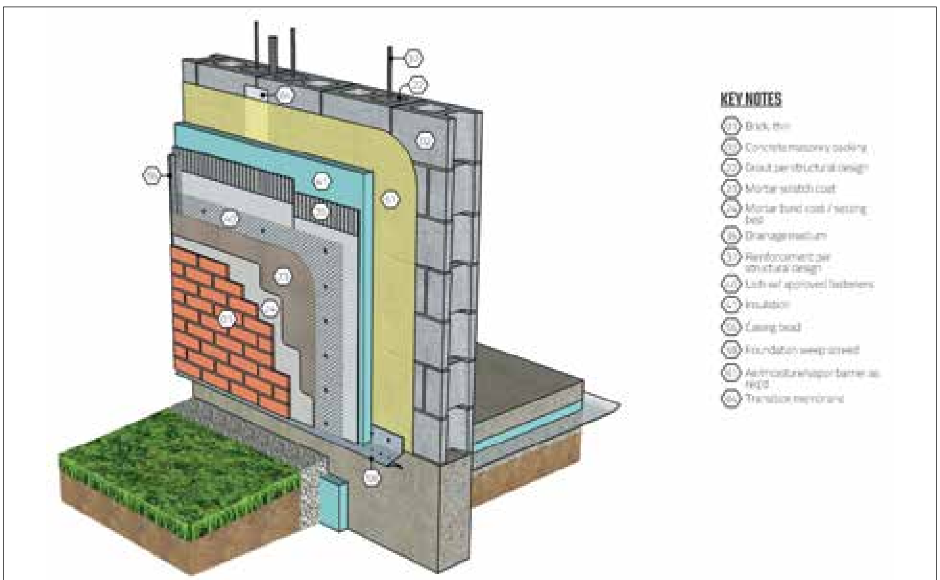

Figure 2. *Typical adhered brick veneer assembly at concrete masonry backing. Image reproduced from the International Masonry Institute (2020).*

TABLE 1. Summary of masonry reference titles.

Year	Masonry code reference	Masonry specification reference
Pre-1992	N/A*	N/A*
1992–2015	ACI 530/ASCE 5/TMS 402†	ACI 530.1/ASCE 6/TMS 602†
2016–present	TMS 402	TMS 602

* Prior to 1992, the only masonry veneer requirements were contained within the adopted model code of the jurisdiction.

† From 1992 to 2013, the Masonry Standards Joint Committee (MSJC), consisting of the American Concrete Institute (ACI), the American Society of Civil Engineers (ASCE), and TMS, developed and published the masonry code and specification. In late 2013, the MSJC was disbanded, and TMS solely published the masonry code and specification from 2016 onward.[1]

PRESCRIPTIVE DESIGN OF MASONRY VENEER

Before diving into engineered design, it is important to note that prescriptively designed masonry veneer is allowed and used in many situations. This overview of the prescriptive design requirements is intended to differentiate the circumstances where each design method is appropriate. A good starting point for the discussion is the masonry unit materials used within the veneer. **Figure 3** can be found in the commentary to TMS 402/602-22.[1] While compliance with code commentary is not required for design or construction, this particular table summarizes the specific unit requirements in the subsequent prescriptive and engineered veneer sections. Dimension stone is defined as "natural stone that has been selected and fabricated to specific sizes and shapes."[1] The properties of natural stone inherently vary depending on the type of material and location of the quarry. Because naturally occurring materials cannot be standardized like manufactured masonry units, anchored dimension stone veneer design requires material testing to determine the compressive strength, durability, and mortar bond strength. The results of the testing determine whether the design assumptions were correct, or revisions are needed to meet the design intent. Therefore, the design of all anchored dimension stone masonry veneer must be engineered.

Seismic design category and wind pressure control the permitted design method (**Fig. 4**). Strength-level design wind pressures for masonry veneer (p_{veneer}) are determined using the ASCE/SEI 7 Chapter 30 components and cladding provisions, including, but not limited to, surrounding topographical conditions, required design wind speeds, and total height.[6] Sites located at the top of a hill or in a dense, urban area will naturally experience higher wind pressures. Proximity to coasts or mountains will increase the required wind speeds and the correlating wind pressures. Wind pressures also increase with height above grade, so midrise and high-rise buildings may require an adjustment of the masonry veneer design along the height or near building corners.

Seismic activity provides another source of lateral loading on masonry veneer. Due to the mass of the anchored masonry veneer, high-seismic areas (Seismic Design Category D and higher) require more restrictive design provisions regardless of wind pressures. As a result, the anchored veneer prescriptive design method in TMS 402 was split into basic and enhanced provisions for veneer tie spacing (**Table 2**). Simply stated, as lateral loads from

Table CC-13.1.1: Permitted Materials for each Design Method [1]

Masonry Material	Anchored Veneer		Adhered Veneer	
	Prescriptive	Engineered	Prescriptive	Engineered
Clay and Concrete	X	X	X	X
Dimension Stone		X	X	X
Cast Stone	X	X	X	X
Manufactured Stone			X	X

1 Specific requirements for each of these materials can be found in the respective design method sections.

Figure 3. *Permitted masonry material table reproduced from TMS 402/602-22.*

Table 13.2.1.1: Permitted Design Methods for Anchored Veneer

P_{veneer}, psf (kPa) [1]	Permitted Design Method [2]	
	Seismic Design Category A, B, and C	Seismic Design Category D and higher
≤ 50 (2.39)	Prescriptive (Section 13.2.2 Basic) or Engineered (Section 13.2.3)	Prescriptive (Section 13.2.2 Enhanced) or Engineered (Section 13.2.3)
> 50 (2.39) and ≤ 75 (3.59)	Prescriptive (Section 13.2.2 Enhanced) or Engineered (Section 13.2.3)	
> 75 (3.59)	Engineered (Section 13.2.3)	

[1] P_{veneer} is determined from ASCE/SEI 7, Chapter 30.

[2] Section 13.2.2 Basic and Section 13.2.2 Enhanced refer to **veneer tie** spacing requirements in Table 13.2.2.5.

Figure 4. *Permitted anchored design methods table reproduced from TMS 402/602-22.*

TABLE 2. Summary of basic and enhanced prescriptive veneer tie spacing.

Method	Maximum tie tributary area, ft² (m²)	Maximum tie spacing, in. (mm)	Typical tie spacing, in. (mm)
Basic prescriptive	2.67 (0.248)	24 (610)	16 × 24 (406 × 610)
Enhanced prescriptive	1.78 (0.165)	16 (406)	16 × 16 (406 × 406)

Note: 1 in. = 25.4 mm; 1 ft^2 = 0.0929 m^2.

TABLE 3. Summary of prescriptive veneer unit limitations.

Veneer type	Maximum weight, lb/ft² (kg/m²)	Maximum height, in. (mm)	Maximum unit area, in.² (m²)	Maximum unit depth, in. (mm)
Anchored	50 (244)	16 (406)	N/A	5 (127)*
Adhered	30 (146)	N/A	720 (0.464)†	2.625 (66.7)

* Anchored masonry veneer units also have a minimum depth of 2.625 in.

† Adhered veneer units exceeding 360 in.^{2} (0.232 m^2) are required to have an installation procedure approved by the licensed design professional.[1]

Note: 1 in. = 25.4 mm; 1 in.^{2} = 645.2 mm^2; 1 lb/ft^2 = 4.88 kg/m^2.

wind or seismic increase, the maximum veneer tie spacing decreases to maintain the same assumed load per veneer tie.

Correspondingly, prescriptive adhered masonry veneer provisions are limited to a maximum wind pressure p_{veneer} of 60 lb/ft² (2.87 kPa). For Seismic Design Category D and higher, the required mechanical fastener spacings for securing lath over wood and coldformed metal framing are reduced to 80% for adhered masonry veneer.[1] Lastly, the maximum height allowed for prescriptively designed adhered masonry veneer is limited to 60 ft (18.3 m) above grade.

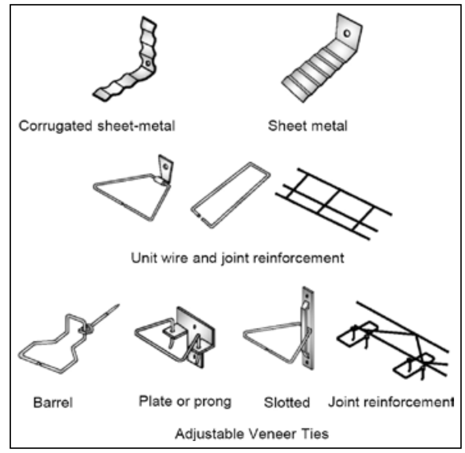

Figure 5. *Veneer tie types figure reproduced from TMS 402/602-22.*

The prescriptive design method is based upon the masonry unit limitations shown in **Table 3.** Any masonry units not meeting the criteria in Table 3 must use the engineered design method. For anchored masonry veneer, the mortar joint width is also required to be at least twice the thickness of embedded tie materials. For example, a mortar joint containing a 3/16 in. (4.76 mm) diameter wire tie must be at least 3/8 in. (9.53 mm) wide. Anchored veneer mortar type must also be specified; Type N is commonly used in anchored veneer for balance in strength and stiffness. TMS 402/602-22 prescriptively requires the setting bed mortar for adhered veneer units to be a polymer-modified mortar for superior bond.[1] Mortar materials greatly impact the overall performance of the masonry veneer, so it is critical that the design intent is conveyed within the design documents.

Figure 5 illustrates the different veneer tie types referenced in TMS 402/602. The 2022 edition reorganized the previous prescriptive anchored veneer requirements into tables limited to the type of backing (**Fig. 6**) and the selected veneer tie type (**Fig. 7**).

While it is not the intent of this paper to review each of the prescriptive design requirements for anchored veneer, Fig. 6 and 7 are included because they are referred to within the engineered design requirements of anchored masonry veneer that are discussed later. Dependent upon the backing type, different veneer tie types are allowed in the prescriptive design requirements. For each veneer tie type, the prescriptive design requirements include but are not limited to the following:

- Maximum specified cavity width
- Fastener type

Table 13.2.2.3: General Prescriptive Anchored Veneer Requirements

Backing	Veneer Tie Type	Maximum Specified Cavity Width	Other requirements
Wood Light Framing	Corrugated Sheet-metal	1 in. (25.4 mm)	Fastener: Minimum 2.5 in. (63.5 mm) x 0.131 in. (3.33 mm) ring-shank nail(s) with minimum 1 ⅜ in. (34.9 mm) penetration into backing or No. 10 screw(s) with ⅝ in. (15.9 mm) penetration into backing. Where sheathing is present, the minimum penetration shall be into the structural member behind the sheathing. Locate fastener within ½ in. (12.7 mm) of the 90-degree bend in the veneer tie. The limiting p_{max} values for prescriptive design method shall be 75 percent of those listed in Table 13.2.1.1. Corrugated ties shall not be used on veneers greater than 30 ft (9.1 m), or 38 ft (11.58 m) at a gable, in height.
	Sheet Metal	4 in. (101.6 mm)	Fastener: Minimum No. 10 screw(s) with 1 ⅜ in. (34.9 mm) penetration into backing, or, where sheathing is present, into the structural member behind the sheathing. Exterior veneer exceeding 30 ft (9.1 m), or 38 ft (11.58 m) at a gable, in height above the vertical support shall be designed and detailed to provide for differential movement.
	Adjustable	6 in. (152 mm)	Fastener: Minimum No. 10 screw(s) with 1 ⅜ in. (34.9 mm) penetration into backing, or, where sheathing is present, into the structural member behind the sheathing. Exterior veneer exceeding 30 ft (9.1 m), or 38 ft (11.58 m) at a gable, in height above the vertical support shall be designed and detailed to provide for differential movement.
Cold-formed Metal Light Framing	Adjustable	6 in. (152 mm)	Fastener: Minimum No. 10 screw(s) extending through the cold-formed metal framing a minimum of three exposed threads. Cold-formed metal framing shall be corrosion resistant and have a minimum base metal thickness of 0.043 in. (1.1 mm). Exterior veneer exceeding 30 ft (9.1 m), or 38 ft (11.58 m) at a gable, in height above the vertical support shall be designed and detailed to provide for differential movement.
Concrete	Adjustable	6 in. (152 mm)	Fasteners shall meet the pullout resistance requirements of Section 13.2.2.3.2.
Clay or Concrete Masonry	Adjustable, Unit Wire, or Joint Reinforcement	6 in. (152 mm)	Fasteners shall meet the pullout resistance requirements of Section 13.2.2.3.2.

[1] Unit wire ties and joint reinforcement do not require fasteners.

Figure 6. *Prescriptive anchored veneer requirements reproduced from TMS 402/602-22.*

- Fastener diameter
- Fastener length
- Veneer tie dimensions

TMS 402/602-22 includes general requirements for both anchored and adhered veneer regarding water-penetration resistance and accommodation for differential movement. Due to an ever-changing array of building enclosure materials, specific flashing and drainage components are not explicitly mentioned by TMS 402/602-22. Differential movement encompasses thermal, moisture, and structural movements, which must be accommodated to avoid the masonry veneer providing unintended restraint, and associated potential future distress conditions, of the completed building system.

ENGINEERED DESIGN OF MASONRY VENEER

The following conditions, though not intended to be exhaustive of all design scenarios, exceed the prescriptive design methods discussed previously and must be engineered:

- Anchored dimension stone veneer (Fig. 3)
- Anchored veneer with components and cladding wind pressures exceeding 75 lb/ft^2 (366 kg/m^2) (Fig. 4)
- Anchored veneer with veneer tie spacing tributary area or spacing exceeding the basic prescriptive and enhanced prescriptive maximum requirements (Table 2)
- Anchored veneer masonry units less than 2.625 in. (66.7 mm) or greater than 5 in. (127 mm) in depth, or greater than 16 in. (406 mm) in height (Table 3)
- Anchored veneer masonry units with weights exceeding 50 lb/ft^2 (244 kg/m^2) (Table 3)
- Anchored veneer or veneer ties not compliant with prescriptive limitations (Fig. 6 and 7)
- Adhered veneer with components and cladding wind pressures exceeding 60 lb/ft^2 (2.87 kPa)
- Adhered veneer exceeding a height of 60 ft (18.3 m) above grade
- Adhered veneer masonry units greater than 2.625 in. (66.7 mm) in depth (Table 3)
- Adhered veneer masonry units with weights exceeding 30 lb/ft^2 (146 kg/m^2) (Table 3)

Prior to TMS 402/602-22, any masonry veneer not complying with the prescriptive limitations was required to be designed using the alternative design method, which resembles the current engineered design of adhered veneer conditions[1] and the modeling analysis method for anchored veneer. This design method for masonry veneer includes the following:

- Units shall comply with the prescriptive requirements or be tested to determine material properties.
- Loads shall be distributed through the veneer to the backing using the principles of mechanics.
- Masonry veneer assembly shall comply with TMS 602 or be tested to determine design properties.

This means engineering analysis can be used to determine the nonprescriptive load path for the given masonry veneer assembly. When the installation of adhered masonry units differs from the prescriptive requirements, the assembly and installation method must be tested to determine the properties to be used with the engineering analysis.

For anchored masonry veneer, two engineered design methods are outlined: the tributary area method and the modeling analysis method.[1] Regardless of the selected engineered method, the veneer tie properties included in **Fig. 8** or the veneer tie manufacturer's product literature may be used. A veneer tie testing standard

Table 13.2.2.4: Veneer Tie Requirements

Tie type	Requirements
Corrugated sheet-metal	1) Minimum 7/8 in. (22.2 mm) wide, base metal thickness minimum of 0.03 in. (0.8 mm). 2) Corrugation wavelength: 0.3 to 0.5 in. (7.6 to 12.7 mm). 3) Corrugation amplitude: 0.06 to 0.10 in. (1.5 to 2.5 mm).
Sheet-metal	1) Minimum ⅞ in. (22.2 mm) wide, base metal thickness minimum of 0.06 in. (1.5 mm). 2) Shall have either: a. Corrugations with wavelength of 0.3 to 0.5 in. (7.6 to 12.7 mm) and amplitude of 0.06 to 0.10 in. (1.5 to 2.5 mm), or b. Bent, notched, or punched to provide equivalent performance in pull-out or push-through.
Unit wire	1) Minimum W1.7 (MW11) wire where the length of the wire that is parallel to and within the veneer is at least 2 in. (50.8 mm) long within the veneer for Z-ties. 2) Minimum W1.7 (MW11) wire with the total length of the wire within the veneer is at least 2 in. (50.8 mm) long for box and triangular unit ties. 3) Drips are not permitted.
	When cavity width exceeds 4 in. (101.6 mm): wires shall be minimum W2.8 (MW18).
Joint reinforcement	1) Ladder-type, truss-type or tab-type joint reinforcement is permitted. Truss-type joint reinforcement across the cavity is not permitted. 2) Longitudinal wires: minimum W1.7 (MW11) size. 3) Cross wires: minimum W1.7 (MW11) wire and spaced at maximum of 16 in. (406 mm) o.c. 4) Drips are not permitted in cross wires or tabs.
	When cavity width exceeds 4 in. (101.6 mm): cross and longitudinal wires shall be minimum W2.8 (MW18).
Adjustable	1) Sheet metal components shall conform to sheet-metal tie requirements. 2) Wire components shall conform to unit wire tie requirements. 3) Adjustable veneer ties with joint reinforcement shall also conform to joint reinforcement tie requirements. 4) Maximum clearance between connected parts of 1/16 in. (1.6 mm). 5) Detailed to prevent disengagement. 6) One or more pintle legs of minimum W2.8 (MW18), have two wires embedded in the veneer, and have a vertical wire offset not exceeding 1.25 in. (31.8 mm).
	1) Part of veneer tie attached to backing: a. For concrete, masonry, wood light framing or cold-formed metal light framing: (1) Barrel with minimum outside diameter of 3/16 in. (4.76 mm) and composed of solid metal. (2) Plate or prong at least 0.074 in. (1.88 mm) thick and 1-1/4 in. (31.8 mm) wide. b. For masonry backing: a tab or two eyes formed of minimum W2.8 (MW18) wire welded to joint reinforcement. 2) Where cavity width exceeds 4 in. (101.6 mm) a. Adjustable part: (1) Two or more pintle legs of minimum W2.8 (MW18) wire. (2) Distance from inside face of veneer to end of adjustable part: maximum 2 in. (51 mm).

Figure 7. *Prescriptive veneer tie requirements table reproduced from TMS 402/602-22.*

Table 13.2.3.1: Veneer Tie Axial Strength and Stiffness Values

Veneer Tie	Design Strength	Allowable Load	Stiffness
Corrugated sheet-metal	125 lb (556 N)	75 lb (334 N)	500 lb/in. (87.6 N/mm)
Adjustable – slotted	330 lb (1468 N)	200 lb (890 N)	3000 lb/in. (525 N/mm)
Adjustable - two leg pintle	210 lb (934 N)	125 lb (556 N)	2500 lb/in. (438 N/mm)
Unit wire veneer ties and joint reinforcement	210 lb (934 N)	125 lb (556 N)	20000 lb/in. (3500 N/mm)

Figure 8. *Engineered veneer tie properties table reproduced from TMS 402/602-22.*

is being developed by ASTM International at the time of this writing. With the publication of this new standard, the masonry industry is facilitating more regular publication of veneer tie capacities and tie assembly stiffnesses for use in engineered design. The tributary area method determines the strength-level force in each veneer tie through the strength-level out-of-plane load on the masonry veneer (p_u), the tributary area of the veneer tie (A_t), and the stiffness of the veneer tie (k_{tie}) using the following equations:[1]

- $2p_uA_t$ when $k_{tie} \leq$ 2,500 lb/in. (438 N/mm) (Equation 1)
- $2.5p_uA_t$ when 2,500 lb/in. (438 N/mm) < $k_{tie} \leq$ 5,000 lb/in. (876 N/mm) (Equation 2)
- $3p_uA_t$ when 5,000 lb/in. (876 N/mm) < $k_{tie} \leq$ 8,000 lb/in. (1,400 N/mm) (Equation 3)
- $4p_uA_t$ when k_{tie} > 8,000 lb/in. (1,400 N/mm) (Equation 4)

Design strengths in Fig. 8 implicitly include strength reduction factors and can be directly compared with the strength-level forces.[1]

To convert to allowable stress level forces, p_u is replaced with p_{allow}, the allowable wind pressure on the masonry veneer. The tributary area method is limited to anchored veneer with masonry units equal to or less than 5 in. (127 mm) in depth. Veneer ties with lower stiffness allow for a more uniform distribution of lateral forces between the ties. As the stiffness increases, more force is attracted by the veneer tie.

For this sample calculation, consider the following scenario:

- Cold-formed metal framing backing
- Masonry unit depth between 2.625 and 5 in. (66.7 to 127 mm)
- Adjustable two-leg pintle veneer tie type (see "plate or prong" type depicted in Fig. 5)
- Typical tie spacing of 18 in. (457 mm) by 16 in. (406 mm) or A_t = 2.00 ft^2 (0.186 m^2)
- p_u of 60 lb/ft^2 (2.87 kPa)

Engineered design is required due to the maximum tributary area exceeding 1.78 ft^2 (0.165 m^2), which is the enhanced prescriptive limit. Due to the stiffness of the veneer tie type, use Equation 1 and the veneer tie properties in Fig. 7.

$2p_uA_t$ = 2 × 60 lb/ft^2 (2.87 kPa) × 2.00 ft^2 (0.186 m^2) = 240 lb (1,068 N) > 210 lb (934 N), therefore, the solution is not acceptable.

Let's retry using the adjustable slotted veneer tie type. Due to the stiffness of the veneer tie type, use Equation 2.

$2.5p_uA_t$ = 2.5 × 60 lb/ft^2 (2.87 kPa) × 2.00 ft^2 (0.186 m^2) = 300 lb (1,334 N) < 330 lb (1,468 N), therefore, the solution is acceptable.

When adjusting the veneer tie type does not reach acceptable results, the tributary area can be reduced by reducing the tie spacing. Alternatively, if large out-of-plane load resistance requires the masonry veneer to be engineered, a wind-tunnel analysis could be performed to potentially reduce the calculated wind-pressure requirements for the components and cladding.

POSSIBILITIES OF ENGINEERED MASONRY VENEER

Anchored dimension stone veneer is a common exterior cladding system where limestone, sandstone, and other natural stone types are readily available. Dimension stone offers an aesthetic that can define the regional architecture where the stone exists. While some natural stone types exceed the properties of manufactured units, many types have poor durability characteristics, such as freeze-thaw resistance, or poor bond to modern masonry mortars. Engineering anchored dimension stone veneer, typically through material testing, will confirm whether the available stone products can be attached with veneer ties laid in mortar or whether mechanical anchors, such as kerfstyle anchors, are required to transfer the loads into the backing.

While high-wind environments are prescriptively excluded above 75 lb/ft^2 (3.59 kPa) for anchored veneer and above 60 lb/ft^2 (2.87 kPa) for adhered veneer, hurricane- or tornado-prone regions can benefit greatly from the use of engineered masonry veneer. Manufactured masonry veneer units can offer wind-blown debris or "missile" impact resistance in highwind events. If exterior cladding is installed correctly, the durability of a masonry veneer finish also can protect against one of the leading causes of damage in a hurricane: water infiltration. A building enclosure system protected by masonry veneer will minimize wind-driven rain-related and enclosure impact damage in the veneer area.

Engineered masonry veneer removes the dimensional constraints of the prescriptive design method, which provides the designer with more aesthetic possibilities. Large cavity widths can occur with continuous insulation requirements. Any adjustments in unit depth or corbelling pattern further exacerbate veneer cavity depth issues. The prescriptive limitations on cavity width remove compressive buckling as a failure mechanism for the veneer ties. When exceeded, the veneer tie capacity will decrease with increased cavity depth to account for buckling. Working with veneer tie manufacturers to determine ways to counter buckling for the desired cavity depth allows the use of nonprescriptive wall sections.

For adhered veneer, units exceeding 30 lb/ft^2 (146 kg/m^2) or 720 in.^{2} (0.464 m^2) may affect constructability. Adhered veneer unit installation methods are critical to the long-term performance of the adhered masonry veneer assembly. Large units are difficult to install with the uniform pressure to fill the space behind the adhered masonry unit and develop the intended bond strength. As a result, poor installation method is a leading cause of adhered masonry veneer failures. Constructability must be a consideration when developing engineered adhered masonry veneer solutions.

Engineered masonry veneer requirements do not necessarily have to exceed prescriptive design method requirements. A powerful application of engineered masonry veneer is optimization of veneers that could be prescriptively designed. Let's revisit the tributary area method calculation with new conditions to explore optimization. For this sample calculation, consider the following scenario:

- Concrete masonry backing
- Masonry unit depth between 2.625 and 5 in. (66.7 to 127 mm)
- Adjustable two-leg pintle veneer tie type (see wire component of "joint reinforcement" type in Fig. 5)
- Typical tie spacing of 16 in. (406 mm) by 16 in. (406 mm) or A_t = 1.78 ft^2 (0.165 m^2)
- p_u of 35 lb/ft^2 (1.68 kPa)
- Located in Seismic Design Category C

Prescriptive design is allowed due to the maximum tributary area not exceeding 2.67 ft^2 (0.248 m^2), p_u < 50 lb/ft^2 (2.39 kPa), and location in a low-seismic region. Engineered design is used to optimize the required veneer tie spacing. Due to the stiffness of the veneer tie type, use Equation 1 and the veneer tie properties in Fig. 7.

$2p_uA_t$ = 2 × 35 lb/ft^2 (1.68 kPa) × 1.78 ft^2 (0.165 m^2) = 125 lb (556 N) < 210 lb (934 N), therefore, the solution is acceptable, but there's room for optimization.

Let's retry using a typical tie spacing of 24 in. (610 mm) by 16 in. (406 mm) (A_t = 2.67 ft^2). Due to the stiffness of the veneer tie type, use Equation 1.

$2p_uA_t$ = 2 × 35 lb/ft^2 (1.68 kPa × 2.67 ft^2 [0.248 m^2] = 187 lb [832 N] < 210 lb [934 N]), therefore, the solution is acceptable.

The optimized veneer tie spacing removed 33% of the two leg pintles and layers of joint reinforcement required for the masonry veneer. The cost of the reduced material and labor could be applied elsewhere on the project or used to lower project cost.

CONCLUSION

Prescriptive design requirements and limitations for masonry veneer are acceptable in many situations. The new engineered design requirements for masonry veneer in TMS 402/602-22 can be used in situations exceeding the prescriptive limitations or to optimize masonry veneer that could be prescriptively designed. Through use of the engineered design provisions, masonry veneer can be used in new applications in a safe and durable manner. The possibilities of engineering masonry veneer are endless.

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