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11.3.4.2.3 *Transverse reinforcement* — Transverse reinforcement shall be provided where V_u exceeds ϕV_{nAAC}. The factored shear, V_u, shall include the effects of lateral load. When transverse reinforcement is required, the following provisions shall apply:

(a) Transverse reinforcement shall be a single bar with a 180-degree hook at each end.

(b) Transverse reinforcement shall be hooked around the longitudinal reinforcement.

(c) The minimum area of transverse reinforcement shall be 0.0007 bd_v.

(d) The first transverse bar shall not be located more than one-fourth of the beam depth, d_v, from the end of the beam.

(e) The maximum spacing shall not exceed the lesser of one-half the depth of the beam or 48 in. (1219 mm).

11.3.4.2.4 *Construction* — Beams shall be fully grouted.

11.3.4.2.5 *Dimensional limits* — The nominal depth of a beam shall not be less than 8 in. (203 mm).

11.3.4.3 *Piers*

11.3.4.3.1 The factored axial compression force on the piers shall not exceed 0.3 $A_n f'_{AAC}$.

11.3.4.3.2 *Longitudinal reinforcement* — A pier subjected to in-plane stress reversals shall be reinforced symmetrically about the geometric center of the pier. The longitudinal reinforcement of piers shall comply with the following:

(a) At least one bar shall be provided in each end cell.

(b) The minimum area of longitudinal reinforcement shall be 0.0007 *bd*.

11.3.4.3.3 *Dimensional limits* — Dimensions shall be in accordance with the following:

(a) The nominal thickness of a pier shall not be less than 6 in. (152 mm) and shall not exceed 16 in. (406 mm).

(b) The distance between lateral supports of a pier shall not exceed 25 multiplied by the nominal thickness of a pier except as provided for in Section 11.3.4.3.3(c).

(c) When the distance between lateral supports of a pier exceeds 25 multiplied by the nominal thickness of the pier, design shall be based on the provisions of Section 11.3.5.

COMMENTARY

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(d) The nominal length of a pier shall not be less than three multiplied by its nominal thickness nor greater than six multiplied by its nominal thickness. The clear height of a pier shall not exceed five multiplied by its nominal length.

Exception: When the factored axial force at the location of maximum moment is less than $0.05 f'_{AAC} A_g$, the length of a pier shall be permitted to be taken equal to the thickness of the pier.

11.3.5 *Wall design for out-of-plane loads*

11.3.5.1 *Scope* — The requirements of Section 11.3.5 shall apply to the design of walls for out-of-plane loads.

11.3.5.2 *Maximum reinforcement* — The maximum reinforcement ratio shall be determined by Section 11.3.3.5.

11.3.5.3 *Nominal axial and flexural strength* — The nominal axial strength, P_n, and the nominal flexural strength, M_n, of a cross-section shall be determined in accordance with the design assumptions of Section 11.3.2. The nominal axial compressive strength shall not exceed that determined by Equation 11-7 or Equation 11-8, as appropriate.

11.3.5.4 Nominal shear strength — The nominal shear strength shall be determined by Section 11.3.4.1.2.

11.3.5.5 *P-delta effects*

11.3.5.5.1 Members shall be designed for the factored axial load, P_u, and the moment magnified for the effects of member curvature, M_u. The magnified moment shall be determined either by Section 11.3.5.5.2 or Section 11.3.5.5.3.

11.3.5.5.2 Moment and deflection calculations in this Section are based on simple support conditions top and bottom. For other support and fixity conditions, moments, and deflections shall be calculated using established principles of mechanics.

The procedures set forth in this section shall be used when the factored axial load stress at the location of maximum moment satisfies the requirement calculated by Equation 11-17.

$$\left(\frac{P_u}{A_g}\right) \le 0.20 f'_{AAC} \qquad \text{(Equation 11-17)}$$

When the ratio of effective height to nominal thickness, h/t, exceeds 30, the factored axial stress shall not exceed $0.05 f'_{AAC}$

Factored moment and axial force shall be determined at the midheight of the wall and shall be used for design. The factored moment, M_u, at the midheight of the wall shall be calculated using Equation 11-18.

COMMENTARY

11.3.5.5.2 This section only includes design equations based on walls having simple support conditions at the top and bottom of the walls. In actual design and construction, there may be varying support conditions, thus changing the curvature of the wall under lateral loading. Through proper calculation and using the principles of mechanics, the points of inflection can be determined and actual moments and deflection can be calculated under different support conditions. The designer should examine moment and deflection conditions to locate the critical section using the assumptions outlined in Section 11.3.5.

The required moment due to lateral loads, eccentricity of axial load, and lateral deformations is assumed maximum at mid-height of the wall. In certain design conditions, such as large eccentricities acting simultaneously with small lateral loads, the design maximum moment may occur elsewhere. When this occurs, the designer should use the maximum moment at the critical section rather than the moment determined from Equation 11-18.

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$$M_u = \frac{w_u h^2}{8} + P_{uf}\frac{e_u}{2} + P_u \delta_u \qquad \text{(Equation 11-18)}$$

Where:

$$P_u = P_{uw} + P_{uf} \qquad \text{(Equation 11-19)}$$

The deflection due to factored loads (δ_u) shall be obtained using Equations (11-20) and (11-21)

a) Where $M_u < M_{cr}$

$$\delta_u = \frac{5M_u h^2}{48E_{AAC} I_n} \qquad \text{(Equation 11-20)}$$

(b) Where $M_{cr} \le M_u \le M_n$

$$\delta_u = \frac{5M_{cr} h^2}{48E_{AAC} I_n} + \frac{5\left(M_u - M_{cr}\right)h^2}{48E_{AAC} I_{cr}}$$

(Equation 11-21)

11.3.5.5.3 The factored moment, M_u, shall be determined either by a second-order analysis, or by a first-order analysis and Equations 11-22 through 11-24.

$$M_u = \psi M_{u,0} \qquad \text{(Equation 11-22)}$$

Where $M_{u,0}$ is the factored moment from first-order analysis.

$$\psi = \frac{1}{1 - \dfrac{P_u}{P_e}} \qquad \text{(Equation 11-23)}$$

Where:

$$P_e = \frac{\pi^2 E_{AAC} I_{eff}}{h^2} \qquad \text{(Equation 11-24)}$$

For $M_u < M_{cr}$, I_{eff} shall be taken as 0.75 I_n. For $M_u \ge M_{cr}$, I_{eff} shall be taken as I_{cr}. P_u/P_e cannot exceed 1.0.

11.3.5.5.4 The cracking moment of the wall shall be calculated using Equation 11-25, where f_{rAAC} is given by Section 11.1.8.3:

$$M_{cr} = S_n\left(f_{rAAC} + \frac{P}{A_n}\right) \qquad \text{(Equation 11-25)}$$

If the section of AAC masonry contains a horizontal leveling bed, the value of f_{rAAC} shall not exceed 50 psi (345 kPa).

11.3.5.5.5 The neutral axis for determining the cracked moment of inertia, I_{cr}, shall be determined in accordance with the design assumptions of Section 11.3.2. The effects of axial load shall be permitted to be included when calculating I_{cr}.

COMMENTARY

11.3.5.5.3 The moment magnifier provisions in this section were developed to provide an alternative to the traditional P-delta methods of Section 11.3.5.5.2. These provisions also allow other second-order analyses to be used.

The proposed moment magnification equation is very similar to that used for slender wall design for reinforced concrete. Concrete design provisions use a factor of 0.75 in the denominator of the moment magnifier to account for uncertainties in the wall stiffness. This factor is retained for uncracked walls. It is not used for cracked walls. Instead, the cracked moment of inertia is conservatively used for the entire wall height. Trial designs indicated that using this approach matches design using Section 11.3.5.5.2. If a 0.75 factor were included along with using the cracked moment of inertia for the entire height would result in design moments approximately 7% greater than using Section 11.3.5.5.2. The committee did not see any reason for the additional conservatism.

CODE

Unless stiffness values are obtained by a more comprehensive analysis, the cracked moment of inertia for a solidly grouted wall or a partially grouted wall with the neutral axis in the face shell shall be obtained from Equation 11-26 and Equation 11-27.

$$I_{cr} = n\left(A_s + \frac{P_u}{f_y}\frac{t_{sp}}{2d}\right)(d-c)^2 + \frac{b(c)^3}{3}$$

(Equation 11-26)

$$c = \frac{A_s f_y + P_u}{0.57 f'_{AAC}\, b} \qquad \text{(Equation 11-27)}$$

11.3.5.5.6 The design strength for out-of-plane wall loading shall be in accordance with Equation 11-28.

$$M_u \leq \phi M_n \qquad \text{(Equation 11-28)}$$

The nominal moment shall be calculated using Equations 11-29 and 11-30 if the reinforcing steel is placed in the center of the wall.

$$M_n = \left(A_s f_y + P_u\right)\left(d - \frac{a}{2}\right) \qquad \text{(Equation 11-29)}$$

$$a = \frac{\left(P_u + A_s f_y\right)}{0.85 f'_{AAC}\, b} \qquad \text{(Equation 11-30)}$$

11.3.5.6 *Deflections* — The horizontal midheight deflection, δ_s, under allowable stress design load cominations shall be limited by the relation:

$$\delta_s \leq 0.007\, h \qquad \text{(Equation 11-31)}$$

P-delta effects shall be included in deflection calculation using either Section 11.3.5.6.1 or Section 11.3.5.6.2.

11.3.5.6.1 For simple support condition top and bottom, the midheight deflection, δ_s, shall be calculated using either Equation 11-20 or Equation 11-21, as applicable, and replacing M_u with M_{ser} and δ_u with δ_s.

11.3.5.6.2 The deflection, δ_s, shall be determined by a second-order analysis that includes the effects of cracking, or by a first-order analysis with the calculated deflections magnified by a factor of $1/(1-P/P_e)$, where P_e is determined from Equation 11-24.

COMMENTARY

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11.3.6 *Wall design for in-plane loads*

11.3.6.1 *Scope* — The requirements of Section 11.3.6 shall apply to the design of walls to resist in-plane loads.

11.3.6.2 *Reinforcement* — Reinforcement shall be in accordance with the following:

(a) Reinforcement shall be provided perpendicular to the shear reinforcement and shall be at least equal to one-third A_v . The reinforcement shall be uniformly distributed and shall not exceed a spacing of 8 ft (2.44 m).

(b) The maximum reinforcement ratio shall be determined in accordance with Section 11.3.3.5.

11.3.6.3 *Flexural and axial strength* — The nominal flexural and axial strength shall be determined in accordance with Section 11.3.4.1.1.

11.3.6.4 *Shear strength* — The nominal shear strength shall be calculated in accordance with Section 11.3.4.1.2.

11.3.6.5 *Flexural cracking strength* — The flexural cracking strength shall be calculated in accordance with Equation 11-32, where f_{rAAC} is given by Section 11.1.8.3:

$$V_{cr} = \frac{S_n}{h}\left(f_{rAAC} + \frac{P}{A_n}\right) \qquad \text{(Equation 11-32)}$$

If the section of AAC masonry contains a horizontal leveling bed, the value of f_{rAAC} shall not exceed 50 psi (345 kPa).

11.3.6.6 The maximum reinforcement requirements of Section 11.3.3.5 shall not apply if a shear wall is designed to satisfy the requirements of Sections 11.3.6.6.1 through 11.3.6.6.4.

11.3.6.6.1 The need for special boundary elements at the edges of shear walls shall be evaluated in accordance with Section 11.3.6.6.2 or 11.3.6.6.3. The requirements of Section 11.3.6.6.4 shall also be satisfied.

11.3.6.6.2 This Section applies to walls bending in single curvature in which the flexural limit state response is governed by yielding at the base of the wall. Walls not satisfying those requirements shall be designed in accordance with Section 11.3.6.6.3.

(a) Special boundary elements shall be provided over portions of compression zones where:

$$c \geq \frac{l_w}{600\left(C_d \delta_{ne} / h_w\right)}$$

COMMENTARY

11.3.6.6 While requirements for confined boundary elements have not been developed for AAC shear walls, they have not been developed for conventional masonry shear walls either, and the monolithic nature of AAC shear walls favors possible applications involving boundary elements. Also see Commentary Section 9.3.6.5.

11.3.6.6.1 See Commentary Section 9.3.6.5.2.

11.3.6.6.2 See Commentary Section 9.3.6.5.3.

CODE

and c is calculated for the P_u given by ASCE 7 Load Combination 5 $(1.2D + 1.0E + L + 0.2S)$ or the corresponding strength design load combination of the legally adopted building code, and the corresponding nominal moment strength, M_n, at the base critical section. The load factor on L in Load Combination 5 is reducible to 0.5, as per exceptions to Section 2.3.2 of ASCE 7.

(b) Where special boundary elements are required by Section 11.3.6.6.2 (a), the special boundary element reinforcement shall extend vertically from the critical section a distance not less than the larger of l_w or $M_u/4V_u$.

11.3.6.6.3 Shear walls not designed to the provisions of Section 11.3.6.6.2 shall have special boundary elements at boundaries and edges around openings in shear walls where the maximum extreme fiber compressive stress, corresponding to factored forces including earthquake effect, exceeds $0.2 f'_{AAC}$. The special boundary element shall be permitted to be discontinued where the calculated compressive stress is less than $0.15 f'_{AAC}$. Stresses shall be calculated for the factored forces using a linearly elastic model and gross section properties. For walls with flanges, an effective flange width as defined in Section 5.1.1.2.3 shall be used.

11.3.6.6.4 Where special boundary elements are required by Section 11.3.6.6.2 or 11.3.6.6.3, (a) through (d) shall be satisfied and tests shall be performed to verify the strain capacity of the element:

(a) The special boundary element shall extend horizontally from the extreme compression fiber a distance not less than the larger of $(c - 0.1l_w)$ and $c/2$.

(b) In flanged sections, the special boundary element shall include the effective flange width in compression and shall extend at least 12 in. (305 mm) into the web.

(c) Special boundary element transverse reinforcement at the wall base shall extend into the support at least the development length of the largest longitudinal reinforcement in the boundary element unless the special boundary element terminates on a footing or mat, where special boundary element transverse reinforcement shall extend at least 12 in. (305 mm) into the footing or mat.

(d) Horizontal shear reinforcement in the wall web shall be anchored to develop the specified yield strength, f_y, within the confined core of the boundary element.

COMMENTARY

11.3.6.6.3 See Commentary Section 9.3.6.5.4.

11.3.6.6.4 See Commentary Section 9.3.6.5.5.

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PART 4: PRESCRIPTIVE DESIGN METHODS

CHAPTER 12
VENEER

CODE

12.1 — General

12.1.1 *Scope*

This chapter provides requirements for design and detailing of anchored masonry veneer and adhered masonry veneer.

COMMENTARY

12.1 — General

12.1.1 *Scope*

Adhered and anchored veneer definitions given in Section 2.2 are variations of those used in model building codes. Modifications have been made to the definitions to clearly state how the veneer is handled in design. Veneer is an element that is not considered to add strength or stiffness to the wall. The design of the veneer backing should be in compliance with the appropriate standard for the material. See Figures CC-12.1-1 and CC-12.1-2 for typical examples of anchored and adhered veneer, respectively.

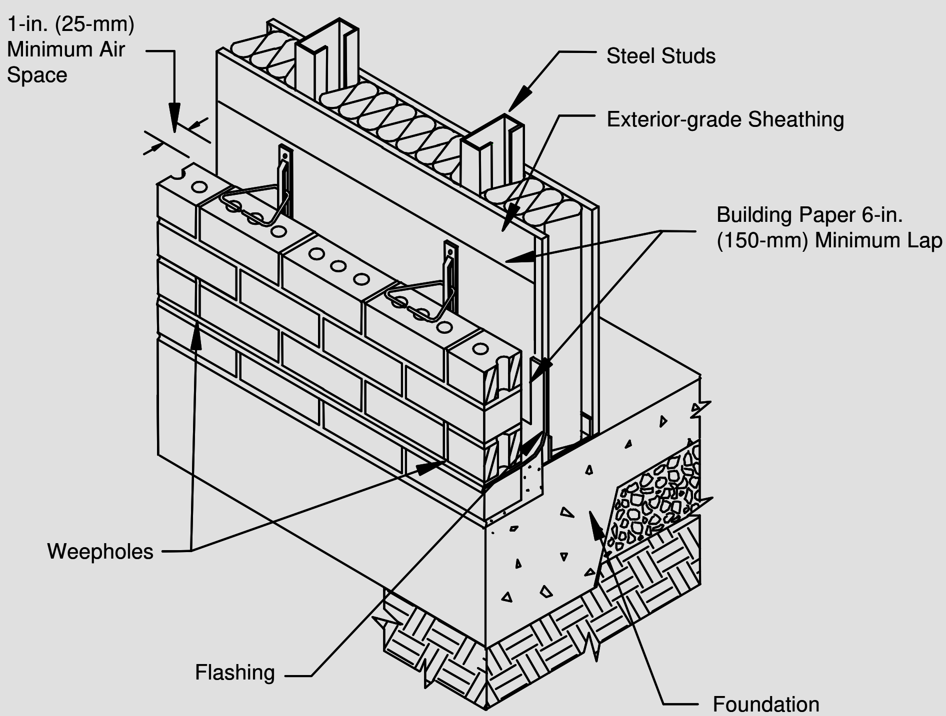

Figure CC-12.1-1 — Anchored veneer

COMMENTARY

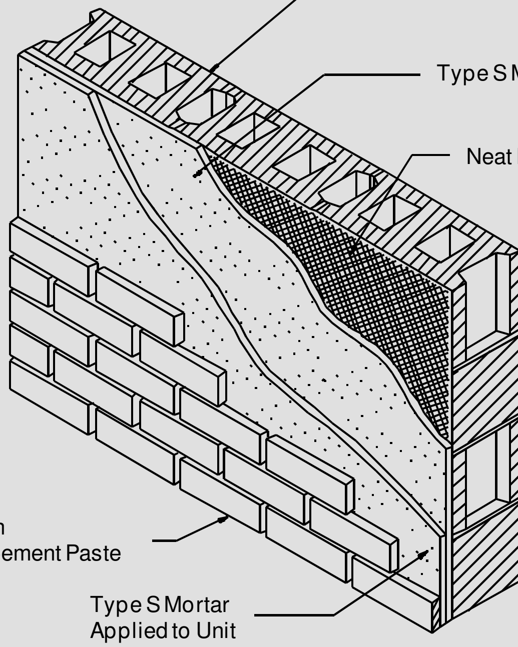

Figure CC-12.1-2 — Adhered veneer

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12.1.1.1 The provisions of Part 1, excluding Sections 1.2.1(c) and 1.2.2; Chapter 4, excluding Sections 4.1 and 4.3; and Chapter 6 shall apply to design of anchored and adhered veneer except as specifically stated in this Chapter.

12.1.1.2 Section 4.5 shall not apply to adhered veneer.

12.1.1.3 Articles 1.4 A and B and 3.4 C of TMS 602/ACI 530.1/ASCE 6 shall not apply to any veneer. Articles 3.4 B and F shall not apply to anchored veneer. Articles 3.3 B and 3.4 A, B, E and F shall not apply to adhered veneer.

12.1.2 *Design of anchored veneer*

Anchored veneer shall meet the requirements of Section 12.1.6 and shall be designed rationally by Section 12.2.1 or detailed by the prescriptive requirements of Section 12.2.2.

COMMENTARY

12.1.1.1 Because there is no consideration of stress in the veneer, there is no need to specify the compressive strength of masonry.

12.1.1.3 The Specification was written for construction of masonry subjected to design stresses in accordance with the other chapters of this Code. Masonry veneer, as defined by this Code, is not subject to those design provisions. The Specification articles that are excluded address materials and requirements that are not applicable to veneer construction or are items addressed by specific requirements in this Chapter and are put here to be inclusive.

12.1.2 *Design of anchored veneer*

Implicit within these requirements is the knowledge that the veneer transfers out-of-plane loads through the veneer anchors to the backing. The backing accepts and resists the anchor loads and is designed to resist the out-of-plane loads.

When utilizing anchored masonry veneer, the designer should consider the following conditions and assumptions:

a) The veneer may crack in flexure under service load.

b) Deflection of the backing should be limited to control crack width in the veneer and to provide veneer stability.

c) Connections of the anchor to the veneer and to the backing should be sufficient to transfer applied loads.

d) Differential movement should be considered in the design, detailing, and construction.

e) Water will penetrate the veneer, and the wall system should be designed, detailed, and constructed to prevent water penetration into the building.

f) Requirements for corrosion protection and fire resistance must be included.

If the backing is masonry and the exterior masonry wythe is not considered to add to the strength of the wall in resisting out-of-plane load, the exterior wythe is masonry veneer. However, if the exterior wythe is considered to add to the strength of the wall in resisting out-of-plane load, the wall is properly termed either a multiwythe, non-composite or composite wall rather than a veneer wall.