

Guide for Design and Construction with Autoclaved Aerated Concrete Panels

Reported by ACI Committee 523



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Guide for Design and Construction with Autoclaved Aerated Concrete Panels

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Guide for Design and Construction with Autoclaved Aerated Concrete Panels

Reported by ACI Committee 523

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This guide is intended for use by architects, engineers, contractors, building officials, and manufacturers. Its purpose is to present, in a single source, information that can help those individuals design, specify, and construct with factory-reinforced panels of autoclaved aerated concrete (AAC). In this guide, introductory information on AAC is first presented, followed by a description of its manufacture, guidance on structural design using reinforced panels, and guidance on construction with such panels. The body of this guide ends with an extensive background chapter on the material characteristics of AAC, and the structural behavior and design of AAC elements.

Keywords: autoclaved aerated concrete; construction; design; panels; reinforced panels.

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FOREWORD

This guide is intended for use by architects, engineers, contractors, building officials, and manufacturers. Its purpose is to present, in a single source, information that can help those individuals design, specify and construct with factory-reinforced panels of autoclaved aerated concrete (AAC). In this guide, introductory information on AAC is first presented, followed by a description of its manufacture, guidance on structural design using reinforced panels, and guidance on construction with such panels. The body of this

guide ends with an extensive background chapter on the material characteristics of AAC, and the structural behavior and design of AAC elements.

Because design and construction provisions already exist for AAC masonry made from masonry-type units without factory-installed reinforcement, this guide touches only briefly on AAC masonry. This guide addresses design, specification, and construction needs for factory-reinforced panels for which comparable design and construction provisions do not yet exist. It does this through a combination of background material and design guidance, written in nonmandatory format.

This guide is intended as a starting point for the development of mandatory-language design provisions, under the mandate of ACI 318 or other committee so designated by ACI. To facilitate that process, the design provisions proposed in this guide, though written in nonmandatory language as required by ACI, are arranged to follow the format of ACI 318-05.

CHAPTER 1—INTRODUCTION

1.1—Definition of autoclaved aerated concrete

Autoclaved aerated concrete (AAC), a form of cellular concrete, is a low-density cementitious product of calcium silicate hydrates in which the low density is obtained by the formation of macroscopic air bubbles, mainly by chemical reactions within the mass during the liquid or plastic phase. The air bubbles are uniformly distributed and are retained in the matrix on setting, hardening, and subsequent curing with high-pressure steam in an autoclave to produce a homogeneous structure of macroscopic voids, or cells (Fig. 1.1). Material specifications for this product are prescribed in ASTM C1386.

1.2—Typical mechanical and thermal characteristics of AAC

In Table 1.1, typical mechanical and thermal characteristics of AAC are compared with those of conventional concrete, including conventional concrete made with lightweight aggregates. AAC typically has one-sixth to one-third the density of conventional concrete, and about the same ratio of compressive strength, making it suitable for cladding and infill panels and for bearing-wall components of low- to medium-rise structures. Throughout this guide, “density” is defined consistently with ASTM C1386, because AAC is defined by C1386. In C1386, what is referred to as “density” is actually a unit weight, with units of lb/ft³ (U.S. customary) and units of kgf/m³ (old metric). This definition is not strictly correct, nor is it consistent with ACI policy for SI units. It is maintained herein for consistency with ASTM C1386.

The thermal conductivity of AAC is 6 to 7.5% that of conventional concrete, making it energy-efficient. Its fire rating is slightly longer than that of conventional concrete of the same thickness, making it useful in applications where fire resistance is important.

AAC has excellent acoustical properties. Because of its characteristic high internal porosity, AAC has very high sound absorption. Because of its lower density, AAC is more resistant to sound transmission as compared to conventional concrete of the



Fig. 1.1—Macroscopic cellular (void) structure of AAC.

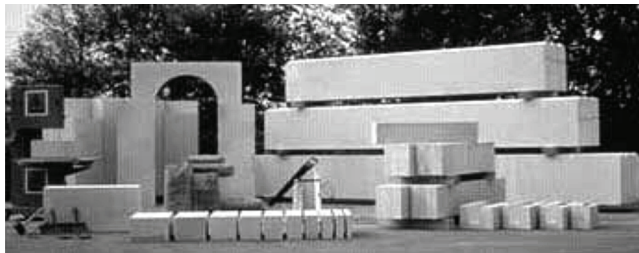


Fig. 1.2—Examples of AAC structural elements.

same thickness. When typical element thicknesses are used, however, AAC has excellent resistance to sound transmission.

1.3—Historical background of AAC

AAC was first produced commercially in Sweden in 1923. Since that time, its production and use have spread to more than 40 countries on all continents, including North America, Central and South America, Europe, the Middle East, the Far East, and Australia. This wide experience has produced many case studies of use in different climates and under different building codes.

In the United States, modern uses of AAC began in 1990 for residential and commercial projects in the southeastern states. United States production of plain and reinforced AAC started in 1995 in the southeast, and has since spread to other parts of the country. A nationwide group of AAC manufacturers was formed in 1998 as the Autoclaved Aerated Concrete Products Association. This guide is an effort by a subcommittee of ACI Committee 523, which includes manufacturers, designers, and researchers, to propose standard design and construction guidelines for reinforced AAC panels.

1.4—Applications of AAC panels

AAC can be used to make unreinforced, masonry-type units, and also factory-reinforced floor panels, roof panels, wall panels, lintels, beams, and other special shapes (Fig. 1.2). These elements can be used in a variety of applications, including residential, commercial, and industrial construction. Reinforced wall panels can be used as cladding systems as well as load-bearing and non-load-bearing exterior and interior wall systems. Reinforced floor and roof panels can be used

Table 1.1—Typical physical characteristics of AAC

Characteristic	AAC	Conventional concrete
Density,* lb/ft ³ (kg/m ³)	25 to 50 (400 to 800)	90 to 150 (1442 to 2400)
Compressive strength f_c , psi (MPa)	290 to 1100 (2.0 to 7.6)	2500 to 8000 (17.2 to 55)
Moisture content after autoclaving	30%	—
Moisture content in use	5 to 15%	—
Coefficient of thermal expansion/°F (°C)	4.5×10^{-6} (8.1×10^{-6})	5×10^{-6} (9×10^{-6})
Coefficient of creep, per psi (per MPa)	5×10^{-7} (0.72×10^{-4})	2.5×10^{-7} (0.36×10^{-4})
Drying shrinkage (ϵ_{cs} by ASTM C1386)	$0.8\epsilon_{cs}/100$	300 to 600 $\mu\epsilon$
Thermal conductivity, Btu-in./ft ² -h-°F	0.75 to 1.20	10 to 20
Fire rating of 8 in. (200 mm) thick panel, hours (by ASTM E119)	≤ 8	≤ 6

*Throughout this Guide, “density” is defined consistently with ASTM C1386, because AAC is defined by C1386. In C1386, what is referred to as “density” is actually a unit weight, with units of lb/ft³ (U.S. customary) and units of kg/m³ (old metric). This definition is not strictly correct, nor is it consistent with ACI policy for SI units. It is maintained herein for consistency with ASTM C1386.

efficiently to provide a structure’s horizontal diaphragm system while supporting the necessary gravity loads.

1.5—Scope and objectives

This guide is limited to AAC with a density of 50 lb/ft³ (800 kg/m³) or less. It is written for structural designers. It addresses design using factory-reinforced AAC panels. Design of AAC masonry is addressed in other documents (Masonry Standards Joint Committee 2005a,b).

Design documents produced by ACI technical committees are classified as standards or nonstandards. The latter include guides, which are intended to present directions for analysis, design, construction, materials, or testing on a general basis. Their language is nonmandatory, permitting the user latitude in judgment concerning particular needs.

The objectives of this guide are to:

- Review the basic characteristics of AAC;
- Provide a brief history of structural applications of AAC;
- Review the fabrication of AAC panels;
- Recommend structural design procedures for factory-reinforced AAC panels; and
- Recommend construction details for use with factory-reinforced AAC panels.

The structural design procedures and construction details recommended in this guide are intended to result in AAC panels with reliable structural capacity, durability, appearance, and overall serviceability.

CHAPTER 2—NOTATION AND DEFINITIONS

2.1—Notation

- A = area of wall, in.² (mm²)
- A_s = effective cross-sectional area of horizontal reinforcement in AAC panel, in.² (mm²)
- d = distance from centroid of tension steel to fiber at maximum compressive strain (for non-shear wall), in. (mm)

d_{cross}	= diameter of cross wire (vertical wire) in reinforced AAC panel, in. (mm)
f_{AAC}	= tested compressive strength of AAC, psi (MPa)
f'_{AAC}	= specified compressive strength of AAC, psi (MPa)
f_{bond}	= tensile bond strength of AAC, psi (kPa)
f_c	= compressive strength of concrete, psi (MPa)
f_r	= modulus of rupture of concrete, psi (kPa)
f_{rAAC}	= modulus of rupture of AAC, psi (kPa)
f_s	= stress developed in horizontal reinforcement of reinforced AAC panel, psi (MPa)
f_t	= splitting tensile strength of concrete, psi (MPa)
f_{tAAC}	= splitting tensile strength of AAC, psi (MPa)
f_v	= tested shear strength of AAC, psi (MPa)
f_y	= specified yield strength of steel reinforcement, psi (MPa)
h	= height of shear wall, in. (mm)
h_{crack}	= height of flexural crack in a shear wall at flexure-shear cracking, in. (mm)
ℓ_w	= plan length of shear wall, in. (mm)
M	= moment at the base of shear wall, k-in. (kN-m)
n_{cross}	= number of layers of cross wires (vertical) between the failure surface and the closest panel end
P	= axial force acting on wall, kips (kN)
S	= section modulus, in. ³ (mm ³)
s_h	= spacing of horizontal wires in reinforced AAC panel, in. (mm)
t	= specified thickness of shear wall, in. (mm)
V	= shear at the base of shear wall, kips (kN)
V_{AAC}	= shear strength provided by AAC, kips (kN)
V_c	= shear strength provided by concrete, kips (kN)
V_{cr}	= base shear at flexural cracking capacity, kips (kN)
V_{ds}	= strength of an AAC shear wall as governed by crushing of diagonal strut, kips (kN)
V_n	= nominal shear strength of a reinforced concrete section, kips (kN)
V_s	= shear strength provided by the shear reinforcement, kips (kN)
V_{ss}	= sliding shear capacity of AAC shear wall, kips (kN)
w	= horizontal projection of the width of the diagonal strut, in. (mm)
μ	= coefficient of friction
ρ	= density of AAC

2.2—Definitions

autoclaved aerated concrete (AAC)—a cementitious product based on calcium silicate hydrates in which low density is attained by the inclusion of an agent resulting in macroscopic voids and is subjected to high-pressure steam curing (ASTM C1386).

CHAPTER 3—TYPICAL MATERIALS AND MANUFACTURE OF AAC

3.1—Materials used in AAC

Materials for AAC vary with the method of manufacture and the raw materials available at the location of manufacture, and are specified in ASTM C1386. They include some or all of the following:

- Fine silica sand (ASTM C33, C144, or C332);
- Class F fly ash (ASTM C618) with up to 12% loss on ignition (LOI);
- Hydraulic cements (ASTM C150, C595, or C1157);
- Calcined lime (ASTM C110);
- Gypsum (ASTM C22);
- Expansive agent, such as finely ground aluminum powder or paste;
- Mixing water (clean and free of deleterious substances); and
- Reinforcement (ASTM A82), welded to form cages, with corrosion-inhibiting coating.

3.2—Manufacture of AAC

Overall steps in the manufacture of AAC are shown in Fig. 3.1. Because the same basic AAC material can be used for unreinforced AAC units (masonry-type units) as well as reinforced panels, information on both types of units is presented in this chapter. The masonry-type units are addressed only briefly, for the sake of completeness. Design and construction provisions for AAC masonry units are not addressed by this document. They are addressed by the Masonry Standards Joint Committee (2005a,b).

3.2.1 Preparation, batching, and mixing of raw materials—Sand is ground to the required fineness in a ball mill, if necessary, and is stored along with other raw materials. The raw materials are then batched by weight and delivered to the mixer. Measured amounts of water and expansive agent are added to the mixer, and the cementitious slurry is mixed.

3.2.2 Casting, expansion, and initial hydration—Steel molds are prepared to receive the fresh AAC. If reinforced AAC panels are to be produced, steel reinforcing cages are secured within the molds. After mixing, the slurry is poured into the molds. The expansive agent creates small, finely dispersed voids in the fresh mixture that increases the volume by approximately 50% in the molds within 3 hours.

3.2.3 Cutting—Within a few hours after casting, the initial hydration of cementitious compounds in the AAC gives it sufficient strength to hold its shape and support its own weight. The material is removed from the molds (Fig. 3.2) and fed into a cutting machine that, using wires, sections the blocks and panels into the required sizes and shapes (Fig. 3.3). After cutting, the units remain in their original positions in the larger AAC block.

3.2.4 Autoclaving—After cutting, the aerated concrete product is transported to a large autoclave, where the curing process is completed (Fig. 3.4). Autoclaving is required to achieve the desired structural properties and dimensional stability. The process takes about 8 to 12 hours under a pressure of about 174 psi (1.20 MPa) and at a temperature of approximately 360 °F (180 °C), depending on the grade of material produced. During autoclaving, the wire-cut units remain in their original positions in the AAC block. After autoclaving, the individual units are dimensionally stable and are specified to have a drying shrinkage of no more than 0.02% (ASTM C1386). They are then separated for packaging (Fig. 3.5).

3.2.5 Packaging—AAC units are normally placed on pallets for shipping. Unreinforced units are typically shrink-

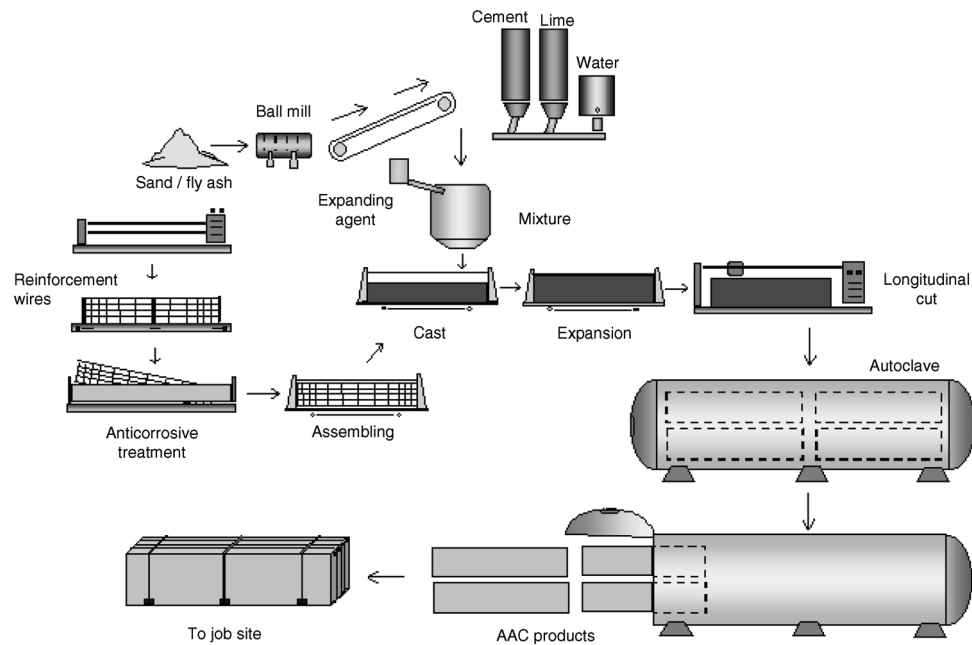


Fig. 3.1—Steps in the manufacture of AAC.

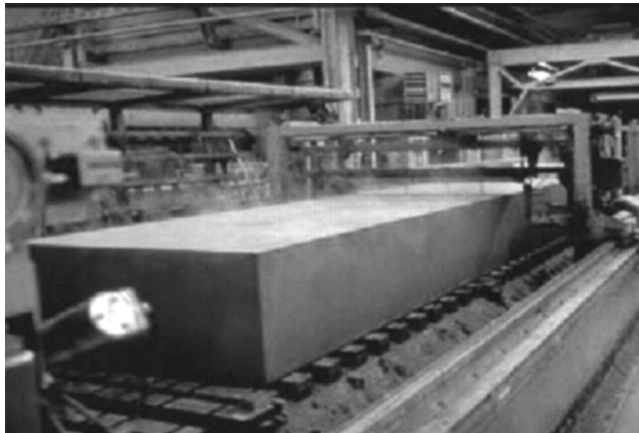


Fig. 3.2—Fresh AAC after removal of molds.

wrapped, while reinforced elements are typically banded only, using edge guards to minimize localized damage from the banding.

3.2.6 AAC strength classes—AAC is produced in different densities and corresponding compressive strengths in accordance with ASTM C1386 and C1452. Densities and corresponding strengths are described in terms of strength classes. In each case, the strength class corresponds to the specified compressive strength, in psi (MPa) (Table 3.1).

3.3—Typical dimensions of AAC units

3.3.1 Plain AAC wall units—Typical dimensions of plain AAC wall units (masonry-type units) are shown in Table 3.2.

3.3.2 Reinforced AAC panels—Dimensional tolerances, requirements for reinforcement, and other requirements for reinforced AAC panels are specified in ASTM C1452, which also cites C1386. Typical dimensions for reinforced AAC wall units (panels) are shown in Table 3.3.

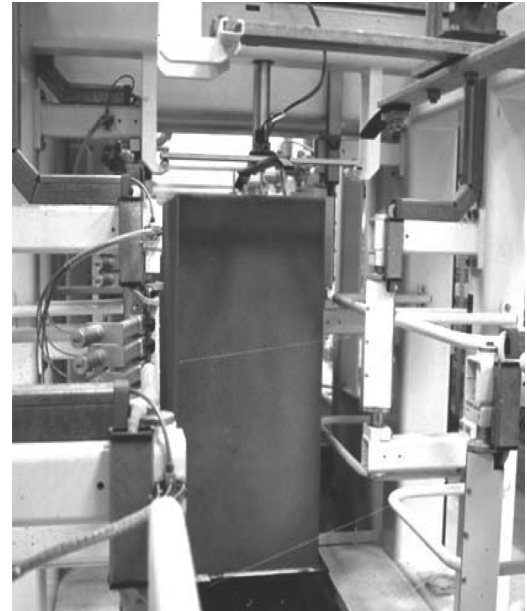


Fig. 3.3—Cutting AAC into desired shapes.

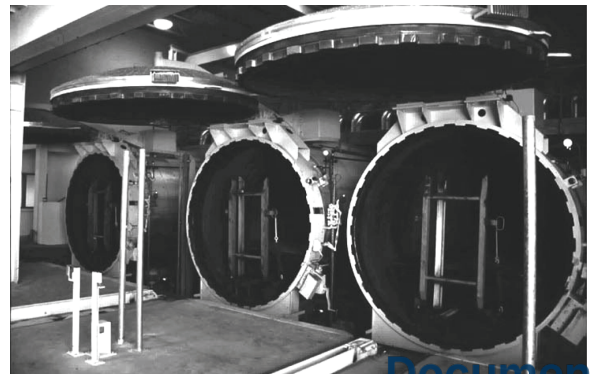


Fig. 3.4—Autoclaving AAC

Table 3.1—Typical material characteristics of AAC in different strength classes*

Strength class	Specified compressive strength f'_{AAC} , psi (MPa)	Nominal dry bulk density, lb/ft ³ (kg/m ³)	Density limits, lb/ft ³ (kg/m ³)
AAC 2.0	290 (2.0)	25 (400)	22 to 28 (350 to 450)
		31 (500)	28 to 34 (450 to 550)
AAC 4.0	580 (4.0)	31 (500)	28 to 34 (450 to 550)
		37 (600)	34 to 41 (550 to 650)
		44 (700)	41 to 47 (650 to 750)
		50 (800)	47 to 53 (750 to 850)
AAC 6.0	870 (6.0)	44 (700)	41 to 47 (650 to 750)
		50 (800)	47 to 53 (750 to 850)

*Other strength classes within these ranges and densities may be produced depending on specific design requirements.

Table 3.2—Typical dimensions of plain AAC wall units (masonry-type units)

AAC unit type	Width, in. (mm)	Height, in. (mm)	Length, in. (mm)
Standard block	2 to 15 (50 to 375)	8 (200)	24 (610)
Jumbo block	4 to 15 (100 to 375)	16 to 24 (400 to 610)	24 to 40 (610 to 1050)



Fig. 3.5—Packaging of finished AAC units.

3.4—Dimensional tolerances

In accordance with ASTM C1386, dimensional tolerances for plain AAC wall units are ±1/8 in. (±3 mm) in length, thickness, and height. Dimensional tolerances for reinforced elements are given in ASTM C1452, and are listed in Table 3.4.

3.5—Identification and marking of AAC units

Pallets of unreinforced AAC units should be labeled with strength class, production identification code, and size of units. Reinforced AAC panels should bear product identification information indicating the strength class, production identification code, and a number indicating the specified location in the structure.

Table 3.3—Typical dimensions of reinforced AAC wall units (panels)

Product type	Thickness, in. (mm)	Height or width, in. (mm)	Typical length, ft (mm)
Wall panel	2 to 15 (50 to 375)	24 (610)	20 (6090)
Floor panel	4 to 15 (100 to 375)	24 (610)	20 (6090)
Lintel/beam	4 to 15 (100 to 375)	8 to 24 (200 to 610)	20 (6090)

Table 3.4—Dimensional tolerances for reinforced AAC panels (ASTM C1452)

Dimension	Floor or roof panels, in. (mm)	Wall panels, in. (mm)
Length	±0.20 (±5)	±0.20 (±5)
Width	±0.12 (±3)	±0.12 (±3)
Thickness	±0.12 (±3)	±0.12 (±3)
Tongue	±0.12 (±3)	±0.12 (±3)
Groove	±0.12 (±3)	±0.12 (±3)

CHAPTER 4—STRUCTURAL DESIGN OF REINFORCED AAC PANELS
4.1—Introductory remarks regarding design provisions

This document is a guide. Its design provisions are non-mandatory, and are a synthesis of design recommendations from the Autoclaved Aerated Concrete Products Association, and from the results of research conducted at the University of Alabama at Birmingham (UAB), the University of Texas at Austin (UT Austin), and elsewhere.

In this chapter, the proposed design provisions are briefly introduced in narrative form. In Chapter 5, handling and erection of panels are addressed. In Chapter 6, typical design details are used to introduce the reader to specific configurations of the AAC structural elements whose design and construction are addressed by this document. Chapter 7 presents the detailed technical justification for the proposed design provisions. The proposed provisions themselves and corresponding commentary are presented in Appendixes A and B, respectively. Appendix C provides design examples.

The specific design provisions of Appendix A, and their associated commentary in Appendix B, are written in non-mandatory language. They are intended to be compatible in organization, numbering, and form with the design provisions of ACI 318 to facilitate their use by concrete designers and also to facilitate their future consideration, in mandatory form, by ACI Committee 318. For that reason, the provisions are arranged to refer directly to ACI 318-05. Additions and exceptions are specifically noted. New subcategories are inserted for new design provisions.

Loads for structural design of AAC panels should be taken from appropriate standards, such as ASCE 7. Strength-reduction factors (φ-factors) for AAC panels depend on the actions under consideration. They reflect the statistical variability of the capacity, and the accuracy of the capacity-calculation formulas. When failure is governed by yield and fracture of tensile reinforcement, φ-factors are justifiably identical to those used for reinforced concrete. When failure is governed by crushing or diagonal tension of the AAC itself, φ-factors are similar to those used for the design of conventional concrete. They may even be higher, because the

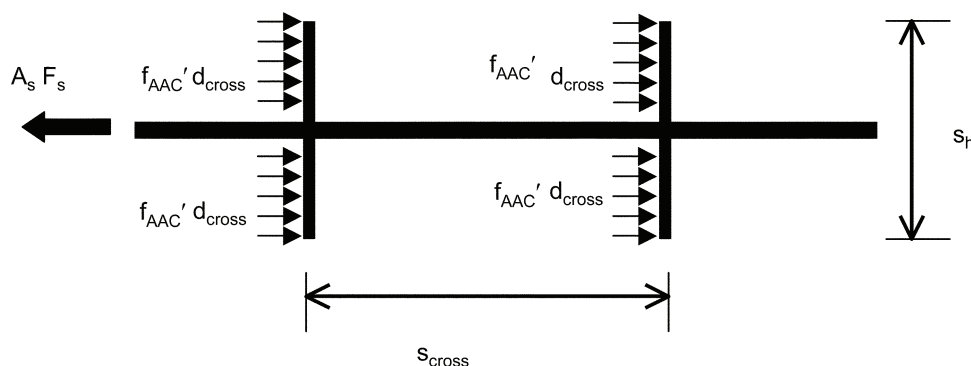


Fig. 4.1—Bond mechanism of steel wire cages in AAC (Tanner 2003).

factory production of AAC leads to decreased variability in its mechanical characteristics compared with conventional concrete.

The design provisions of this guide are not intended for use with unreinforced, masonry-type units. Design of those units is covered by the Masonry Standards Joint Committee (2005a,b).

4.2—Proposed design provisions for reinforced AAC panels

4.2.1 Basic design assumptions—The proposed design provisions for reinforced AAC panels are based on the same principles used for strength design of conventional reinforced concrete elements: strain compatibility between AAC and reinforcement (with some modifications as noted); stress-strain behavior of AAC and reinforcement; and equilibrium. The design strength of AAC in compression is based on a specified design compressive strength f'_{AAC} . Compliance with that specified compressive strength is verified by compressive strength testing of AAC cubes, using ASTM C1386, when the AAC panels are fabricated. The design strength of AAC in tension is proposed as a function of the specified compressive strength. The design strength of reinforcement in tension is proposed as the specified yield strength.

4.2.2 Combinations of flexure and axial load—AAC panels are designed for combinations of flexure and axial load using principles identical to those for conventional reinforced concrete. Nominal capacity is computed assuming plane sections; strain in tensile reinforcement depends on whether the section is tension- or compression-controlled; the stress in compressive reinforcement is computed based on its strain and its stress-strain behavior; and the distribution of compressive stress in the AAC is approximated by an equivalent rectangular stress block, whose height is $0.85f'_{AAC}$ and whose value of β_1 is 0.67 (Tanner et al. 2005a,b; Argudo 2003). For the complete flexure and axial load behavior, an interaction diagram can be constructed using the principles described previously for various levels of axial load.

Because reinforced AAC panels usually have equal areas of tensile and compressive reinforcement, flexural capacity is usually tension-controlled (in the terminology of ACI 318-05). The stress in the compressive reinforcement is often neglected in computation of nominal capacity. Sections are under-reinforced (in the terminology of ACI 318-99). As

compression steel is added to a beam, the neutral axis shifts toward the extreme compression fiber. Because the compressive strain in the top fiber is fixed, the strain in the extreme tensile steel increases. By using equal compression and tension steel, the neutral axis shifts to a distance less than two times the clear cover, provided that the compressive stress block accounts for 30% of the total compressive force. This results in a strain in the tensile reinforcement of $0.003 \times ([d - 2(\text{cover})]/[2(\text{cover})])$. As long as the ratio of $([d - 2(\text{cover})]/[2(\text{cover})])$ exceeds $1.67 \times (0.005/0.003)$, the section will be tension-controlled as defined in ACI 318-05. For a reinforced panel with a depth of 8 in. (200 mm) and cover of 1 in. (25 mm), this ratio is 2.5, which is greater than 1.67. If the panel depth increases, this ratio increases further.

4.2.3 Bond and development of reinforcement—Reinforcement in AAC panels consists of steel wire cages installed when the panels are produced, and deformed reinforcement installed in 3 to 4 in. (75 to 100 mm) grouted cores as the panels are erected.

Bond and development requirements for deformed reinforcement in grout are identical to those used for concrete or masonry construction. Given the small sizes of deformed bars used in AAC construction, bond between the grout and the AAC itself does not govern the bond capacity (Tanner et al. 2005a,b).

Bond and development requirements for steel wire cages embedded in AAC are quite different from those for conventional concrete. Because the steel wire cage has a corrosion-resistant coating, the bond strength between the coated wire and the AAC itself is negligible. Bond strength comes from bearing of the cross wires against the AAC. For typical cross-wire spacings (s_{cross} in Fig. 4.1), local crushing of the AAC under the cross wires can be assumed to redistribute the bearing stresses under the cross wires, leading to a uniform bearing strength of f'_{AAC} under every cross wire. The stresses are initially greater at the weld due to increased stiffness at this location. Weld strength should meet the requirements of ASTM C1452. After local deformations occur at the weld, the more flexible portion of the wires is assumed to resist a uniformly distributed load. Multiplying this stress by the number of cross wires and by the bearing area of each cross wire gives the maximum force that can be developed in the steel wire cage (Fig. 4.1). The design assumption is to neglect the contribution of welded.

wire reinforcement to the shear resistance of AAC panels subject to reversed cyclic loads (Tanner et al. 2005b). This maximum force in the steel wire cage can limit the flexural capacity of a reinforced AAC panel.

4.2.4 Shear—As with conventional reinforced concrete elements, the shear resistance of AAC panels is computed as the summation of a shear resistance due to the AAC itself (V_{AAC}), and a shear resistance due to reinforcement oriented parallel to the direction of the shear.

The shear resistance due to the AAC itself (V_{AAC}) is computed using the web-shear approach of ACI 318-05. The diagonal tension resistance of the AAC is expressed in terms of its specified compressive strength, and principal tensile stresses, including the effects of axial loads, are equated with this diagonal tension resistance. This produces an expression for V_{AAC} in terms of the diagonal tension resistance of the AAC, and the axial load on the element. The resulting web-shear cracking equation is similar in form to the corresponding equation of ACI 318-05:

$$V_{AAC} = \ell_w t \sqrt{f'_{AAC}} \sqrt{1 + \frac{N_u}{2.4 \sqrt{f'_{AAC}} \ell_w t}} \quad (4-1)$$

The shear resistance due to transverse reinforcement embedded in grout is computed based on the cross-sectional area of the transverse reinforcement crossing a hypothetical 45-degree crack in the AAC. As with conventional reinforced concrete, this shear resistance may also be limited by bond and development of the reinforcement.

4.2.5 Bearing—To prevent local crushing of the AAC, nominal stresses in it are limited to f'_{AAC} . When AAC floor or roof panels bear on AAC walls, shear failure of the edge of the wall is also possible. This is handled by limiting the shear stress on potential inclined failure surfaces.

CHAPTER 5—HANDLING, ERECTION, AND CONSTRUCTION WITH AAC PANELS

5.1—Handling AAC panels

AAC panels should be stored on suitably prepared supports. When the panels are stored for an extended period of time, supports should be placed to minimize any warping due to creep. They should be carefully placed in their final position without being overstressed or damaged. Instructions from the manufacturer on how to handle the units should be followed. Special equipment is usually used or recommended by the manufacturer to assist in the transportation and erection of the units.

5.2—Erection of AAC wall panels

AAC panels are lifted and placed using specially designed clamps, and are aligned using pry-bars with sufficient bearing area to prevent indenting the soft AAC material. Pry-bars should be used to slide the panel being placed into the desired final location.

5.2.1 Erection of AAC cladding systems—AAC panels can be used as non-load-bearing cladding systems. This application usually involves horizontally oriented panels attached to

steel or reinforced concrete frames. Erection of such panels follows these steps:

- The supporting columns are made plumb and true;
- The bottom panel is set against the supporting columns and over the floor slab or slab-on-ground, on top of a bed joint of conventional masonry mortar. The panel is made true and level;
- Immediately after placing the first panel, a wall anchor plate is fastened to the column (using a dovetail or mechanically locking connector), and the plate is nailed to the AAC panel. The back face of the panel should be flush with the face of the plate anchored to the column;
- Subsequent panels are placed on top of the first one. The top and bottom faces of the horizontal wall panels can have either a tongue-and-groove or a flat profile. Tongue-and-groove joints do not require mortar for structural reasons, but may require mortar to prevent leaks. Flat joints are mortared with thin-bed mortar. ASTM standards for thin-bed mortar are under development. In the meantime, mortar for thin-bed AAC construction should meet the performance standards prescribed by the AAC manufacturer. These standards address minimum dry compressive strength, minimum wet compressive strength, minimum bond strength, minimum open time, and minimum working time. They also require that the mortar provide sufficient bond to the AAC masonry unit so that flexural tensile strength is controlled by the flexural tensile strength of the units rather than by the bond between units and mortar; and
- Horizontal and vertical joints are sealed with a flexible sealant resistant to ultraviolet and ozone exposure. Silicone sealants are most commonly used.

5.2.2 Erection of vertical AAC panels for bearing wall systems—Vertical AAC panels may also be used as a load-bearing wall system. In such cases, the floor and roof systems are usually designed and detailed as horizontal diaphragms to transfer lateral loads to shear walls. The tops of the panels are connected to the floor or roof diaphragms using a cast-in-place reinforced concrete ring beam. This and many other structural details are addressed in the next chapter.

When vertical wall panels are used in this way, they are set either on flashing, or on a bedding joint of conventional masonry mortar, with or without a waterproofing admixture. Flashing is usually more weather-resistant than mortar for this purpose. Vertical wall panels are usually mortared together with thin-bed mortar.

5.3—Erection of AAC floor and roof panels

AAC floor and roof panels can be erected on concrete, steel, or masonry construction. All bearing surfaces should be level, and minimum required bearing areas (to prevent local crushing) should be maintained.

As in any precast construction system, care should be exercised in the installation of the first panel to ensure correct alignment of the remaining panels. All floor and roof anchors should be installed before placement of the panels, thus expediting panel installation.

Most floor and roof panels are connected by keyed joints that are reinforced and filled with grout (ASTM C476) to lock the panels together and provide diaphragm action to resist lateral loads. A cast-in-place reinforced concrete ring beam is normally placed along the perimeter of the diaphragm, completing the system.

5.4—Electrical and plumbing installations in AAC

Electrical and plumbing installations in AAC are placed in routed chases. Care should be taken when laying out chases to maintain the structural integrity of the AAC panels. If reinforcement is cut or AAC is removed, the remaining section should be capable of supporting the design actions, and its calculated deformations and deflections should not exceed permitted values. In vertically spanning AAC elements, horizontal routing should be minimized. In contrast, in horizontally spanning AAC elements, vertical routing should be minimized. When electrical or plumbing installations are large in volume, designated chases are better than routed chases.

5.5—Exterior finishes for AAC

Unprotected exterior AAC deteriorates when exposed to cycles of freezing and thawing while saturated. To prevent such freezing-and-thawing deterioration, and to enhance the aesthetics and abrasion resistance of AAC, exterior finishes should be used. They should be compatible with the underlying AAC in terms of thermal expansion (Table 1.1) and modulus of elasticity, and should be vapor permeable. Many different types of exterior finishes are available, and the most common are discussed in this guide. Such finishes should be maintained throughout the life of the building.

5.5.1 Polymer-modified stuccos, paints, or finish systems—Polymer-modified stuccos, paints, or finish systems are the most common exterior finishes for AAC. They increase the AAC's water-penetration resistance while allowing the passage of water vapor. Heavy acrylic-based paints containing aggregates are also used to increase abrasion resistance. There is generally no need to level the surface, and horizontal and vertical joints may be chamfered as an architectural feature, or may be filled.

External finishes for AAC walls should be compatible in performance with vapor barriers. In geographic areas where vapor transmission is from outside to inside (typical of the southern United States), moisture in vapor form can condense within the AAC, and should be able to pass in vapor form to the conditioned space. In geographic areas where vapor transmission is from inside to outside (typical of very cold regions), a vapor barrier should be used on the inside face of the AAC wall to control the condensation of moisture inside the AAC.

5.5.2 Masonry veneer—AAC can be used with a wythe of masonry veneer. The veneer is attached to the AAC wall using masonry ties. The space between the AAC and the masonry can be left open (forming a drainage wall), or can be filled with mortar (forming a barrier wall). Drainage walls are generally preferable because they have lower water penetration.

5.5.3 Finishes for basement walls—When AAC panels are used in contact with moist or saturated soil (for example, in basement walls), the surface in contact with the soil should be coated with a waterproof material or membrane. The interior surface should either remain uncoated, or be coated with a vapor-permeable interior finish. Because AAC panels are factory-manufactured, there is no need for the additional cover requirements that are invoked for conventional concrete placed in contact with soil.

5.6—Interior finishes for AAC panels

Interior finishes are used to enhance the aesthetics and durability of AAC. They should be compatible with the underlying AAC in terms of thermal expansion and modulus of elasticity, and should be vapor permeable. Many different types of interior finishes are available, and the most common are discussed in this guide.

5.6.1 Interior plasters—Interior surfaces of AAC wall panels may have a thin coat of a mineral-based plaster to achieve a smooth finished surface. Lightweight interior gypsum-based plaster may provide a thicker coating to level and straighten walls, and to provide a base for decorative interior paints or wall finishes. Interior plasters have bonding agents to enhance their adhesion and flexibility, and are commonly installed by either spraying or troweling.

5.6.2 Gypsum board—When applied to the interior surface of exterior AAC walls, gypsum board should be attached using metal or pressure-treated wooden furring strips. When applied to interior walls, moisture-resistant gypsum board can be applied directly to the AAC surface.

5.6.3 High-durability finishes for commercial applications—For commercial applications requiring high durability and low maintenance, acrylic-based coatings are often used. Some contain aggregates to enhance abrasion resistance. High-durability finishes for exterior use should be vapor-permeable and impervious to liquid water.

5.6.4 Ceramic tile—When ceramic wall tile is to be applied over AAC, surface preparation is normally necessary only when the AAC surface requires leveling. In such cases, a portland cement- or gypsum-based parge coat is applied to the AAC surface before setting the ceramic tile. The ceramic tile should then be adhered to the parged wall using either a cement-based thin-set mortar or an organic adhesive. In moist areas, gypsum should not be used. Only a portland cement-based parge coat should be used, and the ceramic tile should be set with cement-based thin-set mortar only.

CHAPTER 6—TYPICAL CONSTRUCTION DETAILS FOR AAC PANELS

The details shown in this guide are intended to address a wide range of typical structural configurations. They cannot include every structural configuration.

The details shown in this guide are intended primarily to address structural issues. They are not intended to address the complete range of requirements for water-penetration resistance. They should be supplemented by the judgment of those experienced in the detailing of AAC walls for water-penetration resistance.

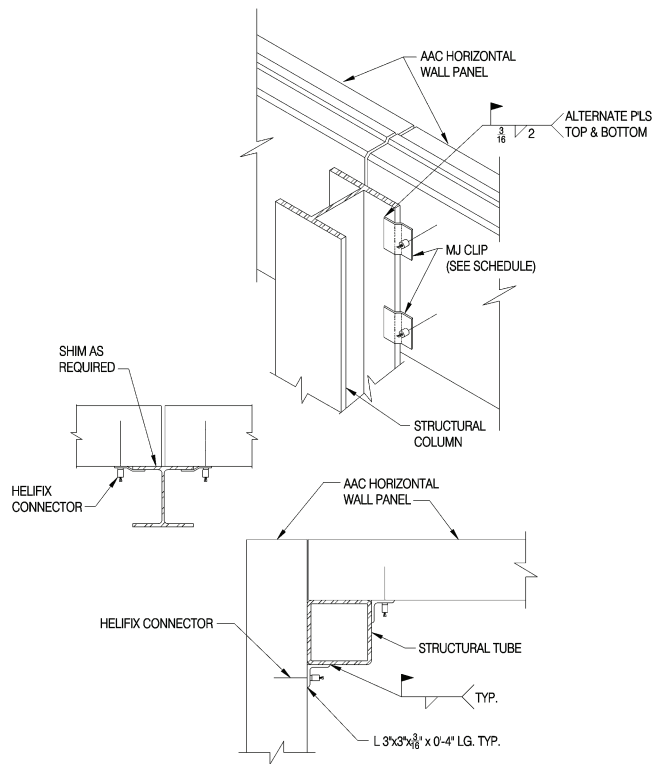


Fig. 6.1—Exterior horizontal wall panels at steel column.

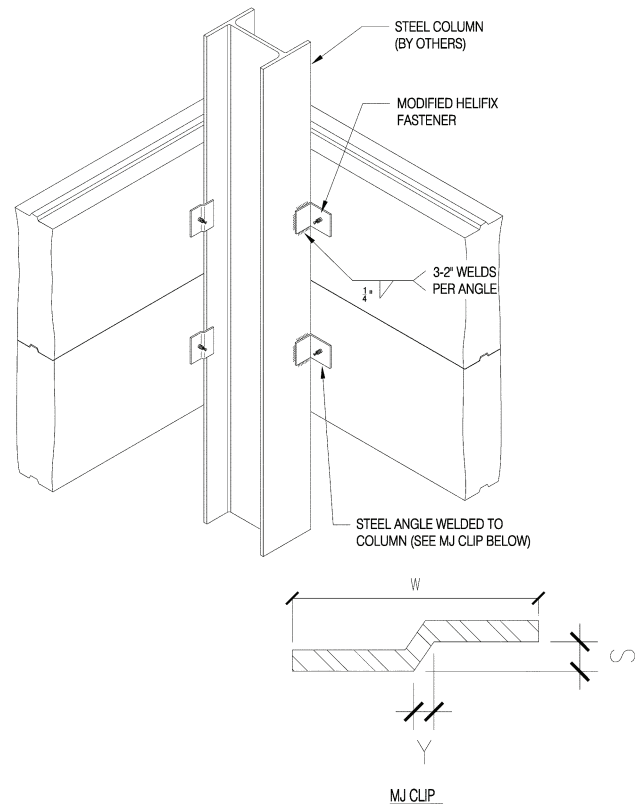


Fig. 6.2—Exterior horizontal wall panels at steel column (additional details).

6.1—Cladding wall panel systems

6.1.1 Exterior horizontal wall panels at steel column—Typical exterior horizontal wall panels at a steel column are illustrated in Fig. 6.1 and 6.2.

6.1.2 Exterior vertical wall panels at steel beam—Typical exterior vertical wall panels at a steel beam are illustrated in Fig. 6.3 and 6.4.

6.1.3 Typical vertical wall panel and sections—A typical vertical wall panel and sections are illustrated in Fig. 6.5.

6.1.4 Typical horizontal panel layout—A typical horizontal panel layout is illustrated in Fig. 6.6.

6.1.5 Typical vertical panel layout—A typical vertical panel layout is illustrated in Fig. 6.7.

6.1.6 Large door frame detail—A typical large door frame detail is illustrated in Fig. 6.8.

6.2—Load-bearing vertical wall panel systems

6.2.1 Typical vertical joint profile—A typical vertical joint profile is illustrated in Fig. 6.9.

6.2.2 Typical vertical joint profile at AAC lintel—A typical vertical joint profile at an AAC lintel is illustrated in Fig. 6.10.

6.2.3 Wall section for multiple stories—Figure 6.11 is generic, and is not intended to be specific with respect to foundation details. The roof slope, required for drainage, is not shown.

6.2.4 Exterior wall section for multiple stories with vertical reinforcement—Figures 6.12 and 6.13 are generic, and are not intended to be specific with respect to reinforcement details. Flashing, discussed in Section 5.2.2, is not shown. Some, but not all, manufacturers recommend that exposed AAC be coated with paint or low-modulus stucco.

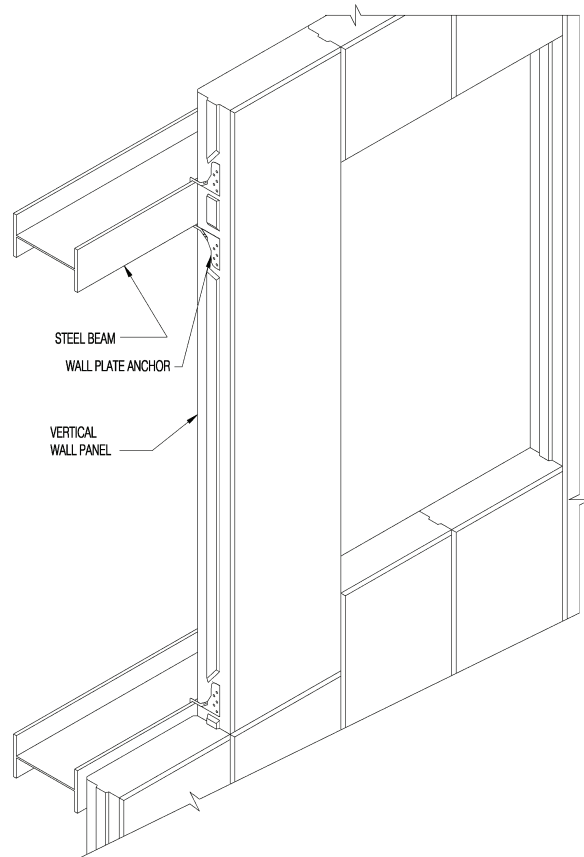


Fig. 6.3—Exterior vertical wall panels at steel beam.

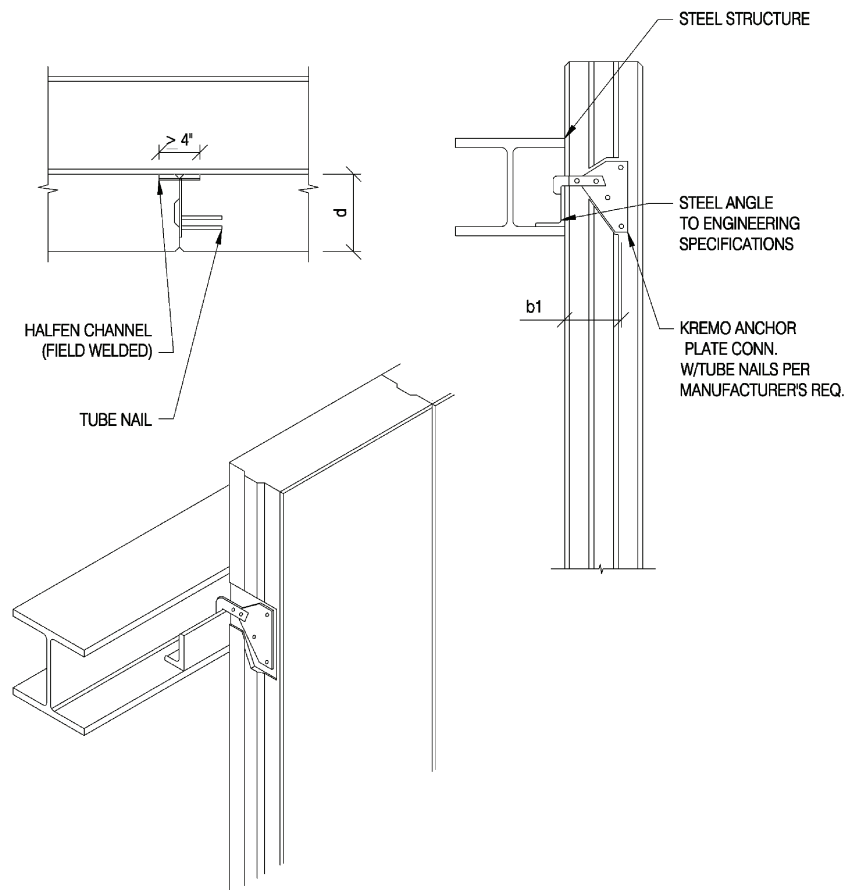


Fig. 6.4—Exterior wall panels at steel beam (additional details).

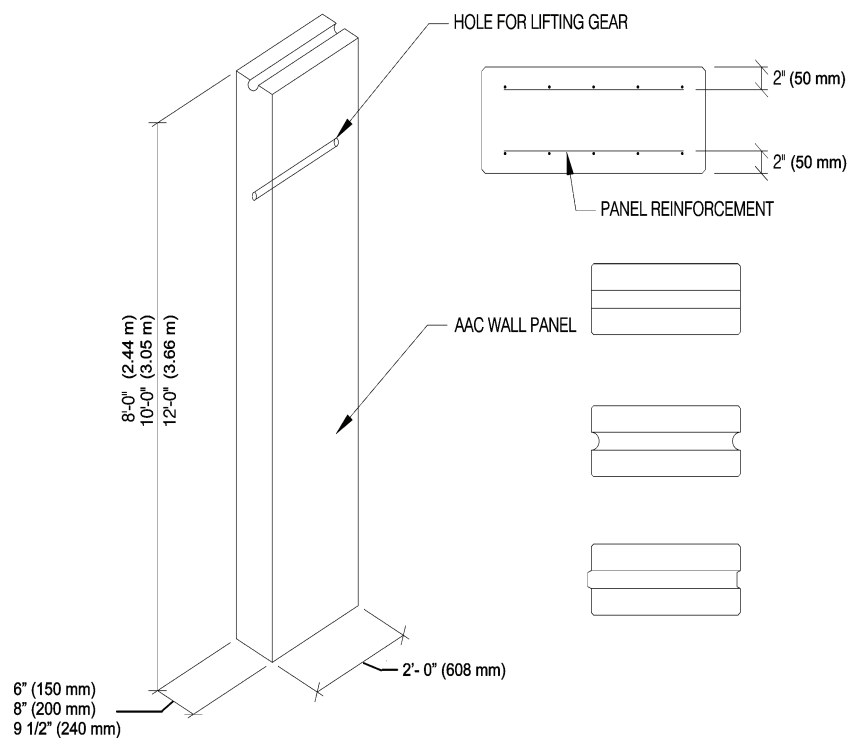


Fig. 6.5—Typical vertical wall panel and sections.

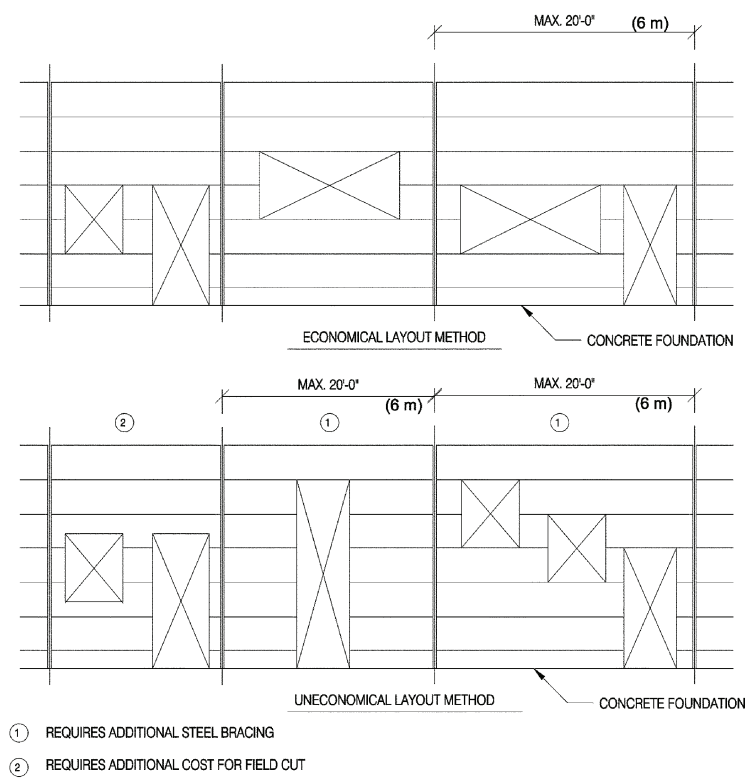


Fig. 6.6—Typical horizontal panel layout.

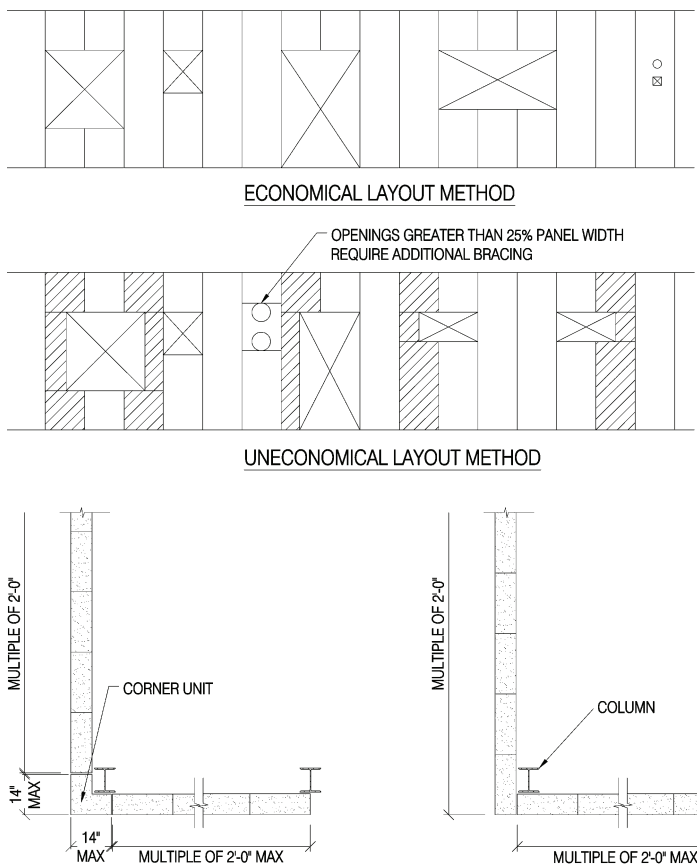


Fig. 6.7—Typical vertical panel layout.

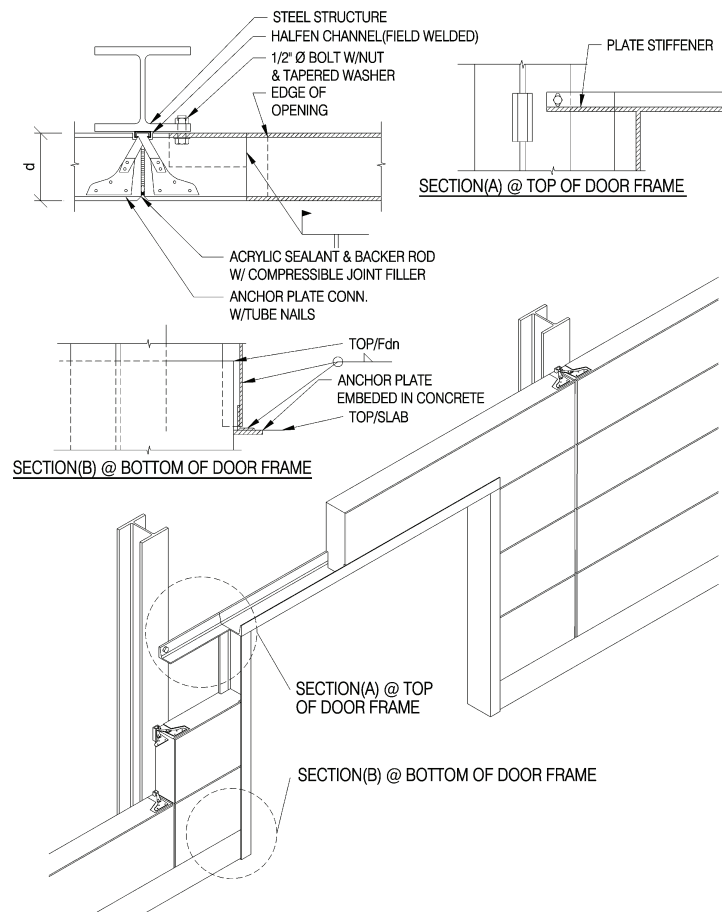


Fig. 6.8—Typical large door panel detail.

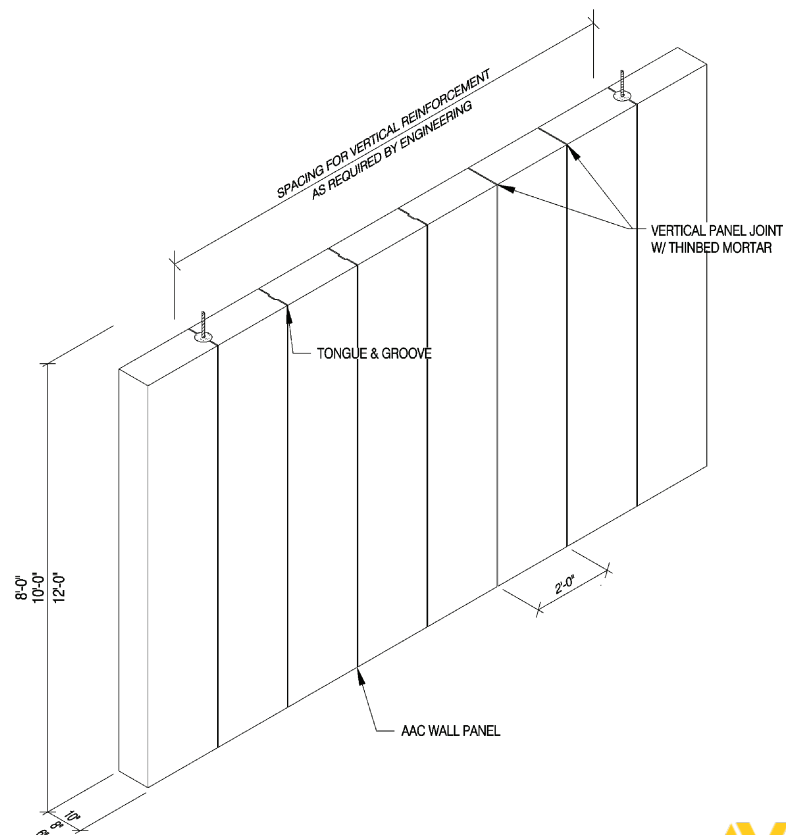


Fig. 6.9—Typical vertical joint profile.

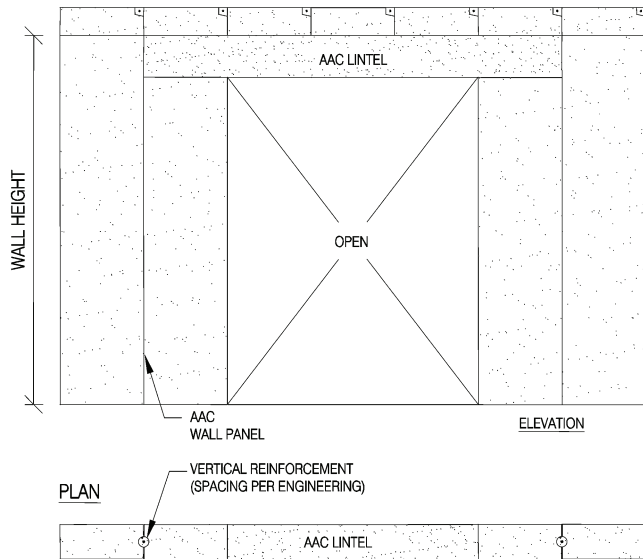


Fig. 6.10—Typical vertical joint profile at AAC lintel.

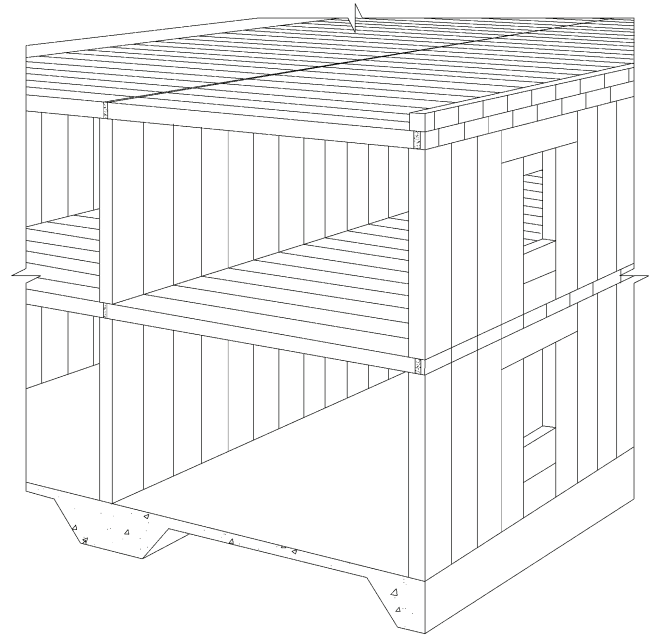


Fig. 6.11—Wall section for multiple stories.

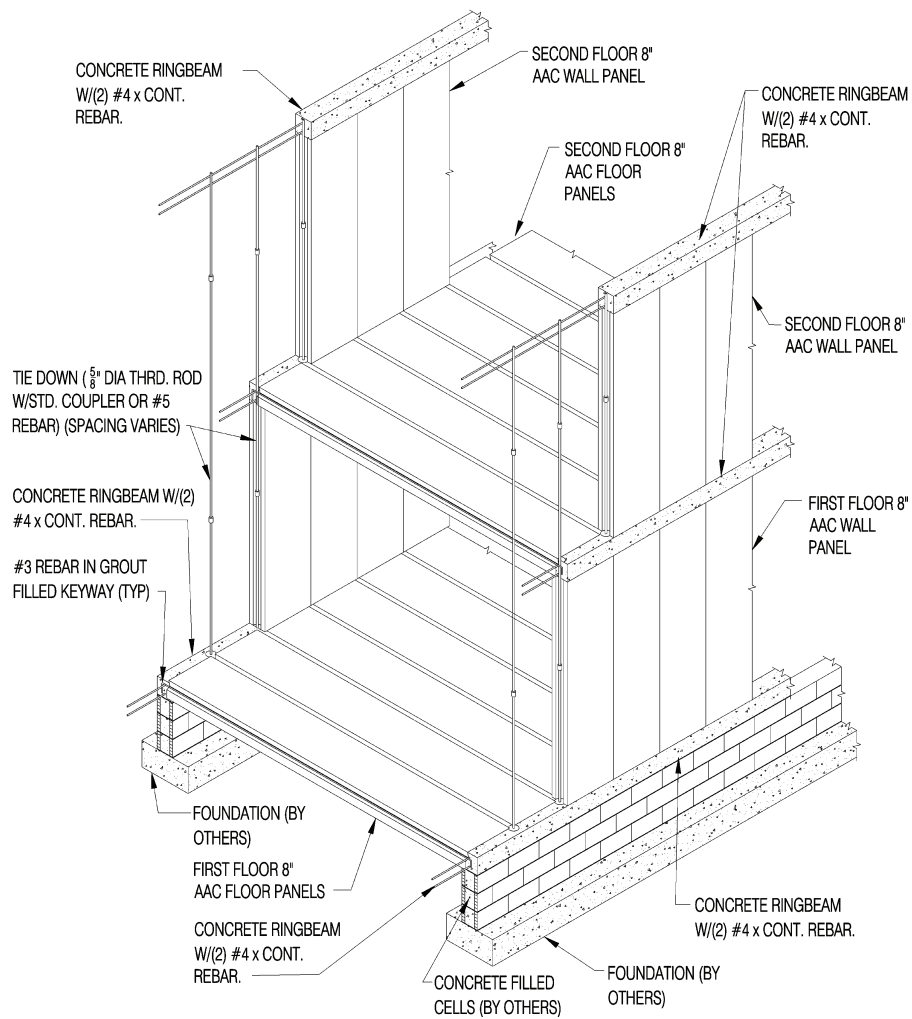


Fig. 6.12—Exterior wall section for multiple stories with vertical reinforcement.



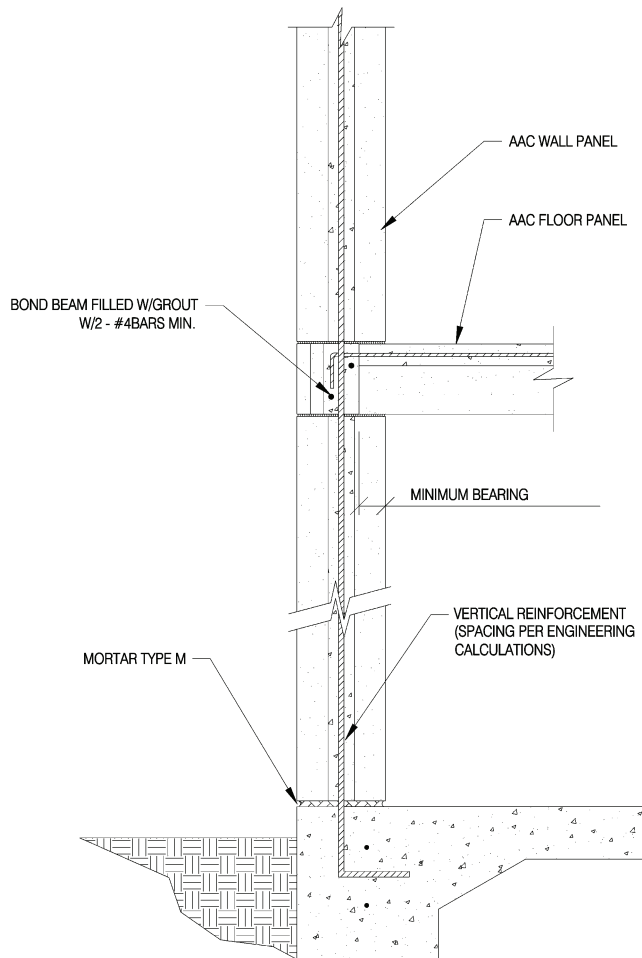


Fig. 6.13—Exterior section for multiple stories with vertical reinforcement (additional details).

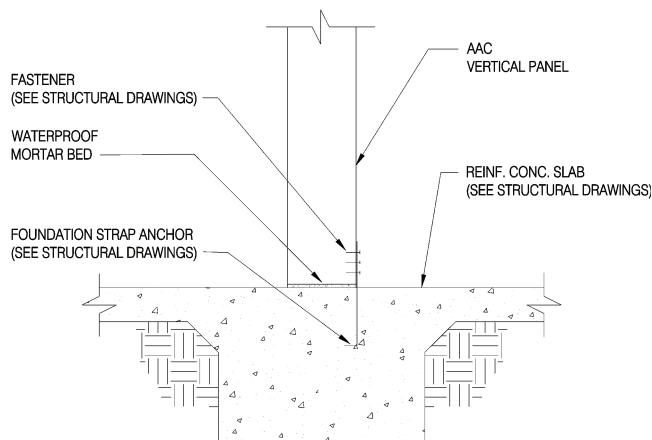


Fig. 6.14—Interior bearing wall section at footing.

6.2.5 Interior bearing wall section at footing—Figure 6.14 is generic, and is not intended to be specific with respect to foundation details. Spacing of the flat anchors should be consistent with loads.

6.2.6 Exterior wall panel at CMU stem wall and footing—Figure 6.15 is generic, and is not intended to be specific with respect to foundation details or waterproofing details. Some,

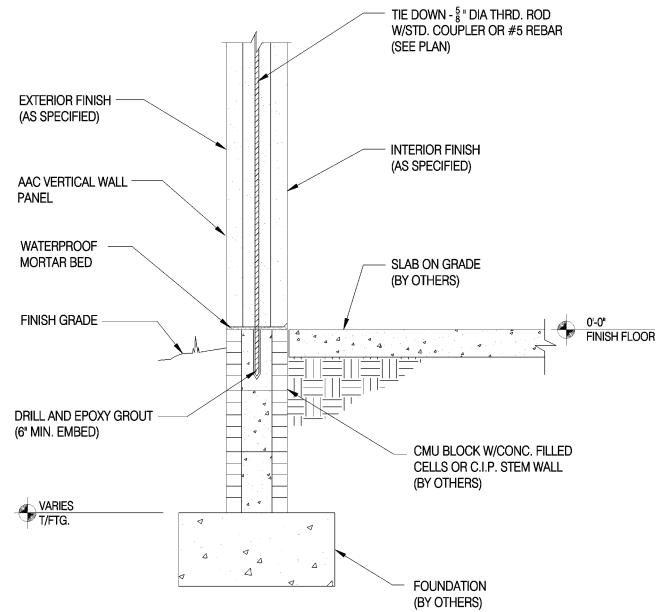


Fig. 6.15—Exterior wall panel at CMU stem wall and footing.

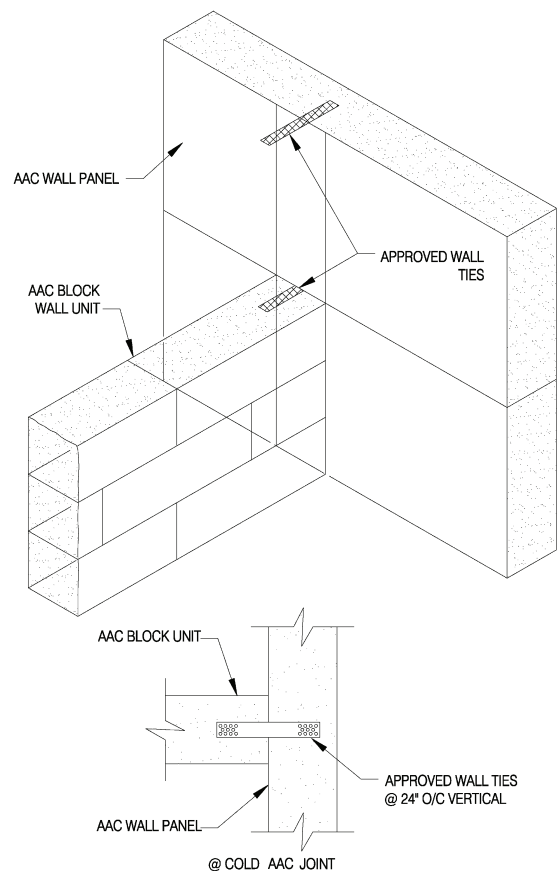


Fig. 6.16—Intersection of AAC panels and AAC blocks.

but not all, manufacturers recommend that exposed AAC be coated with paint or low-modulus stucco. Vapor barriers, discussed in Section 5.5.1, are not shown.

6.2.7 Intersection of AAC panels and blocks—The section of AAC panels and blocks is illustrated in Fig. 6.16.

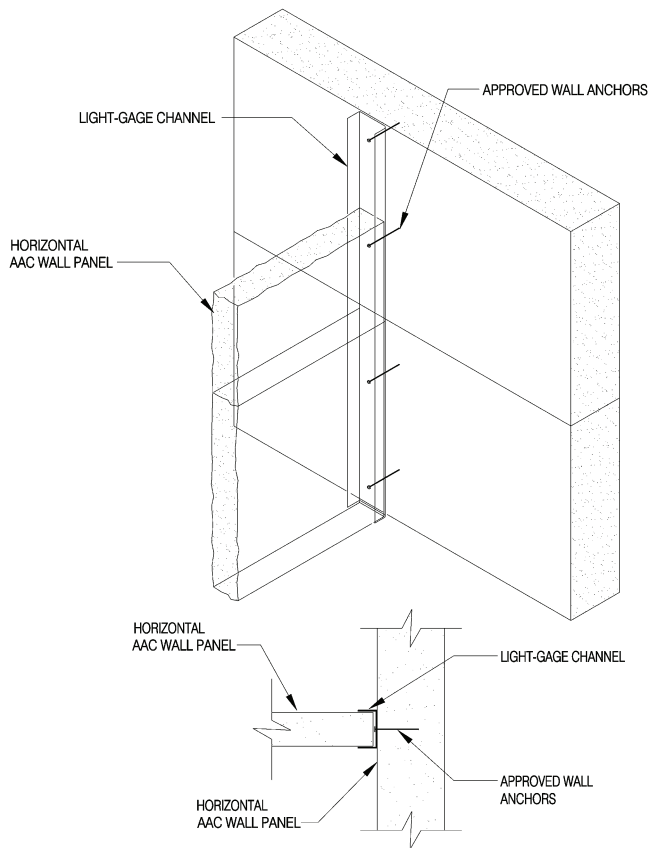


Fig. 6.17—Intersection of exterior partition panels.

6.2.8 Intersection of partition panels—An intersection of partition panels is illustrated in Fig. 6.17.

6.3—Floor and roof details

6.3.1 Minimum bearing details—The minimum bearing details shown in Fig. 6.18 are not intended to replace engineering calculations. Examples of such calculations are addressed in A.1.10.4 of the Commentary of ACI 530-05/ASCE/5-05/TMS 402-05 (Masonry Standards Joint Committee 2005c).

6.3.2 Exterior floor panel support wall detail—Figure 6.19 is generic, and is not intended to be specific with respect to reinforcement details. Ventilation and vapor barriers, discussed in Section 5.5.1, are not shown.

6.3.3 Interior floor panel support detail—Figure 6.20 is generic, and is not intended to be specific with respect to reinforcement details.

6.3.4 Grout key and bond beam reinforcement—Figure 6.21 is generic, and is not intended to be specific with respect to reinforcement details. Flashing, discussed in Section 5.2.2, is not shown.

6.3.5 Floor panel at concrete basement wall—Figure 6.22 is generic, and is not intended to be specific with respect to foundation details or waterproofing details. Some, but not all, manufacturers recommend that exposed AAC be coated with paint or low-modulus stucco. Flashing, discussed in Section 5.2.2, is not shown.

6.3.6 Floor panel at CMU basement wall—Figure 6.23 is generic, and is not intended to be specific with respect to

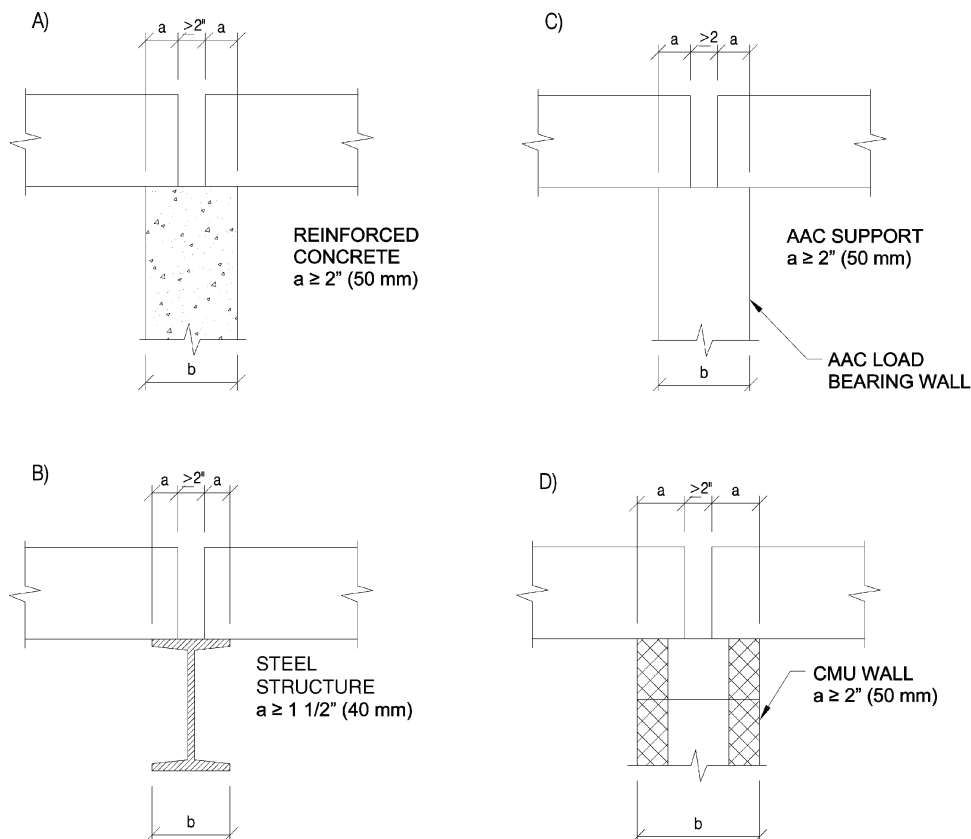


Fig. 6.18—Minimum bearing details.

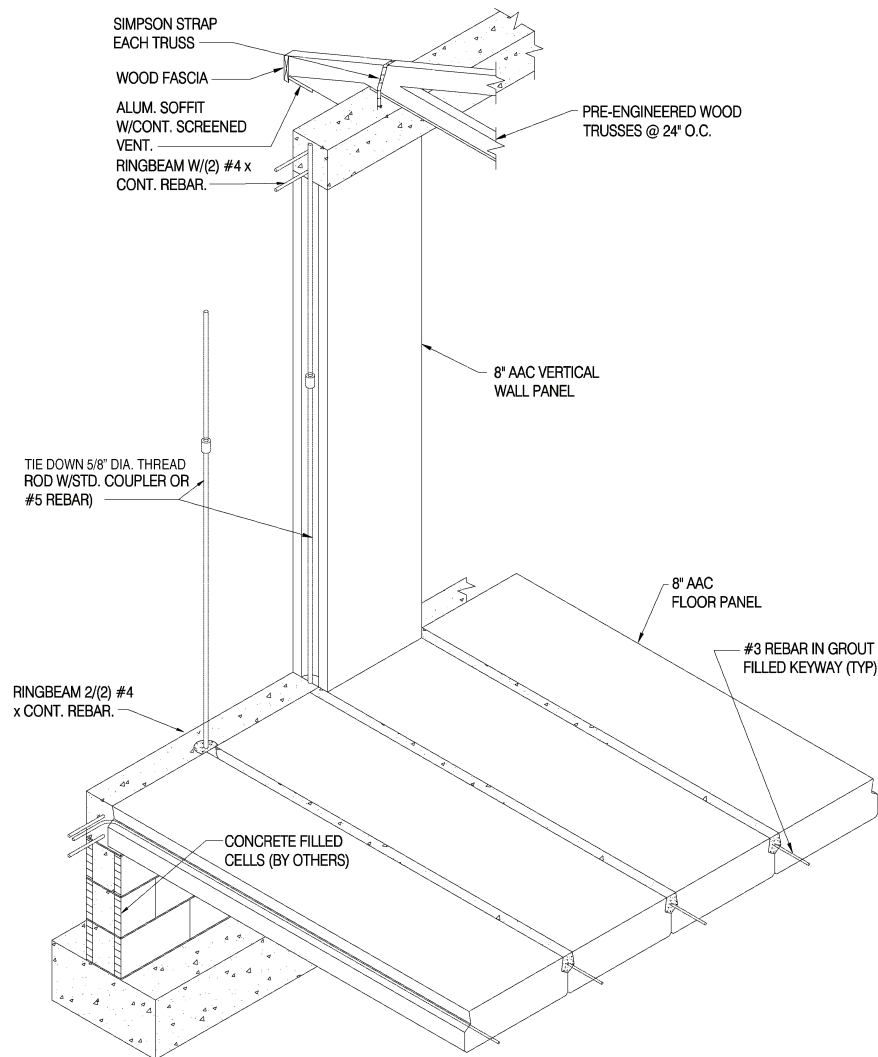


Fig. 6.19—Exterior floor panel support wall detail.

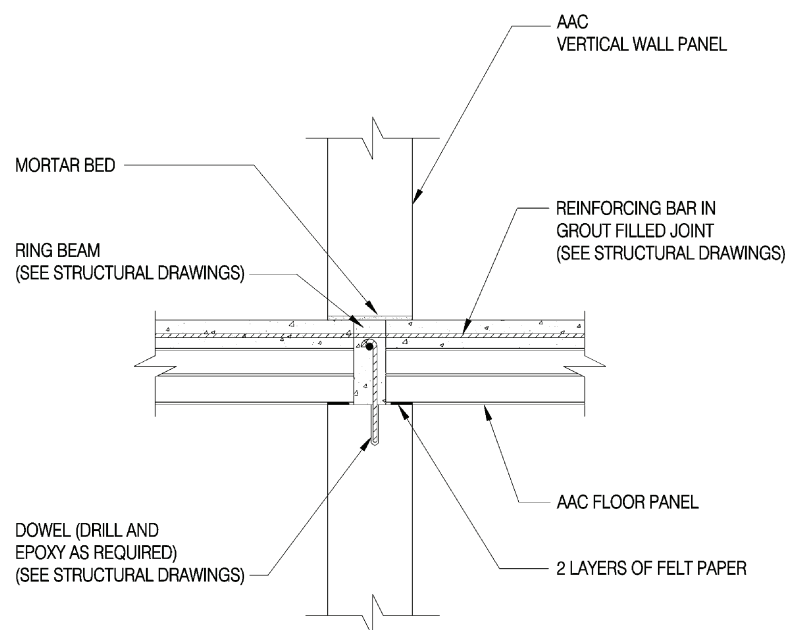


Fig. 6.20—Interior floor panel support detail.

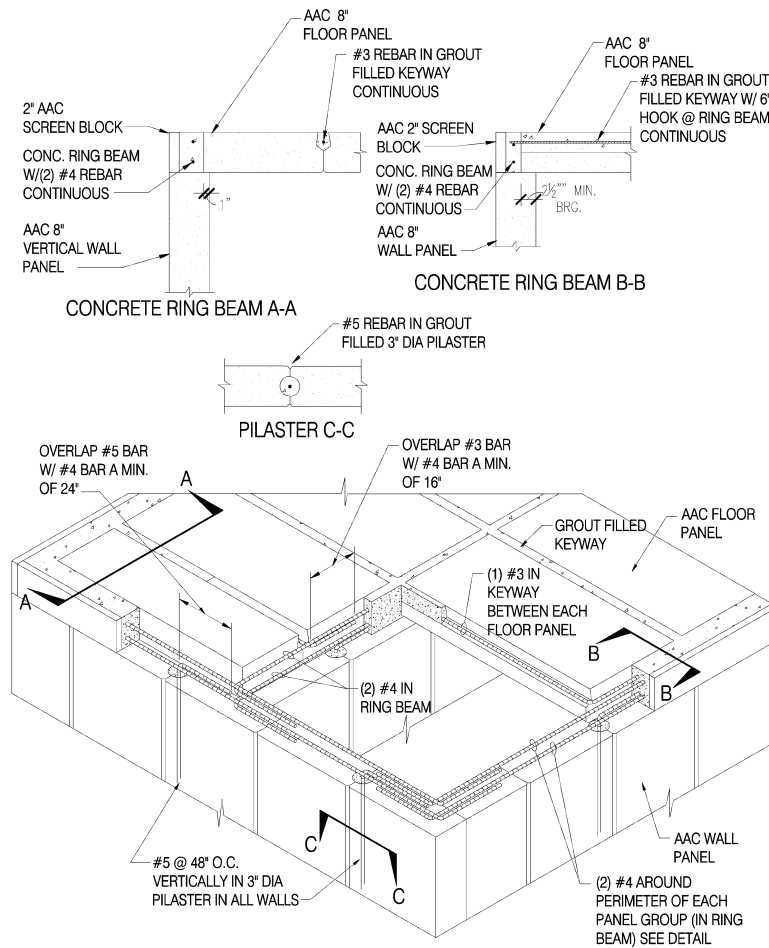


Fig. 6.21—Grout key and bond beam reinforcement.

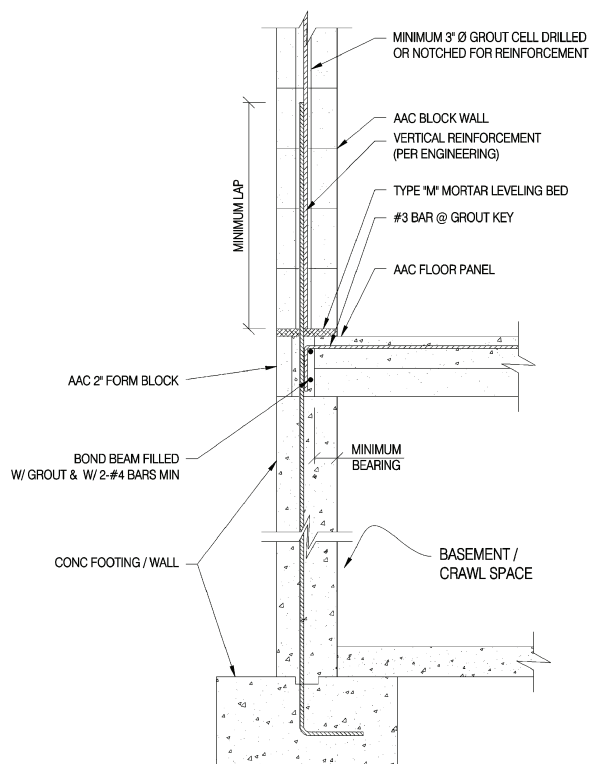


Fig. 6.22—Floor panel at concrete basement wall.

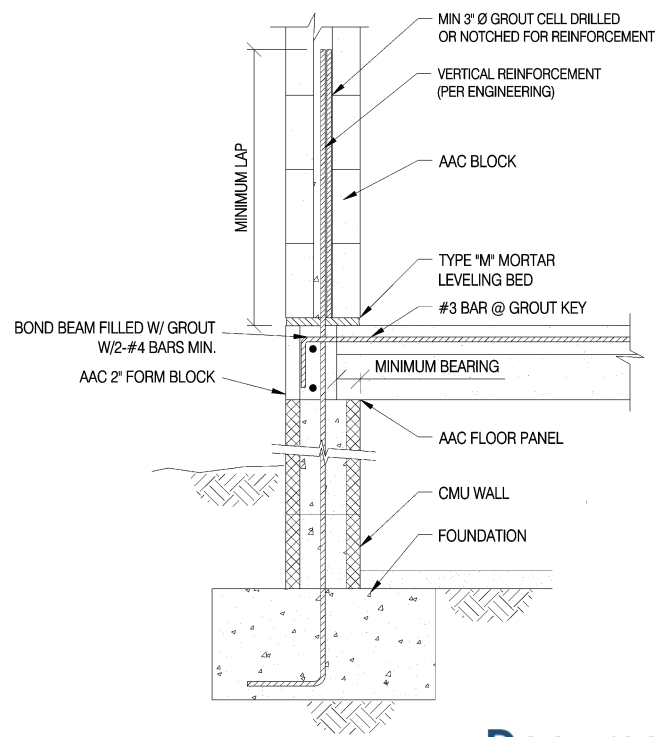


Fig. 6.23—Floor panel at CMU basement wall.



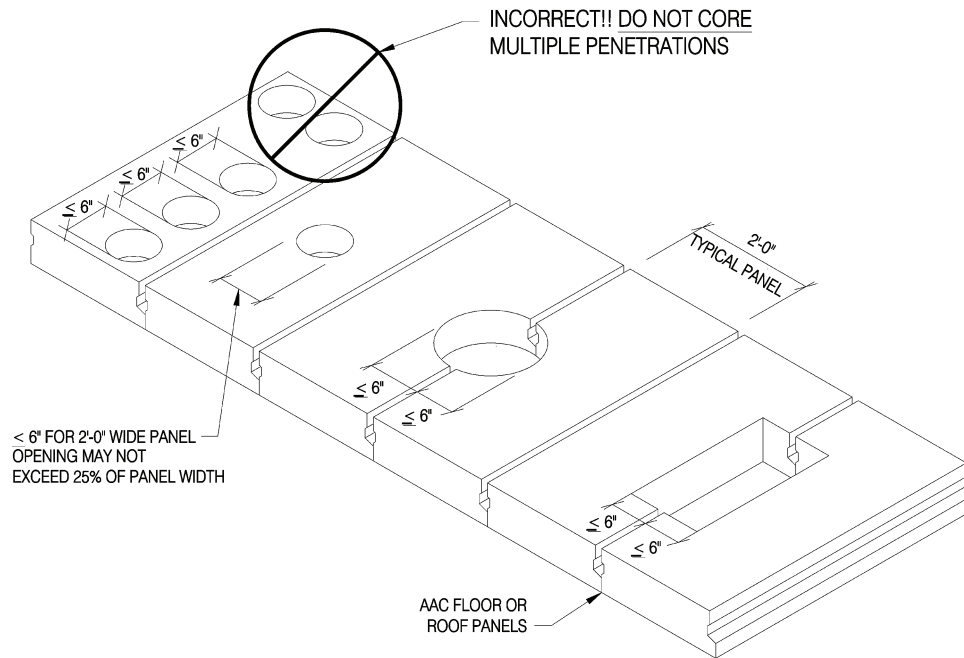


Fig. 6.24—Permitted sizes and locations of on-site coring.

foundation details or waterproofing details. Some, but not all, manufacturers recommend that exposed AAC be coated with paint or low-modulus stucco. Flashing, discussed in Section 5.2.2, is not shown.

6.3.7 Permitted sizes and location of on-site coring—Permitted sizes and location of on-site coring are illustrated in Fig. 6.24.

CHAPTER 7—TECHNICAL JUSTIFICATION FOR PROPOSED DESIGN PROVISIONS

In this chapter, a synthesis of available data (Fouad and Dembowski 2005a,b; Argudo 2003; Tanner et al. 2005a,b; Varela et al. 2006; Klingner et al. 2005a,b) is used to develop a technical justification (“super-commentary”), commentary, and design provisions for reinforced AAC panels. The provisions are compatible with existing ACI 318 organization and style, and consistent with current or modified draft design provisions for AAC masonry provided in Appendix A of ACI 530-05/ASCE 5-05/TMS 402-05 (Masonry Standards Joint Committee 2005a).

7.1—Key mechanical characteristics of AAC

7.1.1 Compressive strength of AAC—Results for the compressive strength and density reported by independent investigators are presented in Table 7.1 (Tanner 2003; Fouad and Dembowski 2005a; Dembowski 2001; Snow 1999). ASTM C1386 gives requirements for average and minimum compressive strengths for 4 in. (100 mm) cubes tested in the dry condition (Fig. 7.1). Each data point of Table 7.1 is the average of a group of three to six specimens based on 4 in. (100 mm) cubes, 4 in. (100 mm) diameter cores, or blocks. A few tests fall below the minimum compressive strength requirements defined by ASTM C1386. This issue is now being addressed by AAC producers, and should continue to be checked.

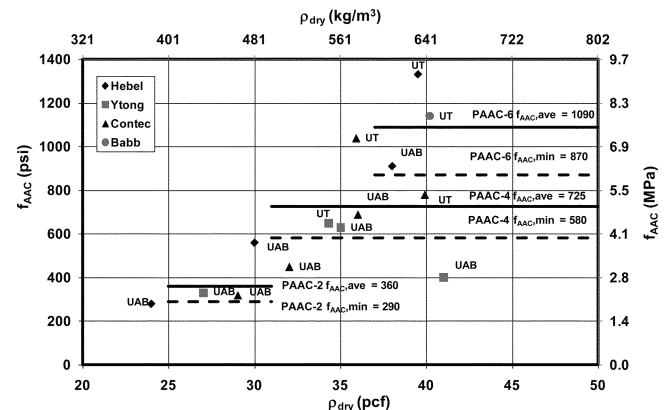


Fig. 7.1—Compressive strength versus dry density with ASTM C1386 requirements (Argudo 2003; Tanner 2003; Dembowski 2001; Snow 1999).

For the specimens of Tanner (2003), the dry density was converted to a density corresponding to a 10% moisture content to compare with the tests performed by Fouad and Dembowski (2005a) (Fig. 7.2). The value of 10% was selected because it is at the middle of the range of moisture contents (MC) permitted by ASTM C1386 (5 to 15%).

Figure 7.2 indicates that the data in two investigations agree (Fouad and Dembowski 2005a,b; Dembowski 2001; Snow 1999; Argudo 2003; Tanner 2003). The linear regression for these data corresponds to an R^2 value of 0.53. The correlation coefficient could be improved to 0.78 by eliminating data for tests on Ytong Grade 3 AAC. This may not be a good idea, however, because this class of material (high-density) is consistently low in compressive strength, modulus of rupture, and shear strength (Fig. 7.3 and Fig. 7.4). This suggests that for Ytong material, as density increases,

Table 7.1—Summary of results for compressive strength and density (Tanner 2003; Fouad and Dembowski 2005a; Dembowski 2001; Snow 1999)

Data source	Manufacturer's specifications		Material density			Measured compressive strength f_{AAC} , psi (MPa)
	Material	ρ , lb/ft ³ (kg/m ³)	Dry density ρ_{dry} , lb/ft ³ (kg/m ³)	Measured density at test, lb/ft ³ (kg/m ³)	Calculated density at MC = 10%, lb/ft ³ (kg/m ³)	
UAB	Hebel-HG1	25 (401)	24.0 (385)	25.9 (415)	26.4 (423)	280 (1.93)
	Hebel-HG2	32 (513)	30.0 (481)	32.4 (520)	33.0 (529)	560 (3.86)
	Hebel-HG3	38 (610)	38.0 (610)	41.0 (658)	41.8 (670)	910 (6.27)
	Ytong-YG1	25 (401)	27.0 (433)	29.3 (470)	29.7 (476)	330 (2.28)
	Ytong-YG2	31 (497)	35.0 (561)	38.0 (610)	38.5 (618)	630 (4.34)
	Ytong-YG3	40 (642)	41.0 (658)	44.5 (714)	45.1 (723)	400 (2.76)
	Contec-CG1	25 (401)	29.0 (465)	31.9 (512)	31.9 (512)	320 (2.21)
	Contec-CG2	32 (513)	32.0 (513)	35.2 (565)	35.2 (565)	450 (3.10)
	Contec-CG3	38 (610)	36.0 (577)	39.6 (635)	39.6 (635)	690 (4.76)
UT	Contec-1	—	39.9 (640)	NA	43.9 (704)	781 (5.38)
	Contec-2	—	35.9 (576)	37.6 (603)	39.5 (634)	1040 (7.17)
	Babb-1	—	40.2 (645)	44.1 (707)	44.2 (709)	1140 (7.86)
	Hebel-2	—	39.5 (634)	40.0 (642)	43.5 (698)	1330 (9.17)
	Ytong-2	—	34.3 (550)	39.1 (627)	37.7 (605)	650 (4.48)
	Babb-2	—	33.5 (537)	35.6 (571)	36.9 (592)	496 (3.42)

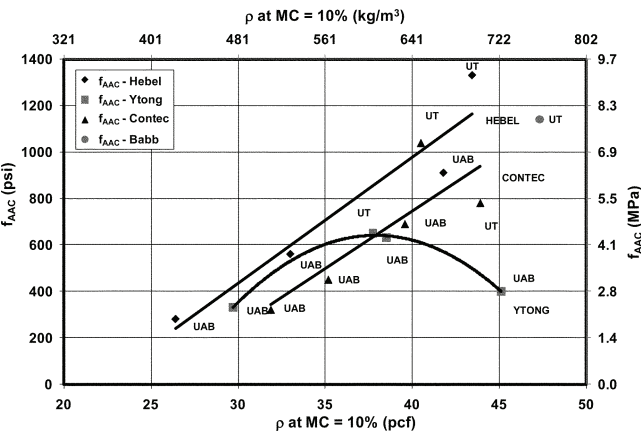


Fig. 7.2—Compressive strength versus calculated density corresponding to a 10% moisture content (Argudo 2003; Tanner 2003; Dembowski 2001; Snow 1999).

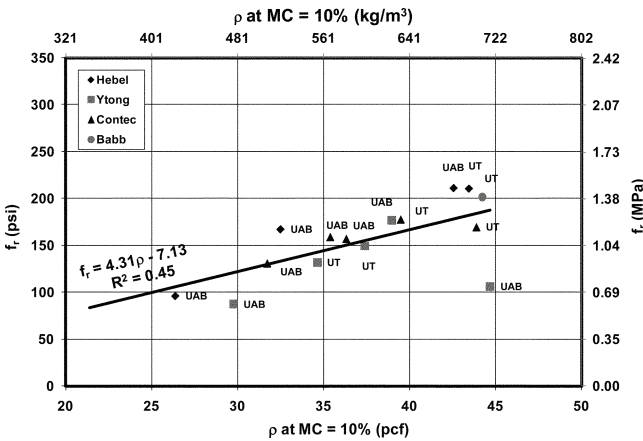


Fig. 7.4—Modulus of rupture versus density for Method 1: stresses perpendicular to direction of rise (Argudo 2003; Dembowski 2001; Snow 1999).

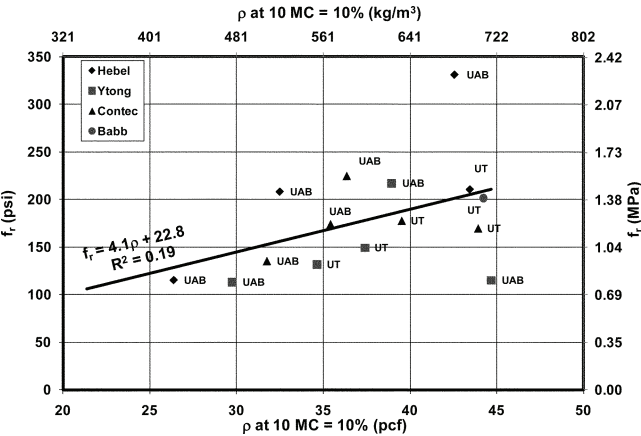


Fig. 7.3—Modulus of rupture versus density for Method 1: stresses parallel to direction of rise (Argudo 2003; Dembowski 2003; Snow 1999).

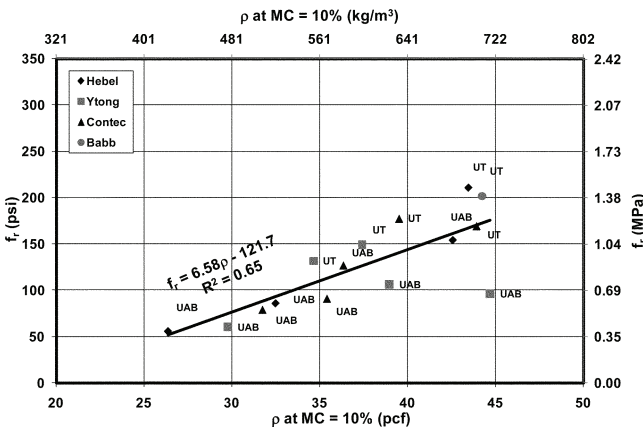


Fig. 7.5—Modulus of rupture versus density for Method 2: stresses parallel to direction of rise.

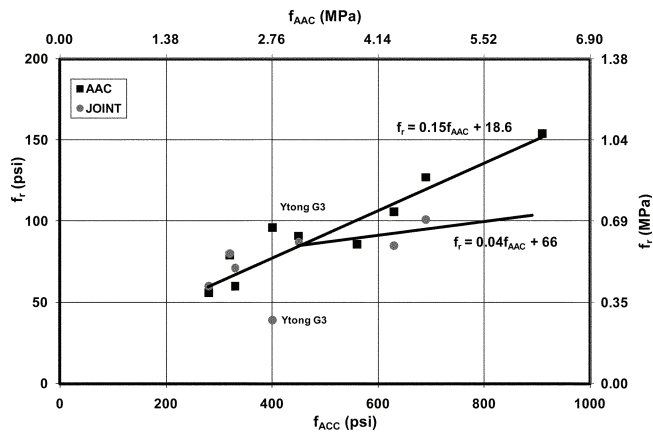


Fig. 7.6—Tensile bond strength versus density.

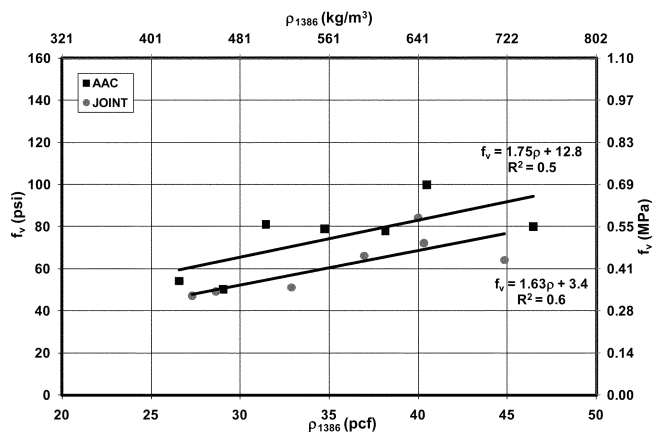


Fig. 7.7—Shear strength of AAC units and thin-bed mortar versus density (Argudo 2003; Dembowski 2001; Snow 1999).

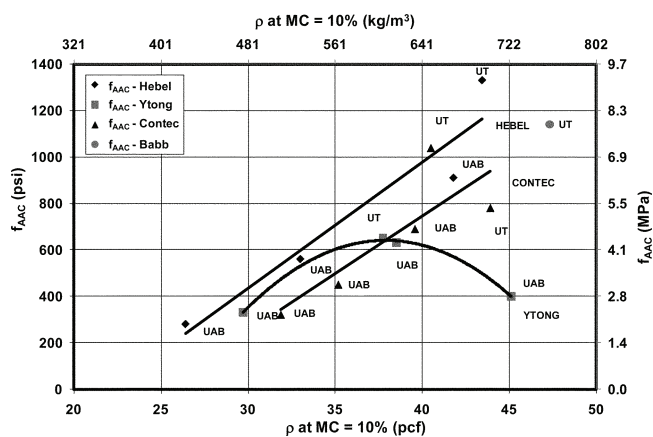


Fig. 7.8—Variation of compressive strength versus calculated density at a moisture content of 10% (Argudo 2003; Tanner 2003; Dembowski 2001; Snow 1999).

these mechanical properties of AAC increase, reach a maximum, and then decrease. This nonlinear tendency cannot be verified for other manufacturers using UAB data, because there are no UAB data for high-strength material from other manufacturers. This nonlinear tendency cannot be verified using data from UT Austin, because UT Austin did not test the high-strength Ytong material.

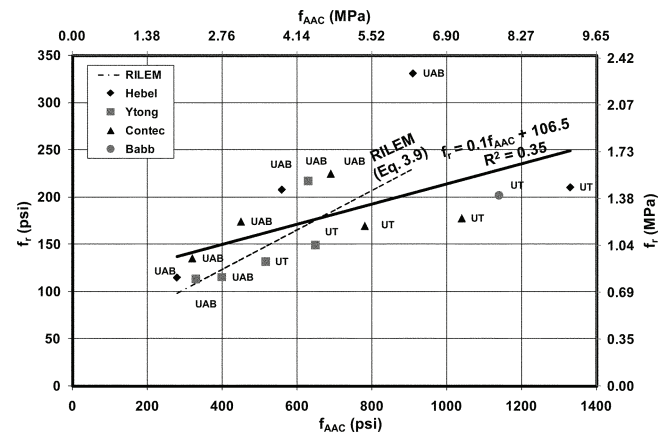


Fig. 7.9—Modulus of rupture versus compressive strength for Method 1: stresses parallel to direction of rise (Argudo 2003; Dembowski 2001; Snow 1999).

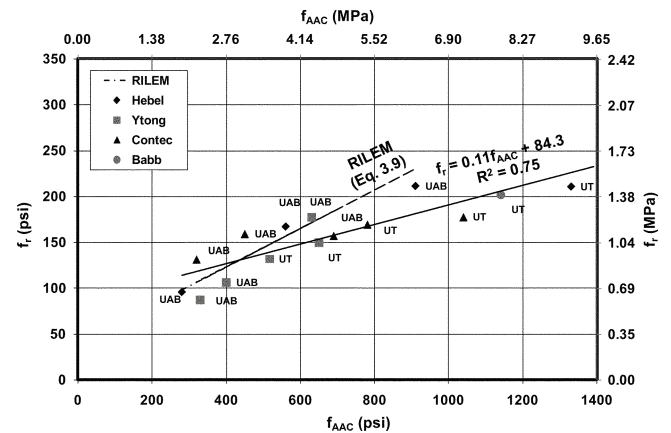


Fig. 7.10—Modulus of rupture versus compressive strength for Method 1: stresses perpendicular to direction of rise (Argudo 2003; Dembowski 2001; Snow 1999).

In general, the regressions of material strengths versus density for individual manufacturers have been linear or parabolic (Fig. 7.8). If results for the Ytong Grade 3 material are considered anomalous, those results can be discarded. If the results are considered reliable, however, it is unconservative to use a linear relationship with density. Because the compressive strength, tensile strength, and shear strength vary in the same way, one independent variable could be selected, and the other two expressed in terms of that independent variable. The compressive strength is a logical choice for that independent variable, because it is calculated routinely. In addition, traditional reinforced concrete design expresses other material properties in terms of compressive strength. The result of this choice is presented in Fig. 7.9 through 7.11. The change in correlation coefficient for these graphs is presented in Table 7.2.

Excluding Ytong G3 increases the correlation coefficient by 30 to 70% when the modulus of rupture is expressed in terms of density; excluding Ytong G3 has almost no effect on the correlation coefficient when the modulus of rupture is expressed as a function of the compressive strength. This is because the compressive and tensile strengths for Ytong G3

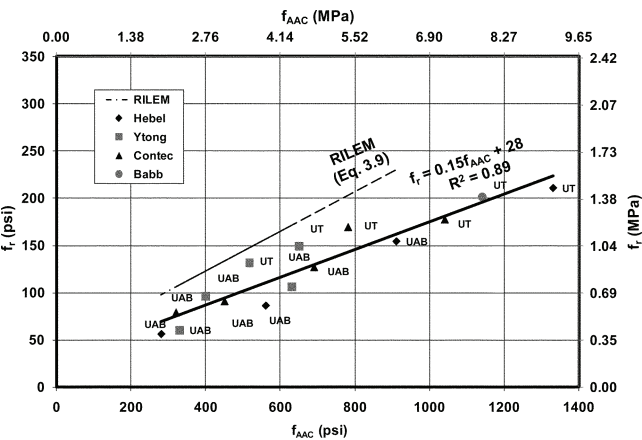


Fig. 7.11—Modulus of rupture versus compressive strength for Method 2: stresses parallel to direction of rise (Argudo 2003; Dembowski 2001; Snow 1999).

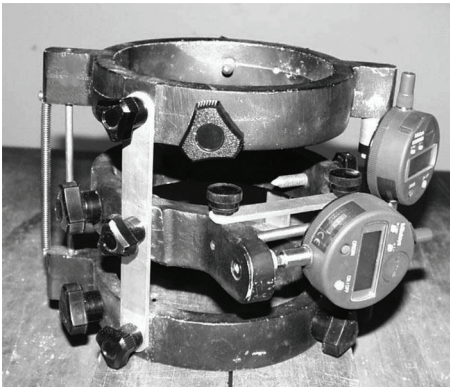


Fig. 7.12—Test setup for measuring compressive stress versus strain (Tanner 2003).

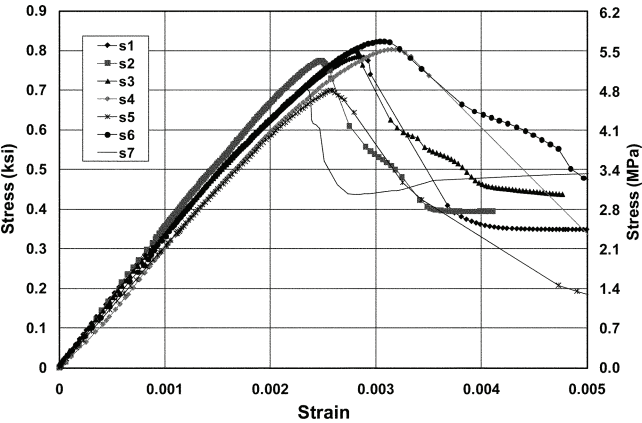


Fig. 7.13—Compressive stress versus strain for Contec Shipment 1 (Tanner 2003).

diverge similarly with respect to density; thus, the relationship between tensile strength and compressive strength is preserved. For design purposes, it is more suitable to express the modulus of rupture for Ytong G3 in terms of compressive strength rather than as a function of density. If the modulus of rupture were based on a linear relationship with density, the design could be unsafe (Argudo 2003).

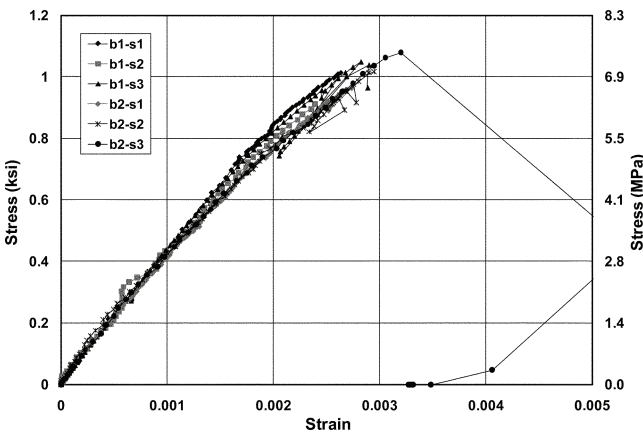


Fig. 7.14—Compressive stress versus strain for Contec Shipment 2 (Tanner 2003).

Table 7.2—Change in correlation coefficients for modulus of rupture tests and compression (Argudo 2003; Dembowski 2001; Snow 1999)

Type of test/direction of stresses relative to rise (MOR only)	All data versus density ρ at MC = 10%	Ytong G3 excluded versus density ρ at MC = 10%	All data versus f_{AAC}	Ytong G3 excluded versus f_{AAC}
Compressive strength	0.53	0.78	NA	NA
Modulus of rupture Method 1/parallel	0.19	0.34	0.35	0.31
Modulus of rupture Method 1/perpendicular	0.45	0.77	0.75	0.74
Modulus of rupture Method 2/parallel	0.65	0.85	0.89	0.89

An additional advantage of expressing other material properties in terms of the compressive strength is the elimination of the effect of moisture content as a variable in the relationships among properties, because all properties vary similarly with moisture content (Section 7.1.2.1).

Finally, the relationship between compressive strength and density is very important for demonstrating the consistency and reliability of AAC. It is less important for actual design, which is usually not controlled by compressive strength.

7.1.2 Stress-strain behavior and modulus of elasticity of AAC—Additional tests performed measured the strains up to failure of 4 in. (100 mm) diameter AAC cores (Tanner 2003; Cancino 2003). Each data point represents the average of six tests. Strains were measured with a set of rings attached to the cylinder (Fig. 7.12). The lower ring remains fixed, and the upper ring pivots around a vertical pin. The vertical displacement is measured and converted into a strain. The center ring is optional, and measures transverse strain. It was used in all tests except Contec Shipment 1 and Babb Shipment 2. Once the specimen begins to lose strength quickly, the reported strains may be smaller than the actual value due to limitations of the scanning rate of the data acquisition system.

The stress-strain curves for each specimen are presented in Fig. 7.13 through 7.19. With the exception of Babb Shipment 3, all but two groups (Contec Shipment 2 and Babb Shipment 2) reached a strain of 0.003. Although Contec Shipment 1 did not reach strains greater than 0.003, data from that shipment

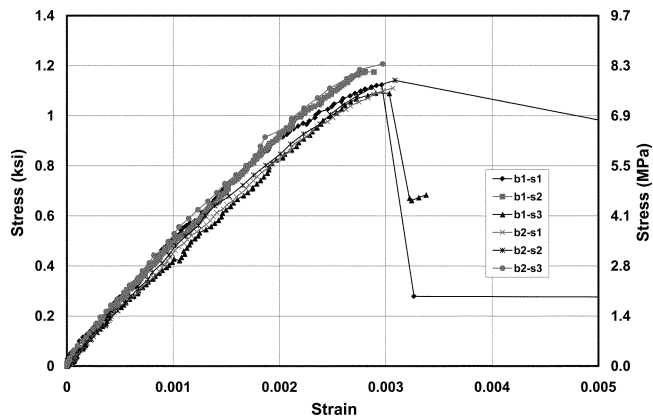


Fig. 7.15—Compressive stress versus strain for Babb Shipment 1 (Tanner 2003).

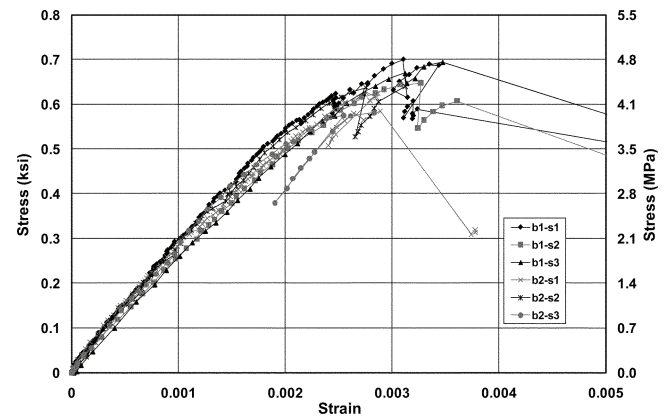


Fig. 7.17—Compressive stress versus strain for Ytong Shipment 2 (Tanner 2003).

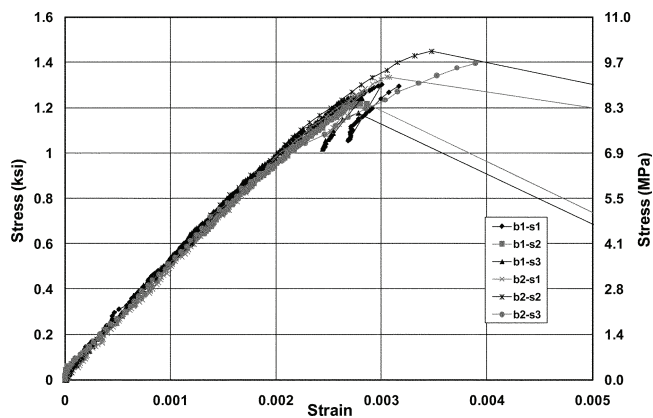


Fig. 7.16—Compressive stress versus strain for Hebel Shipment 2 (Tanner 2003).

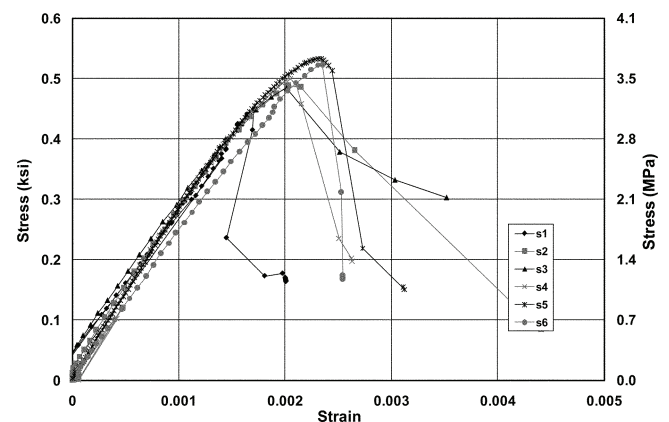


Fig. 7.18—Compressive stress versus strain for Babb Shipment 2 (Tanner 2003).

are at variance with data from other shipments. Data from Babb Shipment 2 indicate strains above 0.003 for initial tests; one reason for low strains in the remaining specimens may be slip between the specimen and the extensometer rings. Contec Shipment 1 results indicate that strains up to 0.004 can be obtained while still carrying half of the maximum load. These results, combined with the results from the other shipments, support using a maximum useful strain of 0.003. Data from Babb Shipment 3 clearly support a value less than 0.003. This performance of low-strength AAC (Class 2) is under review by ACI Committee 523.

7.1.2.1 Discussion of results for modulus of elasticity of AAC—Additional modulus of elasticity tests were performed on prisms with two orientations: load applied parallel to the direction of rise, and load applied perpendicular to the direction of rise (Fouad and Dembowski 2005a; Dembowski 2001; Snow 1999). All specimens were conditioned to moisture contents between 8 and 15%. Additional modulus of rupture tests were performed on 4 x 8 in. (100 x 200 mm) cores with the load applied perpendicular to the direction of rise (Tanner 2003). The relationship between modulus and compressive strength is consistent. Because the specimens used to obtain moisture content were not the same as the specimens used to obtain strength and

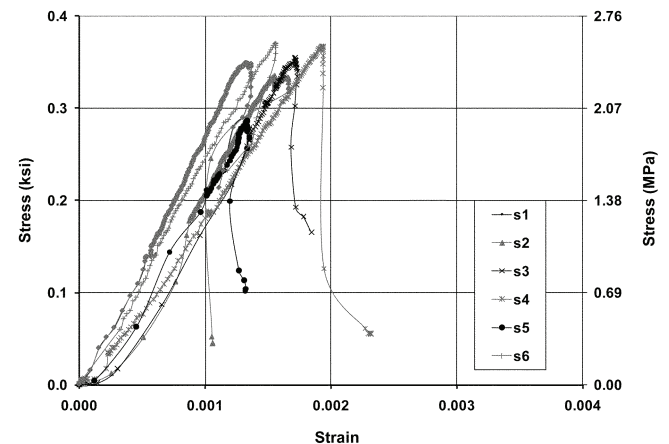


Fig. 7.19—Compressive stress versus strain for Babb Shipment 3 (Tanner 2003).

modulus, the reported densities may not be the same as the densities of the latter specimens. Those specimens were cured in a laboratory environment and weighed within 3 days of testing. The moisture content varied from 1.3 to 16.6%. This variability could have resulted from curing the specimens at different times. Contec Shipment 1 specimens were not

Table 7.3—Modulus of elasticity for load perpendicular to direction of rise (Argudo 2003; Tanner 2003; Dembowski 2005a; Snow 1999)

Data source	Manufacturer	Dry density, lb/ft ³ (kg/m ³)	MC, %	Measured density, lb/ft ³ (kg/m ³)	Calculated density at 10% MC, lb/ft ³ (kg/m ³)	Measured E, ksi (GPa)	COV (%) for E	Measured f _{AAC} , psi (MPa)	COV (%) for f _{AAC}
UAB	Hebel	24 (385)	8.2	26 (417)	26 (423)	186 (1.28)	39.5	290 (2.00)	15
	Ytong	35 (561)	12	39 (629)	39 (618)	310 (2.14)	4.9	600 (4.14)	5.3
	Contec	32 (513)	13.6	36 (584)	36 (565)	294 (2.03)	4.9	570 (3.93)	11.5
UT Austin	Contec 1	42 (678)	5	47 (746)	47 (746)	323 (2.23)	7.9	781 (5.38)	5.6
	Contec 2	36 (576)	4.7	38 (603)	38 (634)	424 (2.92)	2.7	1040 (7.17)	4.7
	Babb 1	40 (640)	10.4	44 (707)	44 (709)	462 (3.19)	7.1	1140 (7.86)	3.8
	Hebel 2	40 (634)	1.3	40 (642)	40 (698)	511 (3.52)	9.3	1330 (9.17)	6.6
	Ytong 2	34 (550)	14.1	39 (627)	39 (605)	269 (1.85)	3.4	650 (4.48)	6.8
	Babb 2	35 (561)	16.6	41 (654)	41 (618)	271 (1.87)	11.7	496 (3.42)	6
CTL	ACCOA	NA	NA	NA	NA	460 (3.17)	13.6	913 (6.29)	5.6

Table 7.4—Modulus of elasticity for load parallel to the direction of rise (Dembowski 2001; Snow 1999)

Manufacturer	Dry density, lb/ft ³ (kg/m ³)	MC, %	Measured density at test, lb/ft ³ (kg/m ³)	Calculated density at 10% MC, lb/ft ³ (kg/m ³)	E, ksi	COV, %	f _{AAC}	COV, %
Hebel	24 (385)	8.2	26 (417)	26 (423)	13 (9.96)	18	177 (1.22)	17.3
Ytong	35 (561)	12	39 (629)	39 (618)	278 (1.92)	29	467 (3.22)	13
Contec	32 (513)	13.6	36 (584)	35 (565)	271 (1.87)	9	450 (3.10)	12

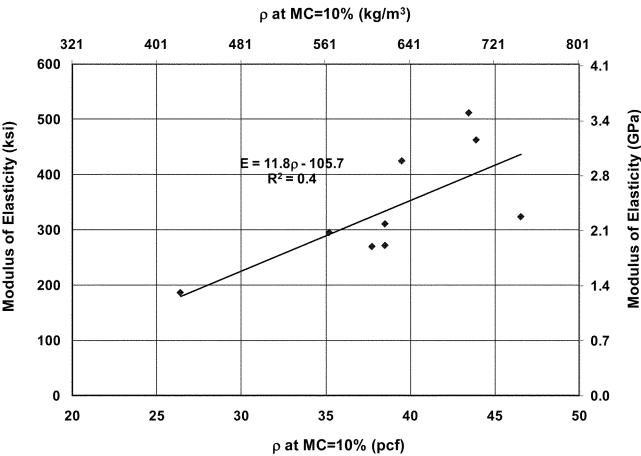


Fig. 7.20—Modulus of elasticity versus calculated density at 10% moisture content for load perpendicular to direction of rise (Argudo 2003; Tanner 2003; Dembowski 2001; Snow 1999).

weighed, so a calculated density corresponding to 10% moisture content is used. Compression tests were performed on four 4 x 8 in. (100 x 200 mm) cores by CTL to determine the compressive strength and modulus of elasticity.* Strains are reported up to a stress of 0.4f_{AAC}. The results of modulus of elasticity tests for load perpendicular to the direction of rise for tests conducted at UAB (Dembowski 2001; Fouad

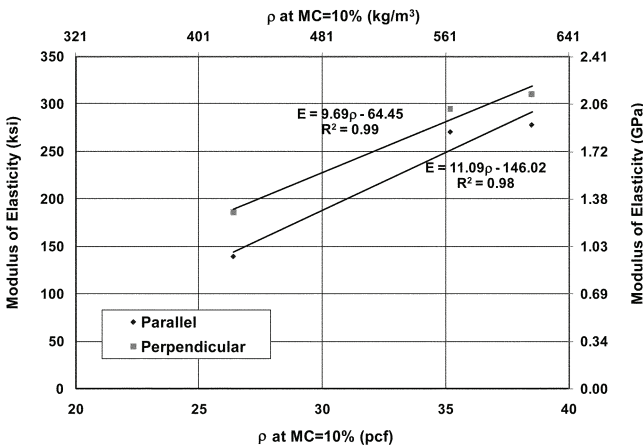


Fig. 7.21—Modulus of elasticity versus calculated density at 10% moisture content (Argudo 2003; Dembowski 2001; Snow 1999).

and Dembowski 2005a) and at UT Austin are presented in Table 7.3 (Tanner 2003). The results for UAB tests for load parallel to the direction of rise are presented in Table 7.4. Modulus of elasticity plotted against ASTM C1386 density indicates poor correlation (Fig. 7.20). Modulus data for loading applied parallel and perpendicular to the direction of rise (Fig. 7.21) are similar, perhaps due to the small range of moisture contents (Fouad and Dembowski 2005a; Dembowski 2001; Snow 1999). The modulus of elasticity is 25 to 50 ksi (172 to 345 MPa) higher for loading perpendicular to the direction of rise. Figure 7.22 shows the modulus of elasticity versus compressive strength. A linear regression gives Eq. (7-1), with a correlation coefficient R² of 0.97. It is proposed to determine modulus of elasticity as a nonlinear function of the compressive strength, as shown in Eq. (7-2). Tests performed at CTL for ACCOA provide results similar to the data in Tables 7.3 and 7.4. (Fig. 7.22), which further supports the proposed Eq. (7-2).

E = 300f_{AAC} + 105,000 (7-1)

E = 6500f_{AAC}^{0.6} (7-2)

*Construction Technology Laboratories, Inc., 1999, "Material Tests of ACCOA Autoclaved Aerated Concrete (AAC) Masonry Blocks and Assemblies," CTL Project No. 183035, Construction Technology Laboratories, Inc., Skokie, IL, Aug. 11.