

The Road to Code Acceptance for Autoclaved Aerated Concrete

By Keith Itzler, P.E.

As Lao-tzu, the Chinese philosopher said, "A journey of a thousand miles begins with a single step." Drafting and shepherding building code provisions for Autoclaved Aerated Concrete (AAC) through the consensus process has been a long trip. For the researchers and authors involved, it has been a journey that sometimes felt like a thousand-mile forced march. The good news, however, is that they are well along to their destination.

The journey that AAC has taken through the code approval process is unique. Code provisions for the classical construction materials such as steel, concrete, and timber are regularly improved, revised and modernized. The introduction of AAC into the model design and building codes is, however, one of the few times, if not the first, that a "new" construction material has been introduced in modern times.

The First Step

AAC Overview

A form of cellular concrete, AAC is a low-density, cementitious product made of calcium silicate hydrates. The manufacturing process uniformly distributes macroscopic air bubbles throughout the material to obtain AAC's relative low density, typically in the 30-pound to 40-pound per cubic foot (pcf) range, compared to approximately 105 pcf for light-weight concrete block and approximately 125 pcf for normal-weight concrete block. In order to produce its specified strength and enhance the dimensional stability of the product, the manufacturer uses high-pressure steam in an autoclave to cure AAC. Typical design strength in the common structural grade of AAC is 580 pounds per square inch compared to approximately 1900 pounds per square inch for concrete masonry units.

AAC is well suited for bearing walls in low- to medium-rise buildings, cladding and infill panels, and for use as floor and roof structure in the form of factory-reinforced panels. Its thermal conductivity is roughly seven percent of conventional concrete, making it energy efficient and a good insulator. The internal porosity of

AAC provides for relatively low sound transmission through the material. AAC's fire rating properties are exceptional, with four-inch wall assemblies providing four-hour fire ratings.



Custom Residence, Hilton Head, South Carolina. Courtesy of AERCON Florida LLC.

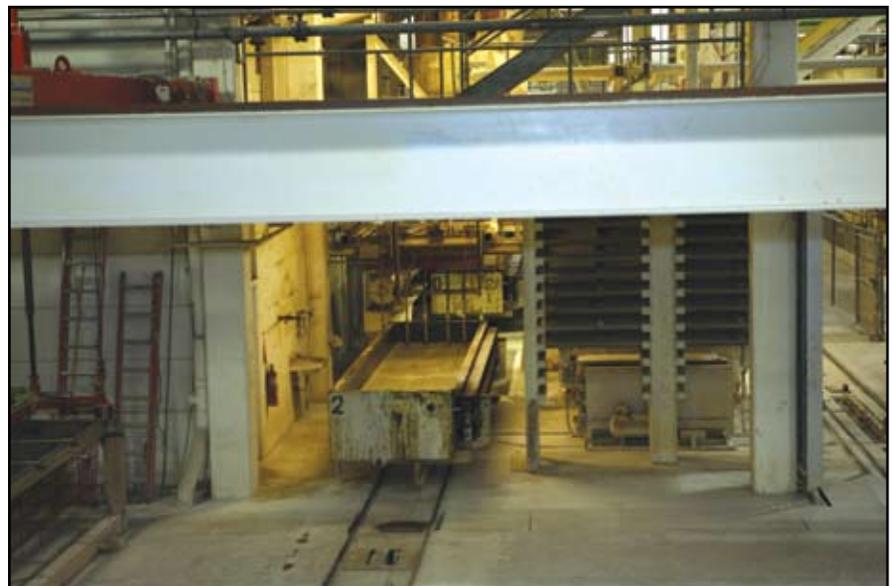
Beginning the Journey

Developing AAC Codes and Testing the Material

In the United States, AAC was introduced to the construction industry with the opening of multiple factories in the 1990s. Code groups such as Building Officials and Code Administrators International, Inc. (BOCA) and Southern Building Code Congress International, Inc. (Standard Building Code) granted approvals to use AAC as a structural material. The manufacturers of the product developed design provisions. Preliminary work began with the development of the American Society for Testing and Materials (ASTM) standard for manufacturing AAC: ASTM C1386-98: *Standard Specification for Precast Autoclaved Aerated Concrete (PAAC) Wall Construction Units* standardizes basic manufacturing and material properties for AAC block units (Ref. 1). ASTM C1452-00: *Standard Specification*

for Reinforced Autoclave Aerated Concrete Elements followed the standard for block units and provided properties for reinforced AAC panels. Testing at Underwriters Laboratories allowed for the establishment of basic fire ratings for AAC wall and floor assemblies (Ref. 2). Most recently ASTM C1555-03a: *Standard Practice for Autoclaved Concrete Masonry* and ASTM C1591-04: *Standard Test Method for Determination of the Modulus of Elasticity of AAC* have been published to provide additional industry and construction standards.

With the inception of the Autoclaved Aerated Concrete Producers Association (AACPA), funding for research and testing became available. Research to develop much of the current code provisions was conducted at the University of Texas at Austin and the University of Alabama at Birmingham under the direction of Dr. Richard Klingner and Dr. Fouad Fouad, respectively. Dr. Jennifer Tanner,



AAC rising in the mold at the AERCON production facility in Haines City, Florida. Courtesy of AERCON Florida LLC.



AAC is cut to size using a band saw.

currently of the University of Wyoming, also had a significant role in the research and the testing while at UT Austin.

The researchers' tests included procedures related to the strength of AAC for basic design parameters such as shear strength, modulus of elasticity, tensile strength, and an approach to flexural design. They used an ultimate strength design approach, rather than an allowable stress design approach, in keeping with the most recent trends in the design of masonry and reinforced concrete. The researchers also tested a wide variety of full-size shear wall specimens to separately reflect structural response dominated by in-plane shear and flexure, and to determine the ultimate strength and failure mechanisms associated with each type of wall. Finally, the researchers tested a full-size, two-story building mockup, complete with an AAC panel floor diaphragm, for seismic response and probable behavior of an AAC structure subject to seismic loading in service.

Moving Further Down the Road

Design Codes and Design Guides

The industry approach to introducing AAC into the standard referenced design codes was to have the masonry units, defined as units manufactured without factory reinforcing, covered in the Masonry Standards Joint Committee (MSJC) Code and Specification, formally titled *Building Code Requirements and Specification for Masonry Structures* (Ref. 3), and factory reinforced panels covered by documents prepared by the American Concrete Institute (ACI) Committee 523 on Cellular Concrete and its Subcommittee 523a on AAC.

In 2005, AAC was introduced into the MSJC Code. In keeping with ACI's recommendation with respect to introducing new materials and procedures into the Code, the design provisions for AAC were included in Appendix A. Construction specifications for AAC were

also provided, as well as appropriate Code and Specification commentary. Volunteers who serve on the MSJC, a group of design professionals, academics and industry representatives, accomplished this task.

The 2008 edition of the MSJC Code continues to include design provisions for AAC in Appendix A with accompanying specifications and commentary. The MSJC made minor adjustments and clarifications from the original 2005 MSJC document in response to public comments and input from AAC masonry designers. As currently written in the 2008 edition, design and detailing provisions are provided for AAC masonry walls subject to the full array of gravity and lateral loading including seismic loads, both in and out of plane. With respect to shear walls, requirements are specified in Seismic Design Categories A thru F. The author recommends that engineers, who are interested in designing with AAC, should take the time to consult the *Masonry Designer's Guide, 5th Edition*, MDG-5 by The Masonry Society and Council for Masonry Research. In particular, Chapter 12 *AAC Masonry* provides a full range of design examples referenced back to the MSJC Code.

Similar to AAC masonry, design provisions for factory reinforced AAC panels have also been progressing through ACI Committees, albeit at a slower pace. After several years of editing and refining, ACI Committee 523 and its Subcommittee 523a were proud to finally announce that work on the *Guide for Design and Construction with Autoclaved Aerated Concrete Panels*, ACI 523.5R was complete and that ACI's publication is expected in the near future.

Going Cross Country

The International Building Code and AAC

The International Building Code (IBC) is becoming widely adopted around the country as the model building code of choice. Even New York City, one of the first jurisdictions to develop a building code in the mid 19th century, has given up its traditional code and adopted an IBC-based code for new building construction (Ref. 4).

Typically, building codes based on the 2003 IBC will not mention AAC since the reference document for masonry design in the 2003 IBC is 2002 MSJC, which makes no mention of AAC. For designers in this situation, the governing design standards revert back to the ICC Evaluation Service, Inc.-ES Reports that are published by the AAC manufacturers or local code official approvals (Ref. 5).

The 2006 IBC places limitations on AAC masonry in seismic resisting systems. The restriction states that AAC masonry "shall not



Installation of AAC reinforced block walls at State University of New York at Stony Brook.

be used in the seismic force resisting system of structures classified in Seismic Design Category B, C, D, E or F". The balance of the provisions of the 2005 MSJC Code applies allowing unrestricted use in non-shear wall applications, such as cladding. The Building Seismic Safety Council (BSSC) recommended this limitation on AAC masonry so that they would have time to fully review the seismic design provisions associated with AAC masonry. The BSSC is a council established by the National Institute of Building Sciences, and is charged with developing and promoting building earthquake risk mitigation regulatory provisions for the nation. AACPA sponsored discussions with the BSSC have resulted in a significant relaxation of these restrictions. For jurisdictions that can use the 2007 Supplement to the 2006 IBC, designers will find that AAC masonry can be used in Seismic Design Categories A, B and C, with building heights up to 35 feet. These provisions will be in the next edition of the IBC. Code design provisions for reinforced panels continue to be based on ICC-ES Reports.

Next Steps

The Code Future for AAC

In future editions of the MSJC Code provisions for AAC design, for the most part, will remain unchanged. Engineers can look for the design provisions to be moved from an appendix to a chapter in the body of the code and, based on current research, possible changes in the requirements for lap lengths for field-installed reinforcing. Researchers are also addressing the use of AAC masonry as structural in-fill and associated code provisions.

Work continues on the code provisions for the use of reinforced AAC panels by ACI Committee 523 and 523a. The ultimate goal will be either to prepare a separate code docu-

ment for the use of AAC panels, or possibly include the design provisions as an Appendix to ACI 318. The planning to determine the best code path for reinforced AAC panels is in a preliminary discussion stage.

With respect to the IBC, the AAC industry's goal will be to further relax the current seismic restrictions on AAC. The first step will be to allow the use of AAC in Seismic Design Category D, and to increase the allowable height of AAC structures when using AAC in the seismic force resisting system of a building.

Related Journeys

AAC and the Build Green Movement

The AAC industry has begun to take advantage of the "Build Green Movement." The material is being designed in mass wall applications that promote energy efficiency and minimal carbon footprint impact. Since AAC uses a very small amount of cement in the manufacturing process compared to conventional concrete, this has inspired designers to consider AAC as a high performance material for building envelopes, whether used in the structural frame or simply as exterior wall cladding. AAC has also seen increased use in interior, stairwell and shaft walls, improving fire resistance and fire safety. Enhanced sound attenuation is another benefit.



Building two-story assemblage for testing specimen at University of Texas at Austin. Courtesy of UT Austin.

While the recent economic situation has impacted construction activities, more and more designers are considering AAC during the schematic design phase. Angelo Coduto of Aircrete Technologies, a consultant to the AAC industry, reports that, based on projected demand, there is a considerable push to build new AAC manufacturing plants around the country, particularly in the Southwest, Northeast and Midwest. The hope is that these plants can be built in time for the re-

surge of commercial construction in the United States. The industry will concentrate on the new infrastructure push by the new administration and take a proactive role in the school market where AAC has been used on projects around the country, as well as in sound barrier wall applications for the highway and bridge reconstruction. The use of AAC in "Green Buildings" will be a key driver of demand. ■

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References

- Ref. 1: ASTM C1386-98: Standard Specifications for Precast Autoclaved Aerated Concrete (PAAC) Wall Construction Units was updated in 2007.
- Ref. 2: AAC wall and floor assemblies are listed in the UL Fire Resistance Directory at www.ul.com.
- Ref. 3: TMS 402/ACI 530 & 530.1/ASCE 5 & 6
- Ref. 4: Many jurisdictions adopt a version of the IBC and impose local changes. For instance, the 2007 New York State Building Code, which is currently in effect, is based on the 2003 IBC, not the 2006 IBC, which is the most current version of the document. AAC designers should review carefully the governing building code in the jurisdiction of their project as it relates to AAC.
- Ref. 5: Designers may obtain ES Reports—for both AAC masonry and reinforced panels—directly from various AAC manufacturers or on line at www.icc-es.org.