3. AAC Properties

AAC Properties

This chapter includes the description of Contec AAC physical properties based on previous research from European sources, as well as recent tests performed by Texas Contec in various US laboratories.

3.1 Density

Contec AAC is a lightweight construction material with densities ranging from **31** pcf (500 kg/m^3) to **44** pcf (700 kg/m^3).

Contec AAC products are manufactured in different densities; therefore, AAC products are classified according to each density and its own compressive strength.

Contec AAC products are classified as **GP2/0.5** and **GP4/0.7** for non-reinforced elements (masonry units), and **GB3.3/0.6** and **GB4.4/0.7** for reinforced elements. The characteristics for these types of AAC material are described in Tables 3.1 and 3.2.

Characteristics	BLOCK		REINFORCED		Units	Notes
	GP2/0.5	GP4/0.7	GB3.3/0.6	GB4.4/0.7		
Maximum Dry Density	500	700	600	700	kg/m^3	Dry
Design Weight (1)	600	840	720	840	kg/m^3	For Design
Compressive Strength	25	50	35	50	kg/cm^2	
Modulus of Elasticity	15,000	22,500	17,500	25,000	kg/cm^2	
Drying Shrinkage	0.25	0.25	0.25	0.25	mm/m	
Thermal Expansion Coefficient	8×10^{-6}	8×10^{-6}	8×10^{-6}	8×10^{-6}	K^{-1}	
Resistance to Freezing	0.969	0.979	0.979	0.979	- - -	
Moisture Content (Average)	8	8	8	8	%	By mass
Thermal Conductivity	0.12	0.17	0.14	0.17	W/m°C	
(1) Values consider material's moisture content.						

Table 3.1: Characteristics of Contec AAC products (metric units).

Characteristics	BLOCK		REINFORCED		Units	Notes
	GP2/0.5	GP4/0.7	GB3.3/0.6	GB4.4/0.7		
Maximum Dry Density	31	44	37	44	pcf	Dry
Design Weight (1)	37	52	45	52	pcf	For Design
Compressive Strength	355	710	497	710	psi	
Modulus of Elasticity	213,000	285,000	249,000	355,000	psi	
Drying Shrinkage	0.003	0.003	0.003	0.003	in/ft	
Thermal Expansion Coefficient	4.4×10^{-6}	4.4×10^{-6}	4.4×10^{-6}	4.4×10^{-6}	°f^{-1}	
Resistance to Freezing	0.969	0.979	0.979	0.979	- - -	
Moisture Content (Average)	8	8	8	8	%	By mass
Thermal Conductivity	0.83	1.17	0.97	1.17	Btu in/ft^2 h°F	
(1) Values consider material's moisture content.						

Table 3.2: Characteristics of Contec AAC products (inch-pounds units).

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Once the material is taken out of the autoclave, its water content is approximately 30% by weight. This water content remains in the material and is released with time until it reaches an equilibrium value of 5 to 8 % in approximately 9 to 12 months.

Therefore, to calculate the value of density for use in design procedures, a 20 % increasing factor is applied to the maximum dry densities (shown in Tables 3.1 and 3.2) to account for moisture content, and, in the case of reinforcement products, for reinforcing steel in the elements and mortar in panel joints.

3.2 Compressive Strength

The compressive strength of Contec AAC is related to its density and increases with increasing density. The strength on the direction of the rise of the mass during manufacture is generally up to 10% lower than perpendicular to the direction of rise. Contec AAC achieves its final strength during the autoclaving process. In tables 3.1 and 3.2 a summary of compressive strength nominal values for each density is included. These values correspond to cube specimens.

3.3 Tensile Strength (MOR)

The tensile strength in flexure, also called modulus of rupture (MOR), is normally varying between 20 - 40% of compressive strength of AAC material.

3.4 Shear Strength

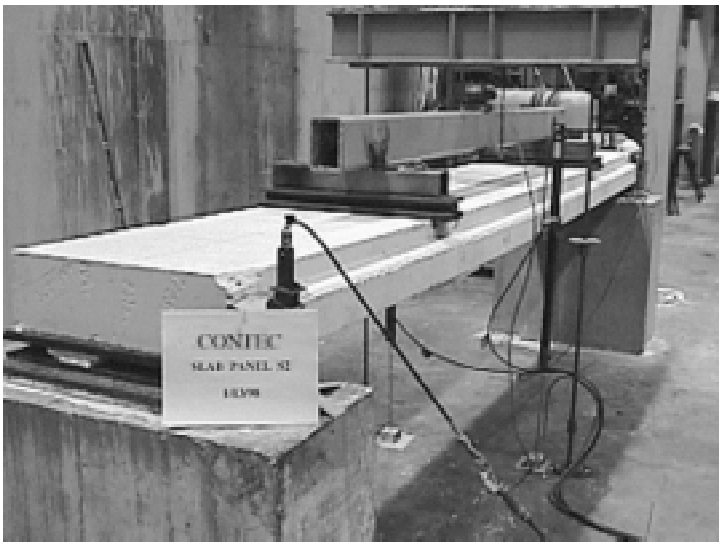
Shear strength can be assumed to be 20-30% of the compressive strength.

3.5 Modulus of Elasticity

The modulus of elasticity depends both on the density and the humidity content of the material, and varies from 12,000 to 25,000 kg/cm^2 (170,000 to 355,000 psi).

3.6 Drying Shrinkage

Similar to other porous building materials, Contec AAC presents drying shrinkage due to water loss. Drying shrinkage depends on the mineral binding agent, the autoclaving process, and in particular, on the amount on ultrafine pores.



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3.7 Thermal Properties

3.7.1 Thermal Conductivity

The thermal conductivity of Contec AAC increases with density and moisture content. Thermal conductivity determination, by using the Guarded Hot Plate (ASTM C177), has been performed in Contec AAC material.

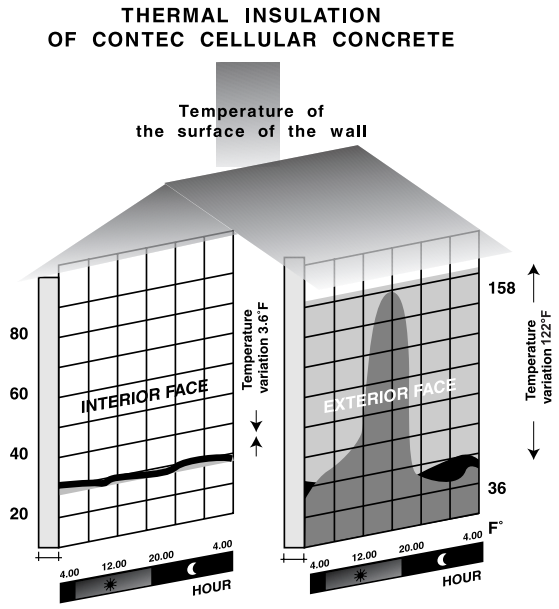
3.7.2 Energy Efficiency

Besides the inherent thermal resistivity (R-value), thermal mass is another parameter which provides insulation characteristics to AAC material. Through energy efficiency studies, an equivalent performance R-value can be obtained which may include seasonal temperature variations, air tightness of construction as well as the static R-value of the material. A significant improvement of insulation capabilities is obtained for AAC since it has a higher thermal mass and the mortar thin-bed joints provide a better air tightness than regular masonry construction.

A comparison study between a wood frame building and the same building using Contec AAC materials was performed at Construction Technology Laboratories (Skokie, ILL), utilizing DOE2 analytical software, (approved by ASHRAE). Results of the study represent the insulation value required to be added to the wood frame building in order to achieve equivalent energy consumption. The analysis was run over one year period and with multiple locations analyzed. Table 3.3 presents a summary of the results.

3.7.3 Thermal Expansion

The thermal expansion coefficient of AAC is of the order of 4.4×10^{-6} /°F. Expansion coefficient of regular concrete varies between 2.2 to 7.78×10^{-6}/°F depending on the type of aggregate and curing procedure.



Location	Contec Materials Assembly R-Value (hr ft² °F/Btu)		Wood Frame Construction for Energy Cost Performance Equivalent to Contec Construction (hr ft² °F/Btu)	
	Roof	Wall	Roof	Wall
Brownsville	6.3	7.8	22.2	8.5
El Paso	6.3	7.8	22.2	8.5
Forth Worth	6.3	7.8	14.5	8.5
Houston	6.3	7.8	22.2	12.8
Laredo	6.3	7.8	22.2	8.5
Long Beach	6.3	7.8	32.3	18.9
San Antonio	6.3	7.8	22.2	8.5
West Palm Beach	6.3	7.8	22.2	12.8

Notes:
Simulation of a three story hotel using ASHRAE accepted DOE2 program.
Contec building consisted of GP4 exterior block walls 8 in thick, interior walls 6 in thick and GB4.4 slabs 6 in thick.
Minimum assembly R-value verified as required by ASHRAE/IESNA 90.1-1989 is acceptable for each location with the exception of Forth Worth where additional insulation should be provided.

Table 3.3: Summary of results of energy efficiency analysis.

3.8 Fire Resistance

Contec AAC is non-combustible, and due to its low thermal conductivity and slow rate of heat transmission, possess remarkable fire endurance capabilities.

Fire Endurance Testing of Contec AAC material in accordance to ASTM E119 (ANSI/UL 263), was performed at Underwriters Laboratories (UL) and was witnessed by a Factory Mutual Research Co. (FMRC) representative. Testing included non-load bearing wall, load bearing wall and slab panels assemblies.

Results of these tests generated the fire ratings presented in Table 3.4 which are included in UL 1998 Fire Resistance Directory.

Elements	Fire Ratings (Hours)	UL Design Numbers (UL Fire Resistance Directory 1998)
Non-load bearing Contec block walls 4” thick and higher	4	U919
Load bearing Contec block walls 6” thick and higher	4	U919
Reinforced Wall Panels 6” thick and higher	4	U920
Roof and Slab Panels 4” to 12” thick	1, 1.5, 2, 3, 4	K909, P932
Lintels 6” thick	4	U919
Fire protection for steel structure framing (4” thick Contec block)	4	X901
Contec wall board (wood frame assembly)	1	U358
Contec wall board (steel frame assembly)	2	V420
Note: Testing performed at Underwriters Laboratories, Inc., Northbrook IL under ASTM E119 (UL/ANSI 263) “Fire Tests of Building Construction and Materials”		

Table 3.4: Fire ratings for Contec AAC products.

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3.9 Acoustic Performance

Contec AAC can be used for a wide variety of acoustic applications. The STC (Sound Transmission Class) rating is a single number guide used to rate acoustic barriers according to their effectiveness in increasing sound transmission loss. Sound Transmission Class ratings are determined by ASTM E90.

The structure of AAC provides higher sound absorption as compared to that obtainable by regular concrete.

Table 3.5 presents a summary of test results on Contec AAC performed at Acoustic Systems, Inc. Acoustic testing reports are available upon request.

Assembly Type	STC	Report No.
Contec 8" wall GB3.3 unfinished	46	AS-TL957AX
Contec 8" wall GB3.3 with 1/2" Gypsum Board one side	46	AS-TL957BX
Contec 8" wall GB3.3 with 1/2" Gypsum Board two sides	44	AS-TL957CX
Contec 6" wall GP2 unfinished	44	AS-TL958AX
Contec 6" wall GP2 with 1/2" Gypsum Board two sides	44	AS-TL958BX
Contec 8" wall GP2 unfinished	47	AS-TL959AX
Contec 8" wall GP2 with furring strips and 1/2" Gypsum Board one side	49	AS-TL975AX
Contec 8" wall GP2 finished with 1/2" Gypsum Board one side	47	AS-TL975BX
Contec 8" wall GP2 with 1/2" Gypsum Board two sides	44	AS-TL975CX
Contec 10" wall GB3.3 unfinished	49	AS-TL977AX
Contec 10" wall GB3.3 with 1/2" Gypsum Board two sides	45	AS-TL977BX
Contec 10" wall GP2 unfinished	50	AS-TL978AX
Contec 10" wall GP2 with 1/2" Gypsum Board two sides	45	AS-TL978BX
Contec 8" wall GP4 with stucco one side	48	AS-TL979AX
Contec 8" wall GP4 with stucco one side and 1/2" pad and carpet on opposite side	49	AS-TL979BX
Contec 8" block wall GP2 unfinished	47	AS-TL1023BX
Contec 8" block wall GP4 unfinished	50	AS-TL1026AX
Contec 8" wall GP4 with 1/2" Gypsum Board two sides	45	AS-TL1026BX
Contec Double 5" block wall GP4 unfinished (airspace no fill)	60	AS-TL962AX
Contec Double 5" block wall GP4 unfinished (airspace, Mineral wool)	65	AS-TL962BX
Contec Double 5" block wall GP4 unfinished (airspace, Mineral wool)	68	AS-TL962CX

Note: Testing performed at Acoustic Systems, Inc., 415 East St. Elmo Rd., Austin, TX in accordance with ASTM E90 "Standard Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions".

Table 3.5: Acoustic STC for different Contec AAC wall assemblies.

3.10 Reinforcing Steel Properties

The steel wire reinforcement used in Contec AAC reinforced products satisfies the physical requirements of ASTM A82. In addition to these requirements, in-house quality control specifications are meet regarding yield strength, tensile strength and chemical composition.
Steel reinforcement is protected by applying an anti-corrosive coating.

3.11 Durability

AAC has been in use for nearly 60 years since it was first developed in Sweden, in approximately 1930. Since that time, AAC has proven its durability all over the world, in the most diverse climatic conditions.

Being an industrially-produced material, it is uniform and homogeneous.

3.12 Moisture Protection

Contec AAC outperforms normal concrete in water permeability because of its cellular structure and discontinuous microstructure. Water penetration was performed in walls according to the severe conditions of ASTM E514 standard with outstanding results for both plain and plastered walls.

3.13 Mortar Properties

3.13.1 Contec Thin-Bed (Adhesive) Mortar

Contec Thin-Bed Mortar (Adhesive) is used when constructing with Contec AAC blocks in walls. It is a ready mix (dry) mortar to which only water is added. Its composition is based on Portland cement, fine silica sand and special additives. A uniform layer, approximately 1 mm (1/16") thick, of mortar is applied on horizontal and vertical joints of AAC blocks.

3.13.2 Contec Repair Mortar

Contec Repair Mortar is used for application on larger zones, primarily for aesthetic considerations. Although its composition varies from that of the thin bed mortar, same specifications shown on Table 4.6 must be met.

Mortar Type	Compressive Strength at 28 days (psi)	Workability (Hrs)
Contec Thin Bed Mortar (Type III)	≥ 1800	4
Contec Repair Mortar (Type III)	≥ 1800	4

Table 3.6: Specifications for mortars.

3.14 Environment Exposure of AAC

Like other cementitious materials, Contec AAC is deteriorated by strong acids. Acid salt solutions such as chlorides or sulphates may also degrade AAC in the long term. On the other hand, AAC is normally unaffected by all alkaline solutions. AAC should not be used in sulphate concentrations higher than 600 mg/l unless protective precautions are taken.

AAC is generally water-resistant even under long term exposures.

AAC has proved to be resistant against termites in tropical regions and is not attacked by living organisms.