Section 3: Material Properties

3.1 Density

Hebel AAC is a lightweight construction material with dry densities ranging from 25 pcf (400 kg/m3) to 44 pcf (700 kg/m3). Hebel AAC is manufactured in compliance with ASTM 1386 – Standard Specification for Precast Autoclaved Aerated Concrete (AAC) Wall Construction Units and ASTM 1452 – Standard Specification for Reinforced Autoclaved Aerated Concrete Elements.

Table 3.1

Characteristics of Hebel AAC products (In Imperial Units)

Characteristics	**AAC-2 /400**	**AAC-2 /500**	**AAC-4 /500[2]**	**AAC-4 /600**	**Units**
Nominal Dry Density Range	22-28	28-34	28-34	34-41	pcf
Design Weight orRange [1]	26-34	34-41	34-41	41-49	pcf
Minimum Compressive Strength	290	290	580	580	psi
Modulus of Elasticity	195,000	195,000	296,000	296,000	psi
Thermal Expansion Coefficient	4.5×10^{-6}	4.5×10^{-6}	4.5×10^{-6}	4.5×10^{-6}	1/ºF
Moisture Content (Average)	8	8	8	8	% (by mass)

(1) Values consider material's moisture content
(2) Hebel AAC is manufactured based on the strength category AAC-4/500.

www.hebelraac.con
One Legacy West Tower, 7950, Legacy Drive,
Suite 240 Plano, TX 75024

Table 3.2

Characteristics of Hebel AAC products (In Metric Units)

Characteristics	AAC-2 /400	AAC-2 /500	AAC-4 /500(2)	AAC-4 /600	Units
Nominal Dry Density Range	350-450	450-550	450-550	550-650	kg/m^3
Design Density Range(1)	420-540	540-660	540-660	660-780	kg/m^3
Compressive Strength	2.0	2.0	4.0	4.0	MPa
Modulus of Elasticity	1345	1345	2040	2040	MPa
Thermal Expansion Coefficient	8.1×10^{-6}	8.1×10^{-6}	8.1×10^{-6}	8.1×10^{-6}	K^{-1}
Moisture Content (Average)	8	8	8	8	% (by mass)

(1) Values consider material's moisture content
(2) Hebel AAC is manufactured based on the strength category AAC-4/500.

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 6 to 12 months.
Therefore, to calculate the value of density for use in design procedures, a 20 % increasing factor is applied to the nominal dry densities (shown in Tables 3.1 and 3.2) to account for moisture content, and, in the case of reinforced products, for reinforcing steel in the elements and in panel joints.

3.2 Compressive Strength

The compressive strength of Hebel AAC is related to its density and increases with increasing density. Hebel AAC achieves its final strength during the autoclaving process. In Table 3.1 and 3.2 a summary of compressive strength nominal values for each density is included.

3.3 Tensile Strength (MOR)

The tensile strength in flexure, also called modulus of rupture (MOR), shall be taken as two times the spitting tensile strength as defined in ACI 530 Section A.1.8.2. Requirements for the modulus of rupture for AAC masonry are listed in ACI 530 Section A.1.8.3.

3.4 Shear Strength

$$f_v = 0.15 f'_{AAC}$$

For purposes of this manual, the allowable shear strength specified by ACI 530 for unreinforced elements (masonry units) will be adopted.

www.hebelraac.con
One Legacy West Tower, 7950, Legacy Drive,
Suite 240 Plano, TX 75024

3.5 Modulus of Elasticity

ACI 530 (Section 1.8.2.3.1) specifies a value for the modulus of elasticity as follows:

$$E_{AAC} = 6500(f'_{AAC})^{0.6}$$

Where f'_{AAC} is the specified compressive strength.

3.6 Thermal Properties

3.6.1 Thermal Conductivity

The thermal conductivity of Hebel AAC increases with density and moisture content. Thermal conductivity is determined by using the Guarded Hot Plate (ASTM C177). Independent research shows the industry value of 1.05-1.1 ft^2-h-°F/Btu per inch is conservative including the known decrease in R-value for representative field moisture contents (ref. 13.16.14).

The thermal mass benefit is a function of the material configuration and climate conditions. To enable wall performance comparisons, the “R-value Equivalent for Massive System” is used. The R-value equivalents for massive walls are obtained by a comparison of the thermal performance of the massive walls and light-weight wood frame walls. The following Tables 3.3 and 3.4 illustrate the Dynamic Benefit for Massive Systems and R value equivalents gathered from Research Series Report No. 08 – A Comparison of Innovative Exterior Wall Construction Techniques prepared by AZ Path dated July 2002 and ESR-1371.

Table 3.3

DBMS and R_{equiv} for AAC-2/500

	8in (200mm)			10in (250mm)		
	R	DBMS	R_{equiv}	R	DBMS	R_{equiv}
Phoenix	10.85	2.48	26.91	13.35	2.51	33.51
Flagstaff	10.85	1.99	21.59	13.35	1.99	26.57
Los Angeles	10.85	1.54	16.71	13.35	1.57	20.96
Sacramento	10.85	2.44	26.47	13.35	2.44	32.57
San Diego	10.85	1.42	15.41	13.35	1.44	19.22
San Francisco	10.85	1.78	19.31	13.35	1.79	23.90
Denver	10.85	1.9	20.62	13.35	1.92	25.63
Miami	10.85	1.73	18.77	13.35	1.76	23.50
Atlanta	10.85	1.93	20.94	13.35	1.94	25.90
Minneapolis	10.85	1.48	16.06	13.35	1.5	20.03
Albuquerque	10.85	2.06	22.35	13.35	2.09	27.90
Santa Fe	10.85	2.14	23.22	13.35	2.17	28.97
Las Vegas	10.85	2.46	26.69	13.35	2.49	33.24
Reno	10.85	2.05	22.24	13.35	2.06	27.50
Eugene	10.85	2.14	23.22	13.35	2.16	28.84
El Paso	10.85	2.31	25.06	13.35	2.34	31.24
Salt Lake City	10.85	2.11	22.89	13.35	2.11	28.17
Washington D.C.	10.85	1.7	18.45	13.35	1.72	22.96
Seattle	10.85	1.39	15.08	13.35	1.41	18.82
Spokane	10.85	1.85	20.07	13.35	1.86	24.83

R = Static R-Value,

DBMS = Dynamic Benefit for Massive Systems

R_{equiv} = R x DBMS

Source: Research Series Report No. 08 – A Comparison of Innovative Exterior Wall Construction Techniques prepared by AZ Path dated July 2002 and ESR-1371.

www.hebelraac.con
One Legacy West Tower, 7950, Legacy Drive,
Suite 240 Plano, TX 75024

Table 3.4 DBMS and R_{equiv} for AAC-4/600

	8in (200mm)			10in (250mm)		
	R	DBMS	R_{equiv}	R	DBMS	R_{equiv}
Phoenix	9.10	2.48	22.56	11.16	2.51	28.01
Flagstaff	9.10	1.99	18.10	11.16	1.99	22.21
Los Angeles	9.10	1.54	14.01	11.16	1.57	17.52
Sacramento	9.10	2.44	22.20	11.16	2.44	27.23
San Diego	9.10	1.42	12.92	11.16	1.44	16.07
San Francisco	9.10	1.78	16.19	11.16	1.79	19.98
Denver	9.10	1.9	17.29	11.16	1.92	21.43
Miami	9.10	1.73	15.74	11.16	1.76	19.64
Atlanta	9.10	1.93	17.56	11.16	1.94	21.65
Minneapolis	9.10	1.48	13.46	11.16	1.5	16.74
Albuquerque	9.10	2.06	18.74	11.16	2.09	23.32
Santa Fe	9.10	2.14	19.47	11.16	2.17	24.22
Las Vegas	9.10	2.46	22.38	11.16	2.49	27.79
Reno	9.10	2.05	18.65	11.16	2.06	22.99
Eugene	9.10	2.14	19.47	11.16	2.16	24.10
El Paso	9.10	2.31	21.02	11.16	2.34	26.11
Salt Lake City	9.10	2.11	19.20	11.16	2.11	23.55
Washington D.C.	9.10	1.7	15.47	11.16	1.72	19.19
Seattle	9.10	1.39	12.65	11.16	1.41	15.73
Spokane	9.10	1.85	16.83	11.16	1.86	20.76

R = Static R-Value,

DBMS = Dynamic Benefit for Massive Systems

R_{equiv} = R x DBMS

Source: Research Series Report No. 08 – A Comparison of Innovative Exterior Wall Construction Techniques prepared by AZ Path dated July 2002 and ESR-1371.

3.6.2 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.

3.6.3 Thermal Expansion (k_t)

The thermal expansion coefficient of AAC as defined in ACI 530 Building Code Requirements for Masonry Structures is:

$k_t = 4.5 \times 10^{-6}$ /°F

3.7 Fire Resistance

Hebel AAC is non-combustible, and due to its low thermal conductivity and slow rate of heat transmission by radiation (given its cellular structure) has remarkable fire endurance capabilities (Valore, 1954).

Fire Endurance Testing of Hebel 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 3.5 which are included in UL 1998 Fire Resistance Directory. UL classification and FMRC listing agreements enrolled Hebel AAC into a Follow Up service program focused on quality assurance of AAC material.

www.hebelraac.con
One Legacy West Tower, 7950, Legacy Drive,
Suite 240 Plano, TX 75024

Table 3.5

Type of Element	Fire Resistance Rating	Minimum Thickness of AAC Materials	UL Design Number(s)	Comments
Floor Panels	4-Hour	6" Nominal	K909	Restrained or Unrestrained
Roof Panels	4-Hour	6" Nominal	P932	Restrained or Unrestrained
Block/Wall Panel	4-Hour	4" Nominal 6" Nominal 8" Nominal	U916, U917 U918, U919, U920 U921	Non-bearing or Bearing Wall
	2-Hour	3" Nominal	V420	Bearing Wall attached to 3 1/2" Steel Stud System
	4-Hour	4" Nominal 8" Nominal	X901	Steel Column Protection
Boards	2- Hour	2" Nominal	U212, U213	Bearing or Non-bearing
Block Wall Assembly	2-Hour	6" Nominal	C-AJ-1556	Through Penetration Firestop
Floor, Roof or Wall Assembly	4-Hour	6" Nominal	C-BJ-1037	Through Penetration Firestop
Floor, Roof or Wall Assembly	3-Hour	6" Nominal	C-BJ-8010	Through Penetration Firestop
Wall Assembly	4-Hour	6" Nominal	W-J-8009	Through Penetration Firestop
Floor Assembly	1 ½ to 3 Hour	4" Nominal	FF-D-0017, FF-D-0018, FF-D-0019, FF-2-20, FW-D-0012, FW-D-0013, FW-D-0014, FW-D-0015, HW-D-0166, HW-D-0177, HW-D-0367, WW-D-0022, WW-D-0023, WW-D-0024	Joint System

3.8 Acoustic Performance

Hebel 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. Wall assemblies using various AAC products are available from the AAC Products Association.

3.9 Reinforcing Steel Properties

The steel wire reinforcement used in Hebel AAC reinforced products satisfy the physical requirements of ASTM A82. In addition to these requirements, in-house quality control specifications are met regarding yield strength, tensile strength, joint shear strength, and break elongation. Steel reinforcement anti-corrosive coating is supplied by an external supplier.

3.10 Durability

AAC has been in use for nearly 85 years since it was first developed in Sweden, in approximately 1923. Since that time, AAC has proven its durability all over the world, in the most diverse climatic conditions.

3.11 Freeze and Thaw Resistance

Senbu and Kamada (1992) present results of AAC freeze thaw testing according to ASTM C666 and also by the critical saturation method recommended by RILEM. For both cases the results obtained are favorable. Kamada et al. (1992) carried out a study of frost resistance of AAC in actual wall specimens. Their main conclusion was that higher AAC density and water repellency was related to higher frost resistance. However, as a matter of principle, building materials should be protected against excessive wetting in severe winter climates.

3.12 Mortar Properties

Mortar for AAC applications shall be specifically manufactured for use with AAC. AAC mortar shall comply with ASTM C 109.

3.12.1 Hebel Thin-Bed (Adhesive) Mortar

Hebel Thin-Bed Mortar (Adhesive) is used when constructing with Hebel 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 1/16” (1 mm) thick of mortar is applied on horizontal and vertical joints of AAC blocks. Mortar shall comply with section 2103.11.1 of the IBC.

3.12.2 Hebel Repair Mortar

Hebel Repair Mortar is used for application on larger zones. Although its composition varies from that of the thin bed mortar, the same specifications shown on Table 3.6 must be met.

www.hebelraac.con
One Legacy West Tower, 7950, Legacy Drive,
Suite 240 Plano, TX 75024

Table 3.6

Specifications for mortars according to ASTM C109

Mortar Type	Compressive Strength at 28 days (psi)	Workability (Hrs)
Hebel Thin Bed Mortar (Type III)	≥1450	4
Hebel Repair Mortar (Type III)	≥1450	4

3.13 Finishes

Various manufacturers supply a complete line of finishing products for exteriors and interiors. The special formulation of these materials allows for excess water to be released from the AAC walls while impeding the entrance of humidity into the blocks. Table 3.7 presents a summary of finishes and characteristics.

Table 3.7

Description of Finishing Products

Material	Application
Finishing Plaster	Interior /Exterior
Textured Finish	Interior / Exterior
Gypsum (Stucco)	Interior/Exterior

The optimum compressive strength of finishes for use on AAC should be the same or less than that of AAC itself. This means a finish with a compressive strength between 435 to 580 psi
which are widely regarded as the optimum finish for both surface hardness and performance.
Fiber glass mesh is embedded in finish at high stress zones to avoid crack development.

3.14 Environmental Exposure of AAC

Like other cementitious materials, Hebel 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.

3.14.1 Moisture Protection

Hebel 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.

3.15 Properties of masonry assemblies

3.15.1 AAC compressive strength

The compressive strength for a prism f'_m is the basis for obtaining allowable axial stress, compressive bending stress and the compression moment resisting capacities for Hebel AAC blocks.

3.15.2 Flexural bond strength

A masonry prism tested as a simple supported beam subjected to third point loading where the ultimate load is used to compute the gross area modulus of rupture for a vertical mortared joint.

3.15.3 Diagonal tension

Diagonal tension in a block wall assemblage is determined by means of ASTM E519 “Standard Tests Method for Diagonal Tension (Shear) in Masonry Assemblages”. The specimen size (4 × 4 ft) permits the evaluation of the shear strength that would be representative of a full size masonry wall. The masonry assemblies are loaded in compression along one diagonal of the specimen.

www.hebelraac.con
One Legacy West Tower, 7950, Legacy Drive,
Suite 240 Plano, TX 75024

3.16 References

3.16.1 - Aroni, S., de Groot, G.J., Robinson, M.J., Svanholm, G., and Wittmann, F.H. (1992) Autoclaved Aerated Concrete. Properties, Testing and Design. RILEM Recommended Practice. RILEM Technical Committees 78-MCA and 51-ALC.

3.16.2 - Senbu, O., Kamada, E. (1992) Mechanism of Frost Deterioration of AAC, Advances in Autoclaved Aerated Concrete, Wittmann (Ed.), 1992, Balkema, Rotterdam, pp. 153-157

3.16.3 - Hama, Y., Tabata, M., Watanabe, T., and Kamada (1992) Frost Resistance of Increased Density Autoclaved Aerated Concrete, Advances in Autoclaved Aerated Concrete, Wittmann (Ed.), 1992, Balkema, Rotterdam, pp. 157-165.

3.16.4 - Schubert, P., Mayer, U. (1992) Compressive Strength and Modulus of Elasticity of AAC Masonry, Advances in Autoclaved Aerated Concrete, Wittmann (Ed.), 1992, Balkema, Rotterdam, pp. 237-245.

3.16.5 - House, Y., Alou, F., Wittman, F.H. (1983) Influence of Moisture Content on Mechanical Properties of AAC, Autoclave Aerated Concrete Moisture and Properties, Elsevier, Amsterdam.

3.16.6 - Aroni, S. and Clvidini, B. (1989) Materials and Structures, Vol. 22, pp. 443-449.

3.16.7 - Valore, R.C. Jr. (1954) Cellular Concretes, Journal of the American Concrete Institute, May-June, 1954.

3.16.8 - Weber, H. (1991) Das Porenbeton Handbuch: Planen und Bauen mit System (The AAC Handbook of Project and Construction), Bauverlag GmbH, in German.

3.16.9 - Neville, A.M. (1993) Properties of Concrete, Third Edition, Longman Scientific & Technical, Harlow Essex, England.

3.16.10 - ACI 523.2/R-96 Guide for Precast Cellular Concrete Floor and Roof Slabs. ACI Committee 523. May 1996.

3.16.11 - ACI 530-05 Building Code Requirements for Masonry Structures and Commentary.

3.16.12 - ACI 530.1-05 Specifications for Masonry Structures.

3.16.13 - International Building Code – 2006

3.16.14 - Christina M. Behrens, MS and Jennifer E. Tanner, PhD (2008) Evaluation of Thermal Resistance of Autoclaved Aerated Concrete (AAC) Masonry Systems. TMS Journal, July 2008

DISCLAIMER. This document is not intended to replace the knowledge, experience and judgment of design professionals. Xella Aircrete North America, Inc., is **not** responsible for ensuring weather-tightness, overall functionality or fitness for use of the panels, or compliance with federal, state, or local laws, ordinances or regulations, including building, environmental and other codes.

WARNING. Property damage or personal injury or death may result from improper design, use or installation. Licensed design and construction professionals, who are in good standing with the governing authority and have the necessary knowledge, experience and judgment of the specific building system and its components, should be retained to ensure a proper design, use and installation.

MODIFICATIONS. Xella Aircrete North America, Inc. reserves the right to change its Technical Manual, Design Guide, safe working loads, panel dimensions or installation techniques at any time without prior notice. Last modified: 4/2/2009.

WARRANTY/DAMAGES. This document and all further technical advice are based upon Xella Aircrete North America, Inc.'s present knowledge and experience. However, Xella Aircrete North America, Inc. assumes no liability for providing such information and advice. Xella Aircrete North America, Inc. disclaims all CONDITIONS AND WARRANTIES, WHETHER EXPRESS OR IMPLIED, INCLUDING THE IMPLIED WARRANTIES OF FITNESS FOR A PARTICULAR PURPOSE OR MERCHANTABILITY. XELLA AIRCRETE NORTH AMERICA, INC. SHALL NOT BE RESPONSIBLE FOR CONSEQUENTIAL, INDIRECT OR INCIDENTAL DAMAGES (INCLUDING LOSS OF PROFITS or USE) OF ANY KIND.

www.hebelraac.con
One Legacy West Tower, 7950, Legacy Drive,
Suite 240 Plano, TX 75024