
ICON Wall System

General Performance Summary



Overview

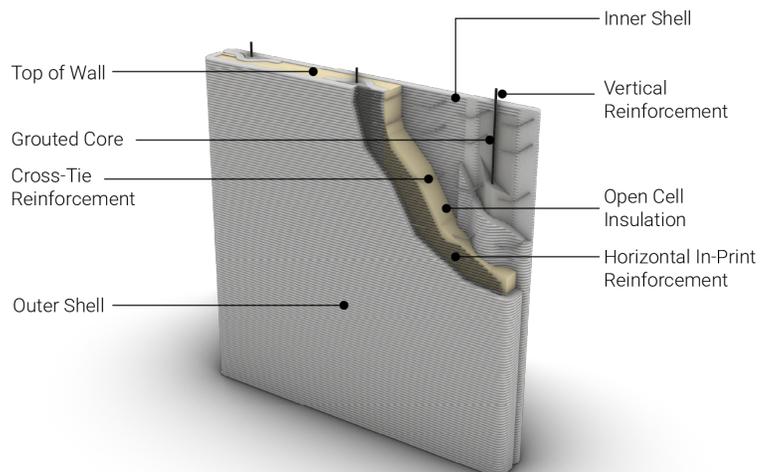
ICON's 3D-printed wall system uses large robotic printers to extrude layers of CarbonX material, building structural walls layer by layer without traditional formwork. The material cures rapidly as it prints, creating walls that serve as the primary load-bearing structure throughout the building's service life. Unlike systems that use printed elements as formwork for cast-in-place concrete, the printed walls themselves provide structural capacity.

The ICON Wall System is a double shelled assembly with vertical reinforced cores on both shells. The nominal 12-inch thick wall distributes structural loads across both the inner and outer shells and resists gravity and lateral loads. Cores—vertical spaces printed integrally with the shells and later filled with reinforced concrete—alternate between inner and outer shells to provide vertical load resistance and lateral stability. The cavity between shells accommodates continuous insulation without thermal bridging and provides pathways for mechanical, electrical, and plumbing (MEP) systems.

This configuration creates continuous load paths from foundation to roof without the joints typical in assembled construction.

Structural Characteristics

The structural design methodology for the ICON Wall System is validated and confirmed by third party structural testing through Acceptance Criteria (AC) 509 developed by the International Code Council Evaluation Services (ICC-ES) - commonly referred to as ICC-ES AC 509. The system can be designed to withstand site-specific loads, and meets the capacity needed for residential construction and light commercial construction. Variations in structural design requirements due to wind speeds, soil conditions, building design, and load distribution patterns are addressed through documented load capacities and flexible design configurations outlined in Engineering Service



Report (ESR)-4652. The design values provided in the ESR are used by structural engineers to design the system to meet site-specific conditions.

For High-Velocity Hurricane Zones (HVHZ), ICON's wall system meets the requirements required by the Florida Building Code and Miami-Dade County for wind and impact testing. The wall system's design methodology meets the 175 miles per hour (mph) design wind speeds and is validated through ICC-ES Evaluation Report ESR-4652.

Wall System Performance Summary

The table below summarizes key performance characteristics of the ICON Wall System. All values are supported by third-party testing and the structural performance characteristics are documented in ICC Evaluation Service (ICC-ES) Evaluation Report (ESR) 4652.

Structural	
Nominal wall thickness	12 inches
Design wind speed	175 mph
Service Level Wind Pressure (tested)	100 psf
Debris impact resistance	Large Missile Passed
Fire Resistance	
Load-bearing walls	Nominal 2 hr. Fire Resistance Rating (178 minutes)
Non-load-bearing walls	Nom. 90 min. Fire Resistance Rating (117 minutes)
Durability	
Freeze-thaw resistance	Passed
Building Envelope	
Material Vapor Permeability	1.15 perm
Rain Resistance	Passed

For detailed test procedures, additional configurations, and design values, see ESR-4652 and the detailed sections below.



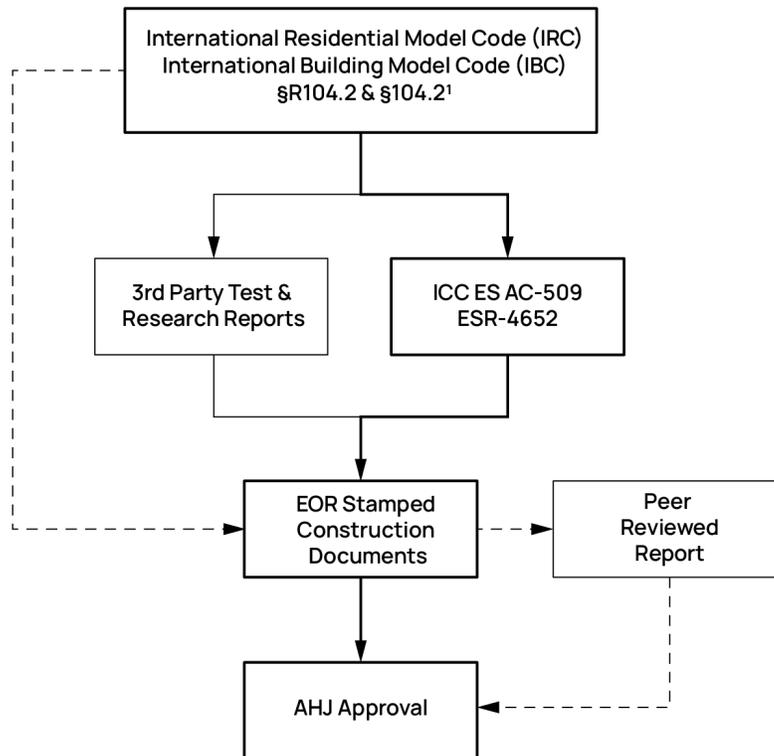
Building Code Compliance

The ICON's Wall System follows an established pathway for building code approval, backed by comprehensive third-party testing and evaluation that building officials recognize across the United States.

The Approval Framework

The model building codes include provisions specifically designed to accommodate construction innovation. These Alternative Materials and Methods (AM&M) provisions provide a structured pathway for approving new technologies when testing demonstrates they meet or exceed code requirements.

Building officials approve 3D-printed construction when objective evidence demonstrates equivalent or superior performance compared to conventional methods. ICON provides the documentation and technical support to streamline this process.



Notes:

1. In versions of the model codes prior to 2024, the Alternative Means and Methods procedures are covered in IBC §104.11 and IRC §R104.11.



Third-Party Evaluation: ESR-4652

ICC-ES, a subsidiary of the International Code Council, has independently reviewed ICON's testing and materials. The resulting evaluation report ESR-4652 documents that the ICON Wall System complies with applicable code requirements based on evaluation against AC 509.

ESR-4652 covers:

- **Material specifications:** The report documents CarbonX printed concrete requirements, including constituent materials, strength requirements, durability requirements, and quality control testing procedures. These specifications ensure consistent material performance across all ICON projects.
- **Wall system configurations:** The report covers approved wall thicknesses, cavity dimensions, and reinforcement options that have been validated through comprehensive testing programs.
- **Structural design requirements:** ESR-4652 provides ultimate design capacities that structural engineers use to design code-compliant wall systems for site-specific loading conditions.
- **Quality assurance and inspection requirements:** The report specifies inspection procedures and acceptance criteria that verify as-built construction matches design intent and maintains structural integrity.

Building officials across the United States recognize ICC-ES evaluation reports as demonstrating code compliance. ESR-4652 is maintained through annual renewals and ICC-ES oversight, including semi-annual facility inspections.

Testing

ICON has completed comprehensive third-party testing programs to establish the performance characteristics of printed wall systems. All testing is performed by independent, accredited laboratories.



Material Testing

Compressive strength (ASTM C39):	Testing establishes design strength values and characterizes directional strength properties relative to print orientation. These values form the foundation for structural load capacity calculations.
Interlayer bond strength (ASTM C1583):	This parameter determines the wall's ability to resist tensile and shear forces across layer boundaries. Bond strength testing validates the structural continuity of the layered construction at varying layer extrusion times.
Flexural strength (ASTM E518):	This parameter determines the wall's ability to resist flexural tensile forces across layer boundaries. Bond strength testing validates the structural continuity of the layered construction at varying layer extrusion times.
Freeze-thaw resistance (ASTM C666):	Durability testing confirms material performance and integrity in cold climates when subject to repeated freezing and thawing cycles.
Shrinkage characterization (ASTM C157):	Shrinkage testing data informs control joint spacing requirements and helps predict long-term dimensional changes in the wall system.



Structural Testing

ICON has tested over 60 full-scale wall specimens under controlled loading conditions:

Axial compression: (ASTM E72)	Full-scale wall specimens are tested under vertical loading to establish capacity for gravity loads from roof and floor systems. Testing validates design values for various wall thicknesses and reinforcement configurations.
Out-of-plane flexure: (ASTM E72)	Full-scale wall specimens are tested under third-point lateral loading to establish capacity for lateral wind loads. Testing establishes maximum span capabilities between horizontal and vertical supports.
In-plane shear: (ASTM E72)	Full-scale wall specimens are tested under in-plane lateral load to establish racking capacity. Lateral load testing validates the wall system's ability to resist wind and seismic forces. Results establish shear design values for lateral load paths.
Cyclic loading: (ASTM E1886/E1996)	Specialized testing under high winds-simulating load patterns evaluates the wall system's ability to maintain capacity through multiple wind loading cycles.
Wind-borne debris impact: (ASTM E1886/E1996)	Large missile impact testing simulates wind-borne debris and evaluates resistance to projectiles characteristic of hurricane conditions. This testing validates compliance with Miami-Dade High Velocity Hurricane Zone (HVHZ) requirements for debris impact resistance.

Life Safety and Enclosure Weatherization

Fire resistance: (ASTM E119)	Load-bearing walls achieve fire resistance exceeding 2-1/2 hours. This performance allows specification as 2-hour fire-rated assemblies for design purposes. Non-load-bearing interior walls achieve approximately 2 hours (117 minutes) of fire resistance, typically specified as 90-minute rated assemblies.
Air Barrier: (ASTM E96)	CarbonX is a Class III Vapor retarder. Tested in accordance with ASTM E96 Method A, CarbonX material has a vapor permeance of 1.15 perms.



High-Wind and Hurricane Compliance

The wall system's compliance with Miami-Dade County HVHZ requirements demonstrates performance under the most demanding wind and impact conditions in the United States. Building officials in high-wind regions recognize this validation as evidence of adequate structural capacity.

Florida Building Code and HVHZ

The ESR-4652 Florida Supplement documents compliance with Florida's HVHZ requirements—developed after Hurricane Andrew as the standard for hurricane-resistant construction. The ICON Wall System meets HVHZ provisions for service level wind loads up to 100 psf, consistent with the 175 mph design wind speed required for Miami-Dade County.

ICON has established a plan review process for projects in Miami-Dade County, creating precedent that streamlines approval for subsequent projects in Florida's most demanding wind regions.

Testing Protocols

HVHZ compliance is supported by comprehensive testing following Florida Building Code Testing Application Standards:

- **TAS 202 (ASTM E330):** Sustained wind pressure resistance testing demonstrates that the wall maintains air and water barrier integrity under design wind loads. This validates the wall's ability to resist wind pressure without structural damage or envelope breach.
- **TAS 201 (ASTM E1886/E1996):** Debris impact resistance testing demonstrates that the wall withstands large missile impact without breach or structural damage. This simulates conditions during hurricane events when wind-borne debris can penetrate building envelopes.
- **TAS 203 (ASTM E1886/E1996):** Cyclic pressure resistance testing on previously impacted specimens demonstrates envelope integrity even after debris damage. This validates the wall's ability to maintain protective function throughout a hurricane event.

Benefits for Project Approval

Projects in high-wind regions benefit from:

- **Established precedent:** Multiple projects have received approval in hurricane-prone jurisdictions using Miami-Dade HVHZ compliance documentation. Building officials recognize this testing as addressing their most severe wind loading concerns.
- **Comprehensive testing documentation:** The testing program addresses wind pressure resistance, debris impact resistance, and water infiltration—the three primary concerns in hurricane design.
- **Transferable approval:** Testing conducted for Miami-Dade HVHZ conditions (175 mph design wind speed) exceeds requirements in most U.S. jurisdictions, simplifying approval in lower wind speed regions.



Seismic Design Approach

ICON's wall system addresses seismic design requirements across different Seismic Design Categories (SDC).

Seismic Design Categories A and B

For projects in SDC A and B, ICON's printed wall systems can serve as the lateral-force-resisting system using the design values and methods documented in ESR-4652. The printed walls function as both the gravity load system and the lateral load system. This approach covers the majority of the continental United States outside of the West Coast and other known seismic zones.

Seismic Design Categories C and Higher

For projects in SDC C, D, and higher categories, ICON has established a compliance pathway using methods already approved in ASCE 7 and ACI 318. Designated walls are designed as special reinforced concrete shear walls, with the printed geometry serving as stay-in-place formwork while cast-in-place concrete and reinforcement provide the code-recognized seismic capacity.

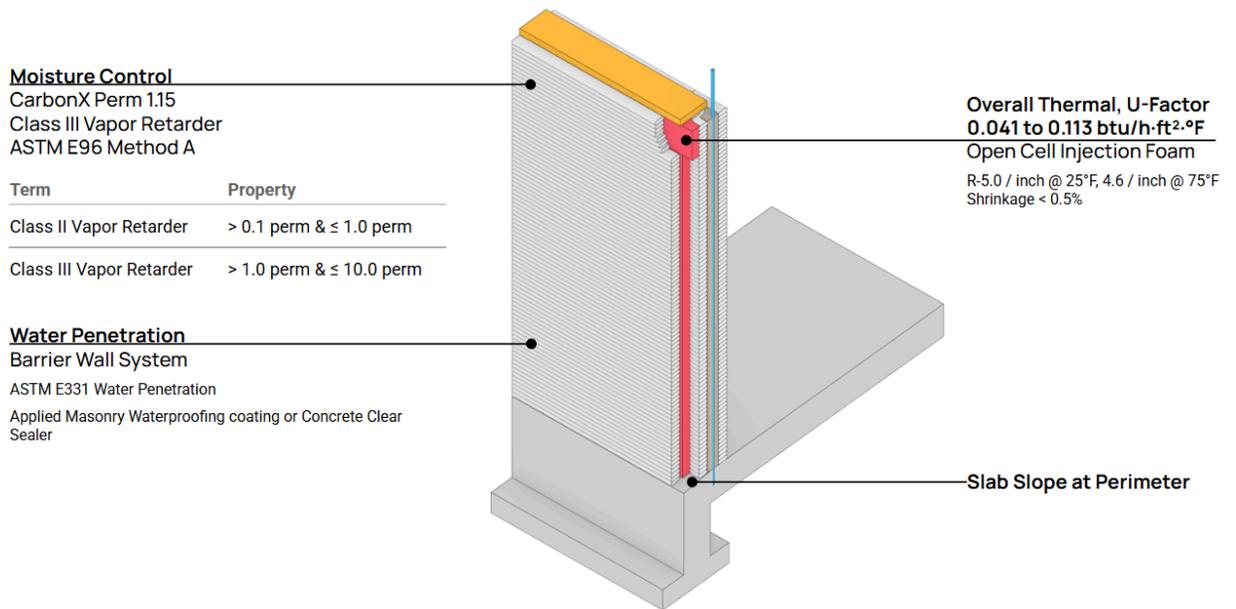
Renovations and Additions

For any major renovation or addition project involving changes to a structural wall, consult a structural engineer before making any changes. ICON supports multiple generations of homeowners as they make changes to their home.

Making changes to ICON's printed wall system is similar to working with a CMU block wall. The International Code Council's Evaluation Services published an engineering report detailing the design equations to use when working with ICON's printed wall system. This allows any structural engineer to use this engineering report to work with the wall system.



Weatherization



Thermal Performance

The ICON Wall System achieves assembly U-factors ranging from U-0.054 to U-0.113 (R-18.5 to R-9) depending on wall thickness, bead configuration, and bond beam detailing. The 12-inch nominal 2-bead configuration with 3×3 in cores and no bond beam achieves U-0.054 (R-18.5); configurations with thermally broken bond beams maintain performance between U-0.059 and U-0.065 (R-17 to R-15).

These values satisfy IECC mass wall requirements in all climate zones where ICON is actively building (climate zones 1–6). Thermal performance is achieved by creating a continuous thermal break between the inner and outer printed shells, with 4.75 to 6.75 inches of open-cell injection spray foam filling the wall cavity. Bond beam detailing—whether continuous or thermally broken—significantly influences overall assembly performance and should be coordinated with structural requirements during design.

Performance Methodology Breakdown

Thermal performance data for the ICON Wall System is determined through three-dimensional steady-state heat transfer analysis using SOLIDO by Physibel, a finite element solver validated against EN ISO 10211 (Thermal Bridges in Building Construction). The analytical approach aligns with physical testing standards defined in ASTM C1363.

Analysis specimens measure 8 ft wide by the full wall height and contain two structural cores at 4 ft on-center spacing, representing the standard structural configuration. This sample geometry captures the thermal bridging effects of cores, bond beams, and cross-tie reinforcement.

U-factors are calculated from the relationship between heat flow, temperature differential, and assembly surface area using standard boundary conditions from ASHRAE Handbook – Fundamentals, Chapter 26, Table 10: 68°F interior temperature, 32°F exterior temperature, with surface heat transfer coefficients for still air (interior) and 15 mph wind (exterior). Because

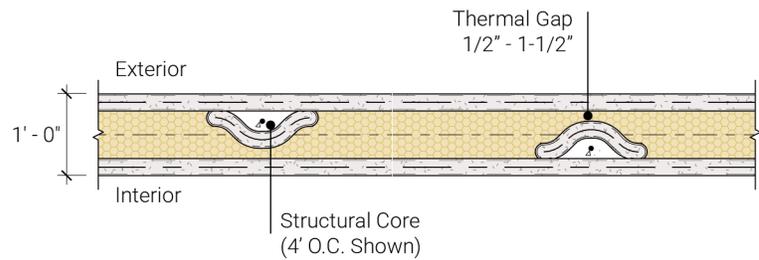


U-factors are based on temperature differential, results are independent of geographic location and applicable to any jurisdiction adopting the IECC U-factor compliance path.

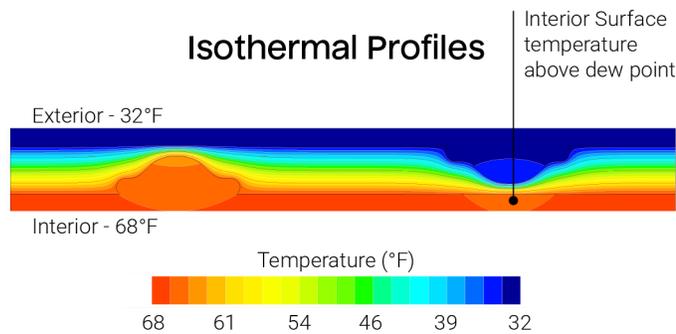
Material Properties

Thermal conductivity values used in the analysis are derived from third-party testing for CarbonX (1.600 W/mK) and manufacturer specifications for InsulSmart spray foam insulation (0.029 W/mK). Cross-tie reinforcement uses standard stainless steel properties (17.0 W/mK). All thermal bridging effects from structural elements are incorporated into the finite element model.

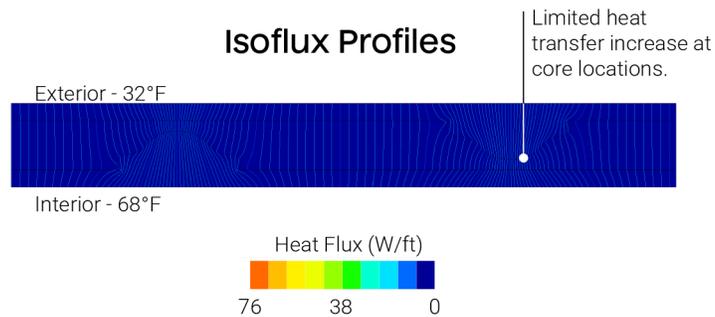
Plan View Thermally Break at Structural Cores



Isothermal Profiles



Isoflux Profiles



Performance Data

The following tables provide U-factors (btu/h·ft²·°F) for wall configurations by height, core size, and bond beam depth. Equivalent R-values are calculated as $R = 1/U$.

	Continuous Bond Beam Depth					Thermally Broken Bond Beam Depth			
Core Size	0 in	8 in	9 in	10 in	Core Size	0 in	8 in	9 in	10 in
10 Ft. Wall					10 Ft. Wall				
3×3 in	0.056	0.092	0.095	0.099	3×3 in	0.056	0.062	0.063	0.065
3×4 in	0.058	0.094	0.097	0.101	3×4 in	0.058	0.064	0.065	0.067
4×4 in	0.082	0.115	0.119	0.122	4×4 in	0.082	0.086	0.087	0.089
12 Ft. Wall					12 Ft. Wall				
3×3 in	0.054	0.084	0.087	0.090	3×3 in	0.054	0.059	0.060	0.061
3×4 in	0.056	0.086	0.089	0.092	3×4 in	0.056	0.061	0.062	0.063
4×4 in	0.079	0.107	0.110	0.113	4×4 in	0.079	0.083	0.084	0.085

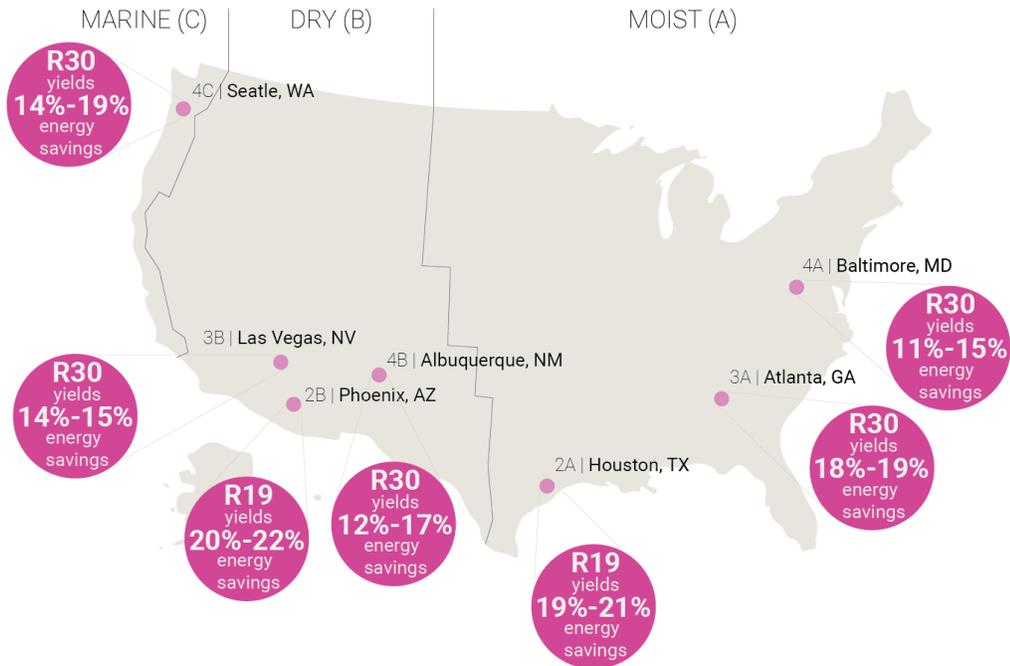
Thermal performance. U-factor in btu/h·ft²·°F.

In colder climates that require higher insulation performance, the cavity's width can be increased to meet specific climate needs.



Impact on Energy Performance

The 3D-printed wall provides more stable indoor temperatures, and in turn, the heating and cooling system have to work less to meet desired temperatures. The map outlined below highlights the suggested R values for climate zones 2 to 4 based on the Phase I energy analysis findings that aim at reducing the impact of heating and cooling to at least 15%.

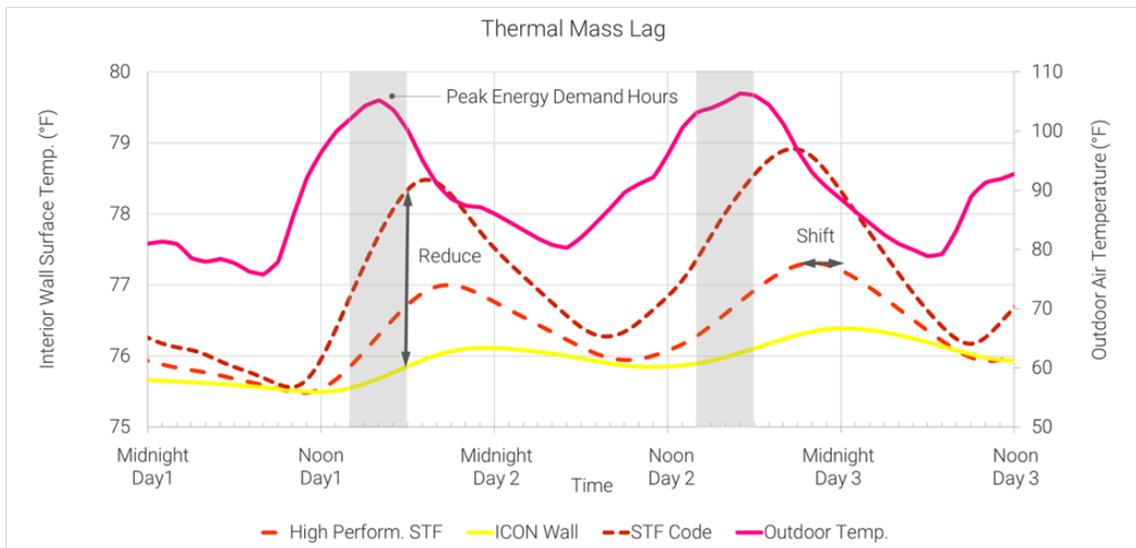


Benefits of Thermal Mass

The thermal mass in the ICON Wall System provides a more consistent and even temperature inside a home throughout the day by delaying when the interior space peak temperature occurs. This saves homeowners money by shifting demand to cooler parts of the day when HVAC units are more efficient.

The printed wall system's thermal mass provides significant performance advantages beyond its static R-value. This mass creates a thermal lag effect that delays heat transfer through the wall by 6 to 12 hours, effectively shifting cooling loads to cooler parts of the day when HVAC systems operate more efficiently and electricity costs may be lower.

Field studies found that thermal stability can reduce energy consumption by 10 to 15 percent compared to similarly insulated lightweight construction in appropriate climate zones, while simultaneously improving occupant comfort by maintaining more consistent interior temperatures with fewer fluctuations throughout the day.



Air Leakage

The ICON wall assembly is a low-leakage assembly that regularly exceeds code-required blower door tests on the first test attempt. This consistency reduces rework to bring the building up to code and contributes to reducing long-term energy costs for homeowners.

ICON developed window, door, and penetration details that ensure the continuation of the air and vapor barrier across the opening and up to the roof to reduce air leakage.

Printed concrete walls have inherent air barrier advantages due to their monolithic construction. Your compliance approach depends on project type.

Commercial projects (IECC C402.5): Printed concrete walls comply through pre-approved assembly classifications. The primary compliance path classifies printed walls as cast-in-place concrete assemblies per IECC C402.5.1.3, Item 13. At locations with reduced wall thickness (core cavities), the assembly provides equivalent performance through solid concrete mass exceeding spray foam requirements per Item 6.



Residential projects (IECC R402.4): Residential code establishes whole-building air leakage performance thresholds rather than prescriptive material requirements. Demonstrate compliance through blower door testing showing the completed building meets air changes per hour requirements for your climate zone.

Moisture and Vapor Barrier

CarbonX has a tested (ASTM E96 Method A) vapor permeance equivalent to a Class III vapor retarder with a permance of 1.15 perm.

Any coatings applied to the interior or exterior surfaces of the wall must be vapor permeable. Non-vapor permeable coatings should be avoided or only used in consultation with an enclosure consultant.



Printed Wall Finishes

Modern homes and buildings built using 3D-printed technology offer two distinct wall finish options: painted or exposed surfaces, each bringing unique advantages to your project. Whether for interior comfort or exterior durability, understanding the aesthetic, practical, and cost considerations to make the choice that best suits a project's vision is an important part of the design process.

Two primary surface treatment approaches are available for ICON's printed walls:

Painted Wall Finish system combines a professional-grade block surfacer with a waterproof masonry coating for exterior walls and premium interior paint for interior surfaces. This system creates a filled and uniform appearance while maximizing water resistance and allowing for color customization. The painted system most closely resembles painted concrete block in texture and maintenance requirements, while sharing durability characteristics with stucco finishes.

Exposed Printed Finish showcases the distinctive layered texture of the 3D-printed construction, similar to premium architectural finishes like precast concrete or natural stone. For exterior applications, a clear protective silicone-based sealant is required that preserves the wall's authentic appearance while providing essential weather protection.

For all applications, coatings must be vapor-permeable (minimum 50 perms) to allow the wall assembly to dry while preventing liquid water intrusion. Non-vapor permeable coatings should be avoided as they can trap moisture within the wall system.

Painted Wall Finishes

The painted finish creates a uniform, consistent surface that maintains its refined appearance throughout the life of the home. Regular wear and moderate damage can be effectively restored to original condition through standard patching and repair techniques available from local hardware stores. The even surface texture allows for straightforward cleaning and maintenance using conventional methods, making it an ideal choice for both high use areas or where flexible or frequent repainting options are desired.

The painted finish is adaptable over time: whether refreshing the color, concealing naturally occurring shrinkage cracks, or repairing wall-hanging holes, the painted surface can be restored to its original quality.



Clear Coats

An exposed finish celebrates the unique character of 3D-printed construction, similar to premium architectural finishes like precast concrete, natural stone, or artisanal brick. For exterior applications, we protect the surface with a clear waterproofing sealant that preserves the wall's natural appearance while providing essential weather protection. Interior surfaces may remain uncoated, or receive a coating depending on the application needs. All exterior exposed printed finishes require a protective clear coating and it is optional for interior surfaces depending on use.

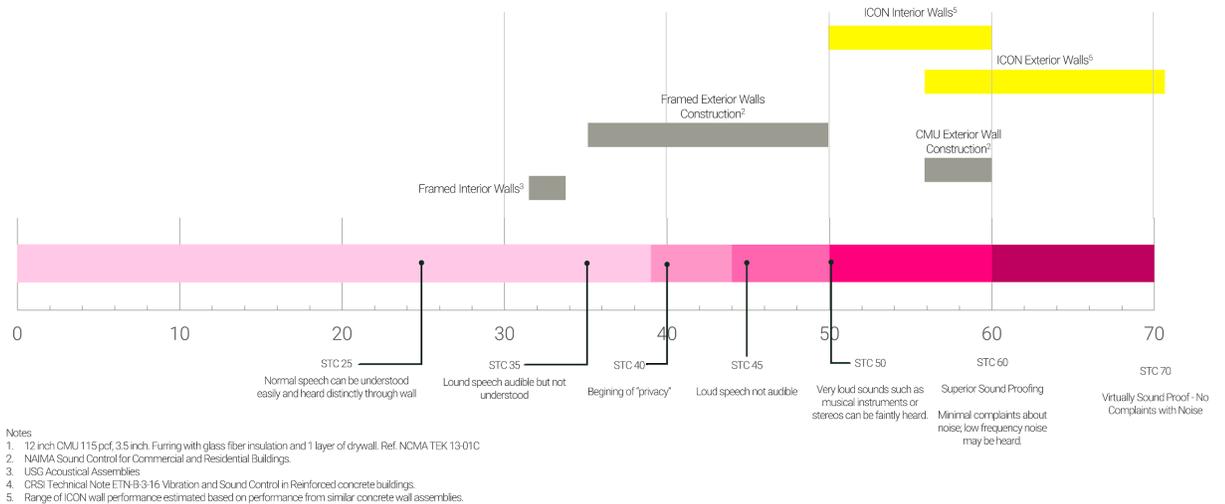
The exposed printed finish creates a premium one-of-a-kind architectural finishes with naturally occurring variations, creating distinctive light and shadow patterns.



Acoustical Characteristics

ICON's mass wall provides superior acoustical performance without additional material – in particular for interior wall partitions that are typically framed walls with drywall and an air cavity. Improving the acoustical performance of framed walls requires adding insulation and/or additional drywall, which increases installation time and cost.

With ICON printed walls, sound isolation measures within the home may be focused on the doors and openings rather than on the walls themselves.



Pests, Mold, and Mildew

ICON homes with printed exterior and interior walls have no structural wood framing near the foundation, providing a more resilient structure to resist termites and other pests compared to CMU and stick frame construction.

Mold and mildew thrive in damp, warm environments, and can be supported by the organic material contained in wood, drywall, and carpeting, deteriorating building materials over time. CarbonX, the material used to print ICON walls, contains similar materials to concrete and does not contain the organic material necessary to support mold by itself. Including printed interior walls helps further reduce organic material available to foster mold growth in the home.



Getting Started with ICON Wall Systems

ICON's 3D-printed wall system delivers proven structural performance, superior energy efficiency, and streamlined building code compliance through comprehensive third-party testing and evaluation. Whether you're designing for high-wind coastal regions, seismic zones, or standard residential applications, the ICON Wall System provides the technical documentation and regulatory pathway to support project approval.

Next Steps

For Design Professionals: ICON's technical team provides design support throughout your project development, including structural design consultation, thermal analysis coordination, and building code compliance documentation. ESR-4652 and supporting technical resources are available only at [iconbuild.com](https://www.iconbuild.com) and the ICC-ES ESR registry.

For Builders and Developers: ICON supports project teams from initial feasibility through construction completion. Our Building Regulatory Affairs team is available to ICON customers to support detailed conversations with local building officials within our service area to streamline the approval process, drawing on established precedent from projects across multiple jurisdictions.

For Building Officials: We provide comprehensive technical documentation including third-party testing reports, evaluation service reports, and quality assurance protocols that demonstrate code compliance. Our team is available to address jurisdiction-specific questions and support plan review processes.



www.iconbuild.com