thermomass®

Insulated Concrete Sandwich Walls

Program Number: CRE001
Provider Number: J187

Brad Nesset – Thermomass

David Tomasula - LJB

PEDCO
SIXTH ANNUAL
High Performance
BUILDINGS
SEMINAR

Insulated Concrete Sandwich Walls

AIA / CES Program Purpose

- For those who may have missed today's opportunity to gain LU's, you can now obtain them online anytime – 24 hours a day – at no cost.
- Log on to: www.Thermomass.com/ce

on-line learning CENTER

FREE ONLINE CONTINUING EDUCATION

AECDAILY

1 SD Credit
Course Approval
#90006752

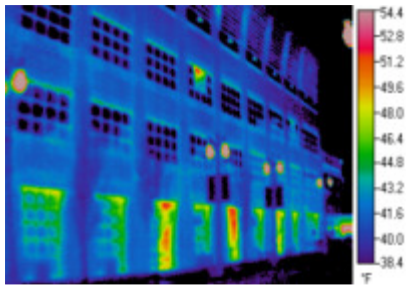
- The online course provides an overview of insulated concrete sandwich panels, their benefits, applications, thermal and moisture resistant properties and contribution to sustainable buildings.

CONTINUING EDUCATION AIA

Insulated Concrete Sandwich Walls

Learning Objectives

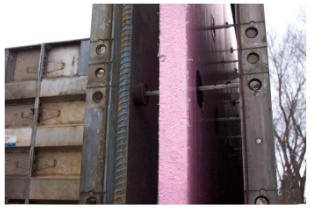
- ***Participants will be able to:***
  - Utilize the architectural aspects of insulated concrete sandwich walls.
  - Understand why it is important to insulate a concrete wall.
  - Understand the different sandwich wall panel types and wythe connectors.
  - Understand the types and properties of rigid foam plastic insulation used in sandwich wall panels.
  - Understand overall physical properties of insulated concrete sandwich walls.



Insulated Concrete Sandwich Walls

Program Agenda

- ***Introduction to Insulated Concrete Sandwich Walls***
- Thermal Performance
- Types of Insulated Concrete Sandwich Walls
  - Non-Composite Wall Panel
  - Structurally Composite Wall Panel
- Sustainability
- Summary

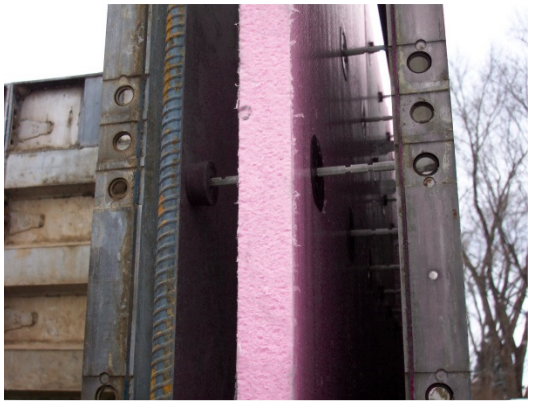


Introduction

Insulated Concrete Sandwich Wall Construction Techniques

Plant Precast

Site Cast Tilt-Up



Cast in Place

Introduction

Benefits to Using Insulated Concrete Sandwich Walls

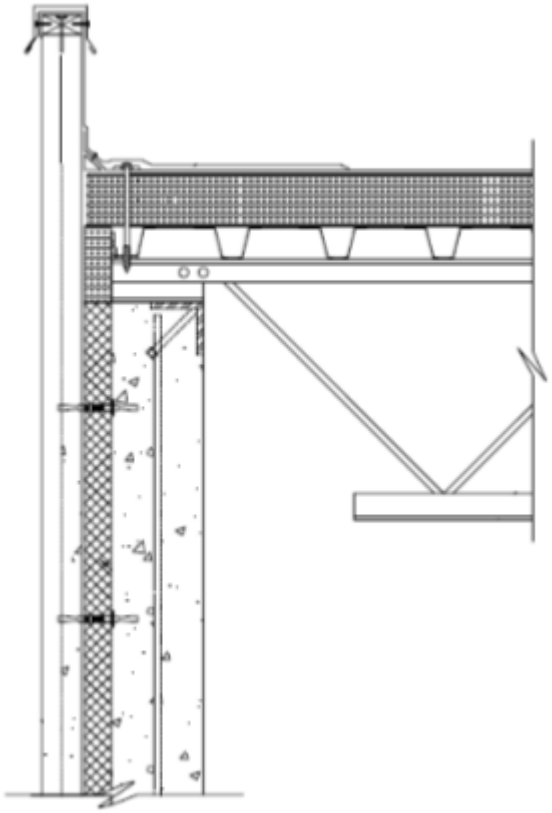
- Speed of Construction
- Limited Site Disturbance
- Load Bearing or Cladding
- Attractive Appearance
- Energy Efficiency
  - Continuous Insulation “ci”
- Air & Moisture Barrier
  - Exceeds requirements of IECC
- Fire & Blast Resistant
  - NFPA 285 & ASTM E-119
- One Economical Assembly
  - Early enclosure allows follow-on trades to start sooner

Introduction

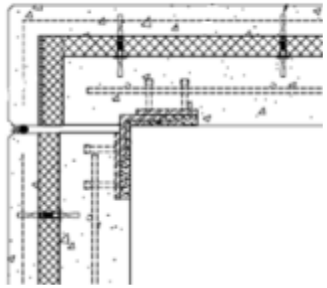
Site-Cast Tilt-Up Construction

Introduction

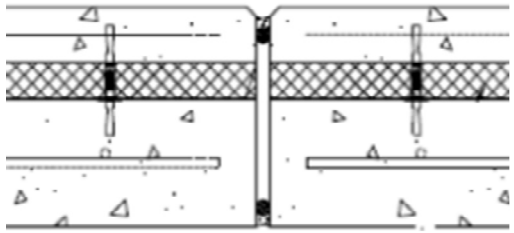
Envelope Details



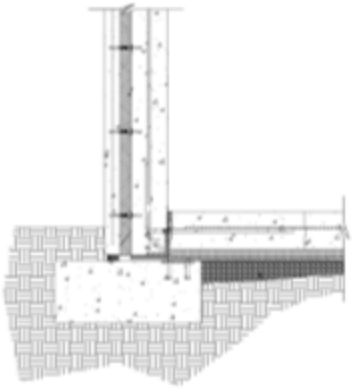
Parapet



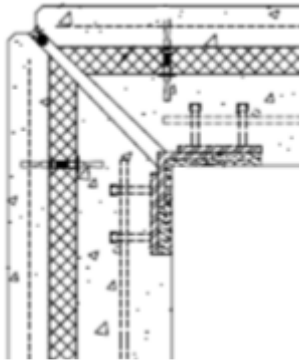
90° Corner



Typical Panel to Panel



Typical Footing

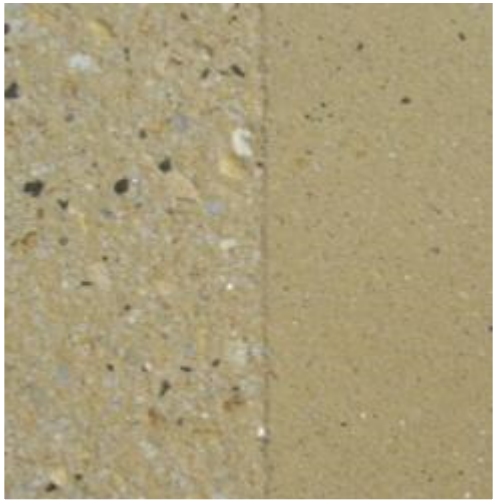


45° Corner

Introduction

Color, Form, & Texture

Thin Brick



Color, Sand-blasting & Etching

Form Liners

Introduction

Thin Brick – West Des Moines, IA

"Durability, strength, thermal value properties and the ability to integrate brick into the wall system made Thermomass the ideal solution"

- Rick Hansen, M+H Architects

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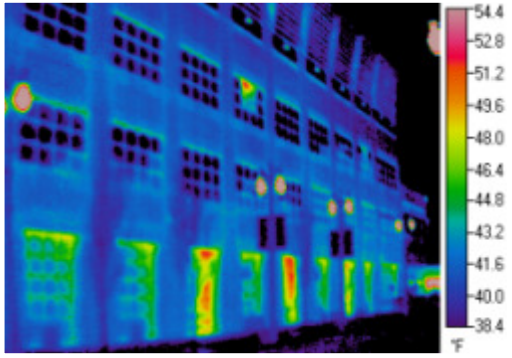
Introduction

Thin Brick – Detroit, MI



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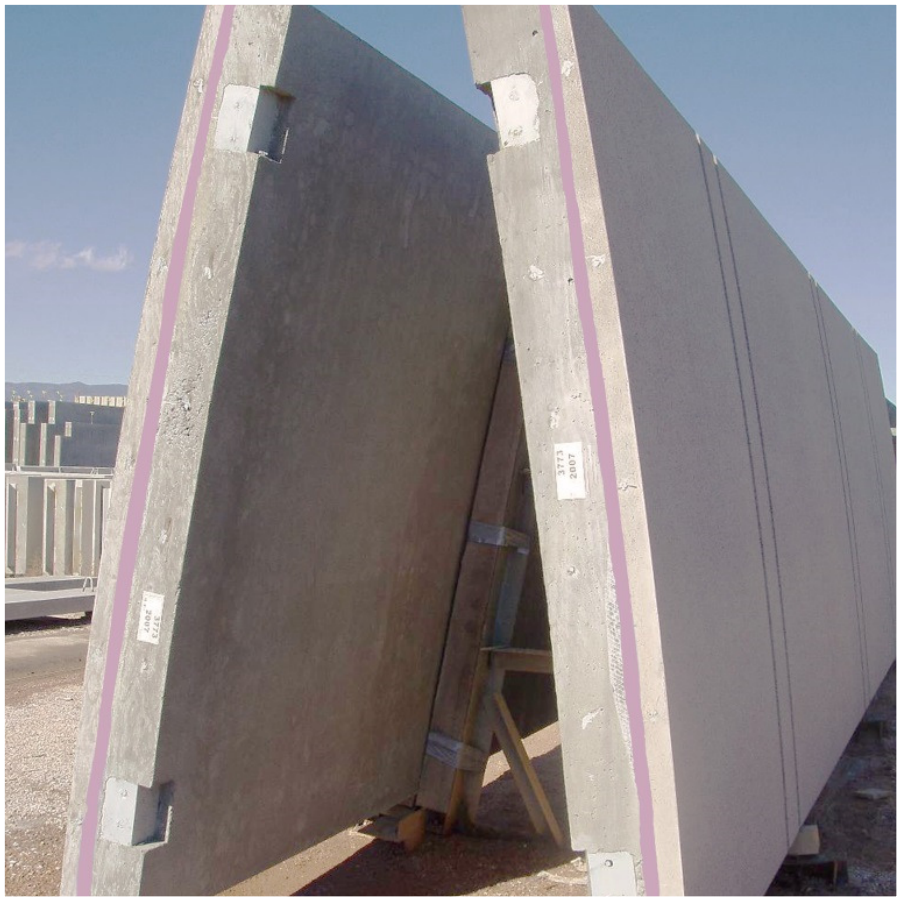
Introduction

Pigmented Concrete, Exposed Aggregate, Radius Panel – Colorado Springs, CO



Introduction

Pigmented Exterior Concrete with Exposed Aggregate – Lehi, UT

Introduction

Painted Concrete with Reveals – Indian Springs, NV

Introduction

Distressed Wood – Modesto, CA

Introduction

Natural Concrete - Colorado

Introduction

Natural Concrete – Des Moines, IA

Introduction

Natural Concrete – Woodinville, WA

Introduction

Redwood Siding - Napa, CA

"Because the concrete absorbs and releases moisture reflecting the relative humidity of the interior air, the interior humidity is stabilized."

- Michael Addleman, Bethlehem Construction

Introduction

Reveals & Paint Replicate Stone – Charlotte, NC

"Concrete is much more durable and can create interesting acoustical conditions for churches looking for slightly reverberant spaces."

- Glen Stephens, SAA Architects

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Introduction

Form Liner and Stain – Norman, OK

Introduction

Form Liner Replicating Stone – Bloomington, IN

Introduction

Form Liners & Colored Concrete – Jacksonville, FL

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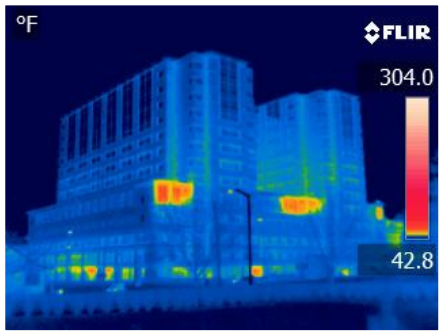
Introduction

Thin Brick – Lexington, KY



CONTINUING EDUCATION
AIA

Introduction

Brick, Form Liner & Color – Ft Worth, TX

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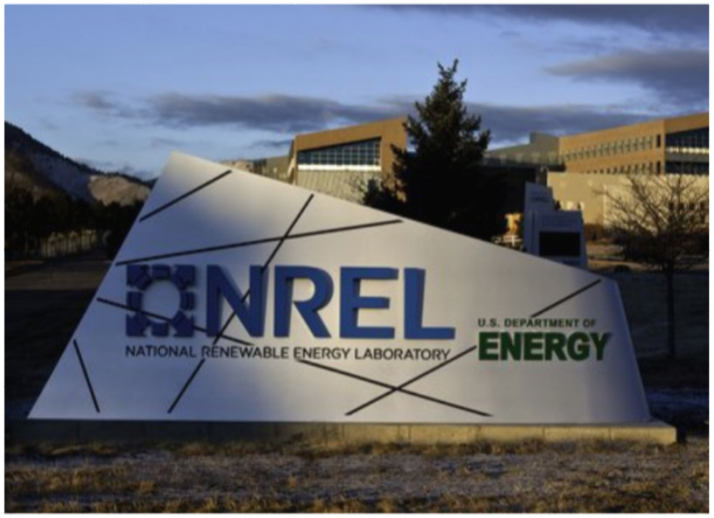
Introduction

White Cement / Thin Brick – Madison, WI

Introduction

Sand Blast Colored Concrete – Golden, CO



- Zero Energy
- LEED Platinum

Insulated Concrete Sandwich Walls

Program Agenda

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- ***Thermal Performance***
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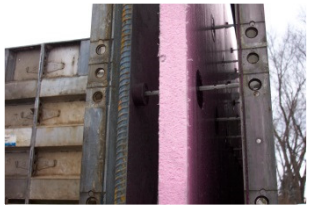
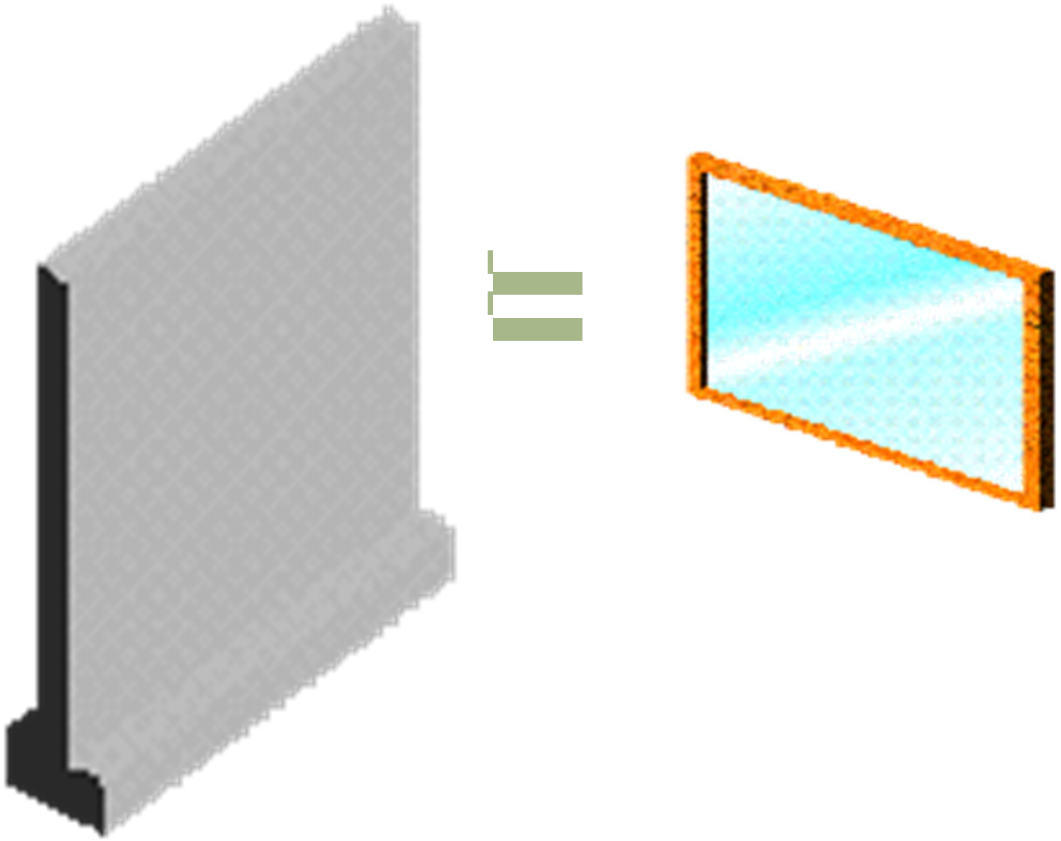


Thermal Performance

Un-insulated concrete walls



- Did you know that 7” of load-bearing structural concrete has approximately the same R-Value as a single panel of glass….**R-1.4** !
- **“ci” is Important !**

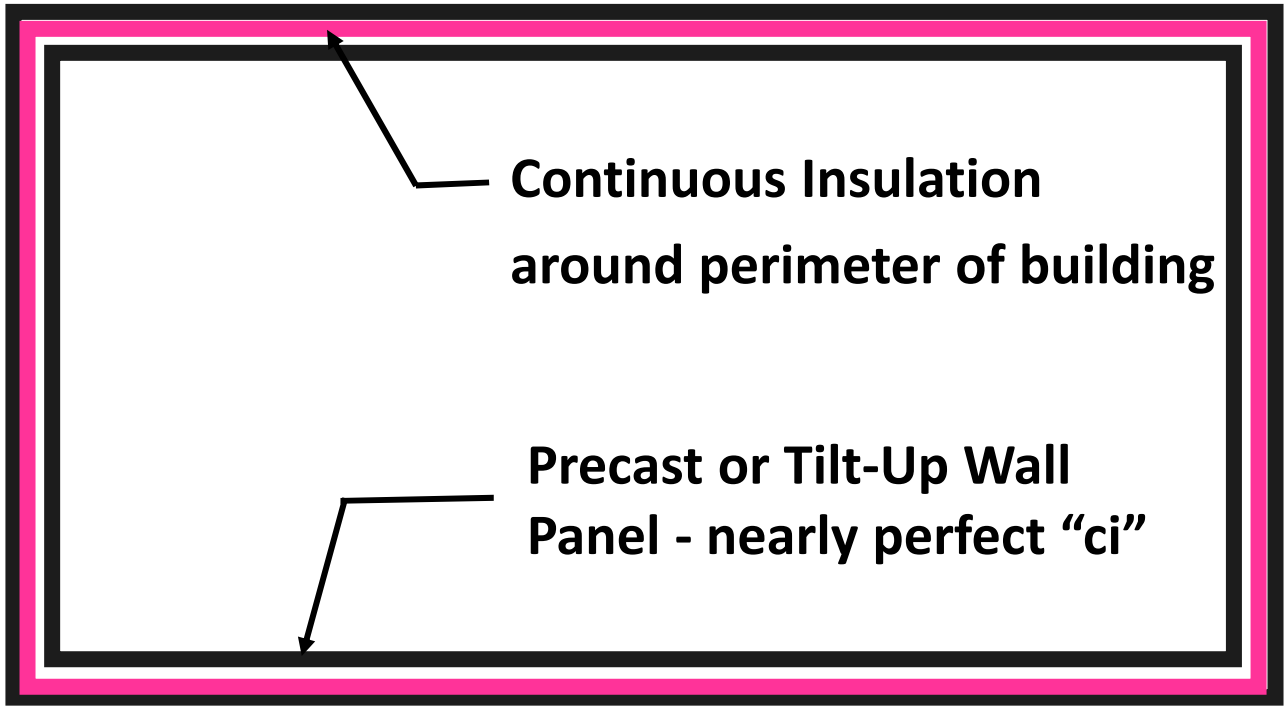
Thermal Performance

The importance of insulation

- ***Why is "ci" important?***
  - Payback for client – it's the right thing to do!
  - Sustainable rating program (IgCC or LEED)
  - Affects HVAC equipment sizing
  - Health of the building environment
    - Moisture Management
    - Indoor Air Quality
  - Minimum code requirements (IECC or ASHRAE 90.1)

- **Continuous Insulation (“ci”) – ASHRAE 90.1 Definition:**

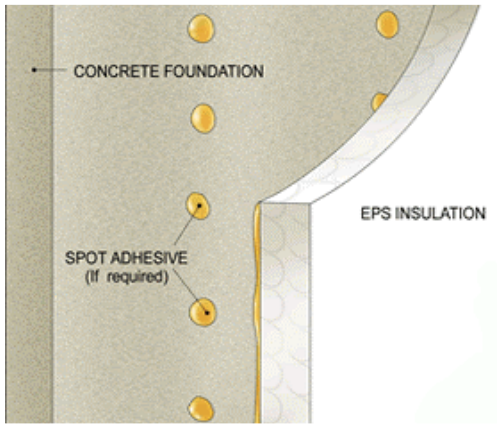
  “Insulation that is continuous across all structural members without thermal bridges other than fasteners and service openings … interior, exterior or integral.”



Thermal Performance

Insulation Position

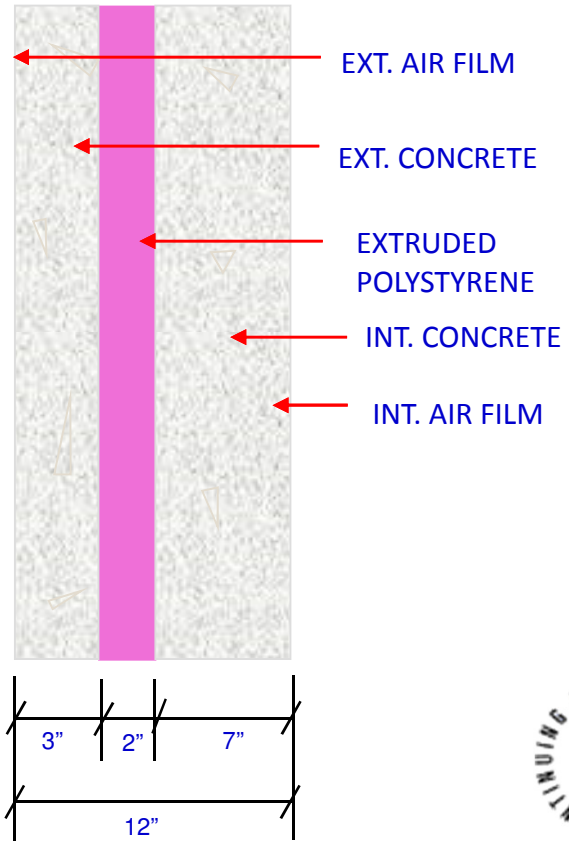
- ***Interior:*** Insulation is on the inside of the bulk mass of the wall system.
- ***Exterior:*** Outside of the bulk mass of the wall system.
- ***Integral:*** Sandwiched between substantial amounts of mass.



Thermal Performance

Material R-Value

Components:	***R-Value:***
Interior Air Film	0.68
7” Concrete	0.56
2” XPS Insulation	10.00 ci
3” Concrete	0.24
Exterior Air Film	0.17
MATERIAL R-VALUE:	***11.65***

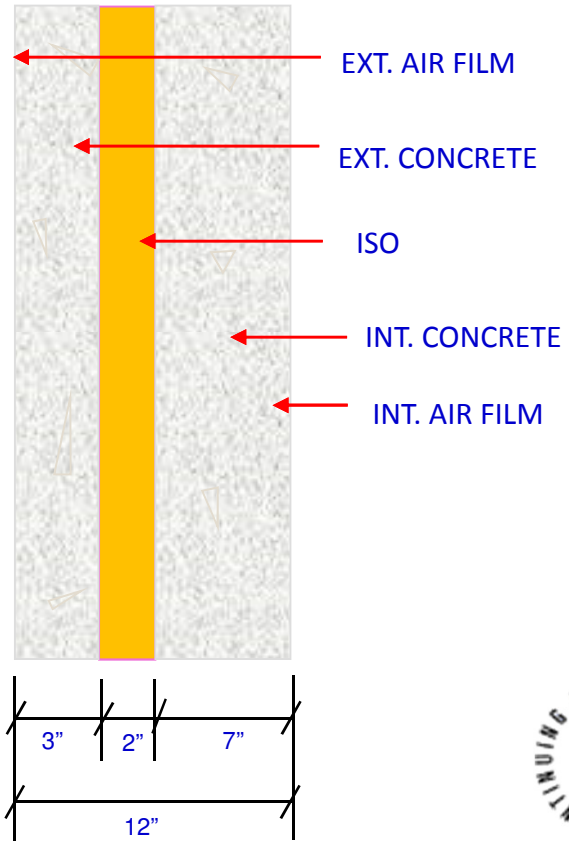


- ***Example:*** 7” int. concrete, 2” XPS, 3” ext. concrete
- ***Note:*** Edge-to-edge continuous insulation (ci)

Thermal Performance

Material R-Value

Components:	*R-Value:*
Interior Air Film	0.68
7” Concrete	0.56
2” ISO Insulation	13.00 ci
3” Concrete	0.24
Exterior Air Film	0.17
MATERIAL R-VALUE:	***14.65***



- ***Example:*** 7” int. concrete, 2” ISO, 3” ext. concrete
- ***Note:*** Edge-to-edge continuous insulation (ci)

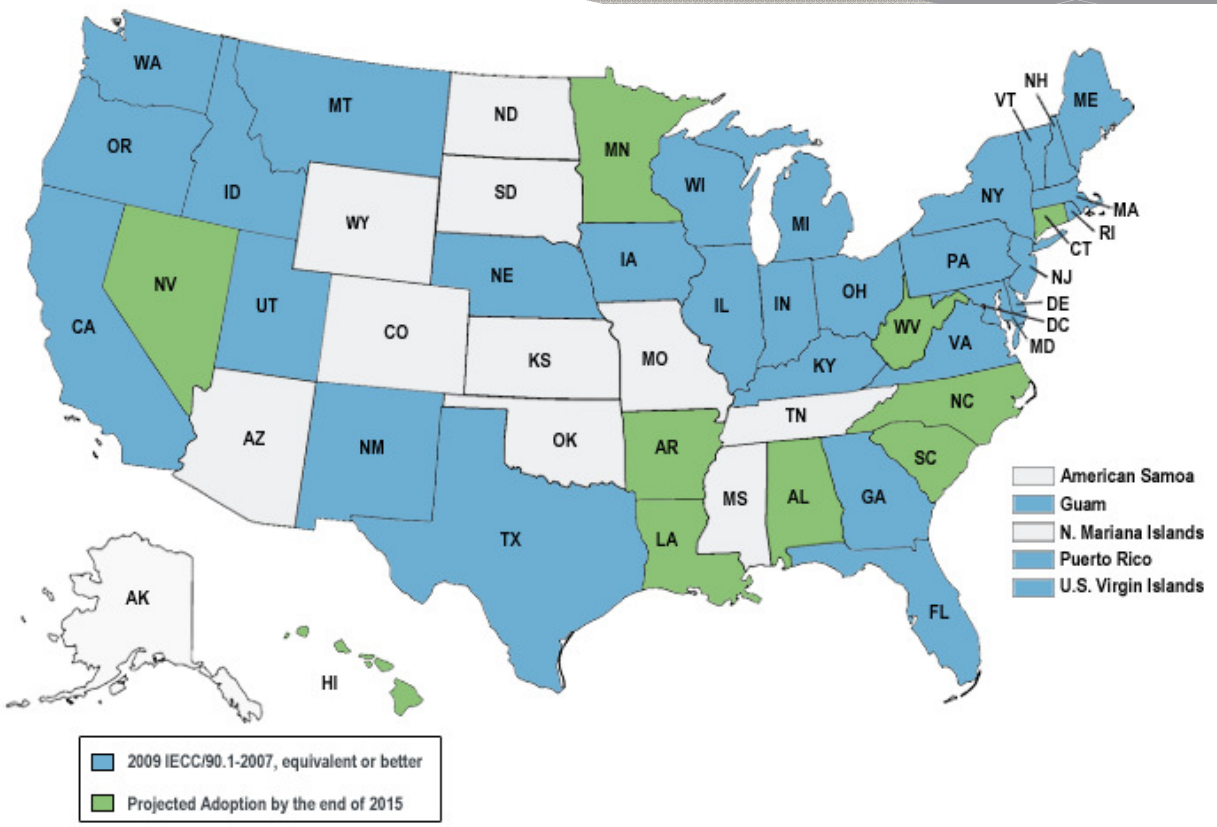
Thermal Performance

Energy Code

- The building insulation world is rapidly changing!
- Since 2007, ASHRAE (American Society of Heating Refrigeration and Air Conditioning Engineers) and the IECC (International Energy Conservation Code) have implemented significant increases to the minimum required roof and wall insulation levels in the national model energy code for buildings.
  - *What does this mean to you?*
- All buildings will become significantly more efficient – a trend seen from the designer all the way to the job-site and into building operations and maintenance.

Thermal Performance

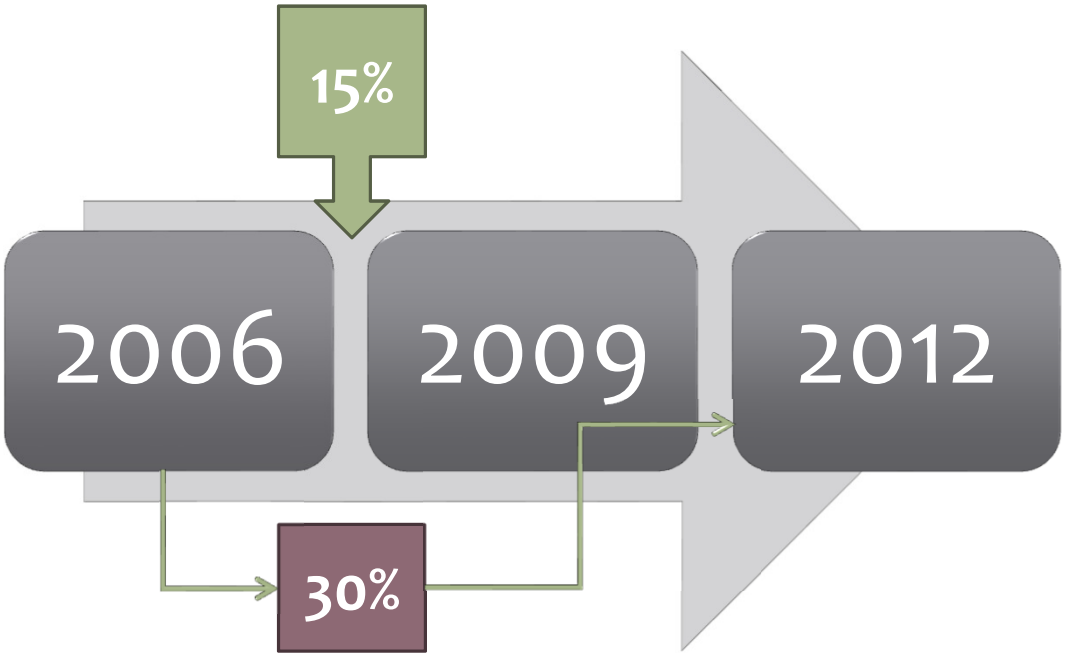
Currently Adopted Commercial Energy Code in Each State



States that are expected to have commercial energy codes meeting or exceeding 90.1-2007 or the 2009 IECC by the end of 2015

Thermal Performance

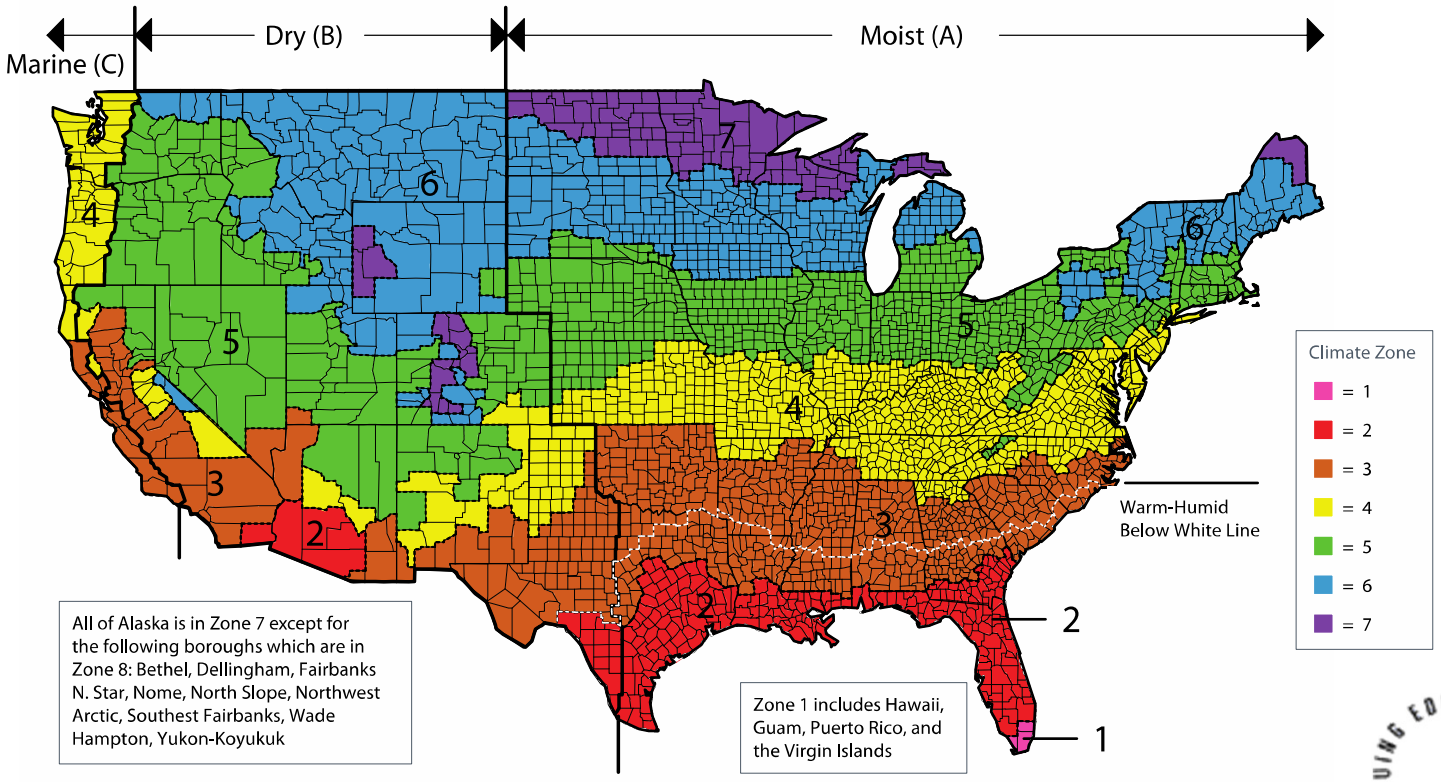
IECC Trend



Thermal Performance & Air Barrier Performance!

Thermal Performance

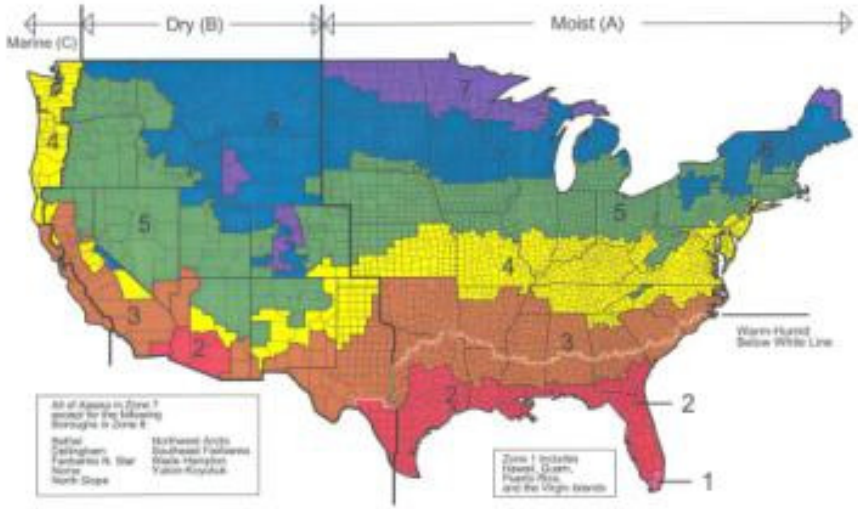
US Climate Zones



Thermal Performance

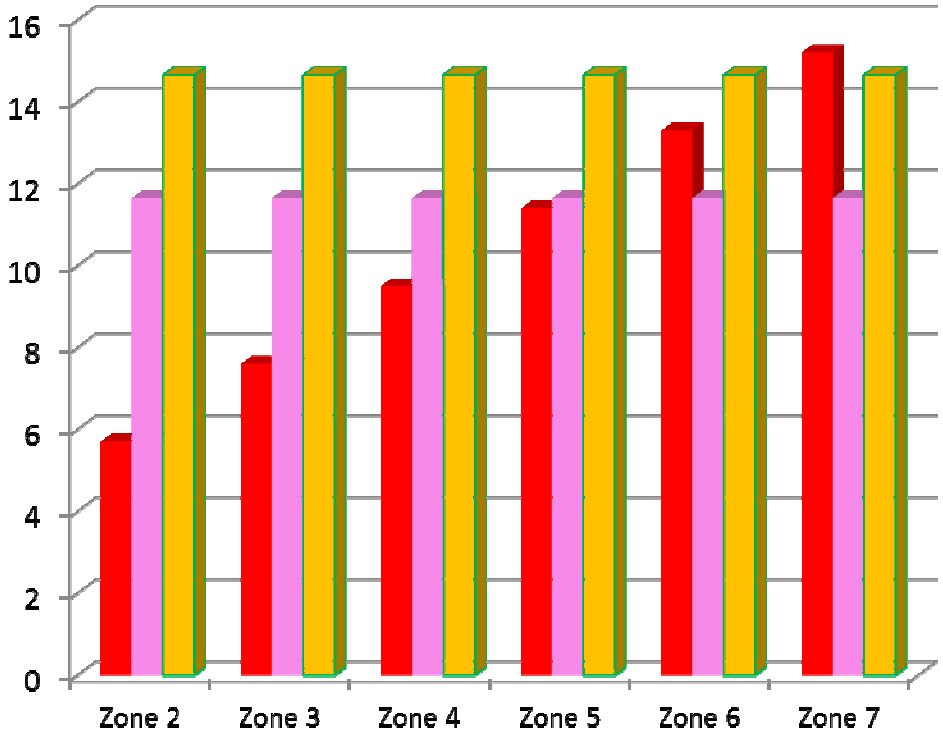
ASHRAE 90.1 -2009: Mass Wall Requirements

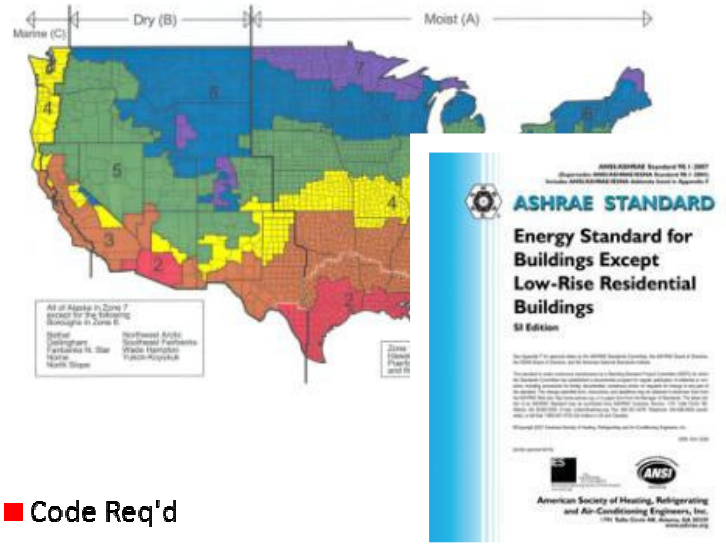
Climate Zone	COM	REZ
3	R-7.6 ci	R-9.5 ci
5	R-11.4 ci	R-13.3 ci
6	R-13.3 ci	R-15.2 ci
2	R-5.7 ci	R-7.6 ci
4	R-9.5 ci	R-11.4 ci



Thermal Performance

ASHRAE 90.1 -2009: Commercial Mass Wall Compliance





Code Req'd

2" XPS

2" ISO

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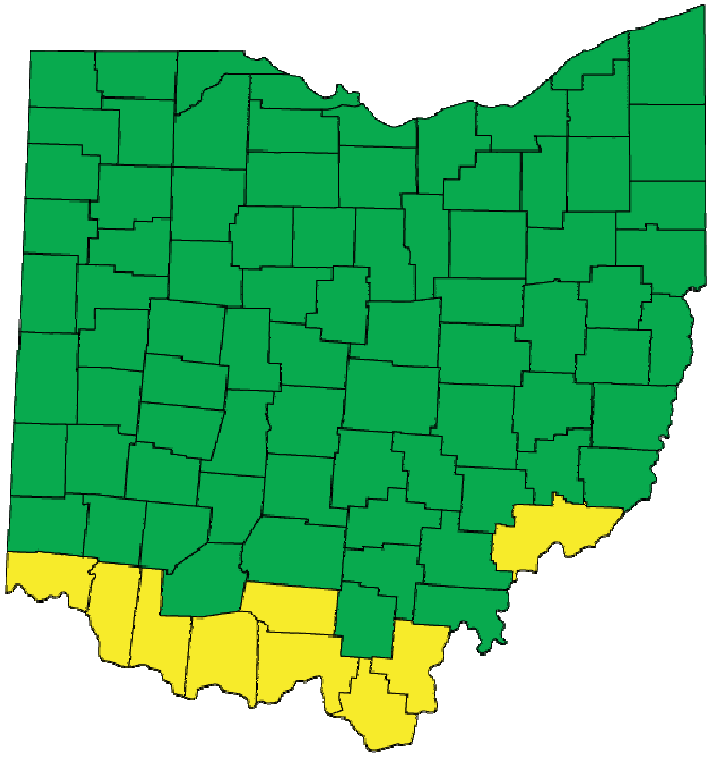
Thermal Performance

IECC 2009: Commercial Energy Efficiency Mass Wall Insulation Requirements

Climate Zone	Above Grade	Group R
4	R-9.5 ci	R-11.4 ci
5	R-11.4 ci	R-13.3 ci



Thermal Performance

Walls Above Grade Requirement – 2009 IECC, Table C502.2 (1)

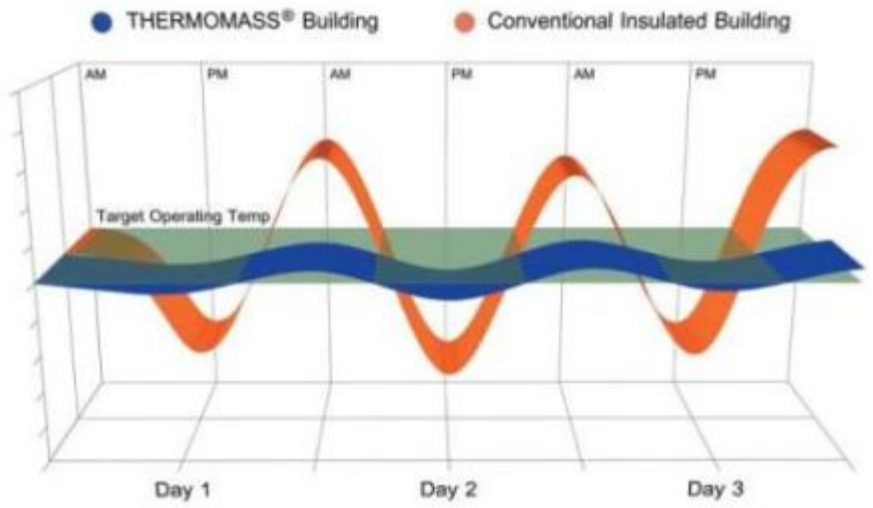
	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8
Mass	NR	5.7 ci	7.6 ci	9.5 ci	11.4 ci	13.3 ci	15.2 ci	25 ci
Metal	16	16	19	19	13 + 5.6 ci	13 + 5.6 ci	19 + 5.6 ci	19 + 5.6 ci
Metal-framed	13	13	13 + 3.8 ci	13 + 7.5 ci	13 + 7.5 ci	13 + 7.5 ci	13 + 7.5 ci	13 + 7.5 ci
Wood-framed	13	13	13	13	13 + 3.8 ci	13 + 7.5 ci	13 + 7.5 ci	13 + 15.6 ci

Thermal Performance

Thermal Mass Effect

- The ability of concrete to store energy and dampen the effect of temperature change on heating and cooling systems is known as the "Thermal Mass Effect."

- Due to the mass effect of integrally insulated concrete walls, the performance R-value of the high performance wall system can be two to three times greater than that of the material R-value, resulting in energy cost savings up to or exceeding 50%.



Thermal Performance

United States City Comparison

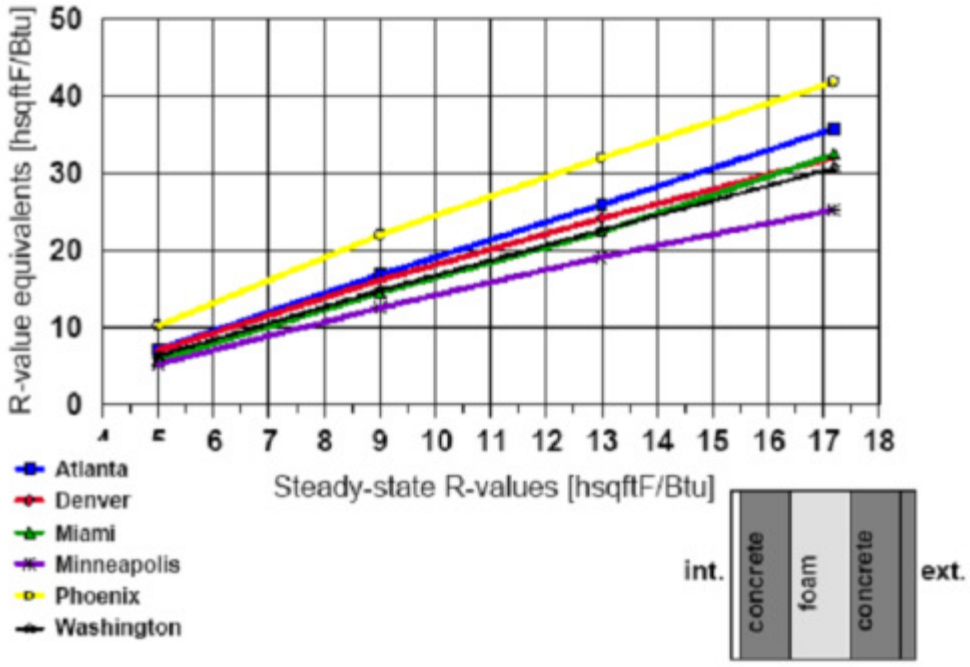


Figure 6. Dynamic R-value equivalents for massive walls with foam core and concrete layers located on both sides.

ASHRAE 90.1: System Performance Criteria

ASHRAE 90.1-1989 Building Envelope Performance Study

Study Provided For:
University of Kentucky
Lexington, KY

SYSTEM PERFORMANCE CRITERIA | **MASS ANALYSIS 1.2**

The result of the balanced equation comparison of the designed, high-mass concrete wall to the similarly designed, non-mass wall is a relationship of energy performance in Btu's to R-value. Note: The material wall R-value is not altered by the dynamics of the building and the climate. The performance value represented below is a portrayal of energy consumption as a function of insulation performance.

PERFORMANCE STUDY SUMMARY

BUILDING AS DESIGNED

	North	East	South	West
COOLING LOAD FOR DESIGNED WALL				
WCc	2.834498	2.691401	3.251193	2.472594
WCt	11.249687			
Btu Consumption	11,249,687			
HEATING LOAD FOR DESIGNED WALL				
WCh	3.724973	3.684414	3.477827	3.667854
WCt	14.563068			
Btu Consumption	14,563,068			
TOTAL ESTIMATED LOAD				
WCt	25.813			
Btu Consumption	25,812,754			

Note I: Btu's consumed equals 1,000,000 x Wall Criteria (WC)
Note II: A negative sum of the Wall Criteria results in a zero value for final calculation

STEADY-STATE WALL R-value:	STEADY-STATE WALL U-value:	WALL HEAT CAPACITY
11.37	0.088	16.25

COMPARISON BUILDING

	North	East	South	West
COOLING LOAD FOR DESIGNED WALL				
WCc	3.555107	3.288535	3.934618	3.253646
WCt	14.031906			
Btu Consumption	14,031,906			
HEATING LOAD FOR DESIGNED WALL				
WCh	2.953994	2.971122	2.910147	2.978463
WCt	11.793726			
Btu Consumption	11,793,726			
TOTAL ESTIMATED LOAD				
WCt	25.826			
Btu Consumption	25,825,632			

Note I: Btu's consumed equals 1,000,000 x Wall Criteria (WC)
Note II: A negative sum of the Wall Criteria results in a zero value for final calculation

STEADY-STATE WALL R-value:	STEADY-STATE WALL U-value:	WALL HEAT CAPACITY
28.73	0.03	1.00

THIS THERMAL MASS, ANALYTICAL COMPARISON RESULTS IN THE DESIGNED WALL BEHAVING AS A WALL WITH A MATERIAL R-VALUE OF:	28.73

Material R-Value of R-11.37 performs as R-28.73

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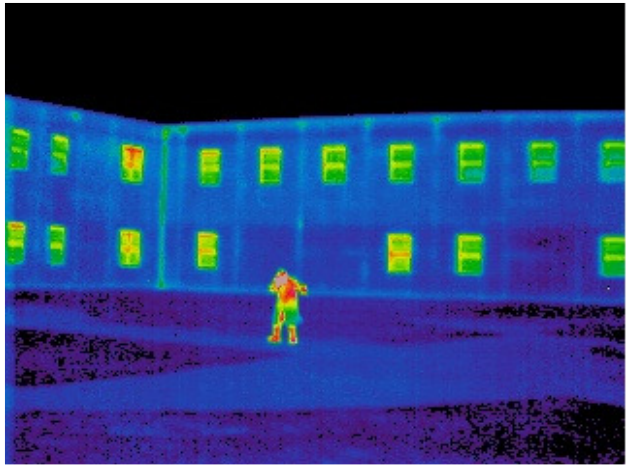
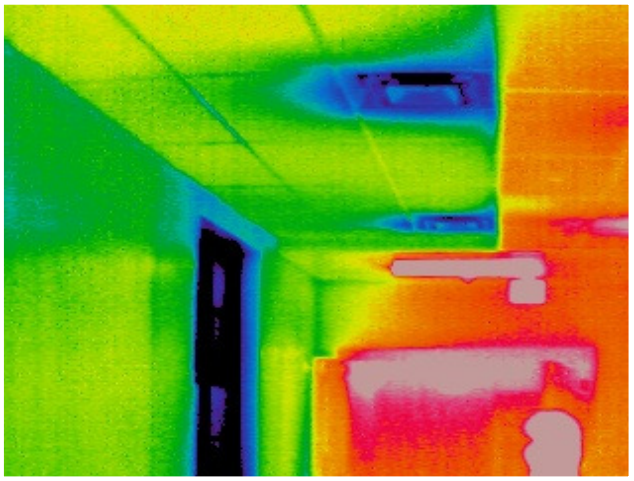
Thermal Performance

Thermal Mass Effect -> Air Barrier

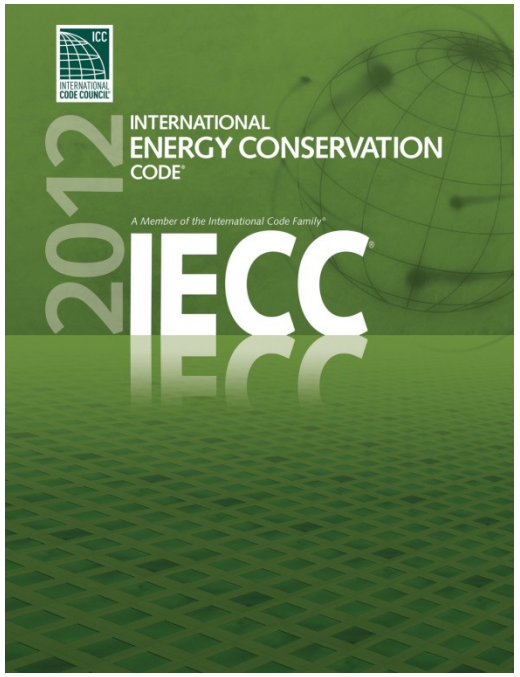




Thermal Performance

Mandatory 2012 IECC Requirements

- C402.4 Air Leakage - The thermal building envelope must also comply by providing:
  - C402.4.1 – A continuous air barrier throughout the building thermal envelope, except climate zones 1-3.
- C402.4.2 - All penetrations caulked and sealed.
- C402.4.3 to C402.4.7 - Minimum air leakage values for fenestrations, doors, vestibules, intakes and exhausts
- C402.4.8 – Minimum air leakage for recessed lighting



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Thermal Performance

Continuous Air Barrier

Tilt-Up Concrete complies with section C402.4.1.2.1 with air permeability of 0.004 cfm/ft2 or less

Thermal Performance

Panel Joint Complies with C402.4.2

Thermal Performance

USACOE Air Leakage Test Protocol

US Army Corps of Engineers®
Engineer Research and Development Center

air barrier abaa association of america

U.S. Army Corps of Engineers
Air Leakage Test Protocol for Building Envelopes

Version 3 - May 11, 2012

- Evidenced the tightest building tested was a concrete building.
- 0.04 cfm/sq.ft. was measured (Durston 2012)
- Results were 4x tighter than average of all buildings tested.
- Results were 10x greater than the minimum requirements of 2012 IECC.

Approved for public release; distribution is unlimited.

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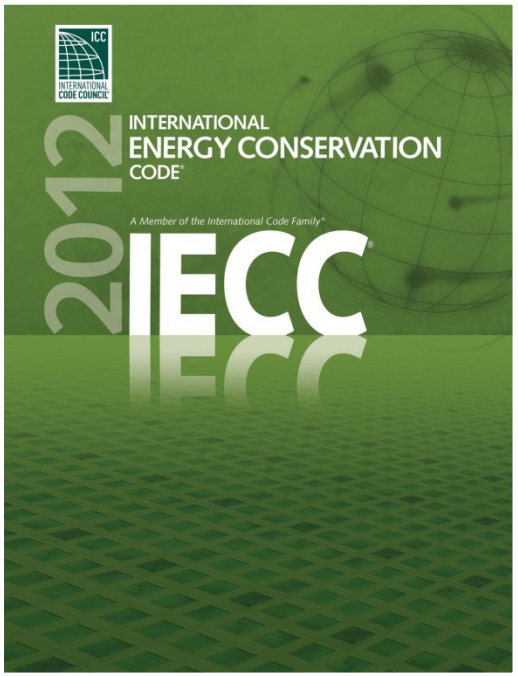
Thermal Performance

Opaque Building Envelope Barrier

- Three Compliance Path Options:
  - Comply with material properties
  - Comply with assemblies rated or tested
  - Compliance demonstrated through whole-building test.



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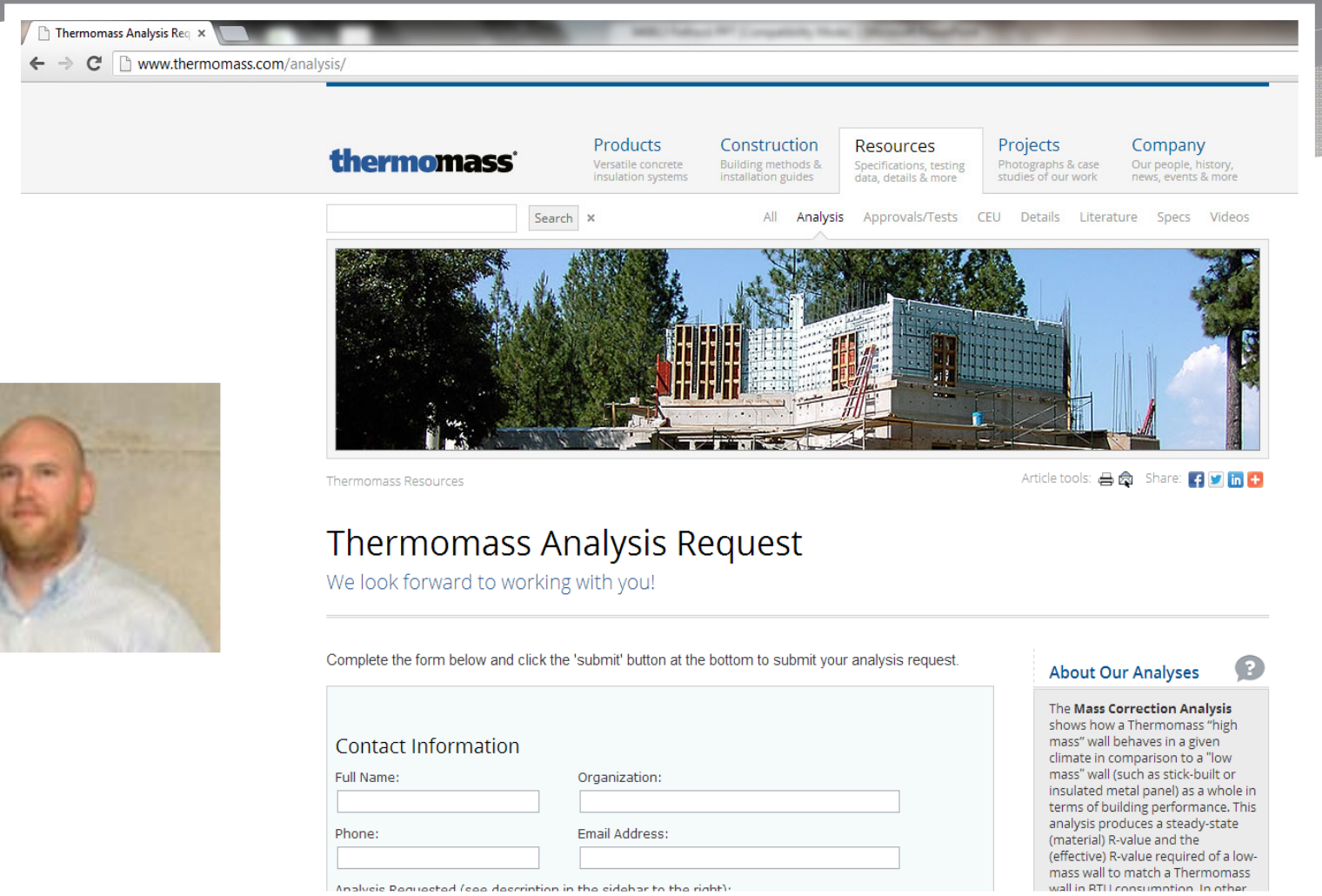
Thermal Performance

www.Thermomass.com/analyses



CONTINUING EDUCATION AIA

Insulated Concrete Sandwich Walls

Program Agenda

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- Thermal Performance
- ***Types of Insulated Concrete Sandwich Walls***
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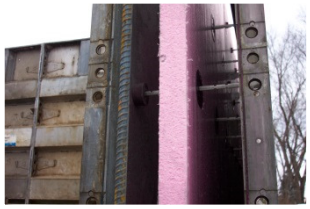
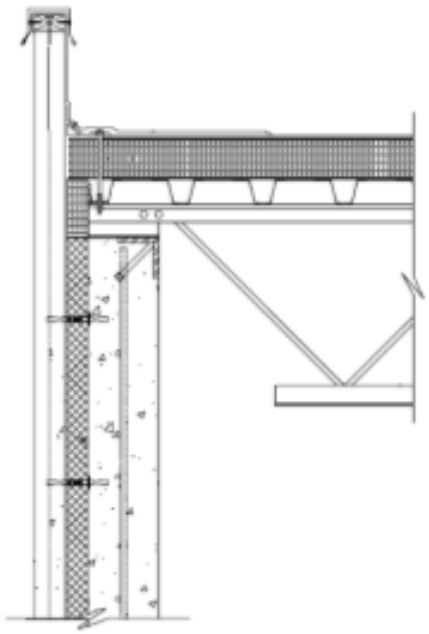
  - Structurally Composite Wall Panel
- Sustainability
- Summary

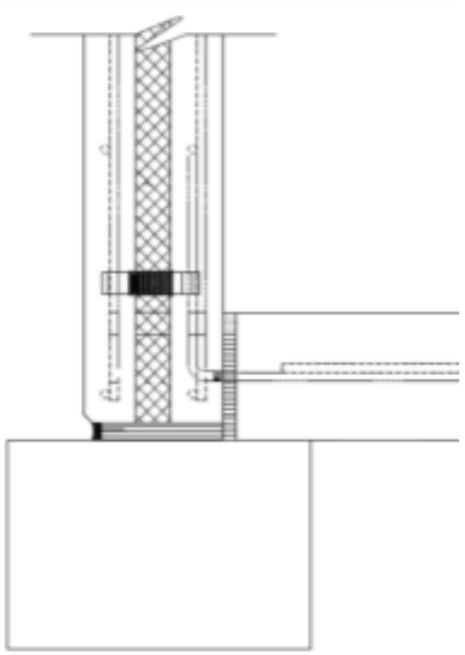


Insulated Concrete Sandwich Walls

Wall Types



Non-Composite Wall Panel



Structurally Composite Wall Panel

Insulated Concrete Sandwich Walls

Non-Composite Sandwich Wall Panel

- Precast, Site-Cast Tilt-Up, and Cast-In-Place
- The inner and outer wythe work independently of one another and are allowed to move due to temperature changes.
- Designed for ambient & low temp facilities.
- Thermal bow is eliminated.
- The inner wythe is the structural wythe.
- The outer wythe acts only as cladding.
- Minimum exterior wythe thickness is 2-in.
- Add any required reveal depths.
- Minimum interior wythe as required by design

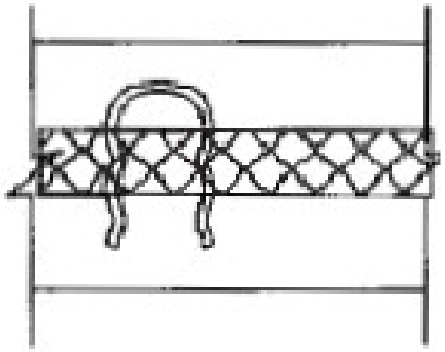
Insulated Concrete Sandwich Walls

Structurally Composite Sandwich Wall Panel

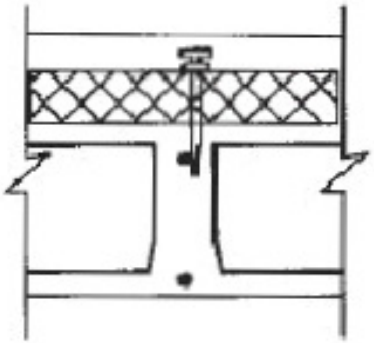
- Precast and Site-Cast Tilt-Up
- The two layers of concrete act together to support the loads imposed.
- Designed for room temperature buildings only.
- Panels can be cladding or support joist loads.
- Panels are either pre-stressed or mild reinforced.
- While the panels are thinner they may be subject to solid sections of concrete to achieve composite action.
- Minimum wythe thickness is 2-in.
- Typical configurations include 3”or 4” of concrete.

Insulated Concrete Sandwich Walls

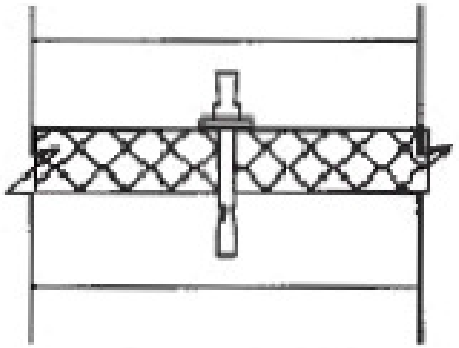
Connection Devices



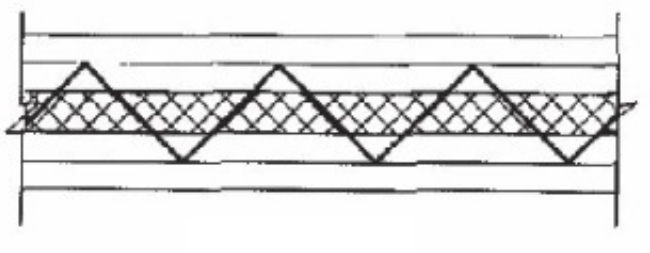
- Metallic Pin



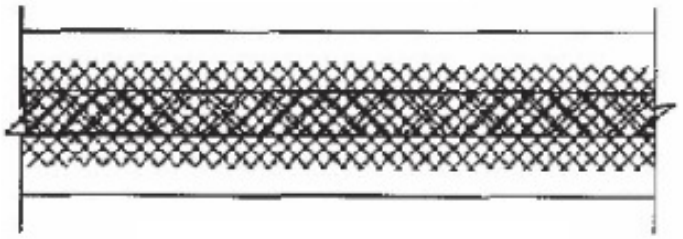
- Plastic Pin



- Fiber-Composite



- Truss

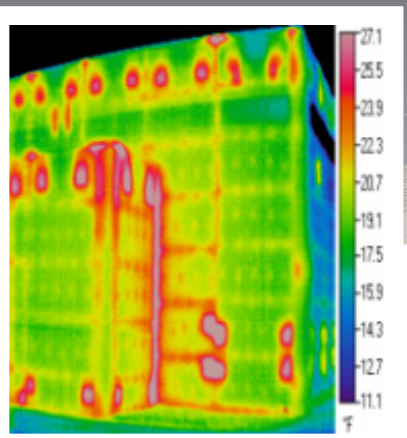


- Carbon Fiber Grid

Connection Devices

Metallic Pin

- Thermally conductive
- Quality control issues
- Typically requires solid areas of concrete
- Used in non-composite designs



Metal Ties

Connection Devices

Fiber-Composite

- 76,000 E-CR Glass Fibers
- Composed of E-CR Glass/Vinyl Ester Resin
- Eliminates thermal short circuits in the wall panel.
- Same Coefficient of Thermal Expansion as concrete.
- Tested ICC ES AC320
- ICC ESR – 1746
- City of Los Angles
- City of New York
- Zulassung
- CSTB (Avis Techniques)
- UAE – Dubai

Ult. Pullout Capacity = 2828 lbs.

Ult. Shear Strength = 608 lbs.

(Based on ESR-1746)

Connection Devices

Thermal Efficiency

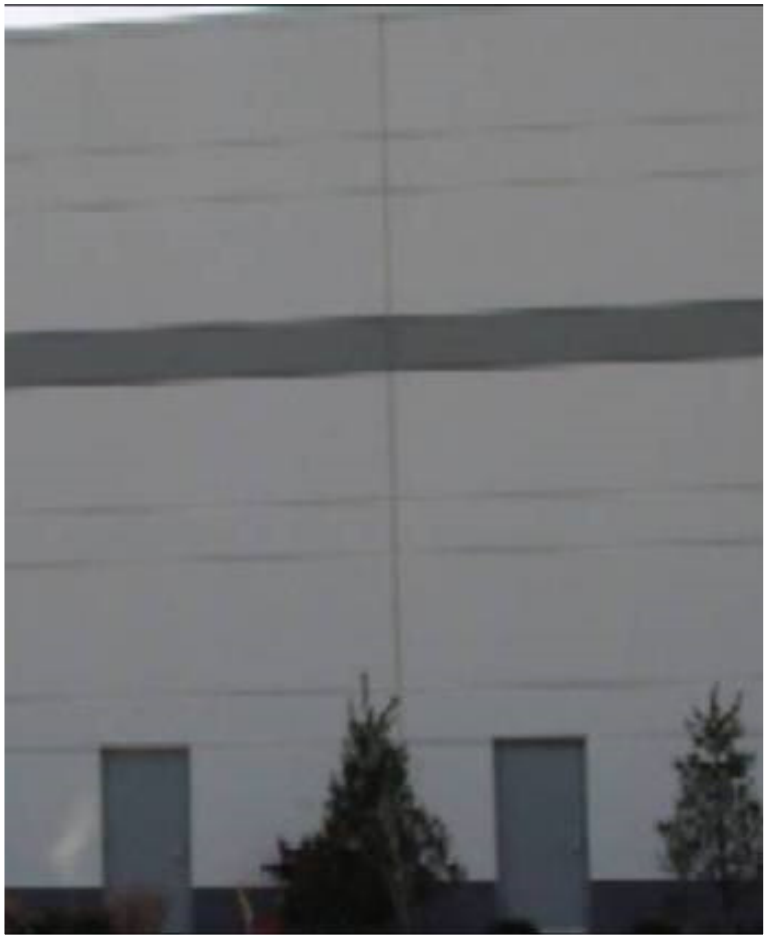
Panel Description	Material R-Value[1]	Test R-Value	Percent Loss
Panel with only steel ties	10.48	7.55	**27.96%**
Panel with only solid concrete	10.48	5.77	**44.94%**
Panel with solid concrete & steel ties	10.48	4.55	**56.58%**
Panel with fiber connector	**10.48**	**10.57**	**-0.86%**

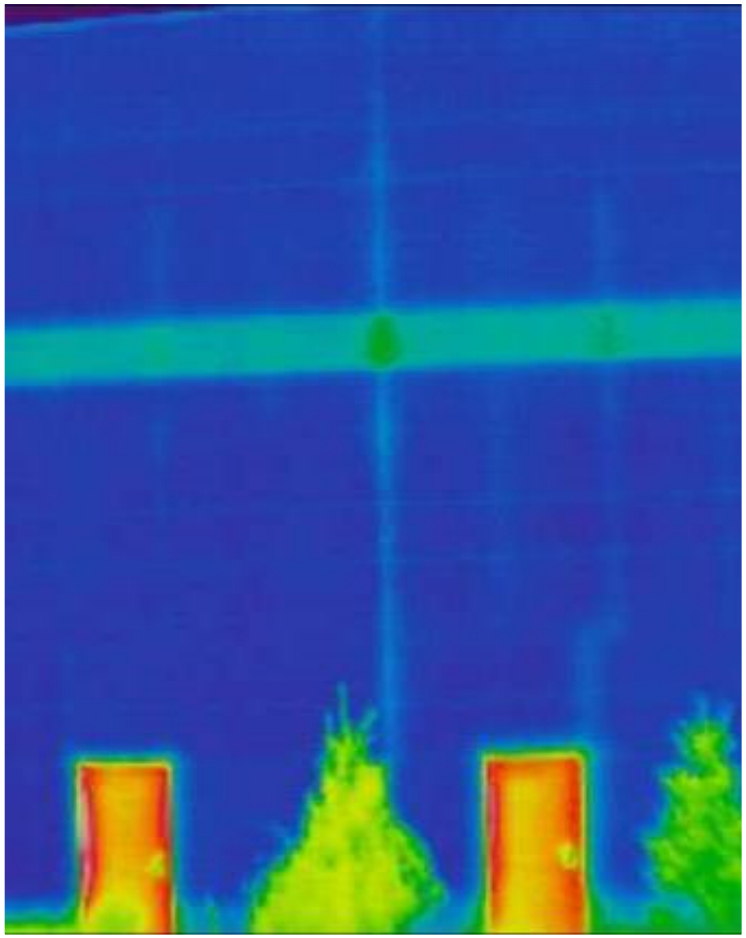
1. Value obtained summing R-values for concrete & insulation layers, no air films included.
Note: All 3-2-3 panels made with extruded polystyrene.

Source: "Summary of Thermal Tests of Insulated Concrete Sandwich Walls U.S.Dept. of Energy 1998-1999." Composite Technologies Corp., IA, 1999.

Connection Devices

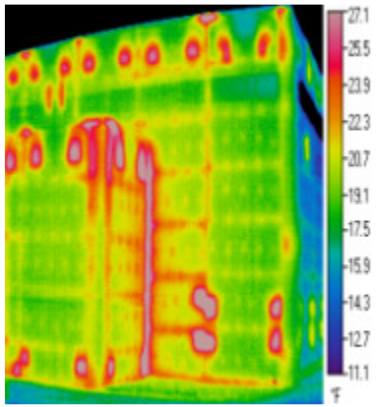
Thermal Efficiency



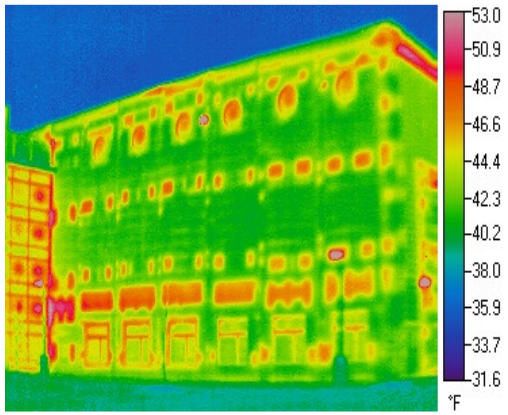


Connection Devices

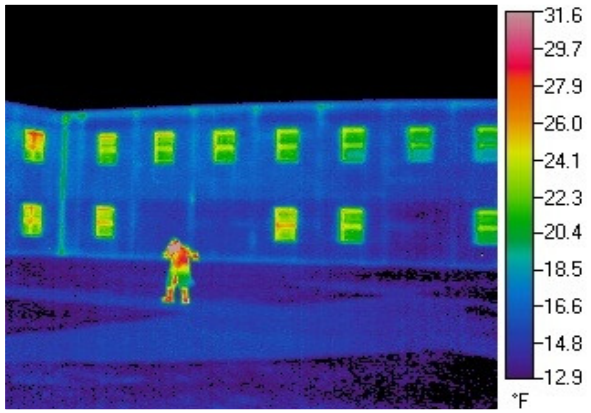
Thermal Efficiency



Metal Ties



Carbon Fiber



Fiber Composite

Air & Moisture Management

Considerations

- There is no “cavity”, any dew point occurs in the foam or exterior wythe, so there is no condensation.
- There are no thermal bridges in the wall.
- The walls are resistant to moisture
- Low-perm insulation creates moisture barrier
- Edge to edge detailing prevents vapor diffusion and air infiltration.

Insulated Concrete Sandwich Walls

Program Agenda

- Introduction to Insulated Concrete Sandwich Walls
- Thermal Performance
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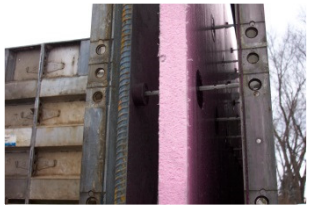
  - Structurally Composite Wall Panel
- ***Sustainability***
- Summary



Sustainability

Case Studies

CONTINUING EDUCATION AIA

Sustainability

Limited Site Disturbance – University of North Florida, Social Sciences - Jacksonville

- Conservation of natural areas on the site and the restoration of damaged ones.
- The requirements can be met by limiting site disturbance to pre-described distances.

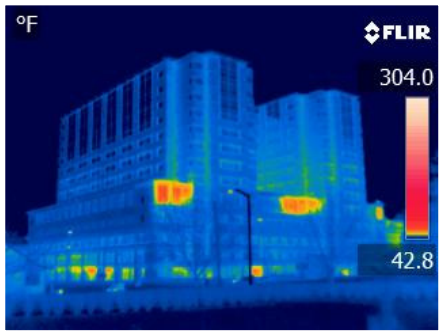
Sustainability

Materials & Resources – NASA – Kennedy Space Center – Cape Canaveral, FL

- Most reinforcing bars and mesh are manufactured from recycled steel
  - Manufactured/melted 100% scrap; 5% post-industrial; 95% post-consumer
- Some insulation types are made up of partially recycled material.
- Aggregates, cement and supplementary materials are all typically extracted, harvested, or recovered from within 500 miles of the project site or plant.

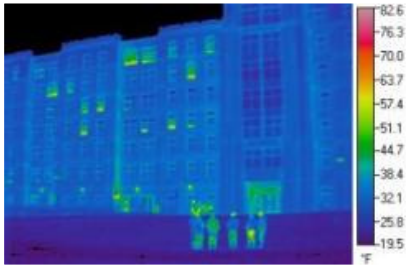
Sustainability

Indoor Environment Quality – University of Kentucky Hospital – Lexington, KY



Sustainability

Energy Efficiency – Catholic University of America, DC



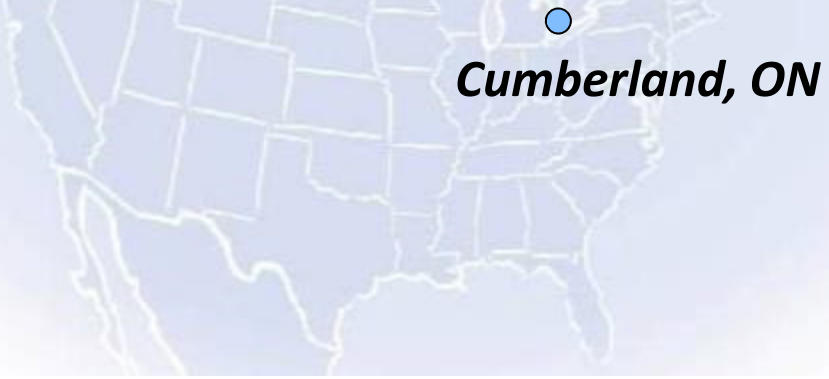
CONTINUING EDUCATION AIA

Sustainability

Energy Efficiency – Cumberland, ON School District

This school is constructed with conventional brick / masonry construction. It took 8½ months to construct.

This school is 4,000 sq.ft. larger but was constructed with a sandwich wall. Construction time was only 5½ months!



School Type	*Electrical* (per day)	*Natural Gas* (per day)
CMU	*$118.89*	*$100.78*
Sandwich	*$91.02*	*$65.95*
% Savings	*23%*	*35%*

Insulated Concrete Sandwich Walls

Program Agenda

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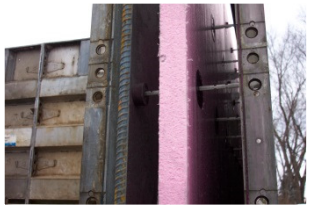


Insulated Concrete Sandwich Walls

Summary

- Speed of Construction
- Limited Site Disturbance
- Load Bearing or Cladding
- Attractive Appearance
- Energy Efficiency
  - Continuous Insulation “ci”
- Air & Moisture Barrier
  - Exceeds requirements of IECC
- Fire & Blast Resistant
  - NFPA 285 & ASTM E-119
- One Economical Assembly
  - Early enclosure allows follow-on trades to start sooner

thermomass®

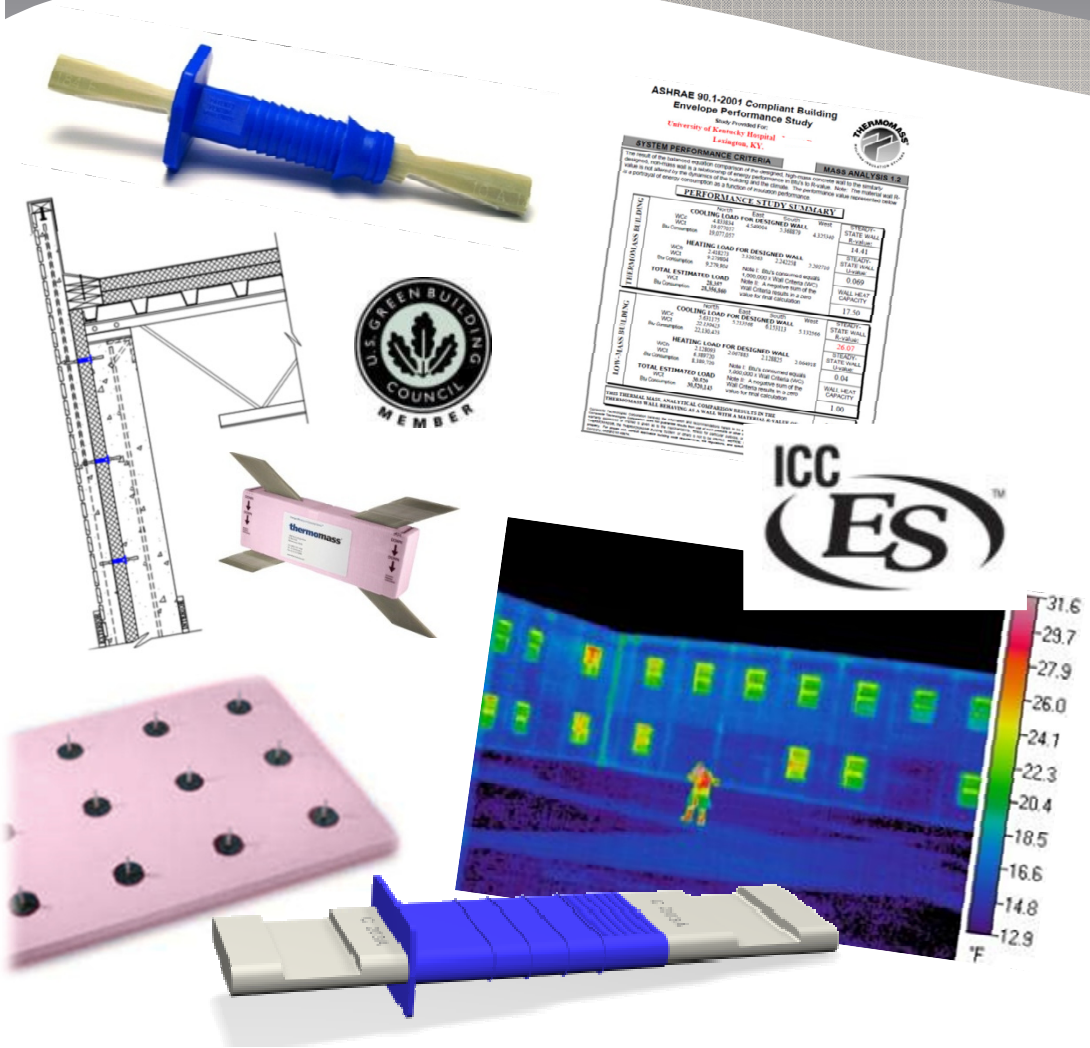
Energy Efficiency in Concrete Terms

Insulated Concrete Sandwich Walls

Program Number: CRE001
Provider Number: J187

Brad Nesset – Thermomass

David Tomasula - LJB



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