American Concrete Institute®
Advancing concrete knowledge

The Art of Thermal Mass Modeling for Energy Conservation in Buildings, Part 2

ACI Spring 2012 Convention
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ACI
WEB SESSIONS

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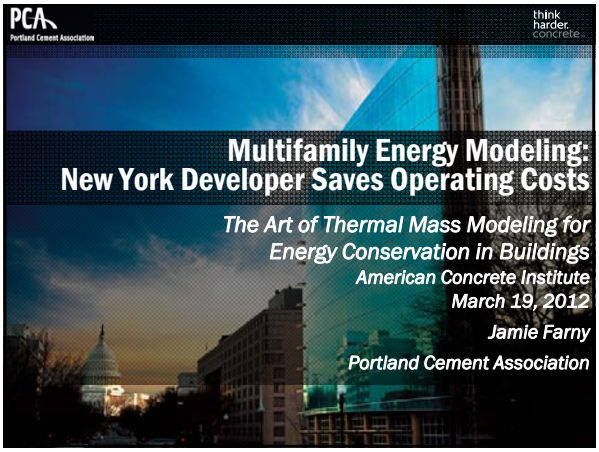
WEB SESSIONS



Outline

- Describe the project, design intent, construction system
- Energy software and building modeling
- Comparison with one year of energy data for occupied building
- Implication of energy usage and savings—MIT
- Green construction outlook—McGraw-Hill

The Andrew

- Queens, New York City location
- 50-unit multi-family residence
- Developer: The Bluestone Group
- Energy consultant: Steven Winter Associates
- Insulating concrete form (ICF) construction with R-20 insulation

The Andrew

The Andrew

Energy Software

- Energy analysis
- New installations
- Retrofitting existing buildings
- Document energy use/savings of various wall systems
- What did developer consider?

TREAT Software

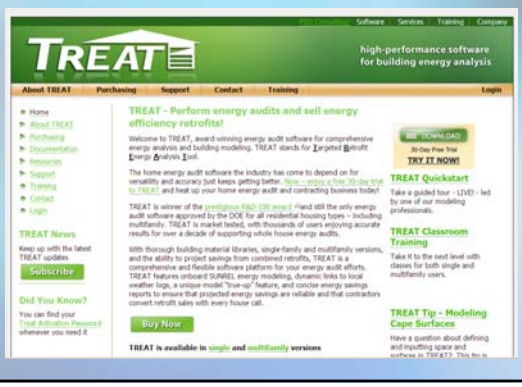
- Targeted Retrofit Energy Analysis Tool
- Performs energy audits
- Used to sell energy efficiency retrofits
- Comprehensive building energy analysis
- Only energy audit software approved by the DOE for all residential– including multifamily
- NYSERDA preferred (NY State Energy Research and Development Authority)

NYSERDA

- Public benefit corporation, 1975
- Initially R&D to reduce state petroleum consumption
- Now, NYSERDA focuses on New York's energy goals:
  - reducing consumption
  - promoting renewables
  - protecting the environment
- Multifamily Performance Program
  - Eligibility, 5 or more units, more than 3 stories
  - **Cash incentives for energy efficiency ($20K for affordable housing, $15K for market rate)**

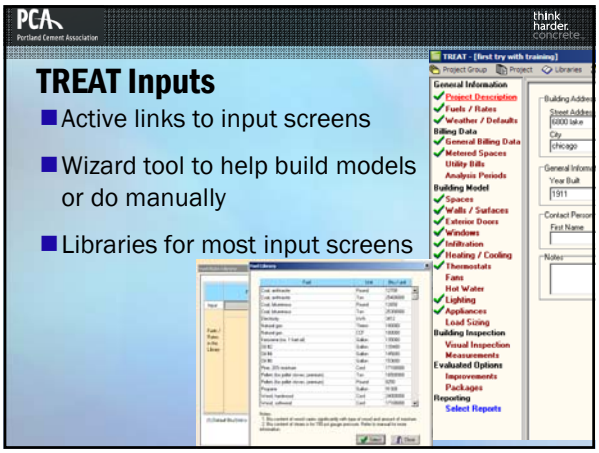
TREAT:

- Create models quickly and easily with building component libraries
- Calculate energy usage and predict energy savings
- Aggregate improvements into packages
- Automatically calculate payback and SIR (savings to investment ratio)



TREAT Inputs

- Active links to input screens
- Wizard tool to help build models or do manually
- Libraries for most input screens



TREAT Inputs – Building Area

The Andrew

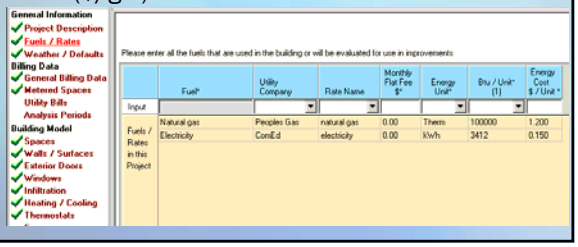
Space Type	Area, SqFt	Notes
Residential	36,585	Include total floor area of all residential units in building
Common Area	8,469	Include combined floor area of corridors, recreation areas, lobbies, elevator shafts, etc.
Commercial Area	0	Include combined floor area of residential-associated office, retail, food sales, etc.
Garage	6,108	Include floor area of residential-associated enclosed/underground garages [ventilated]
Total Conditioned	45,054	

TREAT Inputs - Energy

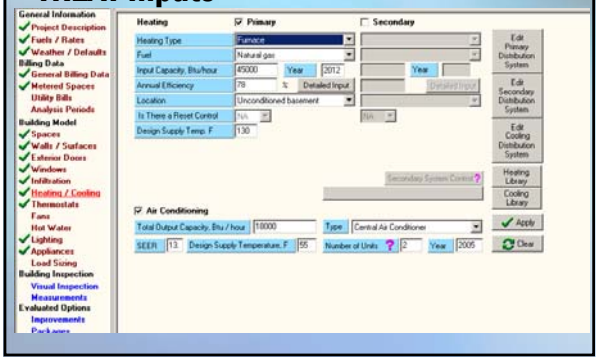
- Heating
- Cooling
- Infiltration and ventilation
- Interior, exterior, in-unit lighting
- Equipment loads (washer/dryer, dishwasher, refrigerator, etc.)

TREAT Inputs – Fuel types

- Electricity ($/kWh)
- Natural gas ($/Therm)
- Oil ($/gal)



TREAT Inputs



TREAT Outputs

Performance Rating Calculation, in Energy million Btu

	Baseline			Proposed			Savings, %	
Annual Load	Natural Gas	Electric	Cost $	Natural Gas	Electric	Cost $	Btu	$
Heating	1,581	0	23,639	819	0	12,248	48	48
Cooling	0	62	2,761	0	40	1,783	35	35
Lighting	0	221	9,839	0	162	7,210	26	26
Hot Water	597	0	8,927	424	0	6,348	29	29
Appliance	1210	663	31,323	121	587	27,962	10	11
Other	0	0	0	0	0	0	0	0
Total	*2,3007*	*946*	*76,491*	*1366*	*789*	*55,553*	*33*	*27*

Contribution from ICFs

- Building energy savings over baseline
  - 48.19% from heating
  - 35.40% from cooling
  - 27.37% total from all improvements
- Clearly, the **insulated concrete walls** (ICFs) make the most difference in the building's performance

Baseline Energy Use vs. Projected

Energy Usage per Square Foot of Conditioned Area, Btu/sq ft

Annual Load	Steel Studs R-13	ICF R-20
Heating	**35,110**	**18,192**
Cooling	**1,377**	**890**
Lighting	**4,909**	**3,597**
Hot Water	**13,260**	**9,429**
Appliance	**17,420**	**15,743**
Other	**0**	**0**
Total	**72,076**	**47,851**

Baseline Energy Use vs. Projected

Energy Usage per Square Foot of Conditioned Area, Btu/sq ft

Annual Load	Steel studs, R-13	ICF, R-20
Heating	35,110	18,192
Cooling	1,377	890
Heating plus Cooling	36, 487 / 72,076	19, 082 / 47,851
	= 50% of total	= 40% of total
Compare ICF to baseline heating plus cooling	—	19,082 / 36,487
	—	= 52% reduction
Total	72,076	47,851

Actual Energy Use

Total Year	14,068	$17,021
Date Bill Rendered	Usage (Therms)	Gas Charge
7/12/2011	396	$501
6/10/2011	492	$616
5/11/2011	905	$1,171
4/11/2011	1,659	$2,024
3/11/2011	2,011	$2,477
2/9/2011	2,535	$3,068
1/11/2011	2,565	$3,022
12/10/2010	1,596	$1,883
11/9/2010	919	$1,053
10/12/2010	384	$438
9/13/2010	330	$401
8/12/2010	276	$363

Actual vs. Proposed Energy Use for Space Heating Only

Space heating for ICF modeled	Space heating for ICF actual (from energy bills)	Comparison
8191 Therms	9466 Therms	~15% more than modeled

Energy Conservation Recommendations and Incremental Hard Costs (RS Means)

Energy Conservation Recommendations		Related Baseline components			
ICF System	Total Cost	Steel framing System	Total Cost	Incremental Hard Cost	
ICF R-20	$49,187	Install R-13 Batts	$39,976	$9,211	**23%**
Floor edge R-12	$5,232	Install R-13 Batts	$1,831	$3,401	**185%**
Slab on Grade R-7.5	$3,289	No insulation	---	$3,289	**---**
Roof with 4" polyisocyanurate R-21	$25,245	Insulate with 3" XPS, R15	$12,623	$12,623	**100%**

Payback (Savings to Investment Ratio)

Realistic Lifetime (varies)			20 year lifetime			Energy Conservation
Life time	Energy Cost Saving	Measure SIR	Life time	Energy Cost Saving	Measure SIR	Recommendation description
60	$642	1.93	20	$642	1.04	ICF wall R-20
60	$67	0.55	20	$67	0.29	Floor, R-12
60	$442	3.72	20	$442	2.00	Slab on Grade, R-7.5
30	$1,016	1.58	20	$1,016	1.20	Roof with 4" polyisocyanurate, R-21

Why the Difference in Performance?

- Comparison in The Andrew was made to a baseline of R-13 steel studs
  - Steel studs are large thermal bridges
  - Baseline R-13 was current code *at that time**
- ICF in MIT compared to wood stud
  - Wood studs have less thermal bridging
  - Higher baseline of R-20 wood stud
- Less of a difference to code compliant now
- Climate effects, too: NY, Chicago, Phoenix

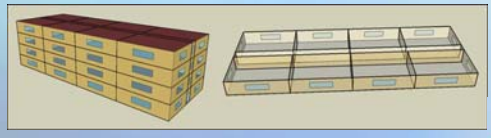
MIT Concrete Sustainability Hub

CSH concrete sustainability hub

- Established by a joint grant from PCA and NRMCA in 2009
- Revolutionize the scientific basis for evaluating the environmental impact of portland cement concrete
- Optimize the use of present materials
- Modify present materials and develop new ones

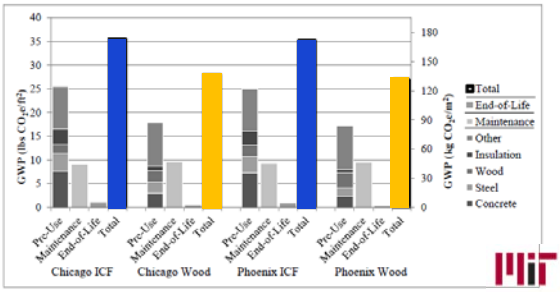
MIT Building Life Cycle Report

- Single-family residential, multifamily residential, and commercial studied
- Let's consider just multifamily for now:
  - Compare ICF to wood frame
  - U.S. DOE 2004 midrise apt. reference building
  - 4 floors, 32 apartments, 33,763 ft^2



MIT Report

- **Key finding:** Concrete multi-family buildings have higher embodied GWP associated with Pre-Use Phase

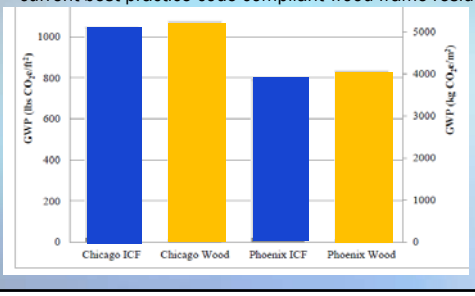


MIT Report

- **Key findings: Multi-family residential LCA**
  - Concrete multi-family has higher embodied GWP associated with the pre-use phase of LCA
  - This phase accounts for only 2% to 12% of overall GWP over 60-year service life

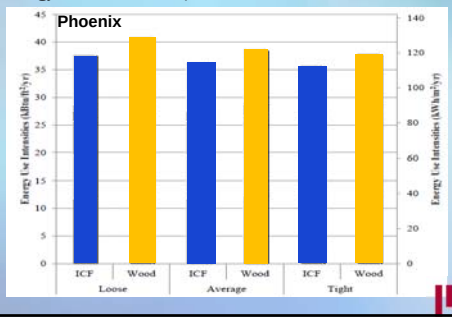
MIT Report

- **Key finding:** Over full Life Cycle, concrete multifamily buildings produce 2.8% to 5% lower GHG emissions than current best practice code compliant wood frame residences



MIT Report

- **Key finding:** Concrete multifamily buildings use 5% to 8% less energy than code compliant wood frame construction



Summary– Residential Buildings LCA

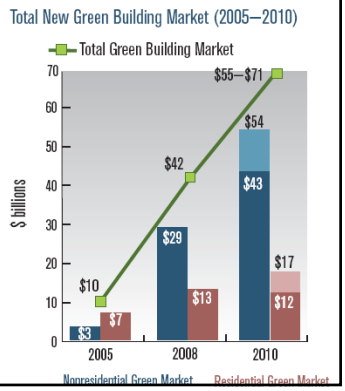
- The efficiency of concrete wall assemblies results in lower overall emissions over a 60-year service life
- Combining the embodied energy with the operating energy over the full life of the structure, the concrete residential structures consume less energy than comparable current, code compliant wood frame construction.

Influence of Green

- **Sustainability will drive choice of construction materials:**
  - "Energy and environmental concerns will play increasing role in the construction materials used in homes" (PCA Economics Long Term Cement Consumption Report January 31, 2008)

Green Building Market

- Green construction was more than 5 times greater in 2010 than in 2005.



Summary

- Continuing growth of green construction
- Real world case study, The Andrew
- Energy modeling of that building by TREAT software, real-world comparison
- General benefits of energy modeling
- MIT study to better understand energy use of multifamily and its implications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Thank you!
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