1st Residential Building
Design and Construction Conference

February 20-21, 2013

Sands Casino Resort Bethlehem, PA, USA

Conference Program

Organized by

The Pennsylvania Housing Research Center (PHRC)

219 Sackett Building
University Park, PA 16802
USA

Telephone: 814-865-2341
Fax: 814-863-7304
http://www.engr.psu.edu/phrc

CONFERENCE ORGANIZATION

CONFERENCE CHAIR:

Ali Memari, (Memari@engr.psu.edu), Penn State University, USA

CONFERENCE ORGANIZER

Pennsylvania Housing Research Center (www.engr.psu.edu/phrc),
Penn State University, USA

CONFERENCE STEERING COMMITTEE

- Chimay Anumba, Penn State University, USA
- Richard Behr, Penn State University, USA
- Richard Button, Penn State University, USA
- Elizabeth Cocke, Office of Policy Development & Research, HUD, USA
- Emanuel Levy, Systems Building Research Alliance, USA
- Lisa Iulo, Penn State University, USA
- Brian Orland, Penn State University, USA
- Andrew Scanlon, Penn State University, USA

CONFERENCE SCIENTIFIC COMMITTEE

- Sherry Ahrentzen, University of Florida, USA
- Sergio Alcocer, UNAM, Mexico
- Donald Bender, Washington State University, USA
- Eric Burnett, Richmond, British Columbia, Canada
- Kevin Chamberlain, DeStefano & Chamberlain Inc., USA
- Jay Crandell, ARES Consulting, USA
- Michael Early, HUD, USA
- Emil-Sever Georgescu, Romania
- Makarand (Mark) Hastak, Purdue University, USA
- Bohumil Kasal, Germany
- Stephen Kendall, Ball State University, USA
- Ted Koebel, Virginia Tech. University, USA
- Joseph Laquatra, Cornell University, USA
- David Lee, Department of Energy, USA
- Christine Liaukus, NJ Institute of Technology, USA
- Carlos Martin, Abt Associates, USA
- Ricardo Medina, University of New Hampshire, USA
- David Prevatt, University of Florida, USA
- Dean Rutila, Simpson Gumpetz & Heger, USA
- Matt Syal, Michigan State University, USA
- Jack Willenbrock, JHW:C/M Consultants, USA
- Tom Williamson, Timber Engineering LLC, USA
- Steven Winter, Steven Winter Associates, Inc., USA
- Joseph Wysocki, Healthy Housing Solutions, USA

The Pennsylvania State University

1st Residential Building Design and Construction Conference

February 20-21, 2013

Sands Casino Resort Bethlehem * 77 Sands Blvd., Bethlehem, PA, USA * Phone: +1(866)599-6674

Message from the Conference Chair

It is a pleasure to welcome you to the First Annual Residential Building Design and Construction Conference, February 20-21, 2013 in Bethlehem, PA. This conference is organized by the Pennsylvania Housing Research Center (PHRC) at Penn State and is being held in conjunction with the 21st Annual Pennsylvania Housing and Land Development Conference at Sands Casino Resort Bethlehem.

The Housing and Land Development Conference has been a successful PHRC program over the years with emphasis on topics of interest to developers, builders, remodelers, design professionals, planners, regulatory and code officials, modular and HUD code builders, and housing product manufacturers.

The Residential Building Design and Construction Conference is a new PHRC program intended to provide a unique forum for researches, design professionals, manufacturers, builders, and code officials to keep up-to-date on the latest advancements and discuss their findings, innovations, and projects related to residential buildings.

In this conference we have two keynote speakers, Sam Rashkin, Chief Architect, Building Technology Program, DOE, and Richard Seifert, Professor Emeritus, University of Alaska, Fairbanks. Sam Rashkin will discuss the need for a new thinking by the housing industry to focus on “maximum value” instead of “minimum construction cost.” Richard Seifert will share his experience and success in creating Building Science educational and training programs in Alaska to reduce carbon footprints while providing a healthy indoor environment.

There are also 36 presentations scheduled on various topics, including Building Science Education; High Performance Buildings; Disaster Resistant Performance, Testing and Evaluation; Energy Efficiency and Retrofit; Innovative Products and Systems; Modular Construction; Innovative Architectural Forms; and Structural Materials and System Design. Finally, there is one session devoted to introducing the book: Design and Construction of High-Performance Homes: Building Envelopes, Renewable Energies and Integrated Practice. The authors of the book will discuss three major aspects of the book: architectural technologies, system integrated photovoltaic, and energy and integrative design process. There will be a book signing opportunity following that session. The papers and some of the presentations are collected in the proceedings of the conference. I hope that you find the technical content of the conference beneficial and that you also find opportunities for interaction with colleagues and networking.

Ali M. Memari, Ph.D., P.E., Professor
Hankin Chair in Residential Building Construction
Director, the Pennsylvania Housing Research Center
Department of Architectural Engineering /Department of Civil and Environmental Engineering
Penn State University

Organized by the Pennsylvania Housing Research Center (PHRC)

KEYNOTE SPEAKERS

Sam Rashkin, R.A.
Chief Architect
Building Technologies Office
U.S. Department of Energy

Keynote Topic: "Money-Housing"

As Chief Architect for the Department of Energy's Building Technologies Office, Sam's primary role is leading deployment of successful research for new and existing high-performance homes. This includes developing a new resource tool that will make latest innovations and best practices from world-class research fully accessible to residential new construction and retrofit stakeholders and overseeing a completely revamped DOE Challenge Home voluntary labeling program for leading edge home builders. In his prior position, he managed ENERGY STAR for Homes since its start in 1996. Under his leadership, ENERGY STAR for Homes grew exponentially to more than 8,500 builder partners, over one million labeled homes, and over 25 percent market penetration nationwide. Mr. Rashkin was most recently recognized for his contributions to sustainable housing with the 2012 Hanley Award. He received his Bachelor of Architecture from Syracuse University; completed Masters of Urban Planning studies at New York University; and is a registered architect in California and New York. During his 20-plus years as a licensed architect, he specialized in energy efficient design and completed over 100 residential projects. He has served on the national Steering Committees for USGBC's LEED for Homes, NAHB's Green Builder Guidelines, and EPA's Water Sense label, and on the development team for EPA's Indoor airPLUS label. He currently serves as an ex-officio member on the Net-Zero Energy Home Coalition and on the National Advisory Board for Sustainability with KB Homes. Sam has authored a new book titled ***"Retooling the U.S. Housing Industry: How It Got Here, Why It's Broken, and How to Fix It"*** that presents a comprehensive strategy for reinventing housing industry at a time of crisis. Sam has also prepared hundreds of articles, technical papers, reports, and seminars; and contributed to other books on energy efficient and green construction.

Richard Seifert
Professor Emeritus
University of Alaska Fairbanks

Keynote Topic: "30 Years in Dogged Pursuit of the Ultimate Super-Insulated Passive Solar Home"

Rich has been the Cooperative Extension Service "Energy guy" at UAF in Fairbanks for 30 years. He has a Bachelor's degree in Physics from West Chester State University in Pennsylvania, and a Master's Degree in Engineering Physics from the University of Alaska. He has lived in Fairbanks for 43 years, save for one year (1985-86) when he was a Fulbright Scholar at the Technical University of Norway, in Trondheim Norway. Seifert is the author of "A Solar Design Manual for Alaska", now in its fourth edition, which he uses as a text for a course to integrate solar design into homes for Alaskans. He has authored two books on cold climate homebuilding. He teaches public seminars for adults, mainly on the topic of Cold and Marine Climate Homebuilding techniques and renewable energy use for prospective homeowners, and has authored numerous technical and public information papers and pamphlets on housing issues, indoor air quality, radon, renewable energy and sustainable building design. He also technically edited eight different editions and revisions of the Alaska Residential Building manual, an Alaska-specific building science guide for residential construction.

Recently he has focused much scholarship and interest in Sustainable Communities and the looming prospect of peak world Oil Production ("Peak Oil") and how it will affect our lives.

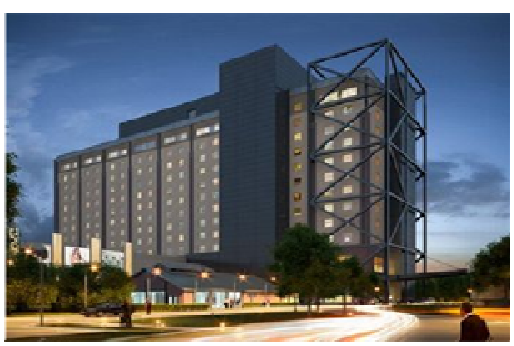
Schedule Summary:

Wednesday, February 20

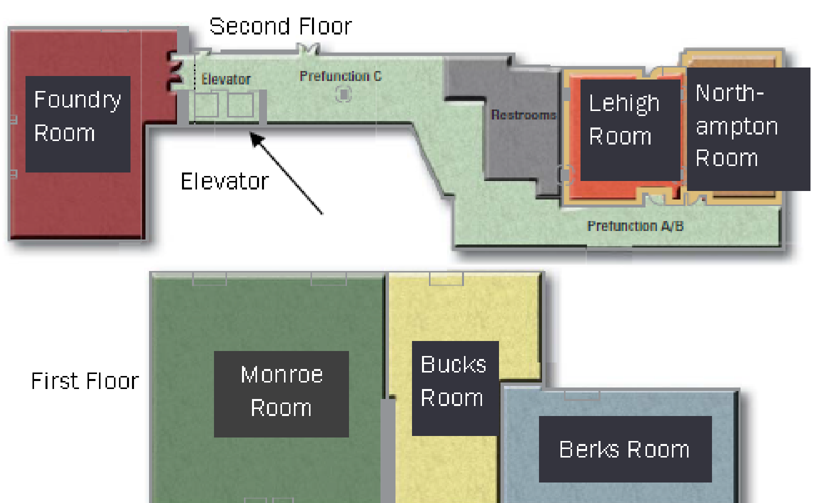
7:30 am – 4:30 pm	Registration	Outside Lehigh Room
8:30 am – 9:30 am	Welcome and Keynote Presentation	Northampton Room
9:30 am – 10:30 am	Technical Sessions	Lehigh/Northampton Room
10:30 am – 10:45 am	Break	Outside Lehigh/Northampton Room
10:45 am – 12:00 pm	Technical Sessions	Lehigh/Northampton Room
12:00 pm – 1:00 pm	Lunch	Emeril's Chop House
1:00 pm – 3:30 pm	Technical Sessions	Lehigh/Northampton Room
3:30 pm – 3:45 pm	Break	Outside Lehigh/Northampton Room
3:45 pm – 4:30 pm	Technical Sessions	Lehigh/Northampton Room
5:00 pm – 6:00 pm	Book Signing Ceremony	Foundry Room
6:00 pm – 8:00 pm	Reception (light refreshments, cash bar)	Foundry Room

Thursday, February 21

8:00 am – 12:00 pm	Registration	Outside Lehigh Room
8:30 am – 9:30 am	Welcome and Keynote Presentation	Northampton Room
9:30 am – 10:30 am	Technical Sessions	Lehigh/Northampton Room
10:30 am – 10:45 am	Break	Outside Lehigh/Northampton Room
10:45 am – 12:00 pm	Technical Sessions	Lehigh/Northampton Room
12:00 pm – 1:00 pm	Lunch	Emeril's Chop House
1:00 pm – 3:30 pm	Technical Sessions	Lehigh/Northampton Room
5:00 pm	Adjourn	



MEETING SPACE



Sands Casino Resort Bethlehem * 77 Sands Blvd., Bethlehem, PA, USA *

Phone: +1(866)599-6674

Conference Secretariat:
Ms. Rhonda Decker – rxd4@psu.edu
Pennsylvania Housing Research Center
219 Sackett Building
University Park, PA 16802
Phone: (814) 865-2341; Fax: (814) 863-7304
www.engr.psu.edu/phrc

1st Residential Building Design and Construction Conference
Conference Program

RDBCC, February 20-21, 2013 — Sands Casino Resort, Bethlehem, PA

	Day 1 – February 20			Day 2 – February 21	
Early Morning 8:30 – 9:30	**Welcome and Keynote Speaker Northampton Room** **Sam Rashkin, Chief Architect, Building Technology Program, U.S. Department of Energy** *Title: Money-Housing*		Early Morning 8:30 – 9:30	**Welcome and Keynote Speaker Northampton Room** **Richard Seifert, Professor Emeritus, University of Alaska Fairbanks** *Title: 30 Years in Dogged Pursuit of the Ultimate Super-insulated Passive Solar Home*	
9:30 – 10:30 am	*Session 1 – Lehigh Room*	*Session 2- Northampton Room*	9:30 – 10:30 am	*Session 9 – Lehigh Room*	*Session 10 – Northampton Room*
	The Need for Building Science Education – *Joseph Laquatra (Cornell University)* **Whole Building Design Approach to Achieve High Performance Buildings** – *Monjia Belizaire (George Mason University)*	**Concrete Building Systems: Disaster Resilient Solutions for Safer Communities** – *T. Peng (NRMCA), L. Lemay (NRMCA), and B. Cody (PACA)* **A New Paradigm for Residential Construction in Regions of High Seismicity** – *M. Sarkisian, E. Long, D. Shook, and A. Diaz (Skidmore, Owings & Merrill LLP)*		**Information Barriers in Home Energy Retrofit Adoption: Research in Progress** – *D. Duah and M. Syal (Michigan State University)* **Prefabricating Charles Moore: Reinterpreted Saddlebags and Aedicules** – *C.A. Debelius, R.C. Everhart and J.A. Russell (Appalachian State University)*	**An Introduction to Steel and Concrete Modular Construction** – *S. English (Larson Design Group, Inc.) and B. Brown (NRB)* **Concrete in Residential Construction** – *Pragati Singh and Andrew Scanlon (PSU)*
	Break			*Break*	
10:45 - Noon	*Session 3 – Lehigh Room*	*Session 4 – Northampton Room*	10:45 - Noon	*Session 11 – Lehigh Room*	*Session 12 – Northampton Room*
	Critical Look into ISOMAX (Zero Energy use structures) Construction – *M.T. Sebright (Energy Reconsidered, LLC) and D. Berg (DSB Energy Services, LLC)* **A Framework for the Process to Identify Dominant Housing Archetypes in a Cold Climate Region: Matching Energy Retrofit Research to Important Archetypes** – *T. Mrozowski, S.-K. Kim, and A. Harrell-Seyburn (Michigan State University)* **Adoption of Innovative Products in the US Housing Industry: Builders' Practices 2000–2010** – *Parisa Nikkhoo, Andrew Sanderford, Andrew McCoy, Theodore Koebbel, Chris Franch, and Hazir Rahmandad (Virginia Tech)*	**Deep energy retrofits with retrofit insulated panels** – *Ted Clifton (Zero-energy Plans, LLC)* **State of the Art Review of Window Retrofit Options for Energy Saving in Single-family Dwellings** – *Tim Ariosto, and Ali Memari (PSU)* **Zero Net-Energy Ready** – *Sam Rashkin (DOE)*		**Reducing Exposure to Thermal Stress in Cuyahoga County, Ohio Through Residential Weatherization** – *Nicholas Rajkovich and Larissa Larsen (University of Michigan)* **Overheating in Multifamily Residential Buildings** – *Jordan Dentz (The Levy Partnership, Inc.), Kapil Varshney (The Levy Partnership, Inc.) and Hugh Henderson (CDH Energy Corp.)* **Air Districution Rretrofit Strategies for Affordable Housing** – *Jordan Dentz (The Levy Partnership, Inc.), Francis Conlin (High Performance Building Solutions), Parker Holloway (High Performance Building Solutions), and David Podorson (The Levy Partnership, Inc.)*	**Innovation in Residential Construction Systems in Sweden** - *Gregory La Vardera (Gregory La Vardera Architect) and Scott Hedges (Australia)* **Chicago Flat Type Planning: Sustainability and the 1902 Tenement House Ordinance** – *Richard Gnat (University of Nevada)* **Introduction to Insulating Concrete Forms** – *Dennis Gerdel (New Holland Concrete)*

1St Residential Building Design and Construction Conference
Conference Program

RDBCC, February 20-21, 2013 | Sands Casino Resort, Bethlehem, PA

	12:00 – 1:00 – LUNCH – Emeril's Chop House			12:00 – 1:00 – LUNCH – Emeril's Chop House	
	Session 5 – Lehigh Room	*Session 6 – Northampton Room*		*Session 13 – Lehigh Room*	*Session 14 – Northampton Room*
1:00 – 3:30 pm	**Prescriptive Details for Wind Resistant Envelope Based on Observations of Newly Built Homes Damaged in 2011 Tornados** – *Bryan Readling and Edward Keith (APA)* **Residential Damage Patterns Following the 2011 Tuscaloosa, AL and Joplin, MO Tornadoes** – *David B. Roueche and David O Prevatt (University of Florida)* **Wind Uplift Capacity of Foam-retrofitted Roof Sheathing Subjected to Water Leaks** – *David Roueche, Elexenberger, Kenton McBride, D.O. Prevatt, F.J. Masters (University of Florida)*	**Housing Reconstruction and Community Recovery Following Disasters – No Easy Choices** – *Dana Bres (HUD) and Carlos Martin (Abt Assoc.)* **Residential Reconstruction in Haiti** – *Mark Taylor (University of Illinois, Urbana-Champaign)* **Haiti Wood-frame Housing Initiative** – *Glyn R. Boone (Weyerhaeuser) and J.D. Kiehl (Entech Engineering, Inc.)*	1:00 – 3:30 pm	**Resisting the Myth of the Monolithic: The influence of Construction Innovation on Single-family House Spatialities in the Work of Gomes and Straub** – *Francisco Gomes (University of Texas at Austin)* **Responsive Housijng: Potential and Projected Impact** – *A.J. Mills and K.J Tiss (State University of New York)* **Investigation for the Removal of Steel Tie Rods in a Historic Segmental Arch Floor** – *Jennifer Lan, Michael Lo, David Sharp, and Ramon Gilsanz (Gilsanz-Murray-Steficek, LLP)*	**The State of the Art Application of Modular Construction to Multi-story Residential Buildings** – *Anthony Jellen and Ali Memari (PSU)* **Identification of Structural Issues in Design and Construction of Multi-story Modular Buildings** – *Issa Jafar Ramaji and Ali Memari (PSU)* **Sierra Bonita: Innovative use of Long Span Metal Deck Slabs and Shored Construction** – *Joseph Mugford, Karl Rubenacker, John Lantry, Ramon Gilsanz (Gilsanz-Murray-Steficek, LLP)* **Lessons Learned from the Process of Retrofitting Existing Housing for Energy Efficiency** – *Lisa Iulo (PSU) and Bruce Quigley (Union County Housing Authority)*
	Break			Break	
	Session 7 – Lehigh Room	*Session 8 – Northampton Room*			
3:45 - 4:30 pm	**Presentation by the authors of the book: Design and Construction of High-performance Homes: Building Envelopes, Renewable Energies and Integrated Practice** **High Performance Architectural Technologies** – *Franca Trubiano (University of Pennsylvania)* **System Integrated Photovoltaic (SIPV)** – *Jeffrey R.S. Brownson (PSU)* **Energy and the Integrative Design Process –Defining the Team of Experts** – *Lisa D. Iulo (PSU)*	**Effects of Installation Method on Nail Withdrawal Capacities** – *Ashlie Kerr and David Prevatt (University of Florida)* **Modular Green Roof System in Mid-rise Multifamily Residential Units** – *Tuan Vo, David Prevatt and Glenn Acomb (University of Florida)* **The Unseating of Naturally Aged Asphalt Shingles: An In-situ Survey** – *Craig Dixon, David Prevatt, Forrest Masters and Kurt Gurley (University of Florida)*	3:45 - 4:30 pm		
	Adjourn			*Adjourn*	

Lehigh Room

Northampton Room

PAPER ABSTRACTS (BY SESSION)

Day 1 – February 20, 2013

Keynote Speaker – (Northampton Room)

Money-Housing, Sam Rashkin (U.S. Department of Energy)

One of last year's more popular films, MoneyBall, depicts the challenges faced by the general manager of the Oakland Athletics after losing his three most productive players while confronted with the lowest player salary budget in professional baseball. When he meets with his senior advisors who all have decades of professional baseball experience, he is frustrated that they are obsessed with the wrong problem: trying to replace three star players even though resources are woefully inadequate. What does this mainstream film have to do with a Residential Building and Design Conference? The current housing industry is confronting an historic down-turn and has also lost its key players:

- **Price Competitiveness** with millions of existing foreclosure and short-sale homes at fire-sale prices;
- **Appreciation** with homebuyers no longer realizing or expecting significant increases in home value and often happy to pace inflation;
- **Size Advantage** where simply building bigger no longer provides significant market differentiation as critical 'baby boomer' and 'Gen-Y' buyers seek to down-size;
- **Minimum Code is Good Enough** with looming codes rapidly increasing energy efficiency requirements and a growing market awareness of 'green' and 'high-performance' homes; and
- **Remote Location Acceptance** as the home buyer preferences demonstrate a strong preference for urban-living in many markets.

Faced with this crisis, builders across the country and their industry association are predominantly focused on the wrong problem: "minimal construction cost". Instead, it is time for the housing industry to apply a 'MoneyHousing' business model that focuses on the right problem: "maximum value." In Mr. Rashkin's book, ***"Retooling the U.S. Housing Industry: How It Got Here, Why It's Broken, and How to Fix It,"*** a detailed blueprint is provided for how the housing industry can add this value across five core components of the housing industry. This session will address critical questions such as:

- What is sustainable development?
- What is good housing design?
- What is high-performance?
- What is quality construction?
- What is effective home sales?

It's time to hold a mirror up to the housing industry and objectively evaluate how well it addresses each of these questions. Detailed recommendations will be presented that suggest we can do so much better fulfilling home ownership dreams while ensuring affordable, comfortable, healthy, and durable performance. If crises are learning moments, now is the time for change.

Session 1 – (Lehigh Room)

The Need for Building Science Education, Joseph Laquatra
(Cornell University)

As the demand for high-performance housing grows, so does the need for improvements in building science education. Even before the energy crisis precipitated by the 1973 Arab oil embargo, building codes in America were gradually addressing energy and moisture issues in prescriptive ways that were not evidence-based. As a result, problems ensued. Builders, engineers, architects, building code officials, and others involved in the home building industry have been learning how to avoid the problems through trial and error. This has led to widespread misconceptions that persist to this day, including beliefs that buildings should not be airtight or "overinsulated." Well-documented problems of mold-infested houses have exacerbated misunderstandings about methods for building high-performance homes.

Stricter building codes or builder licensing requirements are not necessarily the solutions to problems associated with misunderstandings about building science. Motivating professionals currently involved in the housing industry to learn through continuing education is a start, but the core problem must be addressed by including building science education in curricula related to architecture, engineering, construction management, and other fields. This paper will review early developments in the history of housing construction that led to discoveries related to building science, problems that followed, their resolutions, and current efforts to increase awareness of building science education.

Whole Building Design Approach to Achieve High Performance Buildings, Monjia Belizaire
(George Mason University)

The goal of the Whole Building Design Approach is to create a successful high performance building by applying an integrated design and team approach to the project during planning and programming phases. In residential buildings, to achieve success in building a high performance building, the project must consider sustainability. Sustainability is defined as the "quality of not being harmful to the environment or depleting natural resources, and thereby supporting long-term ecological balance". Practicing sustainability means being conscious of our actions and taking responsibility of maintaining our natural resources to protect the harmonious balance with our surroundings while taking into consideration our environmental, economic, and social values — the triple bottom line of sustainability. Once these factors are considered, specific to a residential building's location, the integrated design team can be effective in creating a sustainable high performing building. High Performance Buildings are energy efficient, have limited environmental impact, and operate with the lowest possible life-cycle costs. Green building, green architecture, sustainable building, high-performance building, and low-impact development are among the terms used to denote practices that reduce the environmental impact of components of the built environment. The Whole Building Design Approach structure will allow the integrations of services from the design to operation and maintenance phase; architect, interior designer, engineers, construction manager, and building operators; and intends to synthesize economic, environmental and social impacts of residential development while protecting and ensuring the health, safety, and welfare of the people. The information provided seeks to educate, involve and support the public in sustainable residential building development, reducing resource consumption, encourage the development community to advance the practice of high performing buildings, promote the improvement of policies affecting these practices, and inspire smart growth and smart life principles.

Session 2 – (Northampton Room)

Concrete Building Systems: Disaster Resilient Solutions for Safer Communities, Tien Peng, Lionel Lemay (National Ready Mixed Concrete Association -NRMCA) and Bruce Cody (Pennsylvania Aggregates and Concrete Association - PACA)

Over the past few decades, there was an exponential increase in human and material losses from disaster events. 2011 was a record-setting year for loss of life and property in virtually every part of the country. 2012 has produced another set of tragic, record-setting convective storms and wildfires. While the green building movement has traditionally focused on the environmental aspects of buildings, communities must now address the need for resilience while rebuilding to meet the challenge of the next natural disaster. This paper presents a four step process for resilient construction including adopting a basic building code, promoting market driven resilience programs, adopting more robust resilience standards and building with more robust materials such as concrete. It provides an overview of concrete building systems that have the mass and hardness to resist high winds and flying debris of tornadoes and the devastating effects of flood, fire and earthquakes.

A New Paradigm for Residential Construction in Regions of High Seismicity, Mark Sarkisian, Eric Long, David Shook and Abel Diaz (Skidmore, Owings & Merrill LLP)

21st Century construction will be deeply connected to the concepts of sustainability. To date, sustainable design has mostly focused on the carbon emissions associated with the operation of buildings; however the total life-cycle carbon associated with the construction is rarely, if ever, considered. Additionally, in regions of high seismicity, the carbon associated with seismic damage resulting in demolition, repair and reconstruction can be significant. Cost-benefit comparisons, probable seismic damage, and consideration of operational downtime are especially important in considering building system selection for all disciplines.

In what follows, a case study on a future condominium development to be located in downtown San Francisco, California, which includes two residential buildings base isolated on a common ground level with a Triple Friction Pendulum™ system is discussed. The Environmental Analysis Tool™ is used to calculate life-cycle environmental and fiscal impacts.

Session 3 – (Lehigh Room)

Critical Look into ®ISOMAX (Zero Energy Use Structures) Construction, Michael Sebright (Energy Reconsidered, LLC) and David Berg (DSB Energy Services, LLC)

The intention of this paper is to discuss the opportunities of implementing in the ®ISOMAX Building Technology (1) as a means to achieving Zero Energy Use Structures. ®ISOMAX is a fully integrated building system that collects solar heat energy and stores the heat in the earth just under the building. The system uses circulating fluid to transfer heat between the earth storage and the building envelope. The process allows the entire envelope of the building to take advantage of the collected energy by running the fluid, warmed or cooled, to move heat into or out of the insulated concrete wall and the roof. As Energy Reconsidered continues to prepare this technology for introduction into the American marketplace the team is engaging in dialogue with the construction industry to gather support for advanced modeling and prototype testing opportunities.

A Framework for the Process to Identify Dominant Housing Archetypes in a Cold Climate Region: Matching Energy Retrofit Research to Important Archetypes, Tim Mrozowski, Suk-Kyung Kim, Amanda Harrell-Seyburn (Michigan State University)

One of the strategies of the U.S. Department of Energy's Building American Program is the energy efficiency of existing homes, which supports cost effective retrofitting of existing homes. Our study defined "retrofitting" as the individual or holistic process that encompasses upgrading heating and air conditioning systems, roof and wall insulation, installing new windows and more efficient appliances and thermostats, and replacing worn or compromised ducts. Rather than targeting certain houses in a local market, a more practical and empirical approach may be identifying architectural and market characteristics of existing housing stock and targeting the types of homes that are (1) well represented in a given area and (2) likely to be in need of upgrades. We call such homes "archetypes".

The primary purpose of our study was to identify dominant housing archetypes in a local market through general housing data analysis and intensive two case studies, and propose a systematic process (or framework) for other researchers or stakeholders for future implementation in other local markets. Understanding the characteristics of housing groups referred to as archetypes by vintage, style, and construction characteristics can allow research teams to focus their retrofit research and develop prescriptive solutions for those structure types which are prevalent and offer high potential uptake within a region.

Our study targeted the Great Lakes region and analyzed 2009 American Housing Survey data, 2000 and 2009 American Community Survey data to identify housing stock characteristics in this region. We then chose two specific cities for intensive cases studies. The Cities of Ann Arbor and Grand Rapids were chosen considering their diversity and uniqueness of housing markets. Data collection methods to identify dominant housing archetypes included site visits, informational meetings with housing experts and staff members of local governments, and various analyses of local housing markets and archival documents. Major findings of the research were the dominant archetypes in these local markets and a framework of the process that can be implemented in other local markets when identifying dominant archetypes for energy retrofit research.

Adoption of Innovative Products in the US Housing Industry: Builders' Practices 2000-2010, Parisa Nikkhoo, Andrew R. Sanderford, Andrew P. McCoy, Ted Koebel, Chris Frank and Hazhir Rahmandad (Virginia Center for Housing Research, Department of Urban Affairs and Planning)

Researchers and policymakers have struggled with the lack of technological innovation in the US housing industry (Koebel 1999). While housing is arguably no different in nature than other industries, several unique factors have been established as causing risk and uncertainty in the context of innovative construction technology (McCoy et al. 2009). Previous intervention strategies borrow from other industries to explain prior adoption and diffusion patterns and do not address the divergence of recent residential construction technologies. Where home building innovation has traditionally experienced slower rates of adoption, some green building technologies exhibit accelerated patterns. In order to understand underlying reasons for resistance, it is important to not only understand uncertainty and risk, but also articulate use of innovation in the residential built environment. Towards this goal, the authors examine and highlight broad patterns of innovation use (adoption) by builder firms within clusters of products (i.e. traditional versus innovative) for six energy efficient (EE) products, across recent years.

Session 4 – (Northampton Room)

Deep Energy Retrofits with Retrofit Insulated Panels, Ted Clifton (Zero-Energy Plans LLC)

Builders and contractors have the opportunity to expand their business by taking advantage of the growing energy-efficient retrofit market. Improvements to existing homes range from simple weatherization techniques to comprehensive deep energy retrofits that can improve energy efficiency by up to 50 percent.

Retrofit insulated panels are installed over wall and roof sheathing to provide continuous exterior insulation, whole-house air sealing, and a solid nailing surface for new siding or roofing materials. Similar to structural insulated panels (SIPs), these insulated foam panels are easily cut on the jobsite to fit the profile an existing home.

Insulation and air sealing are only a small part of a complete deep energy retrofit. Other practices that will be covered in the presentation include installing new windows, new heating and cooling equipment, the need for mechanical ventilation, water heating, and other energy efficiency measures.

The presentation will also include the preliminary results from a study conducted by the NAHB Research Center on three deep energy retrofit research projects in New York State. The study will cover the materials and labor costs of performing the energy efficiency improvements, a breakdown of the energy savings, and an analysis of the homeowner's return on investment.

State-of-the-Art Review of Window Retrofit Options for Energy Savings in Single Family Dwellings, Tim Ariosto and Ali Memari (Penn State)

The study presented here involved the investigation of several different window retrofit solutions for energy efficiency. The criteria used to compare each system were Thermal Improvement, Thermal Comfort, Condensation Potential, Impact on Daylighting, Air Leakage, Cost, Ease of Operation, and Aesthetics. This paper introduces various methods for retrofit of existing windows, presents their attributes, and compares various options based on the stated criteria.

Zero Net-Energy Ready Home Training, Sam Rashkin (U.S. Dept of Energy)

It's been about five years since the current housing industry slow-down began. As time marches on, it's become increasingly clear the recovery process will be extremely slow. The DOE Challenge Home offers leading builders a timely solution for differentiating their product from the fire-sale of existing and minimum code homes. In fact, DOE believes the housing market is ready for a label that makes it easy for consumers to identify zero net-energy ready homes that are so efficient, a small renewable energy system can offset most or all annual energy consumption. Further, these homes include comprehensive indoor air quality measures and renewable energy ready details that can save significant costs installing solar energy systems in the future. After examining the resulting consumer value propositions, this paper will address the detailed specifications that earn this label. The primary focus will be mandatory DOE Challenge Home requirements and checklists for comprehensive building science, advanced innovations and best practices for thermal enclosures and HVAC systems, energy efficient components, indoor air quality, and solar readiness. Constructing zero net-energy ready homes is relatively easy. Ensuring they consistently deliver affordability, comfort, health, safety, durability and quality-construction is the goal of the DOE Challenge Home specifications. American homebuyers want this level of excellence when they make the largest investment of a lifetime. They just don't know how to get it… yet.

Session 5 – (Lehigh Room)

Prescriptive Details for Wind Resistant Envelopes based on Observations of Newly Built Homes Damaged in 2011 Tornados, Bryan Readling and Edward Keith (APA)

Damage observations conducted by APA after recent tornados focused on homes built within the last 10 years. Unfortunately many of the damaged homes were built in compliance with existing building codes and were robustly constructed minus a few relatively inexpensive techniques that provide structural continuity. In non-hurricane areas, now assigned with design wind-speed as low as 85 mph, this indicates a need for building practices that take advantage of the inherent strengths of roof, wall and floor assemblies in tornado-prone areas.

To this end APA engineers compiled a set of reinforcement techniques for each of the common weak points along the load path resulting from code-minimum attachment schedules, and commonly used construction techniques. The resulting publication Building for High Wind Resistance in Light-Frame Wood Construction, APA form M310 was published in August 2011.

Instrumental in offering these recommendations is recent testing at APA performed to determine the design capacity of shearwalls subjected to simultaneous shear and uplift forces. Recommendations are prescriptive and apply to many homes otherwise constructed to IRC minimums. The aim was optimization of material assemblages already commonly in-use, while minimizing the effect on cost. Recommendations apply when a higher degree of safety is desired for resisting severe straight-line winds and tornados on the lower end of the EF-scale.

Residential Damage Patterns Following the 2011 Tuscaloosa, AL and Joplin, MO Tornadoes, David Roueche and David Prevatt ***(***University of Florida)

Two of the most powerful tornadoes in 2011, occurred in Tuscaloosa, AL on April 27th, and in Joplin, MO on May 22nd. These tornadoes caused a significant amount of damage ($13 billion), and resulted in an estimated 175 fatalities. Despite decades of damage reports on violent tornadoes, little is known regarding the structural loading imposed on buildings by these events. However, non-engineered residential property suffered the worst damage as documented by two damage survey teams. The post-tornado damage surveys documented the structural performance of houses, and spatial distribution of residential damage within the tornado wind field. The data include damage observations from over 1600 homes that were assigned degrees of damage (DOD) ratings using the EF-Scale procedure. Publicly available information such as the age, construction materials and size of the homes were also collected.

An analysis of the failure patterns was performed on the combined dataset to quantify the magnitudes and distributions of tornado loads on buildings, relating the damage to distance from the centerline of the tornado, orientation of the structure and variation along each tornado path. The study presents correlations among major failure mechanisms; i.e. between roof removal and ensuing wall collapse, and between roof sheathing loss and resulting failure of gable-end walls. The paper presents common failure patterns related to specific construction practices that increase the vulnerability of houses to tornadoes. These field studies and analyses are being used to inform the development of full-scale structural testing wall components with the goal of developing structural retrofits and improved design practices for tornado-resilient houses.

Wind Uplift Capacity of Foam-Retrofitted Roof Sheathing Subjected to Water Leaks, David Roueche, Joseph Eixenberger, David Prevatt, Kenton McBride and Forrest Masters (University of Florida)

A well-known source of damage to houses in hurricanes occurs when water bypasses failed roof coverings that allow water to enter the interior through joints in the wood roof decks. Closed-cell spray-applied polyurethane foam (ccSPF) sprayed to the underside of the roof functions as a secondary water barrier to mitigate this damage, in addition to its primary function as a thermal barrier. Recent studies at the University of Florida revealed that ccSPF also significantly increases the wind uplift resistance of a wood roof deck due to its strong bond to wood substrates. This presentation describes a research project that investigated the effects of incidental water leakage on the strength of the ccSPF-to-wood bond and on moisture retention characteristics in a wood roof.

The two-phased study consisted of the construction and long-term testing of full-scale roof attics exposed to outdoor environmental conditions in Gainesville, FL, and bench-type studies using small-scale roof deck samples. Each roof attic was retrofitted using ccSPF, self-adhered membrane underlayment and/or air gaps between the sheathing and ccSPF. Numerous ½ in. diameter holes (leak gaps) cut into the roofing created sources of water leaks, and we continuously monitored moisture content in the wood in real-time through a web-based application. The wind uplift capacity of roof panels (ultimate failure pressure), were determined at the end of each exposure period. Concurrently, small-scale testing was conducted to measure the tensile strength of the wood-to-ccSPF bond for samples exposed to up to 16 weeks of intermittent water sprays. The moisture distribution in 6 in. x 6 in. wood (OSB and plywood) roof deck samples was also determined, representing common construction patterns such as vertical or horizontal sheathing joints, and the configurations of full-scale retrofit systems.

While ccSPF remains highly effective as a structural retrofit despite significant wetting, elevated moisture content occurs within the wood substrate. Successful techniques were demonstrated to mitigate moisture retention, such as use of self-adhered waterproofing membrane or including an underside-deck air gap s within the ccSPF retrofit layer that resulted in substantial reduction (90% and 80%, respectively) in moisture contents within the sheathing. The study has led to recommendations for the installation and maintenance of ccSPF-retrofitted residential roofs, and the use of similar wood-foam composite systems in wood-framed buildings.

Session 6 – (Northampton Room)

Housing Reconstruction and Community Recovery Following Disasters – No Easy Choices, Dana Bres (HUD) and Carlos Martin (Abt. Assoc.)

In the aftermath of a disaster, communities experience significant housing demands for the survivors. Although there will be many volunteer, local, state and federal organizations involved, a significant housing recovery challenge is the reality that nobody will be in charge. This reflects the fact that while property owners, investors, builders, community leaders, insurance providers, and state and federal leaders all have a stake in the operation and success of the reconstruction effort, none have the absolute power that would be necessary to direct the process. This is not intended as an indictment of the current system but is a description of the reality of disaster recovery. That said, a community's recovery is highly dependent on the availability and quality of housing.

As a framework for discussion, housing recovery challenges will be addressed. Housing supports the larger community recovery effort through the "Seven Rs"; repair, rent, rebuild, remediate, replace, relocate and most importantly, resources. Virtually all housing programs must consider these concepts.

Those involved in the challenge of facilitating community recovery must understand the opportunities and constraints of the various courses of action available to leaders, residents and housing advocates. This will enhance the ability to rapidly respond to the housing demands of the post disaster environment. The decisions that lead to programs for disaster response and recovery often are made quickly and frequently without input from the residential design and construction industry. Increasing the number of parties involved will strengthen the process and speed the recovery of residents and the community at large.

Residential Reconstruction in Haiti, Mark Taylor (University of Illinois, Urbana-Champaign)

The Haitian earthquake of January 2010 revealed inadequacies in the design and construction quality of the island nations' housing stock. The result of these deficiencies turned a natural hazard into a human disaster. This presentation will outline the systemic problems that led to the establishment of such vulnerable construction. Drawing on research gathered from six field trips to Léogâne, Haiti, the town at the epicenter of the January 2010 earthquake, I will also highlight two distinctly different approaches to rectifying historic failings in construction standards:

(1) Working with local partners in the construction industry to strengthen local capacity for sustainable resilience.

(2) Inviting new investors, with new products, into the Haitian market to improve building performance and provide new economic opportunities.

The government of Haiti is pursuing both approaches in order to replace over 200,000 homes that were destroyed or damaged as a result of the 7.0 magnitude earthquake. An examination of this recent tragedy will inform stakeholders of appropriate measures that can and should be taken in the wake of a natural disaster of similar magnitude.

Haiti Wood-Framed Housing Initiative, Glyn Boone (Weyerhaeuser) and Joshua Kiehl (Entech Engineering, Inc.)

The January 2010 earthquake near Port-au-Prince, Haiti was devastating to the nation. The scale of the disaster led many individuals and companies in the housing industry to lend aid in the recovery and rebuilding effort as well as to seek ways to improve the integrity of structures long-term. Forest products company Weyerhaeuser provided an immediate donation of building materials for temporary housing, and committed to introduce safer products for the long-term rebuilding of Haiti. This paper describes these efforts, the results accomplished, and the lessons learned.

Session 7 – (Lehigh Room)

Design and Construction of High-Performance Homes: Building Envelopes, Renewable Energies and Integrated Practice, Franca Trubiano (University of Pennsylvania), Jeffrey R.S. Brownson and Lisa D. Iulo (Penn State)

Description: Both professionals and students are increasingly committed to achieving high-performance metrics in the design, construction and operation of residential buildings. This book responds to this demand by offering a comprehensive guide which features:

- architectural innovations in building skin technologies which make lighter more transparent buildings high performing;
- energy-free architectural design principles and advances in building-integrated photovoltaics;
- essential engineering principles, controls and approaches to simulation for achieving net zero;
- the advantages of integrated design in residential construction and the challenges and opportunities it engenders;
- detailed case studies of innovative homes which have incorporated low-energy design solutions, new materials, alternative building assemblies, digital fabrication, integrated engineering systems and operational controls.

Divided into four parts, the book discusses the requisite AEC (Architecture, Engineering and Construction) knowledge needed when building a high-performance home. It also communicates this information across four case studies, which provide the reader with a thorough overview of all aspects to be considered in the design and construction of sustainable homes. With contributions from experts in the field, the book provides a well-rounded and multi-faceted approach. This book is essential reading for students and professionals in design, architecture, engineering (civil, mechanical and electrical), construction and energy management.

This session, with presentations by the book editor and contributing authors, will provide an overview of the architecture, engineering and construction of High Performance Homes. Each presentation will include case-study projects case studies describing high performance single family homes conceived and engineered to achieve net zero energy consumption. The session will be followed by a book event and reception.

Architecture: "High Performance Architectural Technologies" by Franca Trubiano
This presentation will highlight inventive building envelopes, responsive skins, engineered materials and automated digital fabrication techniques for high-performance residential construction.

Engineering: "System Integrated Photovoltaics (SIPV)" by Jeffrey R. S. Brownson
This presentation promotes the adoption of an alternative approach for the productive integration of photovoltaic technology used in high performance residential designs. Systems Integrated Photovoltaics (SIPV) is a more effective method for engineering solar installations capable of generating greater levels of energy performance. Considered and developed within a whole building system logic, SIPVs advance the field of solar technology by addressing important issues of energy production and integration not otherwise engaged in the design and construction of traditional Building Integrated Photovoltaics (BIPV).

“Energy and the Integrative Design Process – defining the team of experts” by Lisa D. Iulo
A new team of building industry experts is needed in the design and construction of high performance net zero-energy homes in order to respond to their highly integrated nature. This chapter identifies a range of energy professionals who, during the early phase of design working alongside the architect and the engineer, ensure the attainment of performance goals. The building performance specialist, the renewable energy expert and/or installer, the home energy rater, and the homebuilder/ manufacturer contribute particular skills, principles, values and benchmarks for measuring performance excellence. Their role in the process, their contributions to the home’s overall performance, and their participation in the integrative design process specific to high-performance, net zero-energy homes are discussed in this presentation.

Session 8 – (Northampton Room)

Effects of Installation Method on Nail Withdrawal Capacities, Ashlie Kerr, Shelly Dean and David Prevatt (University of Florida)

Nail withdrawal capacities are tested in accordance with ASTM D1761 and are typically estimated using the empirical equation W=6900G2.5D given in the National Design Standard for Wood Construction. A previous study by Shreyans et al found that in-situ nail withdrawal capacities were over-estimated by the NDS equation and suggested that loss of capacity may be due to the installation of the nail through the sheathing, which is not done in ASTM D1761. This paper presents an experimental study that explores the effects of installation method on the nail withdrawal capacity by testing nails installed through both Oriented Strand Board (OSB) and Plywood. Type of nail used for testing was 6d common nails with diameter of 2.87 mm (0.113 in) and length of 50.8 mm (2 in).

The effect of installation method on nail withdrawal capacity was evaluated by comparing capacities using ASTM D1761 Standard Test Methods for Mechanical Fasteners in Wood to those obtained with the nail installed through the sheathing. The effect of the nail withdrawal method was also quantified for three methods: 1) Withdrawal with the sheathing left in place, 2) Withdrawal by means of a steel plate notched to fit around the installed nail, 3) Withdrawal by direct pull using a steel jaw.

Results demonstrated that installation through the sheathing consistently reduced the withdrawal capacity; however the test setup and withdrawal methods also significantly affected the withdrawal capacities. The National Design Standard empirical formula may be non-conservative in representing the withdrawal capacities of nails in a roof setting.

Modular Green Roof Systems in Mid-rise Multifamily Residential Units, Tuan Vo, David Prevatt, Duzgun Agdas and Glenn Acomb (University of Florida)

This paper presents the results of a full-scale research project undertaken to assess scour losses/gains for modular tray green roof specimens placed on a mock-up building, and identify important factors to consider for wind design criteria. Visual assessment of the experimental results showed that usage of vegetation, parapet height, wind direction, and test duration were the predominant factors affecting scour resistance of the growth media in tested specimens. Statistical analysis results indicated that the differences in soil losses measured among Phase 2's test trials were more significant than those in Phase 1. This was attributed to the lack of parapet, cornering wind conditions, and longer test duration found in Phase 2. Findings presented in this paper constitute a benchmark for future research to improve the knowledge gap that exists in green roof wind design.

The Unsealing of Naturally Aged Asphalt Shingles: An In-situ Survey, Craig Dixon, David Prevatt, Forrest Masters and Kurtis Gurley (University of Florida)

As part of a two-year research project investigating causes of premature roofing failures in windstorms, twenty-seven naturally aged asphalt shingle roof systems on residential houses in Florida were surveyed to investigate the condition of the sealant adhesive strips on the shingles. The thermally activated sealant strip located along the leading edge of an asphalt shingle is the primary load path that resists failure of the shingle due to the wind. The non-destructive survey consisted of applying finger pressure to each shingle edge to determine whether or not the sealant strip was adhered to shingle below. The investigation identified two distinct, nonrandom, patterns of partially unsealed shingles corresponding to the method of shingle installation; vertical patterns with racked installations and diagonal patterns for diagonal installation of shingles. The total percentage of roofs with partially unsealed shingles exhibiting these patterns ranged from less than 1% for a six year old roof to over 79% for a twenty year old roof. Whereas, roofs without the distinct unsealing patterns had less than 1% of the total number of shingle strips unsealed. A statistically significant increase in the total percentage of partially unsealed shingles was observed for older roofs (7-13 and 14-20 years) when compared to newer roofs (0-6 years). Partial and full unsealing also occurred on hip and ridge cap shingles, likely attributed to poor adhesion at the onset of service life. A similar pattern of wind damage was observed in shingles reported in post-hurricane damage assessment reports. This similarity suggests that pre-storm partial unsealing condition is a strong influence in the actual wind resistance of asphalt shingle roofs.

Day 2 – February 21, 2013

Keynote Speaker – (Northampton Room)

---

30 Years in Dogged Pursuit of the Ultimate Superinsulated Passive Solar Home, Richard D. Seifert (University of Alaska Fairbanks)

As a participant in the past 3 decades of Building Science Progress in North America, riding the rollercoaster's of energy cost, and enduring the tribulations of housing finance and investment woes, it is my pleasure, and perhaps, my duty to share with this interesting Pennsylvania conference what I have learned from living my professional life in one of the coldest cities in North America, while trying to find a Building Science solution to how to live in the Interior of Alaska efficiently, with low carbon footprint and without being driven into poverty by fuel costs and with a healthy indoor environment.

Starting about 1980, when Jimmy Carter suggested that energy conservation was " The Moral Equivalent of War", my fellow Alaskans and I began the long, cold, march toward the superinsulated home, discovering along the way the pitfalls of moisture, mold, ventilation, financing and the utter lack of romance to be found in the whole energy conservation world. Along this path, we created educational programs, outreach efforts, professional coursework for contractor/builders, ventilation standards, encountered new materials, attempted to use renewable energy resources such as solar energy for heat and electricity, and ultimately were recipients of an amazing state-funded weatherization and energy rebate program totaling more than 800 million dollars over the past four years. That plan is one of the finest in the nation. We found some answers, can advise our fellow building scientists on what to do and not do, for *any* heating climate, and yet there are many things still to be done.

My list would include:

1. Raising housing energy performance standards to include carbon footprint reductions and optimal insulation techniques, ultimately bringing zero-net homes into common practice.
2. Use every available educational tool to optimize investment in housing as a fundamental human right and economic engine to create a better world. Moving toward homes which are durable, need as little energy as possible, provide some of their own utility energy and strengthen the utility grid and the local economy.

Session 9 – (Lehigh Room)

Information Barriers in Home Energy Retrofit Adoption: Research in Progress, Daniel Duah and Matt Syal (Michigan State University)
Generally, buildings, especially residential ones, are a major consumer of energy. The majority of the housing stock consists of existing homes, a large number of which is energy inefficient. Retrofitting existing homes to make them energy efficient has huge economic, social, and environmental benefits.

Though the benefits and opportunities for home energy retrofits (HER) are fairly well established, its adoption has faced huge obstacles. One estimate of market penetration for HER programs puts it at less than 2%.

The research identified lack of information as an important barrier to the adoption of HER. It also identified two types of information barriers as quantitative information and expert knowledge. The need for information to accelerate HER adoption and promotion of HER among homeowners were also emphasized. Finally, the research explored the integration of various information categories for future development of an intelligent decision support system framework.

Prefabricating Charles Moore: Reinterpreted Saddlebags and Aediculae, C. A. Debelius, R. Chadwick Everhart and James Russell (Appalachian State University)

Inspired by Charles Moore's strategy of the use of Saddlebags and Aedicule elements in residential design, this paper describes a design proposal for the retrofit of existing houses in a traditional suburban neighborhood with prefabricated Renewable Energy and/or Efficient Modules (REEMs). The conception and design of the modules is a response to two concerns:

- A 62% increase, between 1978 and 2005, in energy consumption in three of the primary components of residential energy demand: Water Heating, Air Conditioning, and Appliances and Electronics.
- The significant number of existing energy inefficient homes constructed prior to 2000.

Prefabricated Renewable Energy and/or Efficient systems are proposed as an effective means for reducing energy consumption in existing houses. These systems, comprised of (1) an array of Renewable Energy building skin systems (e.g., Solar PV, Solar Thermal, etc.) and (2) Renewable Energy and/or Efficient Modules (REEMs), are designed to decrease energy consumption—either by adding renewable energy capability and/or having more efficient energy systems. The prefabricated modules contain the equipment and components necessary to augment and/or replace the existing energy systems of the house.

The significance of the project, as distinguished from those proposals that focus on new construction, is the demonstration of a variety of design strategies for reducing residential energy consumption by retrofitting existing houses with mass-produced Renewable Energy and/or Efficient systems.

Session 10 – (Lehigh Room)

An Introduction to Steel and Concrete Modular Construction, Stefanie English (Larson Design Group, Inc.) and Bill Brown (NRB)

For many years, wood framed modular construction has been a useful and cost-effective solution in the residential market. While this type of construction has been a good solution for one- and two-family residential construction, it has been limited by factors such as available beam spans, lateral force resisting system requirements, and fire resistance, affecting its use in larger multi-story projects, such as hotels and dormitories. This presentation will explore the benefits of using steel-framed modules to achieve greater exterior opening distances, increased floor plan flexibility, LEED certification, and non-combustible occupancies.

Additionally, we will discuss the concept of the off-site “Build Together” process used by one manufacturer to ensure a precise fit of components, including structural, plumbing, electric, HVAC, and fire protection systems.

Concrete in Residential Construction, Pragati Singh and Andrew Scanlon (Penn State)

Concrete is widely used in residential construction for footings, walls, and slabs on ground. This paper provides a summary of the requirements needed to achieve high quality concrete in residential constructions. Aspects include concrete materials, proportions, mixing, placing, consolidation, finishing and curing. Some of the problems that can occur in concrete discussion are discussed and suggestions for avoiding these problems are mentioned.

Session 11 – (Lehigh Room)

Reducing Exposure to Thermal Stress in Cuyahoga County, Ohio Through Residential Weatherization, Nicholas Rajkovich and Larissa Larsen (University of Michigan)

Each year in the United States more people die from heat waves than from any other type of natural disaster. While research in the environmental health sciences has shown that increasing access to air-conditioning is a strong protective measure for reducing heat-related mortality, weatherizing a residence's thermal envelope may be preferable because it has the potential to improve indoor thermal environmental conditions while reducing electrical demand.

Most weatherization programs in the United States only provide wintertime energy efficiency services. Research indicates that these services can improve wintertime indoor thermal comfort indoors while reducing energy costs; what remains relatively unknown is the effect of these wintertime weatherization measures on summertime interior thermal environmental conditions.

To begin to close this knowledge gap, house configuration data from the Ohio Department of Development and several weatherization program assessments were used to create a set of average "low-income" homes representative of houses weatherized in Cuyahoga County, Ohio. Greater Cleveland is the focus of the study because a national-level assessment of heat vulnerability identified the county as being extremely susceptible to high temperatures. These average home typologies were then input into the EnergyPlus simulation engine to determine if wintertime weatherization measures reduced exposure to extreme temperatures indoors. The results indicate that some of the measures typically selected for weatherization programs may increase exposure to high temperatures indoors. Additional, simple measures to reduce interior temperatures are discussed along with suggested changes to program design to maximize both summer and winter performance of low-income residences.

Overheating in Multifamily Residential Buildings, Jordan Dentz., Kapil Varshney (The Levy Partnership, Inc.), and Hugh Henderson (CDH Energy Corp.)

In this project data have been collected for eighteen multifamily buildings from the archives of multiple companies that provide energy management systems (EMS). Overheating was found in all eighteen buildings: the overall average temperature of all buildings was well above 70°F when the EMSs were not in operation.1 In fifteen of the eighteen buildings, average temperatures in 100% of the apartments when EMSs were not in operation were above 70°F (ranging from 70.7°F to 87.4°F). In the remaining three buildings, average temperatures in 88% of apartments were also above 70°F (ranging from 70.3°F to 85.2°F). Likewise, when the EMSs were on, in seven of eighteen buildings, average temperatures in 100% of the apartments were above 70°F (ranging from 70.3°F to 81.1°F). In the remaining eleven buildings, average temperatures in 67% of the apartments were above 70°F (ranging from 70.0°F to 81.2°F). Based on this analysis, the estimated average increase in annual space heating energy cost for these buildings due to overheating is approximately 18.6% when the EMS is off, compared to a baseline average temperature of 70°F all the time.

Air Distribution Retrofit Strategies for Affordable Housing, Jordan Dentz, David Podorson (The Levy Partnership), Francis Conlin, Parker Holloway (High Performance Building Solutions*)*

In multi-unit buildings, traditional duct sealing methods are often impractical, costly and/or disruptive because of the difficulty in accessing leakage sites. In this project, supported by the U.S. Department of Energy's Building America™ program, two retrofit duct sealing techniques—manually-applied sealants and injecting a spray sealant (Aeroseal®) in combination with manual sealing, were implemented in several duplex buildings in North Carolina. Each method was used in twenty housing units. Duct leakage to the outside was reduced by an average of 59% through the use of manual methods, and by 90% in the units where a combination of aerosol and hand sealing was used. The cost of manually-applying sealant ranged from $275 to $511 per unit and for the Aeroseal®-treated ducts the cost was $700 per unit. Modeling suggests a short simple payback of 1.2 years for manual sealing and 1.5 years for the Aeroseal® system.

Session 12 – (Northampton Room)

Innovation in Residential Construction Systems in Sweden, Gregory La Vardera (Gregory La Vardera Architect) and Scott Hedges (Australia)

Sweden stands out as the preeminent innovator in homebuilding process and energy performance in Europe. 96% of Swedish Housing is built using an of-site process, and on average Swedish houses consume less than 50% of the energy of American Homes. Yet Sweden and the United States share a heritage of wood framed residential building, a result of the timber resources common to both countries. As recently as the 1970s the way houses were built in Sweden and the US was largely the same. But the global oil crisis of the late 1970s set the two countries on divergent trajectories. Sweden entered a period of rigorous innovation, improving the quality, construction efficiency, and energy performance of their houses. Their example is relevant to builders in North America because there remain many areas of commonality both in construction methods, consumer expectations, as well as the challenges presented in cold climate regions. One could consider Sweden as a "crystal ball", showing what American House Building might look like if we had spent the past 40 years committed to improving efficiency.

Our investigation into the Swedish housing industry has occurred both in factories and construction sites in Sweden. We have documented and analyzed our observations to understand the Swedish common building process, and determined how key components have been altered across their industry to support these techniques. We have examined construction drawings and technical documentation from dozens of houses from multiple factories to come to an understand of key characteristics of Swedish residential building system conventions. And finally we have systematically applied these principals to wall and framing prototypes based on American building products in order to lay out a road map to implementing these techniques in the US. These are manifest in a series of prototype wall systems dubbed USA New Wall, and in a next generation development of Western Platform Framing which we have come to call Swedish Platform Framing.

We will present a photographic overview of the Swedish approach to offsite construction and discuss the defining features of both job site and factory process and practices. We will explain how these processes contribute to the superior average energy performance of Swedish houses. Last we will look in detail at the Swedish Wall itself, and our application of their concepts in our USA New Wall and Swedish Platform Framing.

Chicago Flat Type Planning: Sustainability and the 1902 Tenement House Ordinance, Richard Gnat (University of Nevada)

This paper examines the planning flexibility and the passive ventilation and day-lighting potential of the various multi-unit apartment types developed in response to the 1902 Tenement House Ordinance in Chicago. Instead of thinking about the future of sustainable multi-family housing design as built upon current planning strategies, this paper examines a historic planning precedent that may be more applicable, or appropriate, based upon the criteria of the new sustainability paradigm. Beyond explaining the history and requirements of the Ordinance, this paper illustrates how basic planning strategies adapted from the Chicago two-flat apartment building could be combined and repeated to form ever larger, taller and complex apartment buildings. Today, many "sustainable" multi-unit apartment buildings are planned in a manner that requires constant mechanical ventilation and artificial lighting even during daylight hours. This is done without asking whether a building that requires energy to be habitable should even be considered sustainable. Air-conditioning for housing was not technically or economically feasible until after 1930 so these Chicago flat type apartment buildings relied upon passive planning strategies to ventilate and light each unit. In an era of increasingly expensive energy, the advantages of planning every unit to accommodate the passive ventilation and lighting strategies inherent in these pre-air conditioned designs becomes apparent. Historical resources and field documentation were utilized to explain and illustrate the Chicago flat type planning strategy. The paper concludes that the sustainability paradigm shift is an opportunity to rethink the planning models upon which we base our multi-unit apartment building designs.

Insulating Concrete Forms, Dennis Gerdel (New Holland Concrete)

Homeowners and Builders are challenged with meeting budgets and schedules in today's economy with current construction practices and in the foreseeable futures for energy.

Our world's number one challenge is to reduce the amount of carbon dioxide that is being discharged into our atmosphere. The earth's possible warming and as of yet, unproven effects of climate change, may be related to carbon dioxide emissions.

- Landfill construction waste is reduced to less than 1% when you build with ICF's. For every one ton of methane produced by landfill practices, 20 tons of CO2 are produced.

- Every ICF home saves approximately 8.5 trees and effectively preserves nature's air filters. Ask yourself the question, "How much oxygen does sand and gravel produce?"

- If we can reduce our energy bills by as high as 40%, we can reduce CO2 emissions by the same amount. The world's international Kyoto agreement insists on a reduction of emissions by 50% just to slow down the effects of global warming. ICF's are a part of the answer to CO2 reductions.

Insulating Concrete Forms (ICF's) are hollow stay in place lightweight forms "blocks" made of EPS foam that construction crews stack into the shape of the walls of a building. The workers then fill the center with reinforced concrete of thicknesses of 4" to 12" thick to create the structure. There are many brands of ICF's in North America, each with some variations in design and materials. This combination creates a wall with unusually desirable properties: air tightness, strength, sound attenuation, insulation, fire and storm protection and mass.

ICF construction can significantly contribute to USGBC LEED Energy Optimization credits, the toughest points with the greatest savings in life cycle costs. LEED promotes a whole-building approach with performance criteria in five areas: sustainable site development, water savings, energy efficiency, materials selection and indoor environmental quality.

How does the home owner benefit?

Comfort: Houses built with ICF walls have a much more even temperature throughout the day and night. They have virtually no “cold spots”, and fewer drafts than wood or metal frame construction.
Solidity: The rigidity of concrete construction reduces the flex in floors and cuts shifting and vibration from the force of the wind or the shutting of a door. Concrete homes survive high-force winds like hurricanes far better than wood homes and when properly reinforced, they should withstand earthquakes well.

Quietness: About one-sixth as much sound gets through an ICF wall compared with an ordinary frame wall. This sharply cuts the intrusion of noise from outside.

Energy efficiency: The superior insulation, air tightness, and mass of the walls cut the amount of energy needed for heating and cooling by 30-80%. It allows the installation of smaller heating and cooling equipment that can reduce the initial cost of a house.

Session 13 – (Lehigh Room)

Resisting the Monolithic: The Influence of Construction Innovation on Single-Family House Spatialities in the Work of Gomes and Staub, Francisco Gomes (University of Texas at Austin)

Many common architectural design paradigms are founded on the manipulation of formal abstractions such as buildings masses as figure ground relationship of solid versus void or the conception of walls as a monolithic spatial boundaries. These abstractions are often resisted by the contemporary realities of achieving buildable and high-performing building envelopes and their primacy in design thinking is challenged when alternative and innovative construction concepts are introduced during the design conception of a project. The spatial implications of construction innovation can be identified in the single-family residential work of Gomes and Staub Architects.

Spatial implications of design strategies to decrease the costs of modern modular construction are explicitly addressed in the Stitch House, designed in 2005 for Wieler LLC, by reducing the number and interdependence of subcontractor trades on the building site. Similarly, innovations in the increasingly layered condition of contemporary exterior envelope construction are expressed in a series of Gomes and Staub projects. The Poss-Pas House, the Aleutian Island House, and the Travis Peak Trail House each exploit the layered exterior envelope for spatial and architectural expression.

Responsive Housing: Potential & Projected Impact, Allison Jane Mills and Kenneth Tiss
(State University of New York)

Currently, the made-to-last building techniques of American housing are incongruent with personal, family, energy, and technology evolution. Why aren't buildings designed to be flexible enough to respond to the fluctuating cadence of human inhabitance? This paper proposes a new design concept: responsive housing.

Responsive housing is a theoretical building system that can be continuously adjusted at the will of the home's occupants to provide the best living conditions possible. By componentizing the major elements of a home a responsive house can be built in stages, disassembled in stages, reconfigured internally and externally, and completely relocated to a different building site. Akin to providing homeowners with a set of life-sized building blocks, this system makes each home easily customizable. Ongoing occupant-executed customization has the potential to revolutionize the current state of residential building. This paper explains how responsive housing would work and the impact it would have socially, economically, and environmentally.

Investigation for the Removal of Steel Tie Rods in a Historic Segmental Arch Floor, Ramon Gilsanz, Jennifer Lan and Michael Lo (Gilsanz-Murray-Steficek, LLP)

Gilsanz Murray Steficek, LLP investigated the removal of the tie rods in the floors of the landmarked Metropolitan Life Tower in New York City when the tower was converted for residential use. The typical floor is constructed of segmental concrete arches supported on steel beams with tie rods perpendicular to the beams below the arches. GMS evaluated the removal of the rods by performing linear and nonlinear 3D finite element analysis of the floor system. Load tests were also performed at 5 locations in the building in order to confirm that the floor would perform satisfactorily. Both the analysis and the load test confirmed that the tie-rods could be removed safely.

Session 14 – (Northampton Room)

The State-of-the-Art Application of Modular Construction to Multi-Story Residential Buildings, Anthony Jellen and Ali Memari (Penn State)

Modular construction methods show great potential as an alternative to traditional site-built methods and could be a means of providing much needed affordable housing in the dense, land deprived urban areas typical of US cities. The evolving field of modular construction will require significant investment in research to successfully integrate these powerful concepts into mainstream construction practice and provide the industry with the resources and tools it needs to use these cost, time, and material saving construction methods effectively in future designs. This paper aims to review both the current state-of-the-art of multi-story construction and promote its utility for high performance, sustainable multifamily dwellings in U.S. urban areas, particularly for moderate income, one- or two-person families.

Identification of Structural Issues in Design and Construction of Multi-Story Modular Buildings, Issa J. Ramaji and Ali M. Memari (Penn State)

As the modular construction industry tries to find new markets in multi-story buildings, additional challenges are faced along the way that needs to be addressed. This paper initially introduces different types of modular multi-story or high-rise construction systems. The structural systems including gravity and lateral load resisting systems are then discussed. The challenges that structural designers face in addressing load path continuity and gravity and lateral load transfer between adjacent structural components are reviewed. Approaches for system and building modeling needed for structural analysis as well as relevant building code requirements are discussed. Furthermore the challenges in design and detailing of different structural members and components/systems are evaluated. The paper also provides an overview of any special structural safety issues for design and construction. Finally, the paper outlines the R&D needs for advancing the technology of multi-story modular building design and construction.

Sierra Bonita: Innovative Use of Long Span Metal Deck Slabs and Shored Construction, Joe Mugford, Karl Rubenacker, John Lantry and Ramon Gilsanz (Gilsanz-Murray-Steficek, LLP)

Sierra Bonita is a mixed use building providing affordable housing for people living with disabilities. The five story building is located in West Hollywood, CA and was completed in 2010. A 6 inch reinforced metal deck slab system spans 20 feet between supporting steel framing. The supporting framing consists of 43 foot long beams and 60 foot long girders supported by columns at the building perimeter and at the four corners of the central building atrium.

Occupant induced floor vibrations as well as service and creep deflections were taken into account in the design process. Finite element modeling using SAP2000 was used to predict the response of the structure from walking induced vibrations. Testing was later performed during construction in conjunction with The Pennsylvania State University to confirm the acceptability of the structural response. Service and creep deflections were mitigated using slab reinforcement, camber, wood joist shores and loose steel shores. This paper presents our approach to the design of this system, including modeling techniques; use of construction sequencing and shoring; and a comparison of in service vs. design results.

Lessons Learned from the Process of Retrofitting Existing Housing for Energy Efficiency, Lisa Iulo Penn State) and Bruce Quigley (Union County Housing Authority)

This paper discusses lessons learned from the design and retrofit of two existing homes for improved energy efficiency. Principle findings include the necessity for providing cost-effective, replicable solutions for the energy efficient retrofit of existing homes that address both up-front expenses and the long-term energy costs carried forth by the resident. One major conclusion is that process matters; although there are essential principles for retrofitting existing homes for improved energy-performance, actual solutions must be project specific and should be undertaken through a comprehensive process that engages the contractor from the very beginning of the project.