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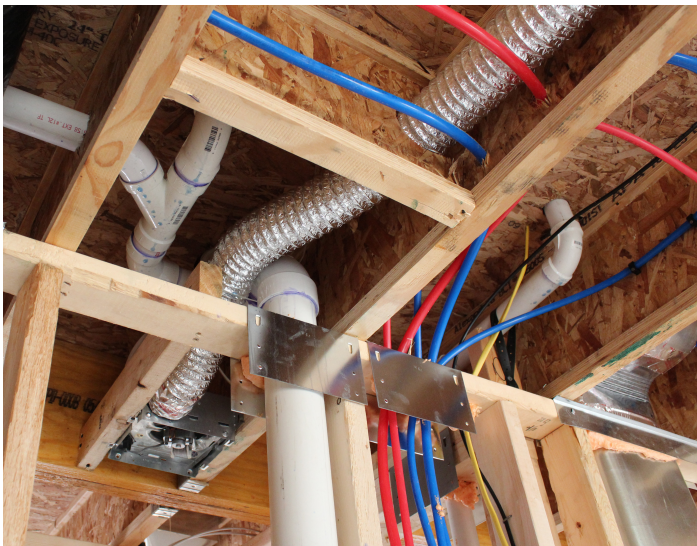


3RD RESIDENTIAL BUILDING DESIGN & CONSTRUCTION CONFERENCE

STATE COLLEGE, PA | MARCH 2-3, 2016



CONFERENCE PROGRAM



CONFERENCE ORGANIZATION

CONFERENCE CHAIR

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Residential Building Construction*

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Lisa Iulo

Department of Architecture, PSU

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PHRC, PSU

Sarah Klinetob Lowe

PHRC, PSU

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Jack Willenbrock

Lancaster, PA, USA

Tom Williamson

Timber Engineering LLC, USA

Joseph Wysocki

Healthy Housing Solutions, USA

WELCOME!

Dear Residential Building Design and Construction Conference Attendee,

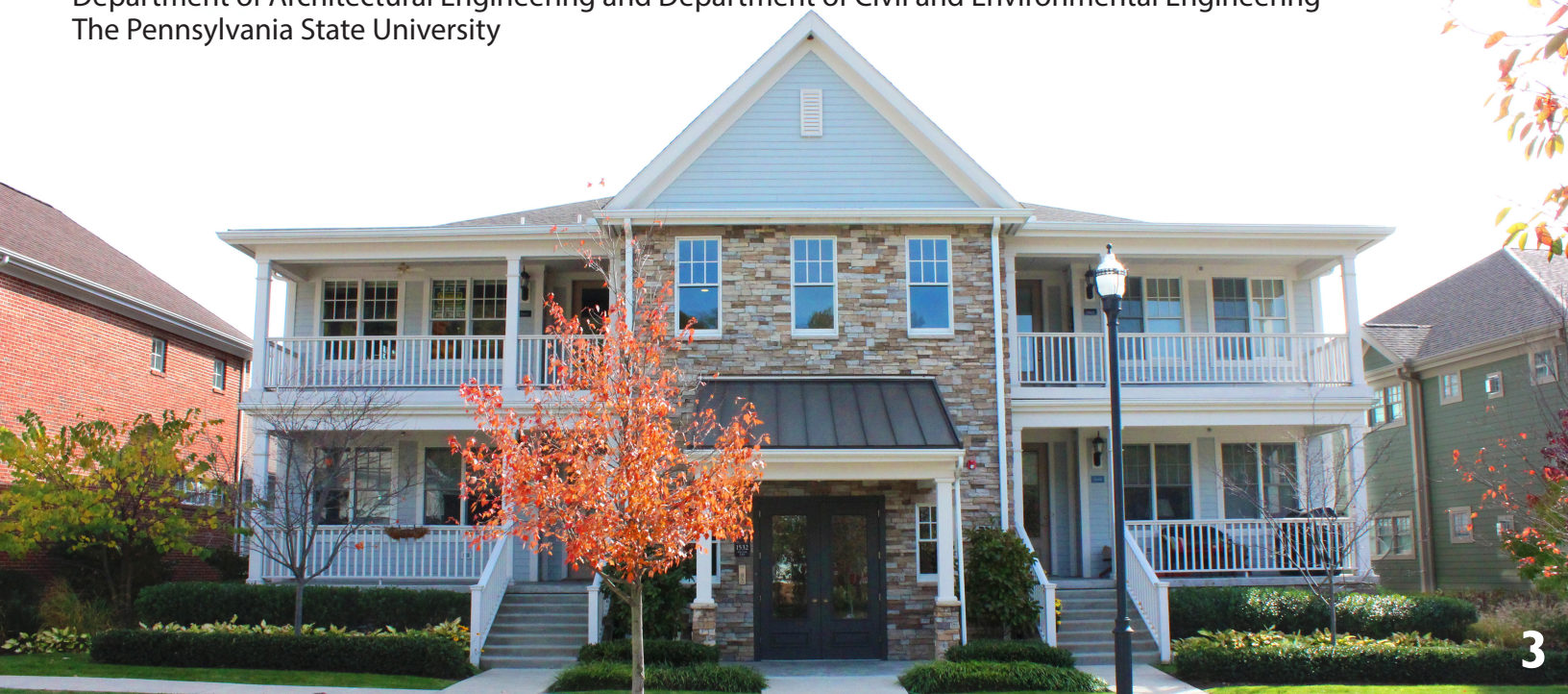
It is my pleasure to welcome you to the Third Residential Building Design and Construction (RBDC) Conference, March 2-3, 2016 in State College, PA. This biennial conference is organized by the Pennsylvania Housing Research Center (PHRC) at Penn State University and is being held in conjunction with the 24th Annual Pennsylvania Housing and Land Development (H&LD) Conference at the Penn Stater Conference Center Hotel.

The H&LD has been a successful PHRC program for 24 years with emphasis on topics of interest to developers, builders, remodelers, design professionals, planners, regulatory and code official, modular and HUD code builders, and housing product manufacturers. The 3rd RBDC Conference is held for the third time now as a program by the PHRC to provide a forum for researchers, design professionals, manufacturers, builders, and code officials to exchange information on the latest research and development advancements and discuss and share their own findings, innovations and projects related to residential buildings.

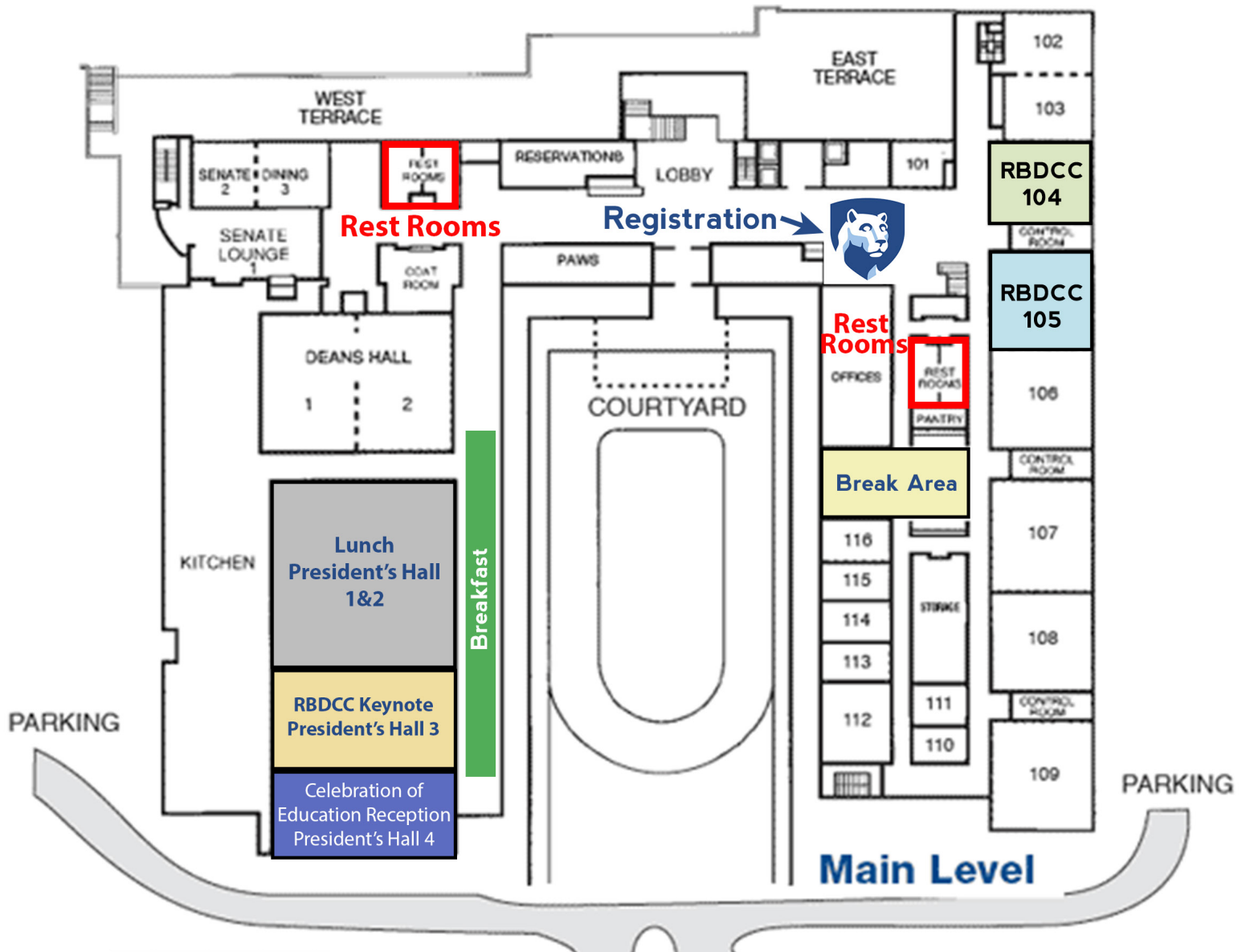
At this 3rd RBDC Conference, we are very excited to have two Keynote Speakers: **Tedd Benson**, President of Bensonwood, and **Dr. John Straube**, Principal at RDH Building Science and RDH Building Science Labs and Associate Professor in the Faculty of Engineering at the University of Waterloo. Tedd Benson will focus on the next generation of homebuilding in his presentation *"The 21st Century Craft of Sustainable Homebuilding: Culture, Technology, and Methods Toward a Better Way to Design & Build."* Dr. John Straube will focus on the importance of building science in his presentation *"Building Science: The Foundation of Future Residential Building Design and Practice."*

Most of the presentations at the conference are by university professors, researchers, graduate students, architects, consulting engineers, product manufacturers, and product related associations / councils. For this conference we have also organized a special session on Innovations in Senior Living by three leading senior living housing developers. The details of most of these presentations in the form of full papers can be found in the proceedings of the conference. The conference proceedings and slide presentations (if a full paper was not submitted) can be found on the PHRC website. I hope that you find the technical content of the conference beneficial and you enjoy the opportunities for interaction and networking with colleagues.

Ali M. Memari, Ph.D., P.E., F.ASCE, Professor
Bernard and Henrietta Hankin Chair in Residential Building Construction
Director, The Pennsylvania Housing Research Center (PHRC)
Department of Architectural Engineering and Department of Civil and Environmental Engineering
The Pennsylvania State University



CONFERENCE MAPS



CONFERENCE SCHEDULE OVERVIEW

TUESDAY, MARCH 1ST RESEARCH NIGHT SCHEDULE

4:00pm-5:30pm	Laboratory Tours	Meet @ Penn Stater
5:30pm-7:00pm	Research Night Mix & Mingle	President's Hall 4

WEDNESDAY, MARCH 2ND DAY 1 SCHEDULE

7:30am - 8:30am	Registration	Main Level
8:30am - 10:15am	Introduction, Welcome, & Keynote	President's Hall 3
10:15am - 10:45am	Morning Break	Break Area
10:45am - 12:15pm	Speaker Sessions #1 & #2	Room 104 & Room 105
12:15pm - 1:00pm	Lunch	President's Hall 1 & 2
1:15pm - 2:45pm	Speaker Sessions #3 & #4	Room 104 & Room 105
2:45pm - 3:00pm	Afternoon Break	Break Area
3:00pm - 4:30pm	Speaker Sessions #5 & #6	Room 104 & Room 105
5:30pm - 9:00pm	Education Night Reception	President's Hall 4

THURSDAY, MARCH 3RD DAY 2 SCHEDULE

7:30am - 8:30am	Registration	Main Level
8:30am - 10:15am	Introduction, Welcome, & Keynote	President's Hall 3
10:15am - 10:45am	Morning Break	Break Area
10:45am - 12:15pm	Speaker Sessions #7 & #8	Room 104 & Room 105
12:15pm - 1:00pm	Lunch	President's Hall 1 & 2
1:15pm - 2:45pm	Speaker Sessions #9 & #10	Room 104 & Room 105
2:45pm - 3:00pm	Afternoon Break	Break Area
3:00pm - 4:30pm	Speaker Session #11	Room 105





WEDNESDAY, MARCH 2ND DAY 1 SCHEDULE

Early Morning 8:30 - 10:15		Late Morning 10:45 - 12:15		Early Afternoon 1:15 - 2:45		Late Afternoon 3:00 - 4:30	
<p>Welcome & Opening Remarks <i>Dr. Ali Memari</i> <i>Dr. Chimay Anumba (Department Head of Architectural Engineering)</i></p> <p>Keynote Presentation "The 21st Century Craft of Sustainable Home Building: Culture, Technology, and Methods Toward a Better Way to Design & Build" Tedd Benson (Bensonwood)</p> <p>Presidents Hall 3</p>		<p>Session #1: Innovations in Prefabrication and Modular Construction Room 104</p> <ol style="list-style-type: none"> 1 An Approach to Analytical Modeling of Modular Vertical Expansions - <i>Tony Jellen & Ali Memari</i> 2 Building Enclosure Design for Modular Construction - <i>Joe Piñon & Colin Shane</i> 3 Ferrocast Structural Elements for Mass Housing for Low Income Group in India - <i>Arun Purandare & Mrudula Kulkarni</i> 		<p>Session #3: Sustainable Housing Case Studies & Explorations Room 104</p> <ol style="list-style-type: none"> 1 The PHFA Project: A National Net-Zero-Energy-Capable Affordable Housing Initiative - <i>Timothy McDonald</i> 2 Enhancing the Viability of Urban Housing Projects through Structural Build-over and Re-use - <i>Benjamin Cornelius</i> 3 Out of Site: A Pedagogical Perspective of Emerging Transitions in Architectural Practice - <i>Shiva Punathambekar, Lisa Iulo, & Nathaniel Belcher</i> 		<p>Session #5: HVAC, IAQ, and Fire Safety Advances Room 104</p> <ol style="list-style-type: none"> 1 Evaluating Small Diameter Ductwork in High Performance Homes - <i>Andrew Poerschke</i> 2 Evaluation of Air Quality in Buildings Located on TCE & Chloroform Contaminated Plume - <i>A Field Study - Hsin-Neng Hsieh & Haydar Erdogan</i> 3 Concepts for High Temperature Furnace Testing of Scaled Building Members and Connections under Axial Load - <i>Farshad Zahmatkesh, Ali Memari, Aly Said, Bryan Griffin, & Paul Kremer</i> 4 A Brief Discussion on Fire Safety Issues of Subdivided Housing Units in Hong Kong - <i>C.L. Chow & K.K. Leung</i> 	
<p>Break - 10:15 - 10:45</p>		<p>Session #2: Advances in Building Enclosures: Quality Room 105</p> <ol style="list-style-type: none"> 1 Comprehensive Enclosure QA for Multifamily Residential Projects - <i>John Runkle</i> 2 Validation and Verification of an Integrated Performance Model for Sustainable Envelope Performance Assessment and Design (IPM-SEPAD) - <i>Joseph Iwara & Abrahams Mwasha</i> 3 Different Methods in Building Envelope Energy Retrofit - <i>Ehsan Kamel & Ali Memari</i> 		<p>Session #4: Advances in High-Performance Homes: Energy Room 105</p> <ol style="list-style-type: none"> 1 An Assessment of Utilizing Phase Change Materials (PCM) Towards Energy Performance in Building Enclosures - <i>Abdullah Abuzaid & Georg Reichard</i> 2 Innovating Continuous Exterior Insulation - <i>Theresa Weston</i> 3 ABAA Air Barrier Research Project - <i>Peter Spafford & Laverne Dalgleish</i> 4 Improving the Energy Audit: Findings of the NELC Holistic Approach on Real Homes' Energy Consumption - <i>Kevin Ketchman, Vikas Khanna, David Riley, & Melissa Bilec</i> 		<p>Session #6: Advances in Structural Design Room 105</p> <ol style="list-style-type: none"> 1 Condition Survey of Assembled Concrete Blocks (Dox Plank) - <i>Anthony Dolhon</i> 2 Analytic Solutions for Bio-Based Renewable Construction Panels Manufactured with Non-Rigid Bonding - <i>Rafaat Hussein</i> 3 Vibration Based Approach for Structural Health Assessment in Retrofitting or Rehabilitation of Construction Buildings - <i>Rafaat Hussein</i> 4 Shear Wall Design in Residential Construction: A Comparison of Methods - <i>Ryan Solnosky & Kevin Parfitt</i> 	
		<p>Lunch - 12:15 - 1:00 Presidents Hall 1 & 2</p>		<p>Break - 2:45 - 3:00</p>			





THURSDAY, MARCH 3RD DAY 2 SCHEDULE

8:30 - 10:15	10:45 - 12:15	1:15 - 2:45	3:00 - 4:30
<p>Welcome & Opening Remarks <i>Dr. Ali Memari</i> <i>Dr. Patrick Fox (Department Head of Civil & Environmental Engineering)</i></p> <p>Keynote Presentation "Building Science: The Foundation of Future Residential Building Design and Practice" Dr. John Straube (Building Science Corporation)</p> <p>Presidents Hall 3</p>	<p>Session #7 : Universities & Net-Zero Energy Design: Solar Decathlon, Race to Zero, and Advancing the Curriculum Room 104</p> <ol style="list-style-type: none">1 A Haptic, High-Performance House: The GRoW Home - <i>Martha Bohm</i>2 The Performance of a Net Zero Home in the Solar Decathlon 2011 and Beyond - <i>Eric Holt, Nathan Berry, & Sarah Causey</i>3 Race to Zero Competition - <i>Dorothy Gerring & Rob Wazniak</i>4 "Not So Difficult Approaches" to Begin or Improve Building Science University & College Programs - <i>Patrick Huelman & Sam Taylor</i> <p>Session #8: Innovations in Senior Living Room 105</p> <p>Session Welcome & Introduction to the Session Topic - <i>Jack Willenbrock</i></p> <ol style="list-style-type: none">1 Vibrant Amenity Spaces Enhance Social Opportunities - <i>James Tracy</i>2 Improving the Quality of Residential Life Through Small-Scale Neighborhood Design - <i>Steve Muller</i>3 Hybrid Homes: The Best of Both Worlds - <i>Linford Good</i>4 Q&A Panel - <i>Jack Willenbrock, James Tracy, Steve Muller, & Linford Good</i> <p>Break - 10:15 - 10:45</p>	<p>Session #9: Advances in High-Performance Homes: Standards Room 104</p> <ol style="list-style-type: none">1 Universal Design/ Aging in Place - <i>Dorothy Gerring & Rob Wazniak</i>2 Using Real World Data to Make the Case for Passive House - <i>Laura Nettleton & Michael Whartnaby</i>3 Accounting for Sustainable Features in Housing Appraisal: The Green MLS Toolkit - <i>Shahrazad Fadaei</i>4 Opportunities and Constraints for Townhouse Developments Meeting the DOE's Zero Energy Ready Home Standard - <i>Georg Reichard & Oluwatemiola Ladipo</i> <p>Session #10: Resiliency in Natural Disasters and Climate Change Room 105</p> <ol style="list-style-type: none">1 Resilient New Design and Retrofit of Existing Buildings at Risk of Natural Disasters - <i>Tim Smail</i>2 Evaluation of Shading the Solid Parts of Building Envelopes under Climate Change Scenarios in Egypt - <i>Mohamed Mahdy & Mariatena Nikolopoulou</i>3 Sustainability: What's That, and So What? - <i>Andrew Lau</i> <p>Lunch - 12:15 - 1:00 Presidents Hall 1 & 2</p>	<p>Session #11: Advances in Building Enclosures: Moisture Room 105</p> <ol style="list-style-type: none">1 Designing and Building Resilient Wall Systems with Engineered Rainscreen Products - <i>Peter Spofford & Laverne Dalgleish</i>2 Finally, the Truth about Condensation - <i>Dan Tempas & Brian Lieburn</i>3 Effects of Exterior Insulation on Moisture Performance of Wood-Frame Walls in the Pacific Northwest: Measurements and Hygrothermal Modeling - <i>Samuel Glass, Borjen Yeh, & Benjamin Herzog</i>4 Twelve Home Case Study Homes in Michigan Yield Surprising Moisture and Air Leakage Data - <i>Brian Lieburn</i>



WEDNESDAY, MARCH 2ND

DAY 1 KEYNOTE INFORMATION



WEDNESDAY KEYNOTE SPEAKER

The 21st Century Craft of Sustainable Homebuilding: Culture, Technology and Methods: Toward a Better Way to Design & Build

TEDD BENSON - Author, Building Pioneer, Founder, and CEO of Bensonwood Homes and Unity Homes; New Hampshire

ABOUT THE KEYNOTE

Our industry is capable of building more durable, sustainable, higher performing homes; therefore we must. In our "social contract" with home-buyers, we have an obligation to build homes that are worthy of their high financial cost, and the significant role they play in our society and in people's lives. We can no longer deliver raw commodities and disaggregated parts and pieces to building sites where consistent control of quality, efficiency and waste is nearly impossible. A need for a better standard calls for a completely different "operating system," in which the highest standards are a natural outcome of an overhauled process. I will talk about our efforts and innovations toward making well-designed, high performance, zero energy homes normal and affordable. We believe homeowners have long been underserved, and it's time for the homebuilding industry to commit to building homes that are a more sustainable and ennobling contribution to our society.

ABOUT TEDD BENSON

Since 1974 Tedd Benson has been the founding owner of Bensonwood Homes. During that time, Tedd has championed high-performance, sustainable homebuilding—always with an emphasis on innovation, quality, and social responsibility. He and the company have been featured on a number of shows in the PBS series, *This Old House*, as well as *Good Morning America*, and the *Today Show*. In addition, Tedd has authored four seminal books on timberframing, the first of which, *Building the Timber Frame House*, (Scribner's Sons, 1980, Simon & Schuster, 1995) was instrumental in the revival of this centuries-old form of building with heavy timber.

Over the next two decades, Bensonwood extended its off-site fabrication capability to include the entire building shell, millwork, and mechanical systems. The company also developed a design and construction methodology called Open-Built®, which provides a rational basis for increased building efficiency and long-term sustainability. In 2008, Tedd gave a keynote speech on "The Future of Green Building" at Greenbuild - Boston. At the 2010 Greenbuild - Chicago, Tedd received a "TOP 10" Green Building Products award for his company's sustainable, R-35 OBPlusWall™.

In 2012, in an effort to bring high quality, near-zero energy homes to a broader market, Tedd optimized Bensonwood's proprietary building systems and launched a new high-performance homebuilding company, Unity Homes, with affordability as its ultimate goal. The following year, Tedd was named co-chair of the Vision 2020 Design+Performance panel tasked with re-imagining home design and construction in the US and mapping a clear path towards sustainability in residential construction by the year 2020.

Most recently, Tedd spoke at the 2015 Greenbuild International Conference and Expo in Washington, DC, with a talk entitled, "Making Sustainable Homes the New Normal". And underscoring the practicality of building high-performance homes today, Unity Homes, in partnership with Hanley Wood and a host of progressive industry suppliers, built a forward-looking demonstration home inside the Greenbuild 2015 Expo Hall, in just 3 days. The home, part of the Zūm platform of Unity homes, was honored as one of Building Green's "Top 10 Picks of 2016," and "Best of Show" by Treehugger.com.



THURSDAY, MARCH 3RD
DAY 2 KEYNOTE INFORMATION



THURSDAY KEYNOTE SPEAKER

Building Science: The Foundation of Future Residential Building Design and Practice

DR. JOHN STRAUBE - Principal at RDH Building Science & RDH Building Science Labs, Professor at University of Waterloo

ABOUT THE KEYNOTE

Residential building design and construction practices have changed significantly since the end of World War II. More changes are underway and likely to continue. One of the tools required to manage the changes will be a more scientific approach to design, product selection, and construction, alongside careful attention to the needs of the consumer. This presentation will review these trends and explore the potential for building science to improve performance, reliability, and affordability in future buildings.

ABOUT JOHN STRAUBE

John Straube, Ph.D., P.Eng., is an Associate Professor in the Faculty of Engineering at the University of Waterloo, where he is cross-appointed between the School of Architecture and the Department of Civil and Environmental Engineering. He is the author or co-author of over 100 published technical papers, author of the book *High Performance Enclosures* and co-author, with Eric Burnett, of *Building Science for Building Enclosures*. Dr. Straube's leadership as a building scientist and an educator has been recognized with multiple awards, including the Lifetime Achievement Award in Building Science Education from the National Consortium of Housing Research Centers (NCHRC). As a Principal at RDH Building Science and RDH Building Science Labs, he conducts forensic investigations, assists the design of new high performance buildings, and leads research projects in the areas of low-energy building design, building enclosure performance, hygrothermal analysis, and field performance monitoring. He has been involved in the development of dozens of new building products, and sat on several product standards committees.



WEDNESDAY, MARCH 2ND DAY 1 ABSTRACTS

Session #1: Innovations in Prefabrication and Modular Construction

Time / Location: 10:45-12:15pm, Room 104

Speaker #1	<p>Title: An Approach to Analytical Modeling of Modular Vertical Expansions Author(s): Anthony Jellen (Dawood Engineering) & Dr. Ali Memari (Penn State)</p> <p>Multi-story modular construction methods may offer advantages over site-intensive construction methods for some vertical expansion projects. Vertical expansions can be design-intensive depending on the condition of the existing building and the availability of design documentation. Feasibility of a modular vertical expansion is highly dependent on a variety of factors such as local ordinance and code, the building construction type and use, as well as the site and existing building conditions.</p> <p>Identifying those factors that can adversely affect feasibility on complex projects, such as vertical expansion, can often be difficult in the preliminary design stages. Front-end planning tools can be used to help identify those factors early on in the preliminary design stages to help eliminate costly design errors. In modular projects, design errors could have an amplified effect due to the inability to make design changes after module production has begun.</p> <p>In this paper, some of the factors that can affect the feasibility of a modular vertical expansion are explored, and the benefits of using a coarse finite-element modeling approach to help identify those factors are discussed. A case study is used to demonstrate this approach and provide project-specific factors, some of which can be generalized to other modular applications. The results of the case study show the important planning information that can be obtained by studying generalized structure behavior in the front-end portion of the design.</p>
Speaker #2	<p>Title: Building Enclosure Design for Modular Construction Author(s): Joseph Piñon (RDH Building Sciences, Inc.) & Colin Shane (RDH Building Sciences, Inc.)</p> <p>Many of the advantages associated with modular wood-frame construction compared to traditional stick-built framing are generally well accepted in the industry: increased quality control, indoor construction, shorter project schedules, ability to service remote locations, and in some cases favorable pricing. Despite all of these advantages, special attention needs to be given to the integration of the building enclosure components, both within and between building modules, to ensure that the performance of these modular buildings meet the expectations of all parties involved.</p> <p>This paper will focus on the building enclosure functions of heat, air, and moisture control in wood-framed residential buildings, and will apply these concepts to the realities of modular construction. Specifically, this paper will detail lessons learned through design and construction of two recently completed modular construction projects. The first project is a multi-unit dormitory located in an isolated northern climate and incorporates super-insulated assemblies and Passive House certification requiring a high performance building enclosure. The second project is a multi-unit transit-oriented and affordable housing development in the San Francisco Bay Area.</p> <p>This paper will inform designers and builders about building enclosure design considerations in modular construction.</p>
Speaker #3	<p>Title: Ferrocass Structural Elements for Mass Housing For Low Income Group in India Author(s): Arun N. Purandare (ANP Consultants) & Dr. Mrudula Kulkarni (Maharashtra Institute of Technology - Pune, India)</p> <p>The present work aims at providing structural design and methods of manufacturing of structural components designed using light weight ferrocass cement. The Ferrocass technology uses reinforced cement mortar to cast structural components of low cost housing scheme. The method of manufacturing these structural components is suggested. This method of manufacturing when employed for mass manufacturing of components, will control cost of housing at minimum level. The method of construction suggested promotes fast construction, making it advantageous, economical in many situations. The technology proposed for low cost housing using ferrocass cement uses ight weight elements, low technology manufacturing and quick responses to constructional need, hence this proposes a solution that is unmatched with normal reinforced concrete construction. This poses a very good alternative for construction industry to face ever increasing demand of low cost, mass housing in India.</p>

WEDNESDAY, MARCH 2ND

DAY 1 ABSTRACTS

Session #2: Advances in Building Enclosures: Quality

Time / Location: 10:45-12:15pm, Room 105

Speaker #1	<p>Title: Comprehensive Enclosure QA for Multi-family Residential Projects</p> <p>Author(s): John Runkle (Intertek / Architectural Testing)</p> <p>Wood framed multi-family residential buildings are often overlooked for application of state of the art practices as they are viewed as highly commoditized, cheap and fast construction. Additionally, the desire for increased durability and energy performance is often not a driver as developers frequently sell these units and utility costs are born by the tenant. However, many large developers are starting to alter their stance by seeking comprehensive building enclosure quality assurance to minimize the chances of leaks/litigation/mold, reduce energy usage, minimize maintenance, maintain unit delivery and ultimately enhance the value of their units. But, as the functional performance layers required for environmental separation (e.g. air, water, thermal and vapor) are buried within the wall assembly such that they are not visible/accessible post construction, the importance of sound design and construction is increased, and effective building enclosure quality assurance plans must start early in the design process and include elements such as mock-ups so that early learning is maximized.</p> <p>A robust quality assurance program can be created by involving building enclosure professionals during the early stages of design and continuing throughout the O & M phase. This presentation will review this comprehensive enclosure quality assurance process, including:</p> <ul style="list-style-type: none"> • Creating a clear Owner's Project Requirements (OPR) document outlining the performance expectations of the building enclosure. • Systems discussions with all team members, including the Owner, Architect, General Contractor and other consultants as they relate to the building enclosure. • How the use of Revit models assists in the construction process • The use of web-based systems for coordination and tracking of inspections by the building enclosure professionals • The use of methods such as Electric Field Vector Mapping and Field Testing such as ASTM E1105 or D5957 to assist with verification of installed assemblies • Final verifications, and one year walkthroughs after substantial completion
Speaker #2	<p>Title: Validation of an Integrated Performance Model for the Assessment and Design of Sustainable Residential Building Envelope in Trinidad and Tobago - IPD-SEPAD Validation</p> <p>Author(s): Dr. Joseph Iwaro (University of the West Indies) & Dr. Abrahams Mwasha (University of West Indies)</p> <p>Environmental concerns and the continual drive for sustainable buildings has led construction and building industries to look more closely at sustainable development and the sustainability of proposed and existing residential building envelopes. Many building performance assessment methods such as LEED, BREEAM and Green Star etc. have been developed across the world while their designed goal of achieving building sustainability is yet to be achieved. The important shortcomings of these methods include lack of life cycle performance assessment framework for life cycle cost, life cycle energy efficiency, life cycle embodied energy, life cycle carbon emission, thermal energy, inability to connect performance value with weight, inadequate coverage of sustainability issues associating with buildings, lack of multi criteria analysis framework and lack of consideration for social issues. In view of these concerns, an Integrated Performance Model for Sustainable Envelope Performance Assessment and Design (IPM-SEPAD) was developed in this study. Therefore, the focus of this present study is to validate the outcomes from the application of IPM-SEPAD to three residential building envelope design case studies through an experimental investigation involving three physical building envelope models. This is to ensure that the IPM-SEPAD is comprehensive, robust and effective in carrying out the sustainable performance assessment and design of the building envelope for building sustainability. The findings obtained suggest that the model is valuable and suitable for sustainable practices in Trinidad and Tobago, and the wider Caribbean region.</p>
Speaker #3	<p>Title: Different Methods in Building Envelope Energy Retrofit</p> <p>Author(s): Ehsan Kamel (Penn State) & Dr. Ali Memari (Penn State)</p> <p>With about 40% of energy consumption in the U.S.A. in 2011 consumed by Residential and Commercial sectors, different energy retrofit measures that lead to reduction in energy consumption for these sectors can result in a significant change in total energy consumption nationwide. Therefore, it is important to study the existing energy retrofit methods and investigate how effective these methods can be. These measures can be categorized into three main groups including energy retrofit and improvement of the building envelope, mechanical, and electrical systems.</p> <p>This paper focuses mainly on different methods of building envelope energy retrofit. Examples of such methods include installation of exterior insulation such as rigid foam to wall or roof, installation of cool/warm roof, reducing air infiltration, changing windows properties such as SHGC, application of PCM and Aerogel in different envelope components, and adding overhangs. The required data for this study are obtained from experimental and numerical studies available in the literature. Moreover, a computer model is developed using BEopt to study and compare the effectiveness of single and multiple retrofit methods in a residential building.</p>

WEDNESDAY, MARCH 2ND

DAY 1 ABSTRACTS

Session #3: Sustainable Housing Case Studies & Explorations

Time / Location: 1:15-2:45pm, Room 104

Speaker #1	<p>Title: The PHFA Project: A National Net-Zero-Energy-Capable Affordable Housing Initiative</p> <p>Author(s): Timothy McDonald (Onion Flats)</p> <p>In the Spring of 2014 The PHFA Project set out to have all affordable housing in Pennsylvania be designed and constructed to a Net-Zero-Energy- Capable standard by 2030. In 2015 PHFA became the first Housing Finance Agency in the country to adopt "Passive House" as part of their scoring criteria. PHFA awarded funding to EIGHT multifamily Passive House projects, 422 units, the largest concentration of Net-Zero Energy-Capable dwelling units in the country. The construction cost premium was less than 2%. 35 other State Housing Finance Agencies are currently engaged to replicate this initiative underway in PA.</p> <p>The PHFA Project is changing the conversation about the viability and "affordability" of Passive House/Net-Zero-Energy-Capable affordable housing in the United States. Within the first year of this 15 year project, a momentous shift in both the awareness and adoption of Passive House design and building principles within the development community in the US is occurring. Additionally, while this project is initially targeted at the 'affordable housing' sector, it also trains precisely the same design and building professionals responsible for the 'market-rate housing' sector. The PHFA Project, therefore, is a catalyst for radical and significant market penetration of Passive House/Net-Zero-Energy-Capable housing not just in Pennsylvania but throughout the country. This presentation will tell the story of The PHFA Project, its conceptual origins at Temple University, the unique opportunity inherent within policy-driven strategies of Housing Authorities across the United States and the importance of the collaborative and interdisciplinary group of "stakeholders" that have made it a reality in PA. It will also present several multi-family projects Passive House projects funded through the first round in both PA and other States.</p>
Speaker #2	<p>Title: Enhancing the Viability of Urban Housing Projects through Structural Build-over and Re-use</p> <p>Author(s): Benjamin Cornelius (Leslie E. Robertson Associates)</p> <p>Structural engineers can contribute to a more sustainable built environment by finding ways to re-use existing structures in new projects. For residential projects in dense urban areas, where demand for new homes is high and open land is scarce, structural re-use is sometimes paired with another strategy: structural build-over. Urban structural build-over projects often involve the transfer of air-rights from the landowner to another party, who then designs a project to fill the volume of air above an existing building. A structural engineer for this type of project is called upon to design a new structure to bridge over, and in some cases support, an existing building on the site, below. In urban housing projects, the combination of structural build-over and re-use not only leads to potentially enhanced sustainability, it can also be critical to a housing project's economic and logistical viability.</p> <p>In this presentation, Benjamin Cornelius, Partner at Leslie E. Robertson Associates Consulting Structural Engineers, will examine factors affecting the reuse of existing structures in combination with structural build-over techniques, approaches to satisfying code requirements that pertain to structural re-use, and strategies for addressing the unique challenges associated with structural build-over projects. Mr. Cornelius will illustrate these topics using a case study involving the construction of a new condominium building over an existing, occupied bank branch office on an underdeveloped site in the Carnegie Hill Historic District of New York City's Upper East Side.</p>
Speaker #3	<p>Title: Out of Site: A Pedagogical Perspective of Emerging Transitions in Architectural Practice</p> <p>Author(s): Shiva Punathembekar (Penn State), Lisa Iulo (Penn State), & Nathaniel Belcher (Penn State)</p> <p>Energy Efficiency is one of the five strategic themes of the Penn State Institutes of Energy and the Environment (PSIEE), which has supported a Sustainable Housing Initiative (SHI) to leverage faculty and student expertise on residential building design and construction. The goal of this initiative is ambitious - to initiate a process that will radically transform the residential building sector from an energy perspective, with partners that will scale-up innovation to a regional and eventually national or international scale.</p> <p>As a short-term curricular agenda for the collaborative team of the Sustainable Housing Initiative, different student classes are coordinating with Penn State's Office of Physical Plant (OPP), Housing, Food Services and Residence Life (H&FS), and with industry representatives such as sustainability consultants to improve the environmental performance of buildings on campus. To that end, an interdisciplinary team of students are interacting simultaneously with the commissioned design team of a 'real' Penn State project, the Trippe residence hall, to develop design proposals in lockstep with the professional team to produce curricular research that impacts the built environment.</p> <p>This research in turn is informing a larger agenda of the Sustainable Housing Initiative – the process of leveraging the University's strong research base to distill the lessons learnt from these collaborative projects and understand the potential implications for the Architecture, Engineering and Construction (AEC) industry.</p>

WEDNESDAY, MARCH 2ND DAY 1 ABSTRACTS

Session #4: Advances in High-Performance Homes: Energy

Time / Location: 1:15-2:45pm, Room 105

Speaker #1	<p>Title: An Assessment of Utilizing Phase Change Materials (PCM) Towards Energy Performance in Building Enclosures Author(s): Abdullah Abuzaid (Virginia Tech) & Dr. Georg Reichard (Virginia Tech)</p> <p>This paper assesses the opportunities of utilizing Phase Change Materials (PCMs) in building enclosure systems to improve energy performance and thermal comfort in buildings. The building sector continues to grow along with population growth, which will further increase energy consumption that is needed for space heating and cooling to provide thermal comfort for occupants. With many practical applications, PCMs are capable of storing and releasing significant amounts of energy by melting and solidifying at a given temperature and can play an important role as a thermal energy storage device by utilizing its high storage density and latent heat capacity. PCMs not only have the potential to reduce air conditioning energy consumption in residential and commercial buildings, but also have the potential to improve occupancy comfort by better maintaining desired surface temperatures. PCMs can be utilized to decrease the overall required energy of buildings by shifting part of the heating and cooling loads to off-peak hours when there is less energy demand within our utility grids. One of the potential applications for PCMs in buildings is to incorporate them within the building enclosure for energy storage. Our research investigates PCMs in an experimental study, from which we will extrapolate results to apply for residential application in different U.S. climate zones. The research extrapolation will be supported by simulation tools, which are capable of simulating PCMs in the building context. The study will also explore different factors contributing to other thermal performance criteria, such as the thermal conductivity and applicable temperature ranges of different PCMs. The results will be presented for better understanding of PCMs' thermal behavior as well as demonstrating the applicability of using PCMs towards improving building performance and overall energy consumption in different climate contexts.</p>
Speaker #2	<p>Title: Innovating Continuous Exterior Insulation Author(s): Dr. Theresa Weston (DuPont)</p> <p>As the need to reduce energy usage and carbon consumption has increased, the need for energy efficient building envelopes has increased. The application of continuous exterior insulation in frame construction is a key technology to achieving an energy efficient building envelope. Continuous exterior insulation includes a variety of products, including insulating sheathing and insulated claddings and while these products have long been available, recent advances in the energy codes have spurred innovation in products and application techniques. This paper reviews the benefits of exterior continuous insulation, including the increase in wall effective R- value, reduction of thermal bridging, and reduction of potential for vapor condensation. The challenges of integrating exterior insulation into a wall system, including the complications of interfaces with other building components and the reduction in wall drying potential and water management will also be reviewed. Finally, this paper will describe recently introduced continuous insulation products and explore how they meet these challenges.</p>
Speaker #3	<p>Title: ABAA Air Barrier Research Project Author(s): Peter Spafford (Air Barrier Association of America) & Laverne Dalgleish (Air Barrier Association of America)</p> <p>The Air Barrier Research Project covers years of in field testing and laboratory testing using ASTM E2357 test requirements. The key question to answer was "Do air barriers reduce energy use?" For years the Department of Energy stated in their documents that reduced air leakage could account for 10% to 40% energy savings for heating and cooling. The hypothesis for this research was that air barriers do save energy used to heat and cool a building. The research covers the construction and monitoring of wall specimens in a two story test facility which was constructed at Syracuse University. There were two rounds of testing, one set involved air barrier manufacturers installing two different air barriers on the wall specimens and then monitoring these over a period of one year. The second set of wall specimens were constructed into three different air leakage rates using the seven different types of air barriers recognized by the Air Barrier Association of America. Laboratory testing of air barrier sub-assemblies was also conducted on wood framed walls. Some of the results were unexpected.</p>
Speaker #4	<p>Title: Improving the Energy Audit: Findings of the NELC Holistic Approach on Real Homes' Energy Consumption Author(s): Kevin Ketchman (University of Pittsburgh), Vikas Khanna (University of Pittsburgh), Dr. David Riley (Penn State), & Dr. Melissa Bilec (University of Pittsburgh)</p> <p>Curbing demand-side energy consumption is a vital component to successful energy policy in the United States and worldwide. The energy audit is considered a key player in disseminating energy information, influencing energy efficiency investments, and bridging the energy efficiency gap within the residential sector, where 20% of national energy consumption occurs. However, state-of-the-practice energy audits fall short in fulfilling this role. Studies suggest as high as 70% of energy retrofit recommendations are ignored by homeowners (Murphy 2014). A study by Fuller et al. at Lawrence Berkeley National Laboratory (2010) examined fourteen existing energy efficiency programs across the nation to discern successful factors in delivering energy efficiency measures to homeowners. They concluded that a holistic approach must be adopted by energy audits to see increased implementation of energy retrofits, a conclusion supported by other researchers in the community (Masoso and Grobler 2010; Ingle, Moezzi et al. 2012; Palmer, Walls, et al. 2013; Hoicka, Parker et al. 2014).</p> <p>Applying a holistic approach to energy assessments, the National Energy Leadership Corps (NELC) has developed a method for engaging homeowners' on their energy consumption through student-performed energy assessments. NELC Energy assessments are adapted from standard energy audits to reduce costly measurements and analysis and increase emphasis on occupant engagement and provide an ideal setting for building deeper relationships with homeowners. The DOE funded NELC program was launched by Penn State and implemented at the University of Pittsburgh in 2012 where over 120 energy assessments have been completed throughout the Pittsburgh, PA community. The lessons learned through the development of the NELC will be presented, and a comparison of utility bills prior to and since the performed energy assessment in combination with pre- and post-assessment survey data will be included.</p>

WEDNESDAY, MARCH 2ND DAY 1 ABSTRACTS

Session #5: HVAC, Indoor Air Quality, & Fire Safety Advances

Time / Location: 3:00-4:30pm, Room 104

Speaker #1	<p>Title: Evaluating Small Diameter Ductwork in High Performance Homes Author(s): Andrew Poerschke (IBACOS)</p> <p>IBACOS will discuss current and ongoing research into alternative and simplified space conditioning strategies. Modern, energy efficient homes require new approaches to providing comfort while maximizing energy efficiency. Results from six test homes investigating the comfort and performance of a small diameter duct system and a mini split heat pump, compared to conventionally sized ducts will be presented for both the heating and cooling season. Cutting edge research on a duct manifold system currently being studied at the Pittsburgh unoccupied lab house will also be presented. These results represent the first field test of a new duct design and configuration methodology that IBACOS has been investigating, which promises to greatly simplify the design and installation of air distribution systems.</p>
Speaker #2	<p>Title: Evaluation of Air Quality in Buildings Located on TCE & Chloroform Contaminated Plume - A Field Study Author(s): Dr. Hsin-Neng Hsieh (NJ Department of Environmental Protection) & Dr. Haydar Erdogan (NJ Department of Environmental Protection)</p> <p>Vapor intrusion (VI) has been recognized since the 1990s as a potential pathway of concern at contaminated sites. VI is the migration of volatile organic compounds (VOCs) from the subsurface soils into overlying buildings. The major sources of organic vapors are waste disposal sites (landfills), contaminated old industrial sites, contaminated subsurface soils, and contaminated groundwater. The volatile organic compounds of concern in vapor intrusion are usually divided into two categories: chlorinated VOCs and petroleum hydrocarbons.</p> <p>Several residential and commercial buildings were built on a closed old industrial site in the 1990s. Due to the presence of TCE and chloroform in a groundwater plume located under the site, VI investigation was conducted at the commercial and residential buildings located on and around the site. Sub-slab soil gas and indoor air samples were collected to determine the indoor air quality in these buildings using Summa canisters equipped with flow controls. All samples were analyzed for volatile organic compounds using the USEPA Method TO-15. The analytical data were compared with background ambient air data and the New Jersey Department of Environmental Protection (NJDEP) soil gas and indoor air screening levels.</p> <p>The results indicated that chlorinated volatile organic compound including TCE and chloroform were present above the NJDEP screening levels in the sub-slab soil gas and indoor air samples collected from several buildings. To remediate the existing condition, a sub-slab depressurization system (SDS) was installed under the slab of each building with elevated levels of TCE and chloroform. After installation of the SDS, indoor air sampling was performed to determine the indoor air quality in these buildings. It was recommended that yearly inspection of the SDS and indoor air sampling be conducted.</p>
Speaker #3	<p>Title: Concepts for High Temperature Furnace Testing of Scaled Building Members and Connections under Axial Load Author(s): Dr. Farshad Zahmatkesh (Penn State), Dr. Ali Memari (Penn State), Dr. Aly Said (Penn State), Bryan Griffin (Penn State), & Paul Kremer (Penn State)</p> <p>Fire can have one of the most damaging and harmful exposure conditions on building components throughout their life-cycle. Recent developments in building materials and designs, such as new architectural trends in sustainable, green, and energy-efficient focused materials and components, have introduced new fire scenarios. Lack of adequate understanding of the behavior of new and emerging materials under fire and high temperature conditions can lead to unpredicted property damage or injury of building occupants. One objective of this paper is to review documented full-scale fire tests on building components and identify potential constraints and conditions that will yield suitable alternative testing options at the small scale. Reduced cost and time and safety considerations make fire testing of small-scale specimens a desired alternative to full-scale fire testing. In the current study, the use of a scaled-down model and full-scale, but small-size connections are considered for small-scale electric lab furnace as alternatives to conventional, full-scale fire testing. This elevated temperature testing approach allows developing a better understanding of the behavior of certain materials and connections when exposed to high temperature under structural load by more convenient and affordable means.</p>
Speaker #4	<p>Title: A Brief Discussion on Fire Safety Issues of Subdivided Housing Units in Hong Kong Author(s): K.K. Leung (City University of Hong Kong) & C.L. Chow (City University of Hong Kong)</p> <p>Subdivided unit (SDU) is a new type of residential housing affordable to the fundamental class citizens of Hong Kong. A flat is subdivided into smaller units in both domestic buildings and industrial buildings without government approval. Fire hazard of SDUs is a public concern, which should be assessed properly.</p> <p>In this paper, fire hazards of SDU will be discussed. Fire regulations for SDUs by the local government will be summarized. Fire accidents happened in SDUs will be briefly reported. A survey was carried out on the potential fire hazards of SDUs located in eight residential buildings and two industrial buildings. Based on the surveyed results, recommendations were made along four areas on fire safety auditing; upgrading the design, installation and maintenance of appropriate fire safety provisions; raising the awareness of occupants on fire safety and providing suitable training; and the establishment of a Building Fire Warden System.</p>

WEDNESDAY, MARCH 2ND

DAY 1 ABSTRACTS

Session #6: **Advances in Structural Design**

Time / Location: 3:00-4:30pm, Room 105

Speaker #1	<p><u>Title:</u> Condition Survey of Assembled Concrete Blocks (Dox Plank) <u>Author(s):</u> Anthony Dolhon (Exponent, Inc.)</p> <p>Condition surveys can be challenging for existing floor and roof slabs constructed of assembled concrete blocks, also known as Doc's Blocks and Dox Plank. Assembled concrete blocks that were manufactured in the 1940's, 1950's, and the 1960's, remain widely in use today throughout the Midwest and the East Coast in schools, motels, apartments, nursing homes, offices, churches, and single family homes. Historical data, design theory, and basis information on the manufacturing process of assembled concrete blocks are not readily available, but these are an important part of the condition survey investigation. Unfortunately, applying the current state of practice in pre-stressed concrete planks will give misleading results. Assembled concrete blocks are machine-made, prefabricated, modular units of pre-cast concrete, with light weight aggregate, made of low strength, hollow core block, bonded together using deformed steel bars grouted into performed voids (i.e., hollow cores). Some blocks have tongue and groove edges and also grooves along the top corners to aid in composition action. This paper aids designers, building officials, and the forensic architect/engineer in conducting a condition survey of assembled concrete blocks in service. It provides a resource on the early developments in precast concrete construction, period design guides, reference standards, patents, technical manuals, product catalogs, and design theory, with tips on conducting a condition survey.</p>
Speaker #2	<p><u>Title:</u> Analytic Solutions for Bio-Based Renewable Construction Panels Manufactured with Non-Rigid Bonding <u>Author(s):</u> Dr. Rafaat Hussein (SUNY College of Environmental Science and Forestry, Syracuse)</p> <p>Under the immense pressure of environmental, energy, economic, and other modern problems, many new materials have been scientifically developed. There is a wide range of renewable materials developed from natural and manmade resources as polymers and composites. Yet, the state of scientific advancements apparently lags behind their applications in the buildings sector. One may argue that there is a gap between the discovery of those materials and the state of residential construction. The needed knowledge about these materials for the engineering designs may shed light on that gap. To elaborate, structural insulated panels have been successfully used nationwide but why renewable components such as green adhesives and biodegradable foams have not been applied as load bearing elements in modular and panelized buildings?</p> <p>This paper is the result of an in-progress effort to close the gap between the scientific development of materials and their applications. It will present accurate analytic models developed for panels manufactured with non-rigid bonding and subjected to various loads. The models are useful to ascertain the effects of the finite values of bonding stiffness on the performance and responses of the panels. Numerical and experimental results indicated that the customary assumption of perfect bonding should not be used beyond a certain level of stiffness. This discovery also provided an answer to what constitutes perfect bonding.</p>
Speaker #3	<p><u>Title:</u> Vibration Based Approach for Structural Health in Retrofitting or Rehabilitation of Construction Buildings <u>Author(s):</u> Dr. Rafaat Hussein (SUNY College of Environmental Science and Forestry, Syracuse)</p> <p>Reports after reports have documented the fragility state of many buildings and called for the urgent attention because of their critical disrepair state due to aging and degradation. Delaying prompt actions implies a high risk of catastrophic failures and probable human loss. Retrofitting and rehabilitation provide remedies to reduce the vulnerability of those systems. Almost always, data about the structural health of the components in a building being considered for retrofitting or rehabilitation is required for any engineering calculations. Nonetheless, the true structural condition is challenging to the practitioners in many projects because of the complexity of geometry, framing systems, detailing of connections, workmanship, etc. This paper is an attempt to deal with these complexities in an easy to apply procedure yet leading to reliable and fast outcomes. It will present a novel approach to assess the stiffness of joints of aged members based on the vibration rigorous fundamentals that have been proven reliable. The procedure require a widely available and affordable signal conditioner, and an algorithm that can be easily developed in a spreadsheet. The method has been successfully evaluated via numeric results obtained.</p>
Speaker #4	<p><u>Title:</u> Shear Wall Design in Residential Construction: A Comparison of Methods <u>Author(s):</u> Dr. Ryan Solnosky (Penn State) & Dr. Kevin Parfitt (Penn State)</p> <p>Current building codes and standards for residential construction are complex and easily misunderstood when it comes to the requirements pertaining to wood shear walls that act as the lateral load resisting system. These walls fall under two categories: engineered or prescriptive in regards to design. This paper will discuss a comparison of provisions and guidelines between the IBC, IRC, NDS, and WFCM. Details will focus on the differences, limitations, and general processes necessary to conduct wood shear wall designs. The results will give designers and builders a better understanding of the complexity of shear wall code provisions and how to go about designing and constructing shear walls through clarifying code intent. Other propriety systems or uncommon engineering-critical solutions will also be discussed and how to approach those projects.</p>

THURSDAY, MARCH 3RD

DAY 2 ABSTRACTS

Session #7: Universities & Net-Zero Energy Design: Solar Decathlon, Race to Zero, and Advancing the Curriculum

Time / Location: 10:45-12:15pm, Room 104

Speaker #1	<p>Title: A Haptic, High-Performance House: The GRoW Home Author(s): Martha Bohm (SUNY Buffalo)</p> <p>This paper discusses the design, construction, and operation of a high-performance passive / active solar residential project which fundamentally engages ecology through daily and annual thermo-climatic patterns of sun and climate. Designed for the 2015 Solar Decathlon competition, the GRoW home endeavors to give solar energy tactile and haptic form, expanding upon the intangible electrical energy generated on the rooftop with photovoltaic panels. This house aims to bring residential occupants into an experiential and ritualized engagement with the biotic and abiotic elements of the solar-based ecology in which they participate. The house's architecture gives the user agency in the stewardship of these energetic flows to simultaneously create a dynamic and captivating set of spaces and a less fossil fuel-intense means of living. This paper reviews the core design concepts which influenced decisions of passive heating and natural ventilation, envelope construction, HVAC system selection and configuration, interior layout and detailing, and performative furniture design. It provides an overview of the analysis processes of lighting and energy simulation throughout design to provide quantitative feedback to the design in the development of performance. Last, it reviews the measured performance of the house during its competition period in Irvine, CA.</p>
Speaker #2	<p>Title: The Performance of a Net Zero Home in the Solar Decathlon 2011 and Beyond Author(s): Dr. Eric Holt (University of Denver), Dr. Nathan Barry (University of Nebraska), & Sarah Causey (Microdesk)</p> <p>The Solar Decathlon is a biennial Department of Energy (DOE) collegiate contest wherein twenty universities are selected to design, build, and showcase residential structures that would ultimately be relocated to a competition campus to be viewed by the general public and judged by representatives of the DOE. The project structures are homes that are designed and built to conform to the parameters set forth by the DOE in an effort to showcase the use of solar power as a practical means of residential line voltage power supply. The projects are then judged according to how well they performed within those parameters.</p> <p>The challenges involved in the design, construction, and operation of a "netzero" house, that is a house that produces at least as much electricity as it consumes, were formidable. Equally formidable were the technical/logistical issues inherent in designing and constructing a building that could be disassembled and transported. Multidiscipline work groups analyzed the architectural, structural, mechanical, electrical, plumbing, building controls, and photovoltaic performance requirements. These systems not only had to be integrated within each other, but they also had to work within a tight construction budget and build schedule. Those requirements are challenging enough on a normal construction project. Added to the complexity is that the home was built on the university campus and then shipped to the competition site, and then shipped back to its permanent location.</p> <p>This paper highlights the process and strategies that a team utilized to design, build, operate, move, and successfully compete in the Solar Decathlon with a net zero home. It also presents the energy usage data that has been collected since it was rebuilt on a permanent location for January 2014 to July 2015.</p>
Speaker #3	<p>Title: DOE Race to Zero Competition Author(s): Dorothy Gerring (Pennsylvania College of Technology) & Rob Wozniak (Pennsylvania College of Technology)</p> <p>Pennsylvania College of Technology students led the development of superefficient affordable housing in the Williamsport, PA community by combining the DOE Race to Zero Student Design Competition with designing and building a Passive House certified home for Habitat for Humanity. Meeting Passive House criteria means that the duplex will also receive DOE Zero Energy Home and Energy Star certification. The Race to Zero is a new competition offered by DOE as a complement to the Solar Decathlon which is intended to inspire and develop college students in building related fields while strengthening the building science curriculum. This competition has clear requirements for creating a robust set of documents for super-efficient homes which are affordable and ready for renewables. At Penn College there are a variety of majors that deal with all aspects of design, estimating, and construction of buildings. Nine interdisciplinary students volunteered to design a home for Habitat. Their documentation was used for Race to Zero competition April 2015 where they won Grand Winner Finalist. Their documents will be used for obtaining building permits in summer 2016. Students worked as an integrated team to determine how to meet certification criteria for a Passive House building while keeping the price of construction affordable to county median income levels and use products that could be built with volunteers. Habitat intends to gain certification for the home and monitor post occupancy for evaluating performance. The combination of local talents and need for affordable housing has resulted in surpassing expectations; improving the neighborhood and two family's quality of living; educating students, professionals, and the public about building performance; and set a community example for a successful superefficient affordable house. This presentation will share project documentation showing how to successfully design an affordable duplex to meet Passive House standards.</p>
Speaker #4	<p>Title: "Not So Difficult Approaches" to Begin or Improve Building Science University & College Programs Author(s): Dr. Patrick Huelman (University of Minnesota) & Sam Taylor (Building Science consultant, US DOE retired)</p> <p>This paper will suggest approaches for beginning, expanding, and improving building science education in colleges and universities – in the context of increasing university and other constraints to changes in curricula. Examples would be provided for infusion of building science into traditional courses and the teaching of building science fundamentals. Resources for adapting traditional courses and traditional teaching resources and teaching building science fundamentals, as well as special advanced courses, would be described.</p> <p>The <i>Toronto Building Science Education Workshop</i>, April 6, 2014, as well as previous meetings and workshops, addressed institutional and other issues impeding building science education in universities and colleges. Possible solutions to the issues were raised, and priority near term actions was suggested. The need was identified for a having good building science fundamentals course, perhaps in the second or third year of undergraduate programs, and infusion of building science into traditional courses (since crowded curricula left little room for new courses). Also, continued support for special courses such as "building science for building enclosures, and building forensics, was noted.</p> <p>The Second Annual Westford Building Science Education Update, August 3, 2014, began this process. At Westford, the development of a new Building Science Fundamentals textbook, with slide modules adaptable by professors, was announced. A new series of webinars on building science infusion and fundamentals would review approaches and content for both infusion and fundamentals. Also announced were expanded building science resources for the Race to Zero (RTZ) Student Design Competition. The first two RTZ competitions have resulted in almost 50 schools with motivated students and faculty understanding the value of building science education, many demonstrating good building science competency. With a growing number of schools participating in the RTZ and their motivated faculty, it is important that "not so difficult" approaches and teaching resources are available to implement or expand university building science education.</p>

THURSDAY, MARCH 3RD

DAY 2 ABSTRACTS

Session #8: Innovations in Senior Living

Time / Location: 10:45-12:15pm, Room 105

Session note: This session is organized and moderated by Emeritus Hankin Chair Dr. Jack Willenbrock and will follow a slightly modified organizational schedule from other RBDCC sessions. This includes a Session Welcome and Introduction to the Session Topic for approximately 15 minutes before the start of the speakers, and Q&A will be saved until the end of the full session.

	<p>Title: Session Welcome</p> <p>Presenter: Dr. Jack Willenbrock (Emeritus Hankin Chair, Penn State)</p>
	<p>Title: Introduction to the Session Topic</p> <p>Presenter: Linford L. Good (Landis Homes)</p>
Speaker #1	<p>Title: Vibrant Amenity Spaces Enhance Social Opportunities</p> <p>Presenter: James M. Tracy (Willow Valley Communities)</p> <p>One of the primary keys for Willow Valley Communities in continuing to attract and engage the active senior has been its dedication to creating innovative common area environments that provide social gathering places and allow Residents to explore various recreational and cultural opportunities.</p> <p>This part of the session will provide an overview of some of the key ideas and design concepts Willow Valley Communities is using to create vibrant social spaces for their Residents. The discussion will focus on four trends in Senior Living --- Wellness & Cultural Activities, Socialization & Intergenerational Engagement, Indoor/Outdoor Connections, and Unique Dining Venues.</p> <p>An 80,000 sq. ft. Cultural Center features large fitness and aquatics spaces, outpatient therapy, a café and a day spa on its lower level. On the upper level, there is an education room, a two-section ballroom and a 500-seat theater. Through a design-build approach, Willow Valley has been able to create a cost-effective space that has a profound impact on bringing Residents from both campuses together.</p> <p>The addition of a 30,000 sq. ft. Clubhouse allows Willow Valley Communities to expand its offerings and deepen its commitment to intergenerational interaction. The building features a bowling alley, a sports center, outdoor pool and tennis courts, a game room, conference area, private dining and a 200-seat full service restaurant and bar. Again, our design-build approach allows for maximum cost-effectiveness.</p>
Speaker #2	<p>Title: Improving the Quality of Residential Life Through Small-Scale Neighborhood Design</p> <p>Presenter: Steve Muller (Garden Spot Village)</p> <p>Garden Spot Village is developing a small-scale neighborhood community that we believe will make a big difference in the quality and health of the lives of those who will live there. Post WWII residential and community design has centered on accessibility by automobile, increasing physical distance between living accommodations and shopping, industry or services, and decreasing or eliminating sustainable travel like walking and bicycling. Small-scale neighborhood design brings back walkability and encourages social interaction. It is not a new concept, but rather one that predates the rise of a suburban lifestyle that has left many in our society living as nameless, faceless people in anonymous neighborhoods.</p> <p>We will explore our application of this pattern of housing which fosters a strong sense of community among nearby neighbors, while preserving their need for privacy. It draws on design principles from a by-gone era, when people lived in small villages or tight-knit neighborhoods and where they knew, and were known by, their neighbors.</p> <p>Often referred to as pocket neighborhoods, these are small, clustered groups of neighboring houses gathered around a shared commons or green space. They are communities where people live a "front porch life" that facilitates social interaction and relationships. This style of community will offer a number of significant benefits that will allow individuals to live healthier, more active lives as they age.</p>
Speaker #3	<p>Title: Hybrid Homes: The Best of Both Worlds</p> <p>Presenter: Linford L. Good (Landis Homes)</p> <p>Hybrid homes offer a senior living option that combines the best of both single-level cottage homes and multi-story apartment living. Multiple exposures, garage parking, outdoor living and an absence of corridors are like a cottage home. Apartment-like features include indoor access to common areas providing opportunities for social connections in shared living spaces including hearth rooms and a community room.</p> <p>Three-story building is comprised of ground floor parking garage with six hybrid homes on each of the two floors above. A small-scale building of 12 homes allows for efficiencies of residential construction, yet offers the higher density of multi-story construction. The number of homes on the plot is 3 times greater than single-level homes constructed on the same parcel (25 hybrid homes vs. 8 cottage homes).</p> <p>Hybrid homes offer many other "green" features in addition to density. Under building parking reduces impervious coverage and the "heat island" effect of surface parking lots. Geothermal heating and cooling does not emit greenhouse gasses and delivers a high efficiency rating by transferring heat rather than burning something. Rainwater harvesting, raingardens and porous paving better manage storm water.</p>
	<p>Title: Question and Answer Panel</p> <p>Moderator: Dr. Jack Willenbrock (Emeritus Hankin Chair, Penn State)</p>

THURSDAY, MARCH 3RD

DAY 2 ABSTRACTS

Session #9: Advances in High-Performance Homes: Standards

Time / Location: 1:15-2:45pm, Room 104

Speaker #1	<p>Title: Universal Design / Aging-in-Place Author(s): Dorothy Gerring (Pennsylvania College of Technology) & Rob Wozniak (Pennsylvania College of Technology)</p> <p>Universal design and aging in place. What is it? Why should it be included in houses? This discussion reviews elements of residential design which are not required by law but will ultimately allow people of different ages, heights and abilities to easily use their homes. While some people are born with their disabilities, many more will develop issues through accidents, disease or complications from age. There is an increasing demand for accessible housing due to the aging of our population as well as those with war injuries. It is unfortunate that many may not have an opportunity to age in the place of their choice: they may be forced into less desirable and more expensive institutional facilities that may not offer the same quality of life. It is a concern if due to a change in circumstances a home becomes unusable for a homeowner, family member, or friend without a renovation to improve accessibility. Depending on the work needed to renovate a house these changes may be too expensive, too difficult to complete in a short time frame, or may not be physically possible. Through this presentation you will know what common design features should be considered when building or renovating a home, both what they look like and their costs. You will understand the need for and costs associated with homes that have universal design features and the importance these features play in sustaining present and future occupants. Universal Design is an important aspect of SustainAbility.</p>
Speaker #2	<p>Title: Using Real World Data to Make the Case for Passive House Author(s): Laura Nettleton (Thoughtful Balance) & Michael Whartnaby (Thoughtful Balance)</p> <p>Developers and building owners are skeptical about how much energy can be saved by building to the Passive House standard. They are even more skeptical about those predicted savings in large-scale multi-family retrofits. There is skepticism in the marketplace about real savings because many developers have been led to have high expectations only to find themselves with very modest reductions in energy consumption. Passive House offers real hope in this area and measured utility data from completed retrofits are a way to begin to tell this story.</p> <p>The savings from Passive House are huge and they can have real impact on a building's operational costs. This session will analyze data from a Passive House retrofit and show how Passive House can significantly alter a building's proforma. Real utility data from a recent 48,000 square foot 84 unit Passive House multi-family retrofit will be presented along with examples of building proformas that pass utility savings into the hands of the developer or building owner.</p> <p>This presentation will identify benchmarking tools and resources, including the Commercial Building Energy Consumption Survey, the Residential Energy Consumption Survey, utility consumption history, and modeled energy consumption. Actual energy consumption from the first 12 months of operation after a Passive House retrofit will be compared to the various benchmarks established for that occupancy to establish actual operational cost savings of Passive House versus "standard" building practices and the existing building stock.</p> <p>Measured energy savings will be used to demonstrate the value added proposition of Passive House in the retrofit market...namely, how to turn energy efficiency into an income stream for the building owner over the life of the building. Based on real world savings attained by retrofitting to Passive House Standards, significant positive cash flow for a proposed retrofit will be demonstrated. The proposed project to be evaluated is a 66,000 square foot multi-unit affordable residential renovation and addition to a masonry school building. Positive cash flow and payback period can be optimized by taking into account the impact of first cost, utility cost over time, and rent/utility structure. Various rent/utility structures will be examined as part of the cash flow analysis.</p>
Speaker #3	<p>Title: Accounting for Sustainable Features in Housing Appraisal: The Green MLS Toolkit Author(s): Sharhzad Fadaei (Penn State)</p> <p>Marketing of sustainable homes is of great importance, as without it the housing industry would be static, not responding to current trends. Although there are many successful examples of marketable projects, in a broad scale, sustainable housing is appraised by a real estate industry that is mainly dominated by old methods of evaluation. In order to evaluate properties, realtors use Multiple Listing Service (MLS) which is their limited access database of all the relevant information of properties including their main features and their prices. While MLS tool in most places does not address sustainability metrics of the homes, efforts have been made to develop a toolkit that actually does so. This toolkit is named Green MLS.</p> <p>Green MLS has multiple fields of entry for various sustainability features a property may have. This toolkit is relatively new however it can play a significant role in introducing green features to the home buyers and taking them into account while evaluating price of a house. This study aims to introduce Green MLS, discuss its importance and bring examples from places where it has been incorporated. Past experiences can provide valuable lessons on how to make a strong case for implementation of the Green MLS in the industry especially for Pennsylvania's real estate entities.</p>
Speaker #4	<p>Title: Opportunities and Constraints for Townhouse Developments Meeting DOE's Zero Energy Ready Home Standard Author(s): Dr. Georg Reichard (Virginia Tech) & Oluwateniola Ladipo (Virginia Tech)</p> <p>This paper discusses opportunities and various constraints that arise when attempting to meet the Department of Energy's (DOE) Zero Energy Ready Home (ZERH) Standard for townhouse developments. Besides a broader analysis of economical limits of performance for different consumption categories, the paper discusses the specific constraints that arise for production homebuilders when trying to meet this design goal. This study builds on findings that emerged from a submission to DOE's Race to Zero Student Competition and expands the application to constraints and opportunities for other climate zones. The submitted design proposal and analysis yielded interesting findings that can be of high relevance for other production builders looking into ZERH, as it identified focus areas of performance that are different to single family detached homes. The paper also discusses the modeling challenges and limitations of the software tools that are currently utilized to demonstrate that ZERH requirements are met.</p>

THURSDAY, MARCH 3RD

DAY 2 ABSTRACTS

Session #10: Resiliency in Natural Disasters and Climate Change

Time / Location: 1:15-2:45pm, Room 105

Speaker #1	<p>Title: Resilient New Design and Retrofit of Existing Buildings at Risk of Natural Disasters</p> <p>Author(s): Tim Smail (Federal Alliance for Safe Homes, Inc. - FLASH)</p> <p>In response to Superstorm Sandy, Federal Alliance for Safe Homes (FLASH)[®] partners, including the American Institute of Architects, developed a <i>Resilient Design Guide (Guide)</i> for high-wind, wood-frame construction. The purpose of the <i>Guide</i> is to convey the why, how and what of enhanced wind-resistant construction practices while offering a way to “upgrade” basic house plans to a more resilient approach. The “why” explains that 39 million U.S. homes are at risk from winds that can exceed 110 mph and that, per the Insurance Research Council’s, “2015 Trends in Homeowners Insurance Claims”, claim costs have increased rapidly over the 17-year period from 1997-2013. Moreover, the report suggests that driving factors include, “... the growing frequency and severity of storms; the growing size and complexity of homes; and, dramatic increases in the price of oil-based building materials.”</p> <p>The <i>Guide</i> demonstrates “how” to achieve resilience by breaking down the home into components, including roof systems, wall systems, foundations, floor systems, and building site. It uses simple graphics and color coding to differentiate (1) ordinary, (2) high-wind and (3) resilient construction. The “what” looks at the specific materials and construction practices that can increase disaster resilience.</p> <p>This session will highlight the partnerships that went into producing the <i>Guide</i>, the technical information in the <i>Guide</i>, and opportunities for development of additional <i>Guides</i>, including the upcoming <i>Resilient Design Guide for Alternative Materials</i>.</p>
Speaker #2	<p>Title: Evaluation of Shading the Solid Parts of Building Envelopes under Climate Change Scenarios in Egypt</p> <p>Author(s): Dr. Mohamed M. Mahdy (Military Technical College, Cairo) & Dr. Marialena Nikolopoulou (University of Kent)</p> <p>As a vital method for mitigating the solar radiation effect on buildings, shading is considered of paramount importance, especially in Egypt as a hot arid climate country, with very high solar radiation intensity most of the year. Hence, the importance of studying shading strategies against future climate change emerged. Therefore, current practice of construction industry in Egypt needs to consider passive architectural design for residential buildings, which consume about 20% of the energy consumed in the built environment, and emit about 4% of CO₂. Wherefore, this paper focuses on the determination of the optimum ratios for shading the solid parts of the building envelope in three main climatic zones in Egypt, under different climate change scenarios, to support both policy and decision makers taking steps forward towards energy efficiency obligations in Egypt. To achieve this objective, multiple dynamic thermal simulations have been conducted in order to evaluate the effect of the solid parts shading while maintaining the optimum thermal comfort conditions, reducing energy consumption and gaining long-term financial benefits. All the possible combinations (for a certain set of assumptions) of shading the solid parts of the envelope were tested for the different orientations (South, East, and West). The findings confirm the secondary role of shading the solid part of the building envelope once appropriate thermal insulation and fenestration have been selected to achieve thermal comfort and long term cost effectiveness, while minimising the energy consumption.</p>
Speaker #3	<p>Title: Sustainability: What’s That, and So What?</p> <p>Author(s): Andy Lau (Penn State)</p> <p>In this paper I try to do two things. One is to describe what is really important to understand about sustainability. Two is to relate that understanding to buildings. I’ve been working on understanding and applying sustainability to engineering education and buildings for over 25 years. In my book in progress on sustainability, three key ideas are identified: growth, happiness, and nature. The paper will explore these ideas, including how our current beliefs and expectations changed with time. You could say that sustainability is a projection of those changing beliefs into the future.</p> <p>We already see sustainability beginning to be expressed in housing. The most likely change is a leveling off of house size and then a gradual decline, reflecting both a decline in materialism, and a rise in being outside. Along with that, homogeneous suburbs will give way to diverse neighborhoods with more multifamily, multigenerational households. Walking and being outdoors will lead to more parks and greenways. There will be community gardens and workshops.</p> <p>On the technology side, buildings will be better insulated and more air-tight, with integrated energy recovery systems, and high-efficiency heat pumps. Electrical appliances will communicate with each other and the grid to make good use of renewable energy. The house will also recharge the electric cars and bicycles. Houses will also be built to utilize sunlight for light, heat, and electricity, and outside air for ventilation and cooling.</p> <p>Overall we’ll live in homes and neighborhoods that better fit our changing norms and visions of happiness.</p>

THURSDAY, MARCH 3RD

DAY 2 ABSTRACTS

Session #11: Advances in Building Enclosures: Moisture

Time / Location: 3:00-4:30pm, Room 105

Speaker #1	<p>Title: Designing & Building Resilient Wall Systems with Engineered Rainscreen Products</p> <p>Author(s): Peter Spafford (Air Barrier Association of America) & Laverne Dalgleish (Air Barrier Association of America)</p> <p>Moisture management is the single most critical function in designing and constructing a building. Today owners want buildings that are resilient, efficient and durable. This presentation covers the key benefits and requirements to building a resilient wall assembly and explores the use of engineered rainscreen technology to do so. The presentation will cover how an engineered rainscreen functions and how this technology can be used to build a resilient wall assembly. The new standard <i>ASTM E2925 – 14 Standard Specification for Manufactured Polymeric Drainage and Ventilation Materials Used to Provide a Rainscreen Function</i> will be introduced and explained. The presentation will show how a rainscreen wall can improve upon traditional construction methods and how it can be designed and constructed to produce a resilient wall assembly.</p>
Speaker #2	<p>Title: Finally, the Truth about Condensation</p> <p>Author(s): Dan Tempas (Dow Building Solutions) & Brian Lieburn (Dow Building Solutions)</p> <p>A lot of ink has been spilled in describing the movement, condensation, and evaporation of water vapor through a building envelope. Unfortunately, all too much of it has been incomplete or even downright wrong. In this presentation the physics of water vapor transport will be described in detail. Some sacred cows will be slain and fundamental concepts regarding more robust envelope designs will be described. Also a look at the strengths and drawbacks of various calculation methods including the humble Dewpoint/Glaser method and the vaunted WUFI. Not for the faint of heart or slow of wit, be ready get re-acquainted with Dihydrogen Oxide on both the molecular and macroscopic scales.</p>
Speaker #3	<p>Title: Effects of Exterior Insulation on Moisture Performance of Wood-Frame Walls in the Pacific Northwest: Measurements and Hygrothermal Modeling</p> <p>Author(s): Dr. Samuel V. Glass (USDA Forest Service Forest Products Laboratory), Borjen Yeh (APA - The Engineered Wood Association), & Benjamin J. Herzog (APA - The Engineered Wood Association)</p> <p>Continuous exterior insulation on above-grade walls is becoming more common in many parts of North America. It is generally accepted that exterior insulation provides advantages for energy performance, by reducing thermal bridging, and for moisture performance, by warming the wood structural members, thereby reducing the potential for wintertime moisture accumulation. However, the effects of vaportight rigid foam insulation on the drying capability of the wall systems are not fully understood. In this study, temperature and moisture conditions in north-facing and south-facing wall assemblies with vapor-open and vapor-tight exterior insulation were monitored in a natural exposure test facility in the Marine 4 Climate Zone over a two-year period. The wall assemblies included interior gypsum board with latex primer and paint, 2x4 framing with nominal R-13 batt insulation, 11 mm (7/16 in.) oriented strand board, nominal R-5 exterior insulation, and white-color vinyl siding. Exterior insulation was either extruded polystyrene or mineral wool. Measurements and hygrothermal simulations indicated that walls with extruded polystyrene and mineral wool exterior insulation in north and south orientations perform similarly. Moisture content in wood framing and oriented strand board were within safe levels.</p>
Speaker #4	<p>Title: Twelve Home Case Study Homes in Michigan Yield Surprising Moisture and Air Leakage Data</p> <p>Author(s): Brian Lieburn (Dow Building Products)</p> <p>A multi-home, 5 year research project, Dow Building Solutions in partnership with Cobblestone Homes, to investigate the performance of building enclosures designed to meet and exceed energy code requirements. Twelve case study single family research houses were constructed in Midland, MI (CZ 5) with four building energy efficiency strategies. Research has now been collected for four years on the cost to build, energy use, and hygrothermal performance of the various strategies. Occupant surveys provide qualitative insight to the value of High Performance Homes. We will present surprising data related to hygrothermal performance of two different strategies used to insulate walls and rim joist areas.</p>



RBDCC NOTES



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Be sure to check out our reception & break sponsors and exhibitors during the Breaks on Day 1 of the conference. The break and exhibitor space is located on the **first floor across from Rooms 106 and 107.**

RESEARCH NIGHT



EDUCATION NIGHT



DAY 1 FOOD AND BEVERAGE SPONSORS



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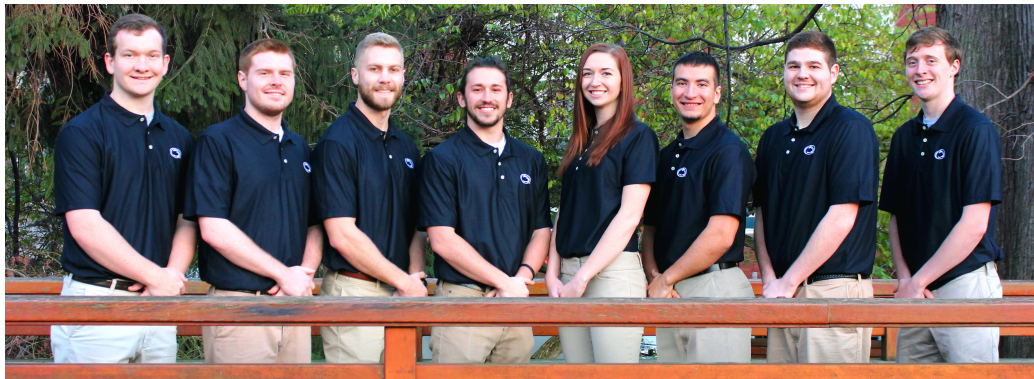


ANNOUNCEMENTS

CELEBRATION OF EDUCATION - WEDNESDAY NIGHT!

We hope you can join us for our Wednesday night reception from 6pm to 8pm in the Presidents Hall! As a "Celebration of Education", we will be honoring the Penn State National Association of Home Builders (NAHB) Student Chapter for winning sixth place in the 2016 Residential Construction Management Competition held at the International Builders Show in Las Vegas, and introducing you to our representatives for the Department of Energy (DOE) Race to Zero competition. We will also be hosting a beer tasting by local brewery **Elk Creek Cafe and Aleworks**!

Preregistration for the event is required. If you haven't already signed up, please stop by the conference registration table. In addition to the beer tasting, the event includes heavy hors d'oeuvres and two drinks!



ASCE JAE - SPECIAL SECTION ON *HOUSING AND RESIDENTIAL BUILDING CONSTRUCTION*



The American Society of Civil Engineers' (ASCE) Journal of Architectural Engineering (JAE) is running a **new Special Section on Housing and Residential Building Construction**. This peer-reviewed Special Section covers various aspects of residential buildings, such as single- and multi-family dwellings, mid-rise and high-rise apartment buildings, dormitories, and hotels/motels, and includes technical research and development, technology transfer, case studies, and state-of-the-art review types of papers.

Please consider submitting a paper to the Special Section. To submit a paper, please go to the following site: <http://www.editorialmanager.com/jrnaeng/>. When you see the "Additional Information" section, in response to the following question: "Is this manuscript part of a Special Issue? If yes, please provide Special Issue title and guest editor name.", please type the following in the dialogue box: "Housing and Residential Building Construction; Ali Memari".

For more information, contact **Dr. Ali Memari** at memari@engr.psu.edu.

SAVE THE DATE - 2016 HANKIN DISTINGUISHED LECTURE



DATE: NOVEMBER 9TH, 2016 | 4:00 PM
SPEAKER: SAM RASHKIN, CHIEF ARCHITECT OF THE DEPARTMENT OF ENERGY
LOCATION: NITTANY LION INN, PENN STATE UNIVERSITY PARK

The Hankin Distinguished Lecture Series invites world-class speakers to the Pennsylvania State University to address students, faculty, staff, and industry professionals. The lecture is **free** and **open to the public**. The lecture series was established in 2006 **in honor of the late Bernard Hankin and his family** for their continuous and dedicated support of the residential building construction program at Penn State.

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The PHRC Team (left to right): Brian Wolfgang, Chris Hine, Sarah K. Lowe, Dr. Ali Memari, Dr. Katie Blansett, Bryan Heitzmann, & Tracy Dorman

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