2ND RESIDENTIAL BUILDING DESIGN AND CONSTRUCTION CONFERENCE

FEBRUARY 19–20, 2014 | STATE COLLEGE, PA

Hosted by the Pennsylvania Housing Research Center

Conference Program

PENNSTATE

PHRC

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CONFERENCE CHAIR

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

CONFERENCE ORGANIZER

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Penn State University, USA

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The Pennsylvania State University

2nd Residential Building Design & Construction Conference

February 19-20, 2014

Penn Stater Conference Center Hotel

Message from the Conference Chair

It is my pleasure to welcome you to the Second Residential Building Design and Construction (RBDC) Conference, February 19-20, 2014 in State College, PA. This conference is organized by the Pennsylvania Housing Research Center (PHRC) at Penn State University and is being held in conjunction with the 22nd 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 22 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 2nd RBDC Conference is held for the second time now as a new program by the PHRC to provide a forum for researchers, design professionals, manufacturers, builders, and code officials to keep up-to-date on the latest advancements and discuss their own findings, innovations and projects related to residential buildings.

At this 2nd RBDC Conference, we are very excited to have the new Dean of the College of Engineering at Penn State, Professor Amr Elnashai address the conference at the opening session. We are also very pleased this year to have two Keynote Speakers, Tim McDonald, President, Onion Flats LLC, and Dr. David Crowe, Chief Economist, National Association of Home Builders. Tim McDonald will focus on the need for passive house, net-zero energy and sustainable design and construction in his presentation "Pump-Up the Volume – Passive House, Mass Production and Multi-Family – can HOUSING save the planet?" Dr. Crowe will shed some light on whether building new homes will help the economy, its benefits and its cost in his presentation "Home Building Impact". We are also pleased to have two invited speakers, David Crump, Director of Legal Research, National Association of Home Builders, who will talk about the litigation aspects of "Sunlight Reflected from Double-Paned Low-e Windows, and Damage to Vinyl Siding and Other Materials," and Erik Churchill, Project Manager, SHoP Construction, who will discuss "New Methods of Delivery: Prefabrication Strategies in Residential Construction."

Aside from the invited presentations, we have presentations by university professors, researchers, graduate students, architects, consulting engineers, product manufacturers, and product related associations / councils scheduled. The details of these presentations in the form of full papers and a few as power point slides can be found in the proceedings of the conference.

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

SCHEDULE SUMMARY

Wednesday, February 19

7:30 am – 8:30 am	Registration	Main Level
8:30 am – 10:15 am	Introduction, Welcome, Keynote, and Invited Speaker	Room 204
10:15 am – 10:30 am	Morning Break	Break Area
10:30 am – 12:00 pm	Technical Session	Room 204
12:00 pm – 1:00 pm	Lunch	Gardens Restaurant
1:00 pm – 3:00 pm	Technical Session	Room 204
3:00 pm – 3:15 pm	Afternoon Break	Break Area
3:15 pm – 5:15 pm	Technical Session	Room 204
5:30 pm – 8:30 pm	Networking Reception	Hintz Alumni Center

Thursday, February 20

8:30 am – 10:15 am	Welcome, Keynote, and Invited Speaker	Room 204
10:15 am – 10:30 am	Morning Break	Break Area
10:30 am – 12:00 pm	Technical Session	Room 204
12:00 pm – 1:00 pm	Lunch	Gardens Restaurant
1:00 pm – 3:00 pm	Technical Session	Room 204
3:00 pm – 3:15 pm	Afternoon Break	Break Area
3:15 pm – 5:15 pm	Technical Session	Room 204

CONFERENCE SECRETARIAT

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RBDCC AGENDA

	Day 1 – February 19		Day 2 – February 20
Early Morning 8:30 – 10:15	**Introduction & Welcome** **Dr. Ali Memari, RBDC Conference Chair** **Dr. Amr Elnashai, Dean, Penn State College of Engineering** **Keynote Speaker** **Tim McDonald, President, Onion Flats LLC** *Title: Pump-Up the Volume – Passive House, Mass Production and Multi-Family – Can HOUSING save the planet?* **Invited Speaker** **David Crump, Jr. Esq., Director of Legal Research, National Association of Home Builders** *Title: Sunlight Reflected from Double-Paned Low-e Windows, and Damage to Vinyl Siding and Other Materials*	Early Morning 8:30 – 10:15	**Welcome** **Dr. Ali Memari, RBDC Conference Chair** **Keynote Speaker** **David Crowe, Chief Economist, National Association of Home Builders** *Title: Home Building Impact* **Invited Speaker** **Erik Churchill, Project Manager, SHoP Construction** *Title: New Methods of Delivery: Prefabrication Strategies in Residential Construction*
	Break (10:15-10:30)		*Break (10:15-10:30)*
Late Morning 10:30 – 12:00	**Moderator: Andrew McCoy (Virginia Tech)** **87 Dikeman Street** Alexis Lenza (SHoP Construction) **Adoption Patterns of Energy Efficient Housing Technologies 2000-2010: Builders as Innovators** Matthew Keefe, Andrew McCoy, Drew Sanderford, & Dong Zhao (Virginia Tech) **Residential Vertical Expansion of Existing Commercial Buildings Using Modular Construction Methods** Anthony Jellen & Ali Memari (Penn State)	Late Morning 10:30 – 12:00	**Moderator: Paul Kremer (Penn State)** **Performance Optimization and Development of a Home Modular Delivery System** Lisa Iulo, Bruce Quigley, & Aaron Wertman (Penn State) **Structural Systems and Design Considerations for Low-Rise Senior Living and Multifamily Residential Buildings** Jason Dreher & Mark Erdman (Structura) **Cost Effective Ways to Construct Energy Star Homes** Rick Gazica (ICF International)
	Lunch (12:00 – 1:00)		*Lunch (12:00 – 1:00)*

RBDCC AGENDA

	Day 1 – February 19		Day 2 – February 20
Early Afternoon 1:00 – 3:00	**Moderator: Lisa Iulo (Penn State)** **An Effort to Refine Regional Energy Assessment Methods in Support of Energy Auditors to Increase Assessment Accuracy and Consumer Confidence** Oluwateniola Ladipo, Andrew McCoy, Annie Pearce, & Georg Reichard (Virginia Tech) **Lifecycle Assessment of Residential Buildings** Lionel Lemay & Tien Peng (NRMCA) **Policies to Enhance Resilient Communities** Lionel Lemay & Tien Peng (NRMCA) **Value-Based Evaluation of the Residential Energy Assessment Process** FuJu Wu, David Riley, Kelly Sprehn, and Tabitha Sprau Coulter (Penn State), Michael Whelton (IERC)	Early Afternoon 1:00 – 3:00	**Moderator: Ryan Solnosky (Penn State)** **Meeting Residential Energy Requirements with Wood Frame Construction** Lori Koch, John Showalter, & Loren Ross (American Wood Council) **Prescriptive Residential Deck Design** Lori Koch, John Showalter, & Loren Ross (American Wood Council) **Changes to the 2012 Wood Frame Construction Manual** Kenneth Bland, Bradford Douglas, Lori Koch, Peter Mazikins, Loren Ross, & John Showalter (AWC) **Superstorm Sandy Storm Surge and Structural Damage Correlation – A Case Study of Long Beach, NY** Nicole Braxtan, Kerryanne Donohue-Couch, & Kerianne Westphal (Manhattan College)
	Break (3:00 – 3:15)		*Break (3:00 – 3:15)*
Late Afternoon 3:15 – 5:15	**Moderator: Prasenjit Basu (Penn State)** **Observations from Model Scale Thermal Tests on Heat Exchanger Pile** Prasenjit Basu, Omid Ghasemi-Fare, & Cory Kramer (Penn State) **Evaluation of Venetian Blind Attributes for Energy Efficiency** Tim Ariosto and Ali Memari (Penn State) **Twelve Simple Steps to Net-Zero Energy Design** Ted Clifton (Zero Energy Plans)	Late Afternoon 3:15 – 5:15	**Moderator: Lisa Iulo (Penn State)** **Resuspension and Transport of Allergen-Carrier Particles in Residential HVAC** Dong Hee Choi, Dong Hwa Kang, Paul Kremer, & James Freihaut (Penn State) **Structural BIM Processes for Modular Multi-Story Buildings in Design and Construction** Ryan Solnosky, Ali Memari, & Issa Ramaji (Penn State) **Integrated BIM Platform for Multi-Story Modular Building Industry** Issa Ramaji, Ali Memari, & Ryan Solnosky (Penn State) **Review of Different Components of Solar Decathlon House Projects** Ehsan Kamel & Ali Memari (Penn State)
	Networking Reception 5:30-8:30 Penn State Hintz Alumni Center *Transportation from the Penn Stater Conference Center Hotel will be provided*		

KEYNOTE SPEAKERS

Timothy McDonald, President, Onion Flats LLC

Title: Pump-Up the Volume – Passive House, Mass Production and Multi-Family – Can HOUSING save the planet?

Timothy McDonald is an Associate Professor of Practice in Architecture at Temple University, a Registered Architect in Pennsylvania and New Jersey, LEED AP, Certified Passive House Consultant and Tradesman (CPHC) and President of Onion Flats LLC, an award winning development/design/build collective centered in Philadelphia. Tim received his BArch from Penn State and his March in Architectural History and Theory from McGill University. He has been teaching and practicing for over 20 years with a focus on community development, multidisciplinary thinking and making, high-performance building technologies and alternative construction methodologies. Through his research and practice, Tim, along with his partners at Onion Flats, has developed, designed and built some of the first LEED Gold and Platinum projects in the country and the First Certified Passive House, Net-Zero-Energy-Capable project in Pennsylvania.

David Crowe, Chief Economist, National Association of Home Builders

Title: Home Building Impact

David Crowe is Chief Economist and Senior Vice President at the National Association of Home Builders (NAHB). Dr. Crowe is responsible for NAHB's forecast of housing and economic trends, survey research and analysis of the home building industry and consumer preferences as well as microeconomic analysis of government policies that affect housing.

Dr. Crowe is also responsible for the development and implementation of an innovative model of the local economic impact and fiscal cost of new home construction, which has estimated the net impact of new housing in over 500 local markets. Past research has concentrated on home ownership trends, tax issues, demographics, government mortgage insurance, local land use ordinance impacts and the impacts of housing on local economies.

Before becoming NAHB's Chief Economist, Dr. Crowe was NAHB's Senior Vice President for Regulatory and Housing Policy. Prior to NAHB, Dr. Crowe was Deputy Director of the Division of Housing and Demographic Analysis at the U.S. Department of Housing and Urban Development.

He has served on federal advisory committees to the Census Bureau and to the U.S. Department of Housing and Urban Development.

Dr. Crowe holds a PhD in Economics from the University of Kentucky

INVITED SPEAKERS

David Crump, Jr. Esq., Director of Legal Research, National Association of Home Builders

Title: Sunlight Reflected from Double-Paned Low-e Windows, and Damage to Vinyl Siding and Other Materials

David Crump is the Director of Legal Research for NAHB's Office of General Counsel. David administers NAHB's Legal Research Program, and provides construction liability guidance on a diverse range of subjects from immigration enforcement to green building liability. His publications include "Contracts and Liability - 5th Edition", "Warranties for Builders and Remodelers – 2nd Edition", and "Copyright Law for Homebuilders". His article, "The Risks and Rewards of Green Building", was published in the New Jersey Law Journal. David is a graduate of The University of Virginia School of Law, and frequently speaks at NAHB educational programs on housing related legal issues. His 35 plus years of legal experience include 19 years as the municipal attorney for Front Royal, Virginia, and 6 years as General District Court Judge for Virginia's 26th Judicial Circuit.

Erik Churchill, Project Manager, SHoP

Title: New Methods of Delivery: Prefabrication Strategies in Residential Construction

As a Project Manager with SHoP Construction Erik utilizes his background in construction, architecture, and business to manage projects that push the boundaries of design, sustainability, and traditional AEC practice. He recently managed the BIM/VDC integration of the B2 Bklyn Modular project for Forest City Ratner Companies during design and prototype production. Currently Erik is developing SHoP Construction's design/build services for pre-fabricated projects. He has experience with pre-construction services, estimating, design coordination, and managing architectural design. As an author Churchill has written on the changing roles of architects, publishing "Re-Negotiating Architects' Relevancy - A U.S. Perspective of IPD and BIM".

Previous to SHoP Construction, as a project manager Erik managed the design and build of single family homes including two of the first in the LEED-H pilot program. As a consultant he has worked with Clif Bar on sustainable packaging initiatives, Gerding Edlen Developers in Portland, OR on financing Living Building Challenge projects, and with Gehry Technologies in Paris on technology development. At the University of Oregon he developed the community design-build program, designBridge, into a nationally recognized program. Erik received a BA from Brown University, a Master of Architecture and a Master of Business Administration from the University of Oregon.

Wednesday, 2/19	
Early Morning	Technical Sessions
8:30 – 10:15 AM	**Introduction & Welcome** Dr. Ali Memari, RBDC Conference Chair Dr. Amr Elnashai, Dean, Penn State College of Engineering
	Pump-Up the Volume – Passive House, Mass Production and Multi-Family – Can HOUSING save the planet? **Keynote Speaker – Tim McDonald, President, Onion Flats LLC** "Affordable" Housing is an oxymoron. "Net-Zero-Energy" Housing is, for most, illusive and impenetrable. "Modular" Housing conjures images of cheap double-wides and trailer parks. "Housing" itself carries it's own baggage in need of constant qualification: Subsidized Housing, Market-Rate Housing, Student Housing, Senior Housing, Co-Housing, Suburban Housing, Urban Housing…..? With such variety in scale, program, social and economic strata, what possible common denominator would allow us to discuss, if not rethink, the standards by which we envision the design and construction of "housing" in this country, and for that matter, why would we? Given the not-quite universally accepted knowledge that climate change is real; that it's affects are, at best, a threat, at worst, catastrophic; that it is man-made and therefore solvable; and the less commonly known fact that making and operating of buildings account for almost 50% of all CO2 emissions in this country, it would seem a reasonable request, as a society, for buildings to take on a much more intentional role in helping to solve this real and present danger. Most European Union countries have approached this issue head-on, and with the help of a 30 year old proven building standard initiated in Germany know as Passivhaus, these countries are redesigning their building codes to require all new buildings to achieve "Net(or "Near")-Zero-Energy by 2030. Passivhaus (or Passive House in this country) is a "fabric first", super-insulated and air-tight approach to the design and construction of buildings which is based on rigid metric standards meant to reduce energy consumption in any type of building by 70-90% relative to current building codes in this country. With such radical reduction in energy consumption, these buildings can readily generate the remainder of the energy they need to survive with radically reduced on-site renewable energy generation, therefore reaching the "Net-Zero-Energy" moniker. Too good to be true? Too European? Maybe not. What do you get when you combine really rigorous German building science with a few guys in Philly with a penchant for design, a fascination for more efficient and alternative construction methods and a slightly naive belief that architecture, more specifically housing, can change the world? You get the work of Onion Flats. I would like to propose a no-frills, no-brainer approach to "affordable" housing which gets better with scale, makes more sense in the city, is inspiring to live in, might help save the planet and will leave politicians, developers, builder, architects, academics and students alike asking, "Why would we do any less?!!!!".
	Sunlight Reflected from Double-Paned Low-e Windows, and Damage to Vinyl Siding and Other Materials **Invited Speaker – David Crump, Jr. Esq., Director of Legal Research, National Association of Home Builders** In the past, damage to vinyl siding from sunlight reflected by double-paned windows was occasionally noted. But, with the increasing use of energy efficient, highly reflective low-e windows, reports of vinyl siding damage from reflected sunlight have become much more frequent. Following manufacture, double-paned windows may develop a concavity due to a difference in barometric pressure between the glass panes and the outside air. While the concavity does not affect window performance, and is not considered to be a defect, it may act much like a magnifying glass to focus the sunlight (now often with greater low-e reflectivity) on nearby surfaces, including the vinyl siding of neighboring homes. In addition to the window pane distortion and enhanced low-e reflectivity, a number of factors may also contribute to this phenomenon, including the angle of the sun, the time of year, separation distances, and the absence of intervening foliage. The focused reflected sunlight can generate heat in excess of 200 degrees Fahrenheit, sufficient to distort vinyl siding and other materials, including auto parts, lawn furniture, and decking. This paper will examine the causes of this occurrence, its regional impact, prevention, remedial solutions, and potential liability issues.
10:15 – 10:30 AM	Break

Wednesday, 2/19	
Late Morning	Technical Sessions
10:30 AM – 12:00 PM	**87 Dikeman Street** **Alexis Lenza (SHoP Construction)** The demand for modular buildings ranges from storm-resistant sea-front homes, to low-rise residential and/or mixed use buildings, to hotels, luxury residential and commercial towers. We regard each project as unique, and through evaluation of critical factors such as —architectural, structural, mechanical, electrical, plumbing and fire protection systems, along with logistics, schedule and cost, determines project-tailored prefabricated building solutions for their clients. As a result of our approach, a highly-engineered component-based system is developed which achieves the goals of maximizing production efficiency while minimizing on-site construction, without sacrificing opportunities for programmatic versatility and architectural expression. In order to minimize the cost of design, the component system and related building details are formed as part of an integrated engineering, detailing and 'just-in-time' manufacturing system based on a flexible approach to plant production. By reducing the amount of complex decisions and the number of nonconforming conditions, the flexible plant production system reduces the number of unique components which must be created and managed, delivering inherent compatibility with digitally-driven manufacturing techniques. The dimensional envelope of each building module is managed utilizing precision fixturing, which enhances product precision in the plant and tolerance management in the field. The 87 Dikeman Street Project in Red Hook, Brooklyn is a four story ground up construction of a 2-family residence, consistent with the R5 underlying zoning, including a 40 ft height limitation on the site. The site is a vacant lot situated between two existing 2-3 story residential buildings. The design proposal includes a 3-bedroom, 2.5 bath primary unit on the upper 3 floors and a 1-bedroom, and 1 bath secondary unit on the 1st floor. The project, which is designed to be fabricated and erected using modular construction techniques, comprises 4 modules that will be stacked and mated together on-site. The modules sit on a foundation of concrete mini-piles to allow for all living spaces and all mechanical and electrical equipment to be raised above an elevated base flood plain elevation established by FEMA. Led by SC and Island International Exterior Fabricators (teamed as Design-Builder & Modular Fabricator), the 87 Dikeman Street Project team includes SHoP Architects (Design Architect and AOR), AVRO Consult Engineering (Structural Engineer), GZA (Geotechnical Engineer), Engineering Solutions (MEP/FP Engineer), and DS Engineering Services (Civil Engineer).
	Adoption Patterns of Energy Efficient Housing Technologies 2000-2010: Builders as Innovators **Matthew Keefe, Andrew McCoy, Drew Sanderford, & Dong Zhao (Virginia Tech)** The U.S. housing industry is often considered an innovation laggard. Whether because of endogenous or exogenous risks, homebuilding firms have traditionally resisted innovation. However, recent evidence suggests builders' material selections have been growing more innovative—more specifically, these selections have been growing greener. Though little empirical work exists that measures and analyzes such phenomena, the proposed paper will report on a national study* of "green building" innovation in residential construction from 2000-2010. This paper asks two research questions: 1) to what extent are builders, if any, adopting higher efficient building products over their traditional economic substitutes? And 2) what are the market, demographic, and regulatory factors associated with homebuilders' green and energy efficient technology selections? The authors analyze data from the National Association of Homebuilders' Builders' Practices Survey (BPS) from 2000 to 2010, estimating a series of logit models focusing on builders' choices to install high performance building technologies including PEX piping, custom sized-HVAC systems, programmable thermostats, and high efficiency insulation. This research builds both methodologically and substantively upon the foundation laid by McCoy et al's (2013) work examining builders' choices to adopt high efficient windows.

Wednesday, 2/19	
10:30 AM – 12:00 PM	**Residential Vertical Expansion of Existing Commercial Buildings Using Modular Construction Methods** **Anthony Jellen & Ali Memari (Penn State)** Modular Construction is ideal for the construction of buildings with repetitive floor plan elements. Residential structures such as apartment buildings, student housing and workforce housing tend to be ideal candidates for modularization. The projects that are highly compatible with modular construction methods tend to be those that would significantly benefit from off-site construction, construction schedule time-savings, and reductions in community disturbance or business operations. Renovation projects, particularly those planned for congested urban areas, can potentially take full advantage of these benefits. Initially, by choosing to renovate a building versus constructing a new one, owners can preserve the historic nature of their building and its relationship with the surrounding community, as well as take advantage of the existing embodied energy, avoid expensive foundation and site activities, and eliminate the need to purchase new land. Owners choosing to renovate a building with modular units can take full advantage of the benefits of offsite construction. The components of the renovation can largely be constructed offsite and the on-site construction activities can be minimized. The stated benefits can have value to a building owner who desires to accomplish renovation quickly, while maintaining operation of an existing business. There are a few different ways to apply modular construction techniques to renovation projects, but one that is particularly well suited for the construction method is vertical expansion. When considering a vertical expansion, modular construction methods have definite advantages of over more traditional site-intensive construction methods. In addition to the benefits stated earlier, the light-weight nature of the modules increases the feasibility of an extension, which is, in part, largely reliant on the existing buildings excess structural capacity. Vertical expansion is an excellent way to add valuable rooftop apartments to buildings that are able to accept extension. Vertical expansion, if feasible for a given existing building, can provide the financial benefits gained from rental or sale of the new units as well as be a part of a more comprehensive roof renovation plan that would not only add more square footage to the building but would simultaneously replace aging roof components and improve the energy performance of the roof system. Modular vertical expansions can be design intensive, depending on the condition of the existing building as well as the available design documentation. Feasibility is dependent on a variety of factors, such as local ordinance and code, building construction type and use, and site suitability. In this paper these factors will be discussed and other design considerations associated with modular vertical expansion of existing buildings noted. Lastly, a conceptual modular vertical expansion of a real building will be presented and the design challenges associated with this unique building discussed.
12:00 – 1:00 PM	Lunch

Wednesday, 2/19	
Early Afternoon	Technical Sessions
1:00 – 3:00 PM	**An Effort to Refine Regional Energy Assessment Methods in Support of Energy Auditors to Increase Assessment Accuracy and Consumer Confidence** **Oluwateniola Ladipo, Andrew McCoy, Annie Pearce, & Georg Reichard (Virginia Tech)** Approximately 61% of occupied homes in the U.S. were constructed before 1980 (U.S. Census Bureau, 2011), many of which waste up to 60% of the consumed energy due to leaky ducts, inefficient equipment, poor insulation, and air leaks (ETO, 2008). Homeowners spend a reported 65.63 billion dollars annually on energy consumption (EIA, 2005), and there is a potential to reduce this expenditure by 21 billion dollars (CEQ, 2009). This return can be achieved through energy retrofit solutions applied to homes. Decisions to pursue a retrofit action in a home are commonly based upon energy assessments provided by auditors, who utilize a mix of diagnostic tools, inspection strategies, evaluation practices such as the blower door test, and energy modelling simulations. Although a variety of energy assessment methods are available today to help identify the most promising retrofit opportunities, many barriers and issues still exist for homeowners to take action. One significant factor contributing to homeowners reduced confidence is a lack of energy assessment accuracy, which has led to a lack of retrofit decision-making. This study investigated the current energy assessment methods used by energy auditors in the Southwest Virginia region in order to reveal insights into their strengths and struggles while conducting assessments and reporting the results to homeowners. Energy auditors from four companies who conduct energy assessments were shadowed on routine audits and subsequently interviewed. As a result, common strengths and struggles were identified regarding the processes of individual auditors, the larger local energy assessment community, and the national energy assessment industry in general. The findings identify opportunities for refinement on a regional basis, and areas for additional research towards improving energy assessment accuracy, increasing stakeholder confidence, and promoting more active retrofit decision-making. This study is an initial local effort to potentially create compatible solutions on a nationwide scale.
	Lifecycle Assessment of Residential Buildings **Lionel Lemay & Tien Peng (NRMCA)** Building owners, contractors, architects, engineers, and consumers are demanding more efficient and environmentally friendly residential projects and products. However, credible and transparent information on building materials is currently very limited, hampering the ability of designers to conduct an accurate analysis. Life Cycle Assessments (LCAs) are increasingly being used to evaluate structures and building products for environmental impact and performance. While LCA is an excellent tool for practitioners to identify environmental impacts, it is not a practical communication device for the design and consumer community. Environmental Product Declarations (EPDs) are starting to appear in the US as the common methodology to report product performance, eliminating the need to wrestle with dozens or more individual sources of a data in the LCA. An EPD is a comprehensive, internationally recognized report that compiles and standardizes technical sustainability information. The US Green Building Council's LEED v4 Rating System and Architecture 2030 for Products are starting the demand for EPD's. This paper considers life cycle assessment methodologies for accounting residential structure's environmental impacts, the environmental product declarations that lists the relevant impacts in a clear, consistent, and concise manner, and the relevant international standards that are increasingly integral to production, marketing, and communication strategies across every industry. Material specifiers and other design professionals can use these tools to meet today's carbon-constrained challenges and other environmental impacts of residential structures.

Wednesday, 2/19	
1:00 – 3:00 PM	**Policies to Enhance Resilient Communities** **Lionel Lemay & Tien Peng (NRMCA)** Natural disasters are physically, socially, and psychologically devastating to a community. It can be extremely difficult to rebuild and restore the lives of residents after the destructive event. Moreover, leading scientists now believe our vulnerability will increase due to climate change. Building resiliency, while reducing future greenhouse gas emissions, is a necessary and complimentary strategy for dealing with the accelerated rate of adverse events. Where do organizations and governments begin to help its constituents? FEMA, USGS, NOAA, EPA, NIBS and IBHS all offer solutions for disaster preparedness with a myriad of processes or protocols in place for dealing with the unthinkable. What is missing however is the development of specific policies to advance the security and disaster risk reduction of our infrastructure. Resilient infrastructure policies move the community from reactive approaches to a proactive stance where stakeholders actively engage in reducing many of the broad societal and economic burdens that disasters can cause. Investing in resiliency, from strengthening building codes to restoring natural ecosystems, can be surprisingly cost-effective, greatly reducing the impact of natural hazards. Policies affecting building practices can also be instrumental in increasing economic investment in making the socio-economic dimension of our society resilient and climate proof. This paper describes strategies that bring together the tools and activities from many different sectors in an effort to address resilience including: 1. Leveraging green-building momentum to include resilience. 2. Development of ordinances and mandatory building codes. 3. Addressing durability with lifecycle costs and ongoing maintenance. 4. Increasing and improving infrastructure investment from all stakeholders. By spreading awareness of the resilient options available to help hazard-risk communities to prepare, policy makers can catalyze the building of efficient, livable communities that are healthier and stronger right now.
	Value-Based Evaluation of the Residential Energy Assessment Process **FuJu Wu, David Riley, Kelly Sprehn, and Tabitha Sprau Coulter (Penn State), Michael Whelton (IERC)** Residential energy efficiency improvements represent a significant opportunity to lower national energy demand, reduce energy costs for consumers, and also to create jobs in the construction and manufacturing industry. The U.S Energy Information Administration (EIA) has stated that the residential sector has a significant impact of global energy use and carbon emissions: the residential sector consumed 22% of the total annual energy consumption, even higher than 19% consumption of commercial sector (EIA 2011). Even the use of home energy audits by energy service professionals to create market demand among homeowners to invest in energy efficiency improvements has proven to be challenging, the existing energy audits are not popular, because of the intention of hard sell, bad (and expensive) advices. (Shelton Group energy 2011). The research proposes to present an innovative approach and reclaim this misunderstanding by maximize the value of residential energy auditing processes through alternative approaches to the engagement of homeowners. The National Energy Leadership Corp (NELC) has established an experimental energy assessment program that engages both leadership training and innovative tools in regional community hubs. Through pilot programs at multiple universities, the NELC has demonstrated key value-generating transactions including pre-audit surveys, the assessment of world view and cognitive style, and the use of data collection and report-writing tools. An overview of the research and development of the NELC program, as well as experimental practices of residential energy auditing are provided. The aim of the research is to address shortcomings of traditional residential energy auditing processes while also demonstrating the value and efficiency of proposed improvements that can be experienced by homeowners, community members, and energy service/retail professionals.
3:00 – 3:15 PM	Break

Wednesday, 2/19	
Late Afternoon	Technical Sessions
3:15 – 5:15 PM	**Observations from Model Scale Thermal Tests on Heat Exchanger Pile** **Prasenjit Basu, Omid Ghasemi-Fare, & Cory Kramer (Penn State)** Geothermal energy harvested through heat exchanger piles can be used to partially meet the heating and cooling energy demand for residential and commercial buildings. Despite the growing recognition of the benefits of this technology around the world, the complex heat transfer performance of these piles is not yet fully understood. This paper describes a series of thermal tests performed on a model concrete heat exchanger pile installed in a standard F50 Ottawa sand bed. A constant-temperature water bath was used to circulate heat carrier fluid (ethylene glycol and water mixture) through the pile. Thus the experiment closely captures different aspects of real-life heat circulation through geothermal piles. Temperature measurements were obtained at different locations within soil, on pile surface, on the tank boundary, and at the inlet and outlet points of the circulation tube. Recorded temperature data is used to obtain time-dependent heat exchange efficiency of the model pile. Results show the effects of operational and site-specific parameters on energy output from geothermal piles. Data gathered during this study not only provide insight into the physics of complex heat transfer process but also can be used for verifying results from numerical simulations with appropriate boundary conditions.
	Evaluation of Venetian Blind Attributes for Energy Efficiency **Tim Ariosto and Ali Memari (Penn State)** The 2011 Building Energy Databook (DOE, 2011) reported that buildings use approximately 40% of the nation's total energy use. Residential buildings use 54% of this energy while commercial buildings use 46%. One method of reducing this value is to replace inefficient single glazed window units with their newer, energy efficient counterparts. Another method involves utilizing window retrofit solutions. Building owners have several options of retrofit solutions, including curtains, draps, blinds, screens, and shutters. While these products are often selected for aesthetic or privacy concerns, they can also provide an effective means of limiting heat transfer (Ariosto and Memari, 2013). Venetian blinds are one of the more common window retrofit solutions. Several researches have investigated the thermal behavior of these systems (Machin et al., 1998, Oosthuizen et al., 2005, Shahid and Naylor, 2005, Yahoda and Wright, 2004). However these studies focused primarily on the heat transfer mechanisms themselves (primarily convection and radiation) without translating results into the metrics often used to compare glazing systems - U-values and SHGC. This makes it difficult for the layman to utilize their results. The study described herein involves investigation of a variety of venetian blind attributes including geometric attributes such as slat width, angle, and spacing as well as material properties such as conductivity and surface emissivity, on the performance indices (U-value, SHGC) of double glazed window systems. The analysis was completed using the publically available software WINDOW (LBNL, 2013). The results of the study will be useful for building owners to understand which blind attributes are most important for energy efficiency.

Wednesday, 2/19	
3:15 – 5:15 PM	**Twelve Simple Steps to Net-Zero Energy Design** **Ted Clifton (Zero Energy Plans)** 1. Building Orientation. Ridge-line needs to be east-west oriented, with lots of clear, south-facing area at an appropriate roof angle for the latitude. 2. Simple Design. Surface area is your enemy, both in terms of cost, and in terms of conductive heat loss. The closer you can keep your design to a cube, the less surface area you will have. "Dress" the house up with covered porches, and other useful outside living areas that will also provide shade when you need shade, and protection from the rain & wind, without needing to be mechanically heated and cooled. 3. Window orientation. Window sizes and locations much match the needs of the climate zone. Shading of the windows, with overhangs and covered porches, should match the requirements of the climate zone. 4. Thermal Mass. There needs to be sufficient thermal mass to absorb and hold excess daytime energy to be released at night, eliminating day-night temperature swings of more than one or two degrees inside the dwelling. Thermal mass should have direct sunlight exposure where possible in heating climates. Thermal mass needs to be entirely within the building envelope! 5. Tight Envelope. The building envelope needs to be tight. Ventilation should be by plan, not by accident. Wall cavities must not be allowed to act as filters for pollutants. 6. Balanced Insulation. It is not cost-effective to super-insulate one part of a house while ignoring other parts. Windows and doors are typically the weakest link, so it is usually more cost-effective to specify and use the most energy efficient windows and doors available. Match the insulation level for walls, floors, and ceilings to the climate zone. The vapor profile of the various components of the building envelope needs to be consistent with the requirements of the climate zone. 7. Balanced Ventilation. Whether fully balanced, or partially balanced, the ventilation system should be designed to use the least amount of energy to operate, with a heat-recovery factor that is appropriate for the climate zone. HRVs do not always pay off. 8. Heat Pump. Where not prohibited by climate zone issues, a heat pump should be used as the primary heating system. Other sources, such as natural gas, should only be used as back-up systems, for the most extreme weather. Ground source heat pumps, in-floor radiant systems, and ductless heat pumps are preferred. Heat with heat, cool with air. 9. Solar Hot Water, or Heat Pump Water Heater. Where appropriate by climate zone, solar hot water heating, and heat pump water heating should be used. Water storage tanks should be inside the building envelope, unless the home is in a hot climate. Heat pump water heaters are preferred inside the envelope in hot climates. 10. Efficient Appliances. Appliances should each be the lowest energy-use of any in their respective categories. 11. Efficient Lighting. Most residential lighting should use standard type "A" sockets. CFLs can be used for most applications, high-use locations should use LEDs. Lighting should be focused on surfaces. Excessive use of redundant lighting systems should be avoided. 12. Alternative Energy. PV system size should match intended annual loads. Local climate conditions and shading will be a primary determinate. Powering your electric car with your house is feasible in most climate zones, and should be considered for the greatest long-term financial benefit.
5:30 – 8:30 PM	**Networking Reception** Penn State Hintz Alumni Center Transportation from the Penn Stater Conference Center Hotel will be provided

Thursday, 2/20	
Early Morning	Technical Sessions
8:30 – 10:15 AM	**Welcome** Dr. Ali Memari, RBDC Conference Chair
	Home Building Impact **Keynote Speaker – David Crowe, Chief Economist, National Association of Home Builders** Home building provides jobs to construction workers, building material suppliers, land developers and countless other occupations. New homes also require additional fiscal costs to provide services to the new residents. Many arguments and misguided statements have been made about whether housing pays for itself. NAHB developed and refined a model of the local economic impact of home building that shows the actual positive economic benefits as well as the added fiscal costs to determine the final and factual answer.
	New Methods of Delivery: Prefabrication Strategies in Residential Construction **Invited Speaker – Erik Churchill, Project Manager, SHoP Construction** Founded in 1998, SHoP has continually sought to improve the design and quality of residential construction by examining methods of delivery and exploring new approaches and technologies. As architects, construction managers, and developers, SHoP has operated in various contractual positions and utilized different scales of prefabrication. Our approach is that prefabrication is not an architectural philosophy, nor defines a style—it is a construction technology, and that when married with the right project team and process, is another tool that can be employed to deliver the highest value to all stakeholders. It is not simply about doing more with less, it is about expanding the opportunities for design. By integrating design, engineering, fabrication, and on-site construction, SHoP works across the entire delivery model to realize the best opportunities for prefabrication. A Virtual Design and Construction process is designed and managed for each project that creates feedback loops between designers and fabricators to help identify and unlock the most value. The additional value can be seen in reduced costs, reduced onsite duration with less impact to the community, higher quality for the tenants, and lower embodied energy. Case study examples of SHoP's use of prefabricated construction solutions include The Porter House, Manhattan, NY; 290 Mulberry, Manhattan, NY; B2 Bklyn Modular, Brooklyn, NY; and a modular brownstone in Redhook, NY.
10:15 – 10:30 AM	Break

Thursday, 2/20	
Late Morning	Technical Sessions
10:30 AM – 12:00 PM	**Performance Optimization and Development of a Home Modular Delivery System** **Lisa Iulo, Bruce Quigley, & Aaron Wertman (Penn State)** Recent estimates project that population increases and loss of housing due to demolition will translate into a need for about 1.5 million additional new housing units in the U.S. each year (McWilliams, 2013). Existing towns are an obvious choice for investing in housing to address this growing need. The walk-able, mixed-use character of existing communities make them inherently sustainable, and the benefits of redevelopment are obvious; a vibrant small town has the potential to be a very desirable place to live. Cost-effective new infill housing and retrofitting of existing homes hold promise for revitalizing existing towns by addressing housing options that will allow aging residents to remain in their community. However, currently most new subsidized housing focuses on multifamily and larger projects inappropriate for the majority of Pennsylvania's existing communities. The project presented in this paper recognizes the need for a delivery model that supports local builders and manufacturers in delivering affordable single homes and small housing projects. Modular construction holds promise for enhancing the quality, energy efficiency, sustainability, and durability of residential construction for new and existing homes. The home modular delivery system, KoP, is intended as the core building blocks for realizing infill housing on a broad scale. Development of a modular "kit-of-parts" has significant potential for the delivery of homes that are highly energy efficient and affordable to construct and maintain. This research explores modular building as a response to multiple apparent and specific needs for housing in Pennsylvania and beyond, including: 1. The need for the production of healthy, energy efficient housing and retrofit of existing homes. 2. Modest housing for an aging population – emerging demographics are driving a strong need for high quality, low maintenance housing that is modest in size and cost. 3. Demand for housing related to the natural gas industry - The rapid expansion of the natural gas industry because of drilling in Marcellus Shale formation is causing unprecedented growth in established towns throughout a region unaccustomed to growth (Thompson, 2011). This paper will present precedents, urban analysis and potential solutions for the modular home delivery system, KoP. KoP includes a carefully considered and flexible modular system for new and retrofit homes that can accommodate contextual adaptation to multiple infill sites and program needs. Modular construction can effectively achieve the level of quality control requisite for healthy and energy efficient homes. Multiple KoP modules can be combined and configured for the delivery of new houses and small housing projects on a variety of site conditions. Modular augmentation cores, that include well-integrated mechanical and plumbing systems, will also be advanced. These cores can be employed to save, update, transform and retrofit existing residences, especially in adapting homes for the accessible single floor living desirable for aging-in-place. Benefits of KoP include its potential for allowing the densification and revitalization of existing towns.
	Structural Systems and Design Considerations for Low-Rise Senior Living and Multifamily Residential Buildings **Jason Dreher & Mark Erdman (Structura)** Each day, approximately 10,000 people from the "baby boomer" generation turn 65 years old. Coupled with the expected population growth the DC-Baltimore region, there is a need for both traditional housing, and generational specific housing--but a stagnant economy has made supplying more housing a complicated endeavor. While low building costs have always been a priority, a hyper competitive marketplace has forced developers to differentiate their properties by adding environmentally friendly and sustainable building features, more amenities, and other building characteristics that don't necessarily contribute to cost efficiency. The onus is placed on the design team to select the most efficient structural system to mitigate the impact of more costly building features. For housing projects less than 10 stories in height, the most efficient structural system is not always obvious, particularly with so many viable options available. The aim of this paper is to explore the design considerations and nuances for traditional and generational specific housing, and to present several of the structural systems used for these types of buildings.
	Cost Effective Ways to Construct Energy Star Homes **Rick Gazica (ICF International)** The ENERGY STAR Certified Homes Program has raised the bar on how to deliver homes that are comfortable, durable, and efficient. This presentation will cover a number of topics relating to the ENERGY STAR HVAC design requirements, including the basics behind Manual J and S calculations, which inputs have the largest impact on load, and how homeowners factor into the equation.
12:00 – 1:00 PM	Lunch

Thursday, 2/20	
Early Afternoon	Technical Sessions
1:00 – 3:00 PM	**Meeting Residential Energy Requirements with Wood Frame Construction** **Lori Koch, John Showalter, & Loren Ross (American Wood Council)** Through the Energy Policy Act of 1992, the U.S. Department of Energy (DOE) offers incentive funding for states to adopt new, more efficient energy codes. The DOE has also directly influenced creation of the new energy code and set a goal of improving its efficiency by 30%. According to the U.S. Census Bureau, residential construction accounts for nearly one third of all construction by value, so the residential market is going to be affected. The 2012 residential energy requirements are established in two coordinated codes, the International Residential Code (IRC) and the International Energy Conservation Code (IECC). The IECC and IRC have four compliance options for meeting building envelope requirements: prescriptive R-value, U-factor, Total UA, and simulation methods. These methods increase in complexity with the simulation method being most complex, but in terms of flexibility, the trend is opposite. Of the four options, the Total UA method strikes the best balance between flexibility and simplicity. With the use of design aids, a builder, designer, or building official inexperienced with energy requirements can more easily determine energy code requirements. The American Wood Council is in the process of publishing a design aid called Design for Code Acceptance 7 (DCA 7): Meeting Residential Energy Requirements with Wood-Frame Construction. DCA 7 provides a simplified approach for determining U-factors for common wood wall construction. It also helps determine trade-offs for window to wall area U-factors so that improvements made in either area provide benefit to the overall energy design. This presentation will provide an overview of DCA 7 along with examples of its use for common wood wall construction. Comparison of the compliance options will show the balance between complexity and simplicity.
	Prescriptive Residential Deck Design **Lori Koch, John Showalter, & Loren Ross (American Wood Council)** Few structures are as ubiquitous yet as little-regulated as residential decks, which potentially makes them one of the most dangerous parts of a home. Currently, the International Residential Code has limited information on decks, so builders, designers, and building officials are often left with little direction. The American Wood Council publishes Design for Code Acceptance 6: Prescriptive Residential Wood Deck Construction Guide (DCA 6), which includes guidance on provisions of the 2009 IRC pertaining to single level residential wood deck construction. It gives prescriptive solutions for single level, 50 pounds per square foot total load, 18 feet wide, and up to 14 feet tall decks. Provisions included in DCA6 that are not included in the IRC are considered good practice recommendations. The prescriptive solutions provide minimum requirements to ensure safety and durability by including joist and beam sizes and lengths, and critical connection configurations such as ledgers and handrails. Conformance with the IRC's lateral requirements is met with the use of tension devices or knee braces. The user is even provided with foundation sizes based upon the tributary area around the columns. Changes are being made to the newest version of DCA6 for conformance to the 2012 IRC and to incorporate updates recommended by industry and users. These include modified joist and beam tables and knee bracing connection requirements.

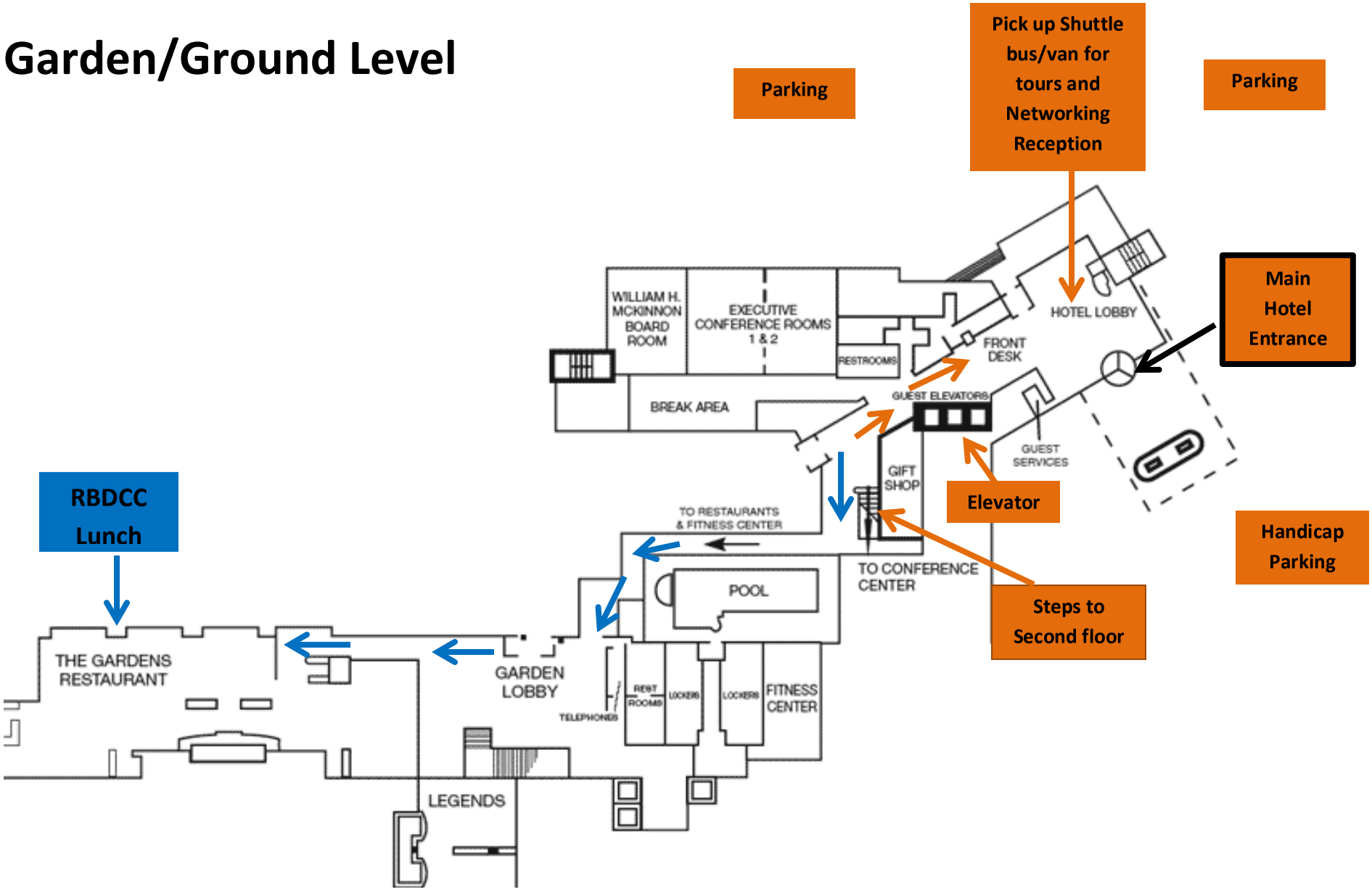
Thursday, 2/20	
1:00 – 3:00 PM	**Changes to the 2012 Wood Frame Construction Manual** **Kenneth Bland, Bradford Douglas, Lori Koch, Peter Mazikins, Loren Ross, & John Showalter (American Wood Council)** The 2001 Edition of the Wood Frame Construction Manual (WFCM) for One- and Two- Family Dwellings (ANSI/AF&PA WFCM-2001) was recently updated. The updated standard designated ANSI/AWC WFCM-2012 was approved November 29, 2011. The 2012 WFCM was developed by the American Wood Council's (AWC) Wood Design Standards Committee and is referenced in the 2012 International Residential Code (IRC) and 2012 International Building Code (IBC). The 2012 WFCM represents the state-of-the-art for design of one-and two-family dwellings for high wind, high seismic, and high snow loads. Its reference in the 2012 IBC and 2012 IRC will allow for its use in those jurisdictions adopting the latest building code. This presentation will serve to highlight the updates in the latest version of the WFCM. Some of the major changes in the updated WFCM include: updated load provisions per ASCE 7-10, design values were updated in accordance with the 2012 National Design Specification (NDS), clarification on shear wall story offset provisions, bringing the engineering design provisions of horizontal diaphragm assemblies and vertical wall assemblies in line with the 2008 Special Design Provisions for Wind and Seismic (ANSI/AWC SDPWS-2008), and allowing wood structural panels to resist uplift.
	Superstorm Sandy Storm Surge and Structural Damage Correlation - A Case Study of Long Beach, NY **Nicole Braxtan, Kerryanne Donohue-Couch, & Kerianne Westphal (Manhattan College)** The NYC region is currently recovering from the damage caused on October 29, 2012 from Superstorm Sandy, the largest low pressure storm ever to make landfall on the US east coast north of North Carolina. This storm tested all aspects to the infrastructure of the communities living close to the Atlantic Coast. Research was performed to review and process data that were collected before, during, and after the storm. The research focused on the city of Long Beach, NY. The scope of the research included three tasks: (1) reviewing and processing hydraulic data collected from USGS tide gages before and during the storm; (2) collecting and processing structural data collected after the storm focused on extent of damage to residential buildings and type of building construction; and (3) correlating, analyzing, and mapping flood data and residential damage utilizing GIS software. The results of this research points to a strong recovery theme– residences designed with heavier and sturdier materials (i.e. brick and stucco facades) are more likely to resist damage during a hurricane than those constructed with lighter materials (i.e. lightweight siding on wood frames). The damage can be resultant of hydrostatic and hydrodynamic forces due to rising floodwaters, as well as hurricane force winds. The extent of damage can also be correlated to the age of the residence and applicable zoning laws. Homes built more recently in accordance with stricter coastal zoning practices are better designed to resist hurricane forces. With Long Beach acting as a snapshot of the Northeastern coast, the research conducted with this city may be applied to many other coastal communities providing invaluable guidance to rebuilding during hurricane recovery and preparation for future events.
3:00 – 3:15 PM	Break

Thursday, 2/20	
Late Afternoon	Technical Sessions
3:15 – 5:15 PM	**Resuspension and Transport of Allergen-Carrier Particles in Residential HVAC** **Dong Hee Choi, Dong Hwa Kang, Paul Kremer, & James Freihaut (Penn State)** HVAC systems play an important role in transporting allergen-carrier particles that trigger asthma episodes in residential indoor environments. Unfiltered particles deposited on interior duct surfaces resuspend and transport when disturbed under mechanical vibration and varying air flow conditions in the system. Experimental data is needed to characterize the behaviors of individual allergen-carrier particles in response to HVAC system disturbances and to inform modeling work that will lead to better design and performance guidance for builders seeking to improve indoor air quality in residential settings. In this study, a combination of experimental work in residential settings and in a more controlled laboratory resuspension chamber setup is conducted to characterize the resuspension of allergen-carrier particles deposited in residential HVAC ductwork and to obtain resuspension rate data for individual allergen-carrier particles in various HVAC system environments. The results of this research investigation are important to understanding the behavior of allergen sources in residential homes.
	Structural BIM Processes for Modular Multi-Story Buildings in Design and Construction **Ryan Solnosky, Ali Memari, & Issa Ramaji (Penn State)** Modular construction and prefabrication is a growing trend in the Architecture, Engineering, and Construction (AEC) Industry based on a series of technological developments and its historical exposure to design and construction practitioners. Some of these technological developments come from a computing side such as Building Information Modeling, and advanced parametric studies or in new methods of structural modularity in the systems. Modular systems are inherently different in structural behavior, construction, design, and modeling in relation to traditional structural stick built structures. Methods to develop efficient solutions differ just as their other attributes do. Furthermore, the inclusion of modular and prefabrication design notions into the design process is often limited based on a lack of well thought out processes; the same can be said for the construction phase. Because of the need for better understanding of how modular systems function and interact with systems is limitedly known, defined processes in how to account for these behaviors can reduced the current high variability that relates to system effectiveness and project teams willing to implement it. This paper will focus on describing current design and construction processes and identify where modular aspects need to be considered at different lifecycle phases such as conceptualization design where the scale of modularity must be determined to selection decision as an example. Beyond the current status of industry processes, recommendations will be made on where more effort needs to be placed on defining more detailed processes around new technologies like Building Information Modeling. Additionally, the ties between defined processes and how they help software developers will be discussed.

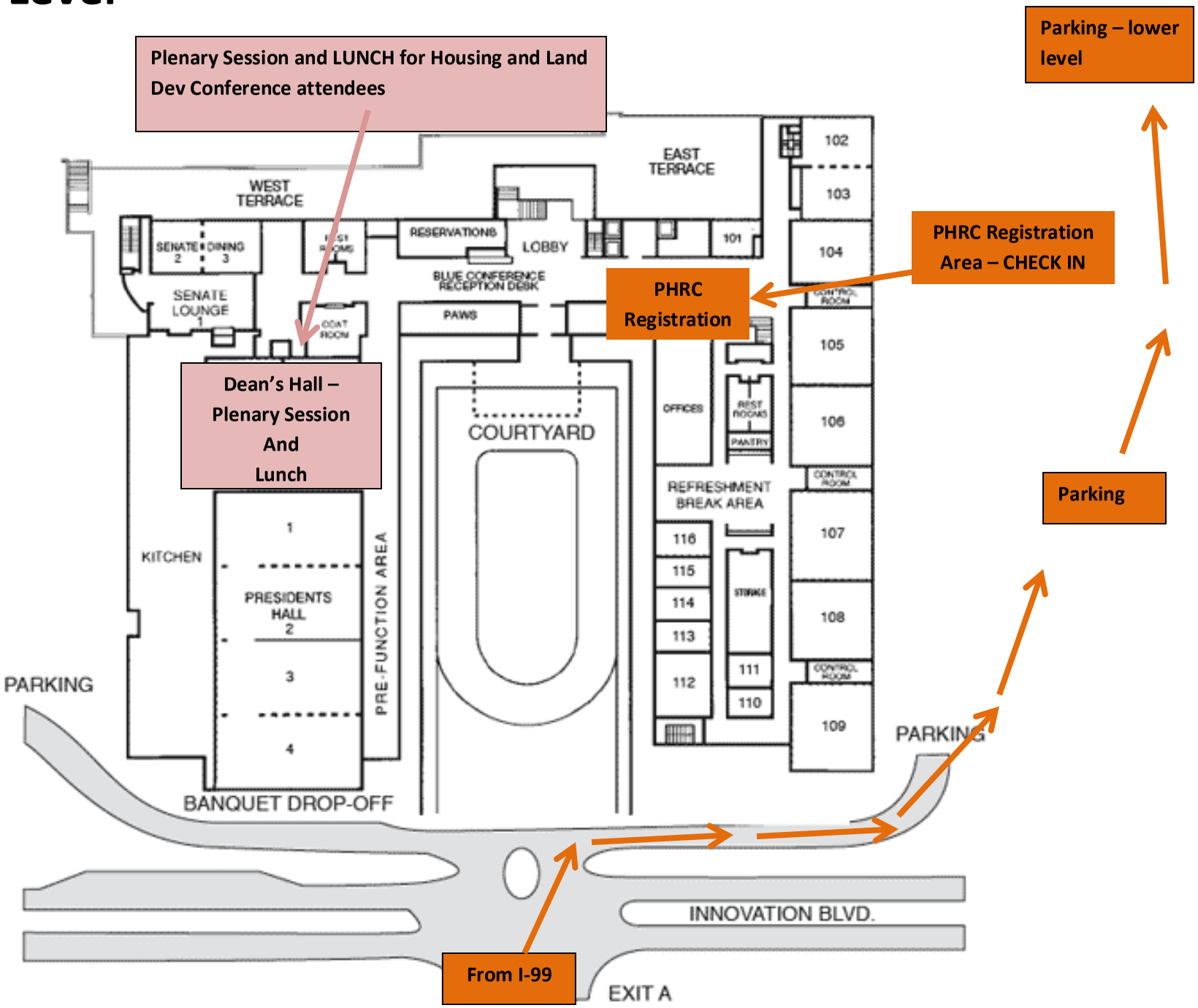
Thursday, 2/20	
3:15 – 5:15 PM	**Integrated BIM Platform for Multi-Story Modular Building Industry** **Issa Ramaji, Ali Memari, & Ryan Solnosky (Penn State)** Modular construction is known for its economic advantages and high construction quality because of the factory construction environment. Despite the simplicity of the construction of modular single-family dwellings that brings about speedy erection at the job site, the same thing cannot be stated for multi-story modular buildings, especially in design phase. Considering complexities in this industry, more integrated project management is required. Integrated project delivery needs an integrated information management system. Building Information Modeling (BIM) has been used during the past decade to address this need. In this system, different disciplines use an identical BIM model as an input for their analysis and a platform to share their results. Constant information exchanges between BIM models and specialized analysis and design software has to be reliable to have a flawless integrated BIM model. National BIM Standard (NBIMS) is established to address this need and has been used in many different types of construction so far. Using NBIMS for standardization of information exchanges in modular building industry will be very helpful for integrated application of BIM application in modular building projects. In this paper major components of the NBIMS that include Information Delivery Manual (IDM)/Model View Definition (MVD), Industry Foundation Class (IFC), and International Framework for Dictionary (IFD) will be discussed. Next, the methodology for extending the NBIMS will be discussed. Then, for more clarification, the efforts for extending NBIMS in structural analysis/design and precast/prestressed construction areas are reviewed. At the end, the processes for information exchange standardization in modular building industry are discussed
	Review of Different Components of Solar Decathlon House Projects **Ehsan Kamel & Ali Memari (Penn State)** Reducing fossil fuel consumption and adopting solar energy can mitigate pollution problems and improve living conditions. The required energy to be consumed in a house could be provided by natural resources such as solar and wind energy. Solar houses are good examples of application of solar energy. Studying different components of these houses could lead to better understanding of the performance and application of different materials and methods in construction of even conventional houses, in particular energy efficient design. In this paper, the past Solar Decathlon Competition projects are reviewed in order to categorize major load-bearing and non-load bearing components. In order to compare and assess the effect of each component, the following criteria as outlined by the solar decathlon competition rules are used: market appeal, affordability, comfort zone performance and energy balance. The components studied in this paper include floor, roof, wall systems, windows and glazing, insulation materials, and structural framing type. Another type of information that is gathered in the study includes available statistical analyses regarding the percentage of different structural framing and insulation types used in the design.

NOTES

Garden/Ground Level



Main Level


Plenary Session and LUNCH for Housing and Land Dev Conference attendees
Parking – lower level
PHRC Registration Area – CHECK IN
PHRC Registration
Dean's Hall – Plenary Session And Lunch
Parking
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EAST TERRACE
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DINING 3
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COAT ROOM
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RESERVATIONS
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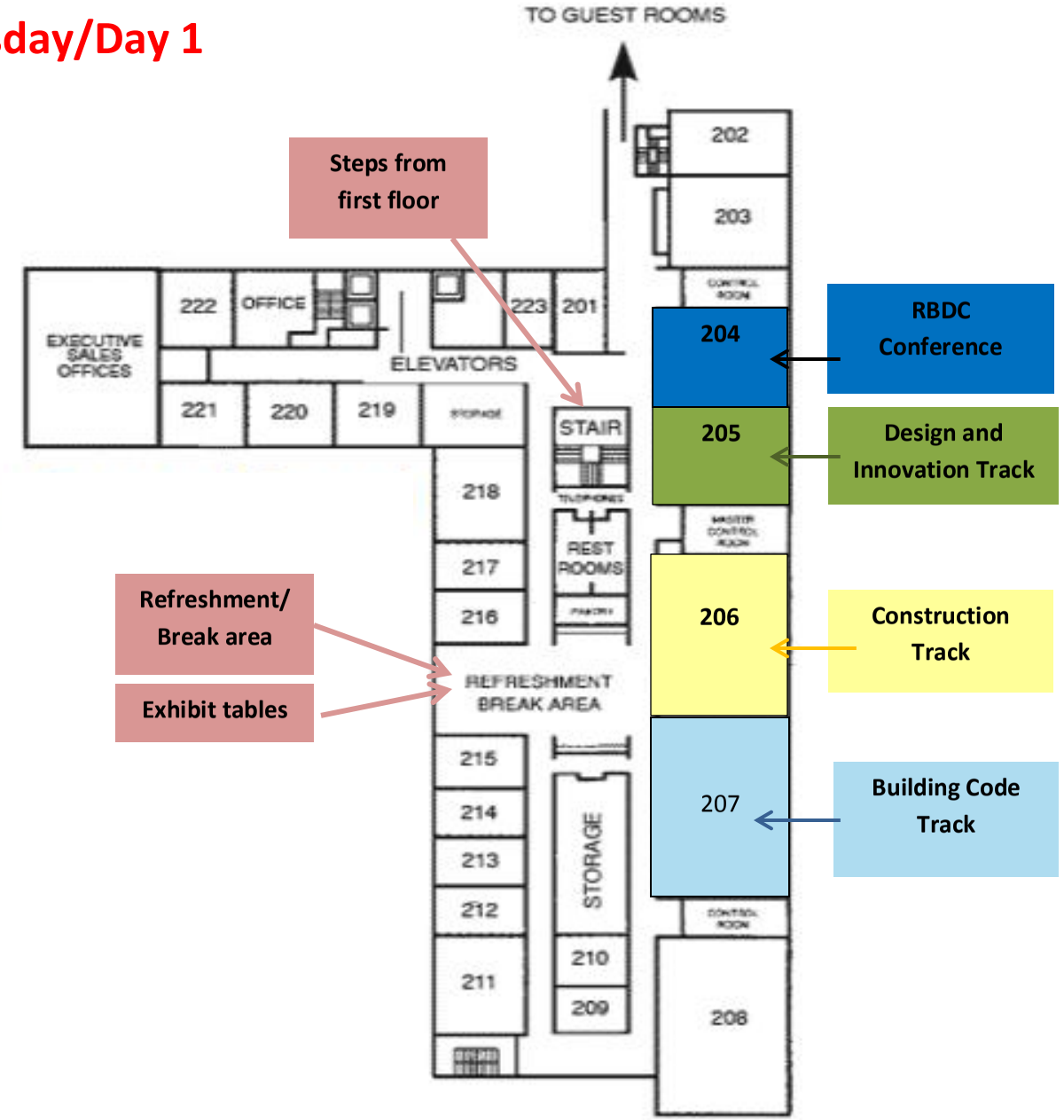
EXIT A

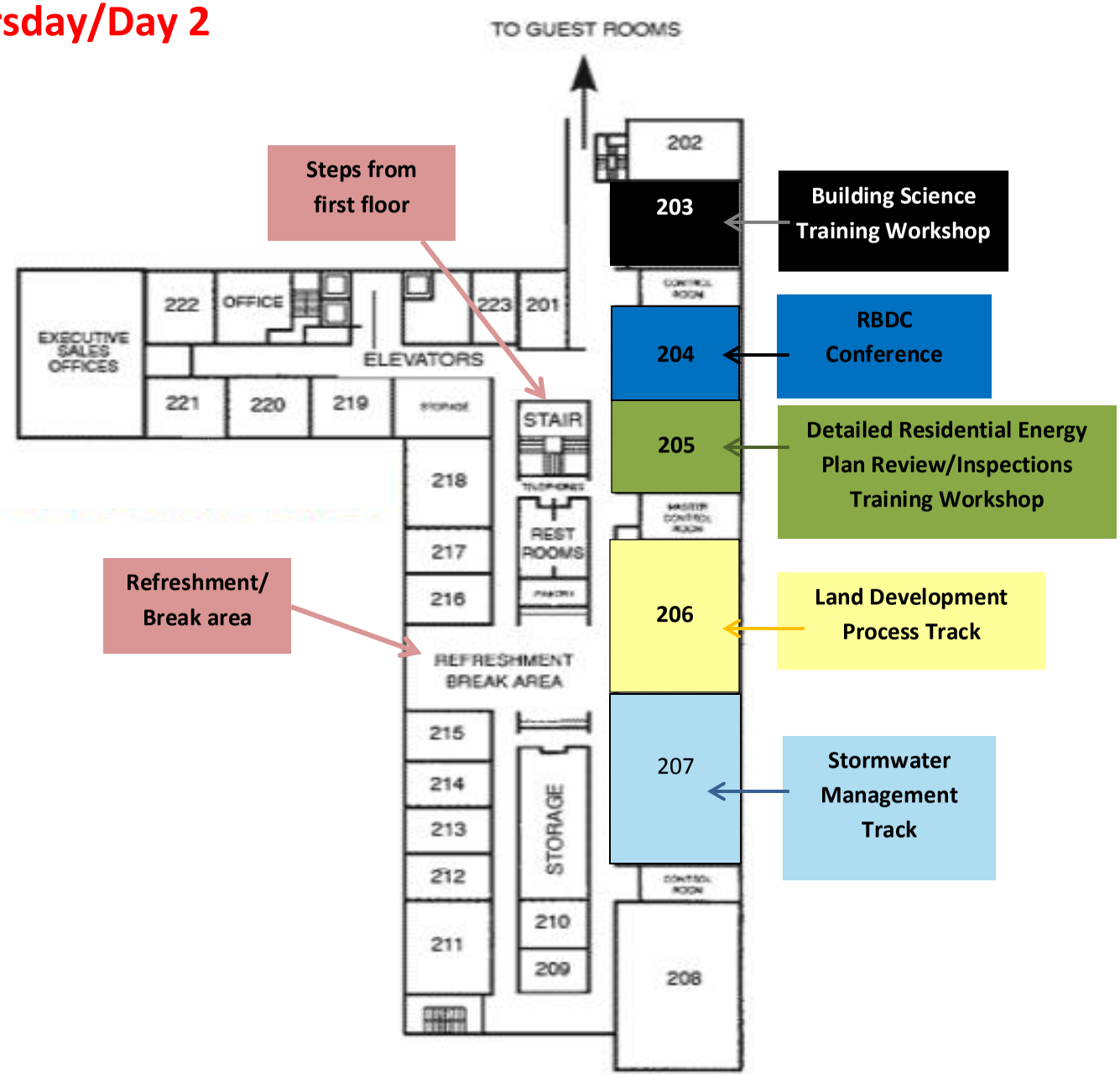
Second Level

Wednesday/Day 1



Second Level

Thursday/Day 2



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