



The Pennsylvania Housing Research Center

PHRC Year in Review

July 2015 – June 2016

Published August 2016

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Introduction

The purpose of this document is to provide a summary of activities the Pennsylvania Housing Research Center has pursued and products that have been delivered between July 1, 2015 and June 30, 2016.

Each year, the Pennsylvania Housing Research Center (PHRC) seeks to conduct a series of projects that collectively satisfy the following criteria. Projects should:

- meet the needs of the residential construction industry and the housing consumer in Pennsylvania;
- be consistent with the mission and goals of the PHRC;
- be affordable and feasible, given the resources available and the prevailing constraints on time, expertise, and facilities; and
- be a balanced program of projects that address both the long- and the short-term needs of the industry.

The PHRC receives funds from multiple sources including funds collected under Act 157 of 2006, which established a two dollar fee collected for each building permit to support training and education for the construction industry. To assure that programs funded in whole or part with Act 157 monies meet the needs of the construction industry, Act 157 requires that education, training and other activities provided by the PHRC be approved by its Industry Advisory Council (IAC).

The projects undertaken were developed with input and assistance from the PHRC's Industry Advisory Council (IAC). This body consist of builders, developers, design professionals, code officials, manufacturers, suppliers, remodelers, and industry associations as well as state and federal agencies. After a thorough discourse at the spring IAC meeting in April 2015, the members of the IAC voted on projects they felt were the highest priority for the industry.

The result of this input was the "*PHRC Project Plan, July 2015 – June 2016*", which outlined projects that the PHRC would undertake during this time period. The plan included only those projects that were to receive funds provided to the PHRC by the Commonwealth of Pennsylvania through the Act 157 permit fees. When appropriate, the PHRC attempts to use state funding to leverage outside support. It should also be noted that the PHRC undertook an array of additional projects that did not receive any state funds. Some of these projects are included in this report but are identified as having no support from the Act 157 funds.

Through the MOC that Penn State University has with the Department of Community and Economic Development (Contract #27-872-0001), the PHRC is required to submit to DCED an annual work plan and an annual report summarizing the activities for the previous year with respect to the fee. This "Year in Review, 2015-2016" is submitted to meet the annual report requirement.

PART I - Education, Technical Assistance & Outreach

The PHRC has a mandate to transfer knowledge by providing the necessary training and education to the wide variety of groups that make up the housing industry. To meet this expectations the PHRC offers an array of activities to educate and transfer appropriate technologies to the industry. These activities can include the development and delivery of educational programming using a variety of media, the hosting of conferences/symposia, and the publication of reports, as well as serving as a general resource to the industry in answering questions.

Counting workshops, webinars, speaker services, and conferences, the PHRC has provided 43 educational services to 1,979 individuals during this reporting period (Table I).

Table I. Summary of all PHRC Educational Programs for the 2015-2016 Project Year

PROGRAM	Activities for 2015-2016	
	# of Events	# of Attendees
Workshops	16	511
Webinars	9	586
Speaker Service	15	688
PHRC Conferences/PCCA Symposium (Central)	3	194
TOTAL	43	1,979

The distribution of the number of educational services over the past 16 years is plotted in Figure 1. The total number of programs delivered during the 2015-2016 period is 43, which is less than the average number of programs offered each year since the PHRC started receiving the Act 157 funds (62). This decrease in delivered programs is due to the lack of a state budget and its impact on the Pennsylvania Construction Codes Academy (PCCA), the PHRC's primary partner in delivering workshops.

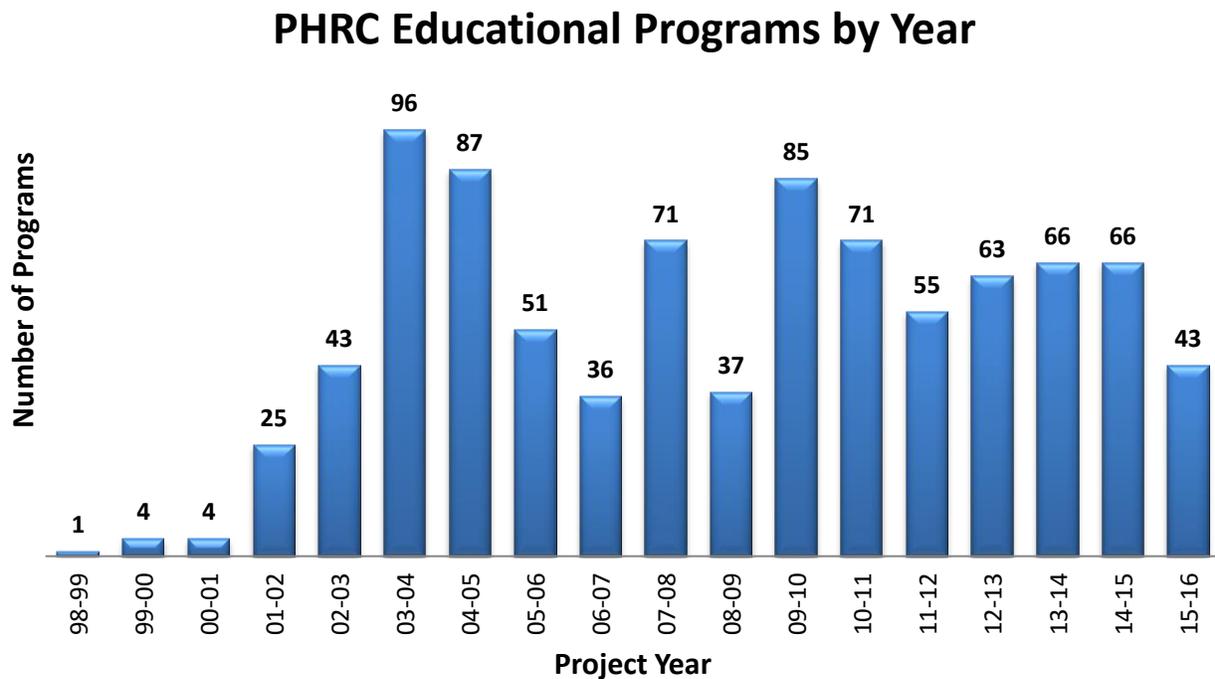


Figure I. PHRC Educational Programs by Year.

The five general categories of the PHRC's work in this area include:

- A. Workshop Delivery
- B. New Workshop Development
- C. Webinar Development and Delivery
- D. General Technical Assistance, Technology Transfer, & Outreach Activities
- E. Builder Briefs

The following sections labeled A through E of the report will provide further details on the PHRC's accomplishments in each of these categories.

A. Workshop Delivery

The PHRC has developed and maintains a wide array of workshops for many sectors of the construction industry with a focus on residential construction. These programs are intended to address technical issues facing the industry. Additionally, the PHRC will customize programs to better meet the needs of an industry partner. Workshops are geared to an audience that may include builders, remodelers, trade contractors, design professionals, teachers, and building code officials.

The following is a full list of in-person training programs available for delivery by the PHRC.

(1) Residential Building Scholars (RBS)/Residential Code Scholar (RCS)/Code Refresher programs are intended for those wishing to attain the RBS designation or for code officials looking for a short review of the key code issues in a 1-day version, as opposed to the multi-day academy version. These programs are also well-suited for anyone interested in an introduction to building codes, an update from 2006 to 2009 IRC provisions, or information to make inspections go more smoothly.

- | | |
|-----------------------------|-------|
| a. IRC Building | 1 day |
| b. IRC Plumbing | 1 day |
| c. IRC Mechanical | 1 day |
| d. IRC Electrical | 1 day |
| e. Residential Energy Codes | 1 day |

(2) Focused Topics programs are designed to immerse the student more deeply into a particular aspect of construction. These programs are ideal for meeting continuing education requirements for RBS designees and certified code officials.

- | | |
|--|-------|
| a. Advanced Framing – Increasing Performance & Reducing Costs | 1 day |
| b. Beginner’s Blueprint Reading | 1 day |
| c. Building Envelope Design and IECC Code Compliance | 1 day |
| d. Commercial Energy Essentials | 1 day |
| e. Residential Deck Design and Construction | 1 day |
| f. Residential Plan Review and Inspections | 1 day |
| g. Exterior Plaster Finish Systems: Avoiding Moisture-Related Failures | 1 day |
| h. Building with Exterior Rigid Foam | 1 day |
| i. 2009 IECC Commercial | 1 day |
| j. 2009 IECC Residential | 1 day |
| k. Residential Energy Plan Review and Inspections | 1 day |
| l. Commercial Energy Plan Review and Inspections | 1 day |
| m. 2009 Mechanical Residential | 1 day |
| n. 2009 IRC Multi-Family | 1 day |
| o. Photovoltaic Installation and Inspection | 1 day |
| p. Solar Domestic Hot Water Installation and Inspection | 1 day |
| q. Residential Sprinkler Inspection/Installation | 1 day |

(3) **Academy Programs** are typically offered twice per year through the Pennsylvania Construction Codes Academy (PCCA). These programs are geared toward beginning code officials seeking to pass their certification exams, or anyone interested in a comprehensive overview of residential building codes.

- | | |
|--|-------|
| a. International Residential Code – Building Academy | 4 day |
| b. International Residential Code – Plumbing Academy | 4 day |
| c. International Residential Code – Mechanical Academy | 4 day |
| d. International Residential Code – Electrical Academy | 4 day |
| e. Residential Energy Code Essentials | 2 day |

Report: During the 2015-2016 project year, the PHRC delivered 16 workshops to 511 builders, remodelers, educators, code officials, design professionals, and planners during this reporting period (see Table 2 for detail).

Table 2. PHRC Workshops Held July 1, 2015 through June 30, 2016

PROGRAM	In-person/ Online	# of Programs	# of Attendees
Achieving Compliance with the International Energy Conservation Code in Commercial Occupancies	Online	1	136*
Exterior Plaster Finish Systems: Avoiding Moisture-Related Failures	In-Person	1	40
Commercial Energy Essentials	In-Person	2	43
Electrical Essentials Academy	In-Person	1	27
IRC Building Code Academy – 4 days	In-Person	1	14
IRC Plumbing Code Academy – 4 days	In-Person	1	23
IRC Mechanical Academy – 4 days	In-Person	1	12
Residential Energy Essentials – 2 days	In-Person	1	7
IRC Electrical Code Refresher – 1 day	In-Person	1	22
Residential Plan Review and Inspection	In-Person	3	69
Residential Deck Design, Construction & Inspection	In-Person	3	118
Total Programs Held		16	511

*Note: Attendees for online courses indicate the number of people who have completed the program as of date of report. A total of 246 are enrolled in the online program.

Online Training Programs

The online program “Achieving Compliance with the International Energy Conservation Code in Commercial Occupancies” was launched in July 2014. It is a self-paced program that allows participants to watch program videos on their own schedule. There are quiz questions for each of the 25 modules, and participants must get the questions correct to move on to the next module. As of July 2016 a total of 246 people have enrolled in the

program, and so far, 136 people have completed all modules of the program. All 136 people used the discount code to receive the free certificate. The feedback from the program is very positive. This program was funded through grant money from the PA DEP and not developed using Act 157 funds.

B. New Workshop Development

The PHRC develops and updates new workshops to address issues challenging the residential construction and design industry (builders, developers, design professionals, remodelers, building code officials, materials suppliers, etc.) During this period the following programs were developed:

1. HVAC Design and Installation

Description: As new home construction introduces tighter and more efficient wall assemblies, the need for design and installation of efficient HVAC equipment is essential. With this flexible program, we will work with industry HVAC experts in creating a full day HVAC design and installation class which can also be delivered in two, half-day sessions, or one full-day session. This will be a two-year project with the focus of the 2015-2016 being on the design portion. Outside content experts will be consulted for assistance in development and final program review.

Manager/PI: C. Hine

Report: After contacting industry professionals, finding the right expertise to consult on the development of the program has proven to be difficult. Moving forward the PHRC will develop the training program internally and provide the industry with a copy for professional stakeholder review. This project is expected to be sent out for review in late October 2016.

2. Update of Existing Deck Program

Description: Based on a 2012 NAHB statistic, 26% of new single family homes are constructed with decks (roughly 5,000). This does not include decks constructed after the certificate of occupancy has been issued. With that being said, the review of code compliant residential wood deck design and construction is vital to the safety of consumers and builders alike. This project will review and update the existing PHRC Residential Deck Program to include up-to-date requirements along with incorporating critical details.

Manager/PI: C. Hine

Report: The Residential Deck program was updated and has been delivered three (3) times since the update. Updates to the program include incorporating the sections of the 2015 International Residential Code that have been adopted in PA as part of the UCC, as well as including figures from the American Wood Council's Design for Code Acceptance (DCA) 6 – Prescriptive Residential Deck Construction Guide. New examples have been

added to the end of the program, more photos have been included throughout, and the template was reformatted to reflect the PHRC's updated branding and template.

3. Moisture Considerations in Residential Building Enclosures Program

Description: The PHRC currently offers a Building Envelope Design and IECC Code Compliance workshop that analyzes some of the fundamental building science concepts and the effect they have on code requirements for residential construction. This full-day workshop will take a deeper look at the design of building assemblies including foundation, wall, floor, and roof assemblies as they relate to moisture. This workshop will focus, in-depth, on concepts such as water resistive barriers, vapor retarders, and rainscreen cladding systems. This workshop will be primarily marketed to design professionals including engineers and architects.

Manager/PI: B. Wolfgang

Report: In evaluating expanded online education content and delivery opportunities, it was determined that an advanced moisture management course would work well in an electronic format and delivered in a similar way as PHRC webinars. With this in mind, a total of four (4) modules were developed that address moisture management in residential construction. These modules were based on the concept of the 4-D's of moisture management – Deflection, Drainage, Drying, and Durability. Each module consists of a 90-minute presentation, to be delivered using Adobe Connect on a weekly or every-other-week schedule. Additionally, if requested, this course could be delivered in the traditional format with minimal modification.

4. Update to Existing Exterior Rigid Foam Program

Description: The PHRC has previously developed a half-day exterior rigid foam workshop that was piloted but did not gain traction. As the industry and above-code programs continue to focus on the reduction of thermal bridging, it is timely to expand this program to a full day workshop by adding content related to building science, updated code provisions, and new products and technologies. This workshop will also focus on details developed by the PHRC related to penetrations through exterior rigid foam.

Manager/PI: B. Heitzmann & B. Wolfgang

Report: The expansion of the exterior rigid foam program from a half day to a full day program was completed by focusing on the development of a robust building science section and on the details of constructability. The program was expanded to include the role of exterior rigid foam in heat, air, and moisture flow. The proper details crucial to providing a high performance assembly, such as fastener selection and tape specification, are also included in the updated program.

5. Deck Details – Expansion of Mock-Up Based Training

Description: Over the past year, the Mockup Training series has been delivered to over 250 people across the state of Pennsylvania through speaker engagements, conference invitations, association board meetings and industry leading corporate meetings. These programs have reached everyone in the industry profession from builders, code officials, architects, engineers and sub-contractors from all trades. We will continue the expansion of our mockup training series by developing a one-hour design/construction program, which will include code compliant requirements along with best practice guidelines from the American Wood Council's document DCA-6 (Design for Code Acceptance, Prescriptive Residential Wood Construction Guide). It will also include development of a mockup for visual aid and generation of critical details to populate the Details that Work detail book.

Manager/PI: C. Hine

Report: The one hour speaking engagement for Residential Decks has been completed and offered. The mockup is scheduled for completion by September 2016. This mockup will add a visual, hands-on dimension to the one hour speaking engagement.

6. Stormwater Regulations Training for Municipal Officials

Description: It is very difficult to keep up with the constantly evolving regulations related to stormwater management (SWM), especially when SWM is the not your primary focus, as is the case for many municipal officials. There is a need for a training to local government officials on the overlapping regulations and permits related to land development and SWM such as Subdivision and Land Development Ordinances, Act 167, and Municipal Separate Storm Sewer Systems (MS4s). This program will be a one- to two-hour overview of the different regulations and how they can apply to and executed in different municipalities.

Manager/PI: K. Blansett

Report: The program provides a concise overview of the MS4 program, Act 167, and local ordinances and how all three overlap and tie together. A preview of the new MS4 permit (that was in draft form at the time the program was developed) is included in the discussion, as are areas of input to DEP needed for permit development. The program was delivered at the PA State Association of Township Supervisors (PSATS) annual conference to an audience of approximately 70 people. The session was well received and can be provided to other organizations.

C. Webinar Development and Delivery

In today's economic climate, there is a need for technical programs without the added cost of hotel stays and transportation. To help meet this need the PHRC has continued its successful monthly webinar series presented on the second Tuesday of every month (Sept – May) at 1:00pm. Special Topics webinars are also developed and delivered when there is a need for timely update on a particular topic, such the adoption of regulation or

legislation related to the construction industry. Webinars are delivered live, and are also archived for on-demand viewing. One certification maintenance credit is offered for each webinar for PA code officials. As appropriate, AIA Learning Units (LUs) for architects and professional development hour (PDHs) for engineers are offered. Continuing education credits are offered following the live version of the webinar and not for viewing an archived recorded.

Manager/PI: Heitzmann

Report: The PHRC delivered nine webinars during this reporting period to a total of 586 people. Due to the PA Housing and Land Development Conference, no webinar was held in March. See Table 3 for the summary of webinars and attendees.

Table 3. 2015-2016 Webinar series titles and number of attendees

Webinar Series		
Month	Title/Topic	Number of Attendees
September	Challenges, Considerations, and Concerns of Indoor Air Quality	40
October	Where to Draw the Line with Thermal Boundaries	49
November	Moisture Considerations for Insulated Building Assemblies	123
December	Technology in the Connected Home	45
January	Defining Failures in Residential Construction	67
February	Affordable Housing Initiatives in PA: Land Trusts	23
March	No Webinar, PHRC Conference	-
April	Shedding Light on Glazing Safety and Performance	30
May	Residential Deck Design & Detailing	102
May	Special Webinar: 2015 PA UCC Code Update	107
	Total Attendees	586

D. General Technical Assistance, Technology Transfer, & Outreach Activities

This reporting item is a continuation or expansion of activities to transfer information and publications to builders, remodelers, design professionals, building code officials and others involved in the residential construction industry.

Manager/PI: Blansett

Report: The PHRC had organized, developed, and/or delivered the follow activities:

- I. The Annual Pennsylvania Housing and Land Development Conference & PCCA Symposia Central

2. Speaker engagements and conference presentations
3. General outreach activities

I. The Annual Pennsylvania Housing and Land Development Conference

This two-day event provides information and updates on issues of interest to the residential construction industry. The intended audience is builders, remodelers, code officials, design professionals, home performance contractors and other industry related professionals. Day 1 of the conference focuses on issues related to the housing structures and their systems, while Day 2 focuses on Land Development. Training programs are also offered on Day 2 of the conference.

Report: The 24th annual Housing and Land Development Conference was held on March 2nd and 3rd, 2016 at the Penn Stater Conference Center and Hotel in State College, PA. Given that each day caters to distinct audiences of the residential building industry, for the purposes of reporting each day is recorded as a separate event.

Housing Day (Day 1): Day 1 of the PHRC Conference started off with a keynote from Tim McDonald, Associate Professor of Practice in Architecture at Temple University, a Registered Architect, LEED AP, Certified Passive House Consultant and President of Onion Flats LLC, entitled “The PHFA Project: A National Net-Zero Energy Affordable Housing Initiative.” This keynote focused on the process, results, and impact of including Passive House certification options within PHFA financing mechanisms. After the conclusion of the Keynote, the conference then broke out into three separate tracks which were geared toward different audiences/professions within the industry.

- Design Track
 - “Choosing an Insulation Strategy for High Performance Housing” by Theresa Weston
 - “Energy and Heat Recovery Ventilators (ERV/HRV): Design + Installation Best Practices for Balanced Ventilation Systems in Houses and Apartment Buildings” by John Semmelhack
 - “Alternative Energy in PA (Solar): New Berlin Energy Independence Project” by Stacy Richards & Jason Grottini
- Construction Track
 - “High Performance HVAC Systems and Strategies for an Evolving Residential Construction Market” by Timothy Beggs
 - “Exterior Cement Plaster and Manufactured Stone Veneer: Lessons Learned” by Jennifer Keegan
 - “The Wide World of WRB’s: Specifying WRB’s as part of a High Performance Systems” by George Caruso
- Building Code Track (PCCA Symposium, Central)
 - “2015 UCC Residential Code Update” by Chris Hine
 - “The Essentials of Bulk Water Management” by Bryan Heitzmann

- “PA UCC/Code Enforcement Q&A” by Bob Buddenbohn, Walt Schneider, & Don Forry

The PHRC worked with the PCCA to plan and deliver the 6th Annual PCCA Symposium-Central held in conjunction with the PHRC Housing Conference which had 23 registrants. The lack of a state budget at the time of the events prevented further teaming between the PHRC and PCCA for the East and West events. Those two events were planned independently by PCCA.

PHRC Education Night Reception: The Education Night Reception was also held at the Penn Stater Conference Center Hotel. During the reception, the activities of the next generation of residential construction professionals who are studying to enter the housing industry, including the Penn State National Association of Home Builders Student Chapter and the DOE Race to Zero Team, were highlighted. Additionally, the reception hosted a craft beer tasting from Elk Creek Café + Aleworks, a local restaurant and craft brewery.

Land Development Day (Day 2): Day 2 of the PHRC Conference (Land Development) started off with the Keynote presentation on “Design and Construction to Not have problems getting your NOT” presented by Jennifer Orr. This session kicked-off the theme around the DEP Notice of Termination (NOT), or permit closeout. After the conclusion of the Keynote, the conference broke out into two tracks.

- Construction Track
 - “How to Bid it Right” by Mark Bowen, P.E.
 - “What are Right, Wrong, and Cost Effective E&S BMPs” by Greg Kramer
- Design Track
 - “Planning Construction for Permit Closeout” by Nathan Crawford, P.E.
 - “Contract Management for Permit Termination” by Mark Bowen, P.E.
- Plenary Session
 - “Getting on the Same Page: How are Contractors, Developers, Engineers, and Regulators Addressing the Same SW BMP Topics” by Jennifer Orr

There were 86 attendees for the Land Development day of the conference.

Training (Day 2): Two full-day workshops were scheduled in conjunction with the conference. “Building Envelope Design & IECC Code Compliance” was canceled last minute due to low enrollment.

- Residential Decks
 - Sponsored and subsidized by PCCA

- Enrollment: 19

Table 4. Attendees at the Housing Day and Land Development Day of the PHRC Annual Conference.

Event	# of people
Housing Day of PHRC Annual Conference (March 2)	98
PCCA Symposia Central - in conjunction with the PHRC Housing Conference (March 3)	23
Land Development Day of PHRC Annual Conference (March 3)	86

2. The Third Biennial Residential Building Design and Construction Conference

The Third Biennial Residential Building Design and Construction Conference (RBDC) was held concurrently with the Annual Housing and Land Development Conference at the Penn State. The session schedule aligned with the Housing and Land Development Conference, allowing attendees from both conferences to mix and match sessions between the two.

While this research conference is and will continue to be hosted by the Hankin Chair at Penn State and is not supported with Act 157 funds it is reported here because of the additional educational opportunity it provides. This biennial conference offers a unique opportunity for Housing and Land Development Conference attendees to learn more about the state-of-the-art in the residential construction industry.

As a research-focused conference the 3rd RBDC Conference provided a forum for researchers, design professionals, manufacturers, and builders to discuss their research findings, state-of-the-art, and innovative projects related to residential buildings and to share the latest advancements in the field, and attracted attendees from across the US and from five other countries. Keynote speakers included Tedd Benson 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 focused 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 focused on the importance of building science in his presentation “Building Science: The Foundation of Future Residential Building Design and Practice.”

3. Speaker Engagements

The PHRC participates in talks, seminars, and conferences directed at the housing and land development industries. This may include trade and professional association functions and regional meetings, local association meetings, or state or national conferences. Over the 2015-2016 reporting period, the PHRC delivered 15 speaker services, reaching 688 people. Speaker service and conference presentations included:

- Blansett, K. “Urban Stormwater Management in the Chesapeake Bay Watershed”, PSU ERM 497A Class, Penn State, Feb. 2, 2016, (~22 attendees)
- Blansett, K. “Issues of Urban Stormwater Management”, Agricultural and Biological Engineering Departmental Seminar, Penn State, April 7, 2016, (~20 attendees)
- Blansett, K. “Stormwater Regulations for Municipal Officials”, PSATS Annual Conference, Hershey, April 18, 2016, (~70 attendees)
- Blansett, K. “2015 UCC Code Update”, *Indiana Armstrong Builders Association*, Indiana, PA, May 4, 2016, ~ (40 attendees)
- Blansett, K. “2015 UCC Code Update”, *York County Builders Association*, York, PA, May 19, 2016, ~ (12 attendees)
- Heitzmann, B. “Providing Code Compliant Air Barriers”, *Somerset Builders Association*, Somerset, PA, March 8, 2016, ~ (34 attendees)
- Heitzmann, B. “UCC Overview and Update,” *PennBOC*, Williamsport, PA, October 22, 2015, (~9 attendees)
- Hine, C. “2016 Code Changes,” *HBA of Northwestern PA*, Erie, PA. September 17, 2015, (~9 attendees)
- Hine, C., and B. Heitzmann. “Roof Moisture Management,” *PBA Board Meeting*, Hershey, PA, November 6, 2015, (~21 attendees)
- Hine, C. “2015 UCC Code Update,” *Somerset Builders Association*, Somerset, PA, January 12, 2016, (~22 attendees)
- Hine, C. “2015 UCC Code Update,” *Lebanon County Builders Association*, Lebanon, PA, February 16, 2016, (~43 attendees)
- Hine, C. and B. Heitzmann, B. “Why Decks Fail – Design and New PA UCC Requirements to Improve Safety,” *Builders Association of Metro Pittsburgh*, March 4, 2016, (~44 attendees)
- Hine, C. “2015 UCC Code Update”, *Keystone ASHI*, Reading, PA, May 2, 2016, (~14 attendees)
- Jellen, A. C. (Presenter) and Memari, A. M., (2016). “An Approach to Analytical Modeling of Modular Vertical Expansions,” *Presented at the 3rd Residential Building Design and Construction Conference*, Penn State University, University Park, PA, March 2-3, 2016.

- Kamel, E. (Presenter) and Memari, A. M., (2016). “Different Methods in Building Envelope Energy Retrofit,” *Presented at the 3rd Residential Building Design and Construction Conference*, Penn State University, University Park, PA, March 2-3, 2016.
- Memari, A. M., (2015). “Overview of Recent Research on Panelized Building Envelope/Wall Systems and Modular Systems,” *Modular Home Builders Association, 3rd Annual Conference*, October 7, 2015, Philadelphia, PA. (Invited Speaker)
- Sagiroglu, M. (Presenter) and Memari, A., (2015). “Evaluation of Connection Systems in Modular Constructions,” *Steel Structure Conference*, Dubai, November 16-18, 2015.
- Wolfgang, B. “Fundamentals of Exterior Plaster and Thin Stone Veneer,” *Lebanon County Builders Association*, Palmyra, PA, September 15, 2015. (~35 attendees)
- Wolfgang, B. and Hine, C. “NAHB at PSU,” *Greenbuild Conference*, Washington, DC, November 19, 2015, (~20 attendees)
- Wolfgang, B. “Wood as a Construction Material”, PSU CE 336 Class, Penn State, April 6, 2016, (~146 attendees)
- Wolfgang, B. “Engineered Wood Products”, PSU CE 336 Class, Penn State, April 8, 2016, (~146 attendees)
- Wolfgang, B. “Stucco/Exterior Plaster”, *ASHI, Plymouth Meeting, PA*, May 10, 2016, (~40 attendees)
- Zahmatkesh, F. (Presenter), Memari, A., Said, A., Griffin, B., and Kremer, P., (2016). “Concepts for High Temperature Furnace Testing of Sealed Building Members and Connections under Axial Load,” *Presented at the 3rd Residential Building Design and Construction Conference*, Penn State University, University Park, PA, March 2-3, 2016.

5. General Outreach Activities

The general outreach activities of the PHRC include activities to let builders know about the PHRC and the services and publications it provides. These activities may include PHRC mailings, promotional pamphlets, articles in research or trade journals, answering phone and email questions, and the maintaining PHRC’s website, as well as various relevant technical meetings attended by PHRC staff.

Publications

The following list includes the scholarly publications published during the reporting period.

- Huang, W. and Memari, A. M., (2016). “Review of Test Methods for Selected Building Enclosure Component Types,” *Proceedings of the 3rd Residential*

Building Design and Construction Conference, Penn State University, University Park, PA, March 2-3, 2016, pp. 340-357.

- Jellen, A. C., Kamel, E., and Memari, A. M., (2015). “Moisture Management in Homes,” Final Report, The Pennsylvania Housing Research Center, Submitted November 2015, 75 p. (equal contributions by authors)
- Jellen, A. C. and Memari, A. M., (2016). “An Approach to Analytical Modeling of Modular Vertical Expansions,” *Proceedings of the 3rd Residential Building Design and Construction Conference*, Penn State University, University Park, PA, March 2-3, 2016, pp. 1-11.
- Kamel, E. and Memari, A. M., (2016). “Different Methods in Building Envelope Energy Retrofit,” *Proceedings of the 3rd Residential Building Design and Construction Conference*, Penn State University, University Park, PA, March 2-3, 2016, pp. 64-84.
- Kamel, E. and Memari, A. M., (2016). “Energy Retrofit Methods for Building Envelope Systems,” Final Report, The Pennsylvania Housing Research Center, Submitted April 2016, 106 p.
- Memari, A. M., (2015). “Seismic Evaluation of Building Envelope Systems and some Innovative Designs,” Chapter 12 in Book: *SAX-S37: New Trends in Seismic Design of Structures*, Editors: Nikos D. Lagaros, Yiannis Tsompanakis, and Manolis Papadrakakis, *SAX/2012/00048*, Saxe-Coburg, ISBN 978-1-874672-37-1, pp. 363-398.
- Memari, A. M. and Lowe, S. K., (2016). Editors, *Proceedings of the 3rd Residential Building Design and Construction Conference*, State College, PA, March 2-3, 2016, The Pennsylvania Housing Research Center, Penn State University, University Park, PA, ISBN: 978-1-62307-004-5, 428 p.
- Memari, A. M., Solnosky, R., and Mukherjee, M., (2015). “Comparative Study of Various Wall Systems Performance Attributes in Different Environmental Conditions,” *International Journal of Architecture, Engineering, and Construction*, Vol. 4, No. 2, pp. 64-79.
- Memari, A., Solnosky, R., and Stallworth, H. (2016). “Experimental Flexural Behavior of a Panelized Reinforced Brick Veneer with FRP Reinforcing on Steel Studs Wall System,” *ASCE Practice Periodical on Structural Design and Construction*, pp. 04016011-1-17.
- Memari, A. M. and Wolfgang, B. M., (2016). “PHRC Review of FEMA P-942, Hurricane Study in New Jersey and New York: Building Performance Observations, Recommendations, and Technical Guidance,” Report Submitted to National Association of Home Builders, Construction, Codes and Standards, May 2016, 23 p.
- Memari, A. M. and Wolfgang, N. M., (2016). “PHRC Review of NIST NCSTAR 3, Technical Investigation of the May 22, 2011 Tornado in Joplin,

Missouri,” Report Submitted to National Association of Home Builders, Construction, Codes and Standards, June 2016, 30 p.

- Ramaji, I. J. and Memari, A. M., (2015). “Information Exchange Standardization for BIM Application to Multi-Story Modular Residential Buildings,” *Proceedings of the ASCE 2015 Architectural Engineering Institute Conference*, Milwaukee, Wisconsin, March 24-27, 2015, pp. 13-24.
- Ramaji, I. J. and Memari, A. M., (2015). “Interpreted Information Exchange: A Systematic Approach for BIM to Engineering Analysis Information Transformations,” *ASCE Journal of Computing in Civil Engineering*, pp. 04016028-1-17.
- Ramaji, I. J. and Memari, A. M., (2015). “Product Architecture Model for Multi-story Modular Buildings,” *ASCE Journal of Construction Engineering and Management*, pp. 04016047-1-14.
- Zahmatkesh, F., Memari, A., Said, A., Griffin, B., and Kremer, P., (2016). “Concepts for High Temperature Furnace Testing of Sealed Building Members and Connections under Axial Load,” *Proceedings of the 3rd Residential Building Design and Construction Conference*, Penn State University, University Park, PA, March 2-3, 2016, pp. 140-151.

Conferences/Meetings Attended

The following is a list of the housing industry-related conferences and meetings attended by the PHRC personnel.

- Blansett, K. and B. Wolfgang. Pennsylvania Department of Community and Economic Development PHRC Introductory Meeting, Harrisburg, PA, October 1, 2015.
- Blansett, K. 2015 Villanova Urban Stormwater Partnership (VUSP) Pennsylvania Stormwater Symposium, Villanova, PA, October 14-15, 2015.
- Blansett, K. and B. Wolfgang. Pennsylvania Housing Advisory Meeting, Harrisburg, PA, October 28, 2015.
- Blansett, K., C. Hine, and B. Wolfgang. Pennsylvania Uniform Construction Code Review and Advisory Council Meeting, Harrisburg, PA, March 31, 2016.
- Blansett, K. WinSLAMM workshop, Penn State Harrisburg, PA, April 1, 2016.
- Heitzmann, B., C. Hine, A.M. Memari, and B. Wolfgang. ATI-Intertek Collaboration Meeting, University Park, PA, October 20, 2015.
- Heitzmann, B., C. Hine, A.M. Memari, and B. Wolfgang. International Builders Show and NAHB Student Chapter Residential Construction Management Competition, Las Vegas, NV, January 19-21, 2016.

- Hine, C. and B. Heitzmann. Industrialized Housing / Building Advisory Group Meeting, Enola, PA, August 26, 2015.
- Hine, C. and B. Wolfgang. Greenbuild Conference & Expo, Washington, D.C., November 18-20, 2015.
- Memari, A. M., (2015). Invited Participant at the NSF Joint NEHRI Experimental Facilities User Workshop; Florida Int. U., Miami, FL and U. of Florida, Gainesville, FL, December 3-4, 2015.
- Memari, A. M., National Association of Home Builders' International Builders Show, and NAHB Student Chapter Residential Construction Management Project Competition, Las Vegas, NV, January 17-21, 2016.
- Memari, A. M., Panelist for NSF Engineering for Natural Hazards (ENH) program Proposal Panel Review, Panel ID: P161855, Arlington, VA, May 18, 2016.
- Memari, A.M. and B. Wolfgang. NAHB Student Chapter Advisory Board Meeting, Las Vegas, NV, January 19, 2016.

Service in Professional Societies

The PHRC staff and faculty are involved in a variety of organizations at both the state and national level.

Pennsylvania Committees and Organizations

- Blansett, K. PA Stormwater Technical Workgroup – Executive Committee
- Wolfgang, B. Builders Association of Central PA, Education Committee Chairman
- Wolfgang, B. State College Area School District Building Construction Technology Program Operations Advisory Committee Member

National and International Committees and Organizations

- Memari, A.M., and K. Blansett. American Society of Civil Engineers, member.
- Memari, A. M., Architectural Engineering Conference 2017, Oklahoma City, Oklahoma, April 12-14, 2017; Role: Steering Committee Member
- Memari, A. M., National Consortium of Housing Research Centers, Executive Committee and Annual meeting, National Housing Endowment meetings; Las Vegas, NE, January 17-21, 2016
- Wolfgang, B., ASTM International, member and CII Committee Gypsum and Related Building Materials and Systems member.

Annual Newsletter

Over the past few years the annual newsletter has been published in January to keep interested parties up-to-date on recent PHRC activities and to promote the PA Housing and Land Development conferences. Last year and this year the newsletter schedule is shifted to be more aligned with the project reporting and planning. The 2016 newsletter is expected to be mailed in early Fall and will include project reports from the 2015-2016 project year and highlights of projects to come in the 2016-2017 year.

Educating the Next Generation of Tradespeople

Educating the “next generation” of residential trade contractors is essential for the future of residential construction. With the support of the IAC, the PHRC is considering the education of the next generation of tradespeople as an ongoing project. The ultimate goal is to increase the detailed knowledge of future industry tradespeople through this general outreach and provide students with professional development opportunities within the residential construction industry. This project includes relationship building, sharing of resources, speaker services at schools, leveraging resources and contacts to bring opportunities to students, and getting feedback from instructors and administrators to better address their needs.

A scholarship program was offered for the 2016 Annual Housing and Land Development Conference. Nine students from across the state were able to attend the conference at no fee due to the scholarship. PHRC staff are also involved with outreach through speaking to various groups including students in other classes at Penn State, the State College High School NAHB student chapter, and elementary school students in the Mifflin County School District.

E. Builder Briefs

Description: The PHRC continues its series of short technical documents that address specific issues that have been identified by builders or remodelers. These documents are intended to be quick to read with a lot of the information presented graphically or pictorially.

Manager/PI: Blansett

Report: Four Builder Briefs have been completed during this reporting period:

- Blansett, K. *Design and Construction of Dry Wells in Pennsylvania*, University Park, PA. July 2015 (Draft currently under final review from PA DEP).
- Dickson, E., C. Hine, and B. Wolfgang. *Frost Protected Shallow Foundations in Pennsylvania*, University Park, PA. June 2015.
- Dickson, E., C. Hine, and B. Wolfgang. *Durability of Insulated Rim Joists*, University Park, PA. June 2015.
- Wolfgang, B. *Rainscreens Gaps in Exterior Walls*, University Park, PA. June 2015.

PART 2 - Applied Research

A very important function of the PHRC is to undertake or stimulate research and development on materials, products, procedures, and processes related to the housing industry. These efforts may have a longer-term or a more fundamental focus than other projects. The projects that are listed below foster partnerships and draw on the expertise and strengths of the persons, groups and facilities available the Pennsylvania State University.

1. Performance Evaluation of Wall Panels Incorporating New and Innovative Materials Developed with High Insulation Properties

Description: The objective of this project is to evaluate the energy efficiency and cost competitiveness of residential wall panels incorporating insulation materials or technologies that enhance thermal resistance or energy performance of enclosure components using them. The study will first perform a comprehensive literature review on traditional and evolving insulation technologies for enclosure systems. Examples of such traditional and advanced technologies are: mineral wool, various types of rigid boards (e.g., EPS, XPS, polyurethane, polyisocyanurate), cellulose, vacuum insulation panels, gas-filled insulation panels, aerogel, and phase change materials. Once the properties of the materials/systems are determined, then thermal performance, energy performance, and condensation potential of walls incorporating such materials/systems will be evaluated for a typical home through simulation tools. By varying the climate data and wall configuration data including the materials and systems identified, it would be possible to predict the performance of different systems in various regions. The end result is a better understanding of the appropriateness and suitability of evolving technologies for residential application.

Manager/PI: Memari

Report: The project is continuing with a literature review on various types of conventional and commonly used insulation materials as well as more innovative systems. Of particular interest in this study is the evaluation of aerogel insulation, vacuum insulation panels, and phase change materials used in sheathing. While most conventional insulation systems are considered static (e.g., rigid or granular insulation, vacuum insulation), some dynamic systems such as phase change materials and dynamic façades are also becoming of interest. An important challenge in this study is the determination of equivalent R-value and SHGC properties of new and innovative systems for energy modeling using software such as BEopt that is linked to EnergyPlus for energy performance evaluation of a typical house with different types of envelope systems (for thermal resistance).

2. Evaluation of Wall Insulation Retrofit Options for Existing Homes

Description: According to the 2011 DOE Building energy Data Book, the energy consumption breakdown for the residential building enclosure is as follows: Roofs: 1.00 Quads, Walls: 1.54 Quads, Foundation: 1.17 Quads, Infiltration: 2.26 Quads, and windows (conduction): 2.06 Quads, a Quad is defined as 1015 BTU. Because of the great heat loss

through windows, there has been significant development in new energy efficient window systems. The next component that has also been focused on is the insulation types for new construction. Currently, various insulation materials have been developed to offer options beyond traditional fiberglass batt insulation. These options include various types of loose insulation materials, different rigid insulation boards, foam insulation, sandwich boards of vapor barrier and rigid insulation, sandwich boards of sheathing and rigid insulation, etc. Most of these products are suitable for new construction. However, information and understanding about the suitability and appropriateness of different insulation systems for retrofit purposes is not readily available. The thought of the expense to tear down drywall or exterior sheathing to add insulation has not encouraged such retrofit projects.

Nonetheless, because the issue is of great importance to reduce energy loss in existing homes through walls with poor insulation, it is proposed that a project be undertaken to look into all possible methods and materials/components suitable for retrofitting existing walls to enhance energy efficiency. In the process, some new ideas can be developed as well and suggested to the industry. Each method will be evaluated for energy saving enhancement through modeling using available software such as a combination of THERM, WINDOW and Energy 10, which can provide energy performance of a typical home with retrofitted wall as compared with a standard baseline wall system. The potential condensation issues will also be studied by using software such as WUFI. The study will also develop a cost analysis for each option so that various retrofit methods can be compared for energy consumption as well as retrofit cost and payback period

Manager/PI: Memari

Report: This project has been completed and a final report has been submitted to PHRC. Based on the results of the research, a paper was presented at the 3rd Residential Building Design and Construction Conference and published in the conference proceedings. Furthermore, a presentation based on the research was made at the Energypath 2016 Conference held July 25-29, 2016 at Penn State. The details of the final report and the two conference presentations are listed below, and it is anticipated that a PHRC webinar based on the research results will be prepared as well.

Kamel, E. and Memari, A. M., (2016). "Energy Retrofit Methods for Building Envelope Systems," Final Report, The Pennsylvania Housing Research Center, Report Submitted April 2016, 106 p.

Kamel, E. and Memari, A. M., (2016). "Different Methods in Building Envelope Energy Retrofit," Proceedings of the 3rd Residential Building Design and Construction Conference, Penn State University, University Park, PA, March 2-3, 2016, 21 p.

Kamel, E. and Memari, A. M., (2016). "How to Retrofit the Envelope of Existing Homes to Save Energy," Energypath 2016 – Emerging Technology and Business, July 25-29, 2016, Penn State University, State College, PA.

3. Resuspension and Transport of Allergen Carrier Particles in Residential HVAC Systems

Description: 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. However, 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. A combination of experimental work in residential settings and in a more controlled laboratory resuspension chamber setup is proposed 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 expected to provide a better understanding of the behavior of allergen sources in residential homes that would benefit the Pennsylvania housing industry and its residents.

Manager/PI: Dr. James Freihaut (Penn State Department of Architectural Engineering)

Report: Laboratory resuspension experiments using the modified resuspension facility programmed with waveforms recorded during in-field resuspension experiments in the subject residences along with supplemental resuspension and dispersion experiments across a range of dust types are ongoing. Further refinements are being made to the resuspension facility upgraded for this project along with the particle dispersion box used to prepare substrates for resuspension testing. In addition, the software for the field resuspension data collection and laboratory resuspension experiments has been integrated with software developed to control the particle dispersion process while sampling the dispersed particles as deposition occurs. These hardware refinements and software modifications are leading to avenues of research not originally anticipated at the outset of the project. Our work with: laboratory challenge testing of low-cost, portable particle sensors that can be used as another feedback loop in demand-controlled filtration schemes in mechanical systems; contrasts in the optical and aerodynamic particle spectra of various particle types; surface-borne allergen dispersion and subsequent UV-C exposure; and improved capabilities to challenge our research-grade particulate sensors with high quality monodisperse particles have all been made possible through the renewed focus on particulate research in our Indoor Aerosol Lab. Authoring of journal and conference papers based on these final experiments and new avenues of particulate research in the Indoor Aerosol Lab is also ongoing. Although the project will be brought to closure for the purpose of writing a final report at the end of the year, we are hopeful that the many capabilities developed during the course of our work on this project will lead to significant future funding from external sources.

4. Performance Optimization and Development of a Home Modular Delivery System

Description: The objective of this research is to expand affordable home energy performance by developing an optimized modular delivery system, a Kit-of-Parts (KoP), applicable for infill development of new homes and for retrofitting existing homes. This innovative system of components will result in homes that surpass Energy-Star performance for energy-efficiency, have improved indoor air quality, and provide realistic options for aging-in-place. Most notably it will provide a way to deliver high quality, well-designed, small affordable housing projects on a broad scale.

Manager/PI: Prof. Lisa Iulo (Penn State Department of Architecture)

Report: A graphic-intensive project overview has been finalized and submitted to the PHRC for the Performance Optimization and Development of a Home Modular Delivery System research. The project team is currently identifying community, industry and academic partners to continue the development of this concept and leverage the PHRC funds. A final report will be delivered by December 2016.

5. Passive Cooling Opportunities for Seasonal Energy Savings in Mass-Produced Homes

Description: Over the last several decades construction practices of contemporary residential structures have improved significantly resulting in good energy performance. The building envelopes are properly insulated, windows are carefully chosen for their resistance to heat flow, gaps in construction are meticulously sealed, and the heating and cooling equipment is selected for high performance. These homes are known as high performance or super-insulated.

While the structures are produced with energy conservation in mind, one major contributor to the final outcome is the home owner or occupant. This project focuses on the prediction of energy savings utilizing passive strategies that promote specific occupant behaviors (operational strategies) to extend the period when the cooling equipment can remain idle. During the period of time when the equipment remains idle, 100% energy savings is realized. If the idle period is 20% of the year, 20% of the annual energy is saved.

Using the basic assumption of “degree-days” to illustrate the point, heating of a tradition residence is considered unnecessary when the outside temperature is above 65°F. By the same definition, cooling is assumed to be needed when outside condition is above 65°F. In the summer, the system is said to be operating at 100% of its cooling load during the summer design condition (hot days). Similarly, the heating system operates at its peak load when outside conditions reach its winter design condition. When outside temperature is 65°F, it is assumed that no energy is spent.

Typical energy conservation strategies aim to reduce the peak design conditions. This reduction results in a proportional saving throughout the year. While reduction of design load is absolutely necessary and saves energy, an often overlooked opportunity is to expand the period when neither heating nor cooling is used in a home. This strategy

depends on occupant behavior. The question is: can passive design strategies be incorporated in residential structures to promote “better” occupant behavior, that is will the occupant leave the cooling and heating equipment de-energized for longer periods? Not running the equipment results in 100% energy savings during those times.

There are significant hours within the mid-Atlantic region where passive solar or natural ventilation can provide thermal comfort in residential situation without the aid of mechanical heating and cooling equipment. Combining Bin weather data and the energy demand curve can produce a 3-dimensional diagram where the volume of the histograms represent the total energy used (Btu/hr x Hours), which allows for the calculation of the possible energy savings when the de-energized period is expanded using passive strategies.

An important parameter to explore is the resultant thermal comfort offered by the alternative cooling strategies. ASHRAE Standard 55 specifically addresses the more-stringent occupant comfort expectations in mechanically cooled spaces. Occupant expectations are less stringent in naturally cooled spaces. This phenomenon will be integrated into the study. This study will first establish the limitations defined by this standard. As a second step, consider the design criteria when natural ventilation is an integral part of the design.

Manager/PI: Prof. Moses D.F. Ling (Department of Architectural Engineering)

Report: A preliminary draft report has been written and is currently being reviewed and edited by the project team. The final report will be submitted to the PHRC by December 2016.

6. Shear Wall Opportunities in Residential Construction

Description: Current building codes and standards for residential construction are complex and easily misunderstood when it comes to the requirements pertaining to wood shear walls. Whether they are engineered or prescriptive the design intent has the potential to be lost resulting in improper construction of walls that can lead to poor performance and failure (both aesthetically and structurally). This pilot study will cumulate the vast knowledge regarding residential shear walls options, provide comparisons between behavior and design steps, and finally recommend best practices for constructing. 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.

Manager/PI: Dr. Ryan Solnosky and Prof. M. Kevin Parfitt (Department of Architectural Engineering)

Report: This project is currently completed by the investigation team. The research has concluded and made clear the commonalities and differences between the various current building codes and standards and what they lack in regards to residential construction. Additionally, areas for future research in residential shear wall opportunities have been identified that could aid in future residential construction. We presented this research at

this past year's PHRC RBDC Conference at the Penn Stater. We are currently finalizing the documentation necessary to complete the report for the PHRC and their records.

7. **Prototype of an Architectural Light Therapy System to Promote Successful Aging in Place**

Description: The goal of the project is to develop a working prototype of a residential living environment outfitted with a novel architectural lighting system designed to promote health by stimulating the human circadian system while maintaining standards for visual quality. The space will be instrumented with measurement devices to verify light exposure performance and will serve as a model for future clinical trials and larger-scale residential installations. This project fosters the research/industry partnership that was a founding goal of the center. The PHRC has provided seed money to fund the first phase of this project.

Manager/PI: Dr. Kevin Houser (Department of Architectural Engineering)

Report: Dr. Kevin Houser and Tony Esposito (Ph.D. student in architectural engineering) presented the results of this project at the Illuminating Engineering Society Light + Color Research Symposium that was held in Gaithersburg, MD from April 3 – 5, 2016. They anticipate submission of a journal article to a peer-reviewed journal by August 2016, and will likely submit this work to the Lighting Research & Technology Journal (lrt.sagepub.com). The researchers will also work with the PHRC staff to develop a Builder Brief on the results.

PART 3 - Applied Projects

These groups of projects are application oriented and have a direct need by the residential construction industry. This includes the development and support of standards, and longer term initiatives.

1. **Moisture Management in Homes**

Description: Moisture damage to home incurs unwanted repair costs to homeowners and potential health hazards if left untreated. Although there is a considerable amount of information about waterproofing and use of vapor barriers and flashings, water damage to basement walls due to rain on basement windows (without proper and reliable well cover protection), water damage to above grade walls due to window failure/malfunction, water damage to floors and ceiling drywall due to overflow of bathroom toilet or tub are common occurrences. In this study, sources of water damage will be identified and, where needed, new concepts such as basement window solutions or bathroom waterproofing ideas will be developed. In particular, the existing monitoring and sensor technologies will be reviewed and potential applications for homes to detect intruding moisture and alarming the homeowner of potential problems will be explored.

Manager/PI: Memari

Report: The project has been completed and the final report submitted to PHRC for publication as a research report. The report is currently being edited by PHRC before its publication.

2. Frost Protected Shallow Foundations

Description: Frost protected shallow foundations are an economically feasible alternative to traditional foundation construction in Pennsylvania, yet they require special attention to structural and insulation detailing. This project will look at the feasibility of different FPSF systems as well as the coordination of FPSF systems with current energy codes.

Manager/PI: B. Heitzmann, B. Wolfgang

Report: Frost protected shallow foundations were studied in the context of code compliance, synergies with current enforceable energy codes, and constructability within Pennsylvania. The basics of this type of foundation system are summarized in a four page Builder Brief which is available on the PHRC website as well as in print upon request. This document includes details and images that were developed in-house, specifically for Pennsylvania requirements.

3. Exterior Plaster Assemblies in Pennsylvania

Description: Exterior plaster continues to be a hot topic in Pennsylvania as efforts to improve best practice are ongoing. The Pennsylvania Builders Association is leading an initiative to address exterior plaster assemblies (including hardcoat stucco and thin stone veneer). This project would allow for support of PBA's efforts and would include activities such as providing technical support, construction detail development, and assistance in the development of general outreach. This project will also include an evaluation of existing research and literature review related to moisture accumulation at exterior wall penetrations, building on the previous report that focused on overall code requirements.

Manager/PI: B. Wolfgang

Report: The PHRC continues to maintain involvement throughout the state regarding the topic of exterior plaster. This includes continuous stakeholder engagement and monitoring of upcoming changes that may affect this part of the residential construction industry. This initiative also resulted in the development of a four page Builder Brief focused on rainscreen systems and their applicability to reservoir cladding systems (including exterior plaster). This document is available for download on the PHRC website and in print upon request. This initiative will continue into the 2016-17 project year.

4. Durability Evaluation of Insulated Rim Joist

Description: Insulated rim joists have traditionally been a weak point in the building envelope. This area not only needs thermal insulation, but also requires air sealing to perform adequately. Insulated rim joists are subjected to moisture damage if not designed properly and often this damage can go undetected for significant periods of time. This project will analyze code provisions related to insulated rim joists, will evaluate insulation options for this assembly, and will investigate the impact of moisture on the durability of insulated rim joists.

This project is in support of a NAHB Construction Technology Research Sub-Committee (CTRSC) Research Priority.

Manager/PI: C. Hine, B. Wolfgang

Report: The PHRC analyzed insulated rim joists from the perspective of moisture management in the exterior building enclosure. This involved the development of exterior wall assembly schematics which represent common methods for insulating rim joists in Pennsylvania. Each scenario was analyzed regarding the ability of the assembly to not only insulate against heat loss and gain, but also to prevent condensation and promote drying should the assembly become wet. The result of this project is a four page Builder Brief which highlights the building science concepts of condensation prevention and drying potential as well as a comparison of risk between common assemblies. This document is available for download on the PHRC website and by print upon request.

5. Guidance of the Downspouts as a BMP for Builders

Description: Sumping of gutter downspouts is a common stormwater management technique to allow the rainwater that falls on a roof to infiltrate and one of the most frequently used BMPs by builders of single homes that aren't part of a larger subdivision plan. The DEP has provided design guidance in the BMP manual on the sizing of these sumps, but the material can be difficult to find and is targeted to an engineering audience. This project will collect and summarize the details on the sizing of downspout sumps for into an easy-to-use reference for homebuilders.

Manager/PI: K. Blansett

Report: The PHRC reviewed design standards from Pennsylvania, as well as more up-to-date design manuals from New Jersey and Maryland used as current best practice, to develop a guide to sizing dry well sumps for a single family home. Actual design values can vary from municipality to municipality so sizing criteria from the DEP Model Stormwater Ordinance and several actual municipal ordinances were used to attempt to make the guidance board and applicable across the state. The Builder Brief includes design details, sizing explanation and equations, and example calculations.

This document is currently under review by the PA DEP and will posted on the PHRC website once that review is complete.

PART 4 - Proposals & Contracts

The PHRC continuously seeks to leverage funding from the Commonwealth with funds from other sources. The following is a list of major grant proposals submitted to the government during the 2015-2016 project year. Several other smaller proposals were also submitted and some are under review/negotiation but those not are reported here.

The following project proposal was submitted during and funded this reporting period. This funding will cover part of the salaries for K. Blansett and S. Klinetob Lowe.

- PA Department of Environmental Protection, “Homeowner BMP Maintenance Booklet and Training,” Date: November 2015 – October 2017; Funded \$75,000, Blansett (PI).

The following research proposals were submitted during this reporting period:

- National Association of Home Builders (NAHB), Title: “Independent Review of FEMA P-942 and NIST NCSTAR 3 Reports”, Date: May-December 2015; Funded \$15,000 Memari (PI)
- National Science Foundation (NSF), Title: “Collaborative Research RSB: A Sequential Decision Framework to Support Trade Space Exploration of Multi-Hazard Resilient and Sustainable Building Designs”, Date: March 1, 2015 – February 28, 2018, Funded \$819,189, Memari share of funding – 15% (Senior Personnel)
- National Science Foundation (NSF), Title: “Pennsylvania State University Planning Grant: I/UCRC Proposal for SMART Sustainable Manufactured Buildings (SSMBs)”, Date: January 1, 2017-December 31, 2018, \$15,000 (pending), Co-PI.
- The Raymond A. Bowers Program for Excellence in Design and Construction of Built Environment, Title: “Additive Manufacturing of Glass”, Date: June 2015 - May 2016, Funded \$19,950, Co-PI.

PART 5 - Act 157 Funds

The PHRC receives funding from diverse sources, including contracts, grants, membership fees, fees for services, and the funds collected under Act 157 of 2006. Additional contributions were made by the Pennsylvania State University through a variety of sources, including the Hankin Endowment and in-kind support.

Act 157 of 2006 funds are collected through a \$4 fee on every building permit issued in the Commonwealth, and are dispersed through the Department of Community and Economic Development. PHRC receives 50% of the collected permit fees minus a 7.5% administrative fee. Funds for the 2015-2016 Project Year are based upon funds received from July 2014-June 2015. Table 5 below shows the amount received during the July 2014-June 2015 time period.

Table 5. Summary of Act 157 Funds received during the 2014-2015 fiscal year used for the 2015-2016 PHRC Project Year.

Collection Period	Amount Received
Q3: July 2014 - September 2014	\$113,319.90
Q4 October 2014 - December 2014	\$151,174.60
Q1: January 2015 - March 2015	\$135,144.35
Q2: April 2015 - June 2015	\$105,579.50
Total	\$505,218.35

During this reporting period, total costs were \$787,710.20 (Figure 3). Funds from Act 157 were utilized for 63% of these costs. Other, non-Act 157 funds sources covered the remaining 37% of cost, including 14% covered by income from fees and services, and 6% covered by other funds. Additionally, external project grants were utilized for 2% of the annual project costs. Funds, grants and contracts managed by the Hankin Chair covered 15% of costs. Table 6 shows the breakdown of expenses by category for the Act 157 account and combined non-Act 157 funding sources.

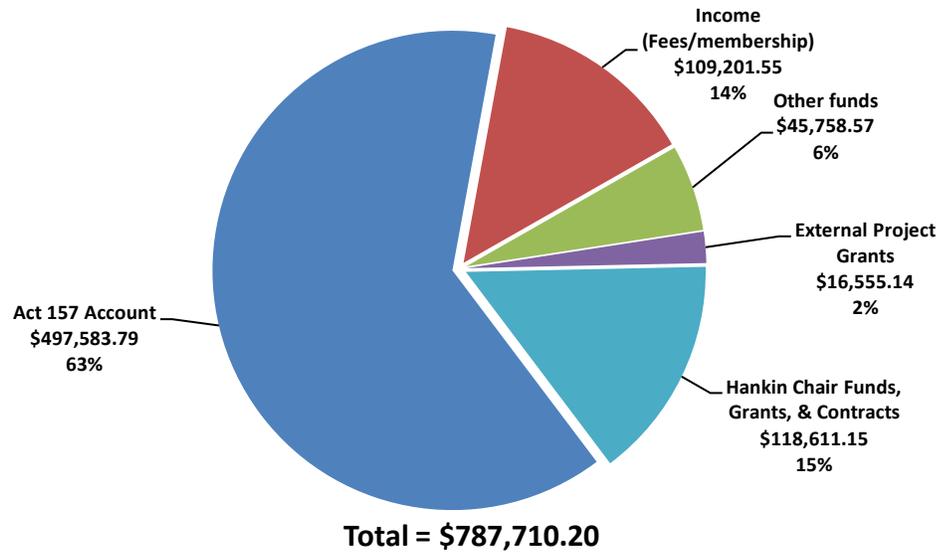


Figure 3. Summary of Funding for the 2015-2016 PHRC Project Year

Table 6. PHRC Expenses for the 2015-2016 PHRC Project Year.

Category	Act 157	Combined Non-Act 157 Funds	Total
Total Salaries	\$311,856.73	\$116,539.39	\$428,396.12
Total Wages	\$33.00	\$9,181.65	\$9,214.65
Total Student Wages	\$533.50	\$0.00	\$533.50
Fringe Benefits	\$118,197.88	\$44,903.05	\$163,100.93
Supplies and Materials	\$12.45	\$3,482.96	\$3,495.41
Communications Services	\$4,635.15	\$0.00	\$4,635.15
Travel	\$17,980.43	\$70,253.13	\$88,233.56
Publications	\$84.86	\$567.45	\$652.31
Consulting & Prof Svc	\$30,250.00	\$1,004.00	\$31,254.00
Copies and Photographic Services	\$13,264.81	\$0.00	\$13,264.81
Scholarships	\$0.00	\$4,200.00	\$4,200.00
Tuition and Fees	\$0.00	\$0.00	\$0.00
Equipment	\$639.98	\$2,372.26	\$3,012.24
Purchased Services	\$0.00	\$432.90	\$432.90
Miscellaneous	\$95.00	\$27,070.36	\$27,165.36
Indirect Costs (Overhead)	\$0.00	\$10,119.26	\$10,119.26
Total	\$497,583.79	\$290,126.41	\$787,710.20