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The Pennsylvania Housing Research Center

# PHRC Year in Review

July 2023 – June 2024

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# I. 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, 2023 and June 30, 2024.

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 projects undertaken were developed with input and assistance from the PHRC's Industry Advisory Council (IAC). This body consists 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 2023, 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 2023 – June 2024*," 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 Uniform Construction Code (UCC) permit fees. When appropriate, the PHRC attempts to use UCC permit fee funding to leverage outside support. It should also be noted that the PHRC undertook an array of additional projects that did not receive any UCC permit fee funds. Some of these projects are included in this report but are identified as having no support from the UCC permit fee funds.

Through the memorandum of understanding that Penn State 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, 2023-2024" is submitted to meet the requirement of an annual report.

### A. PHRC Organizational Chart

Figure 1 shows the current PHRC organizational chart.

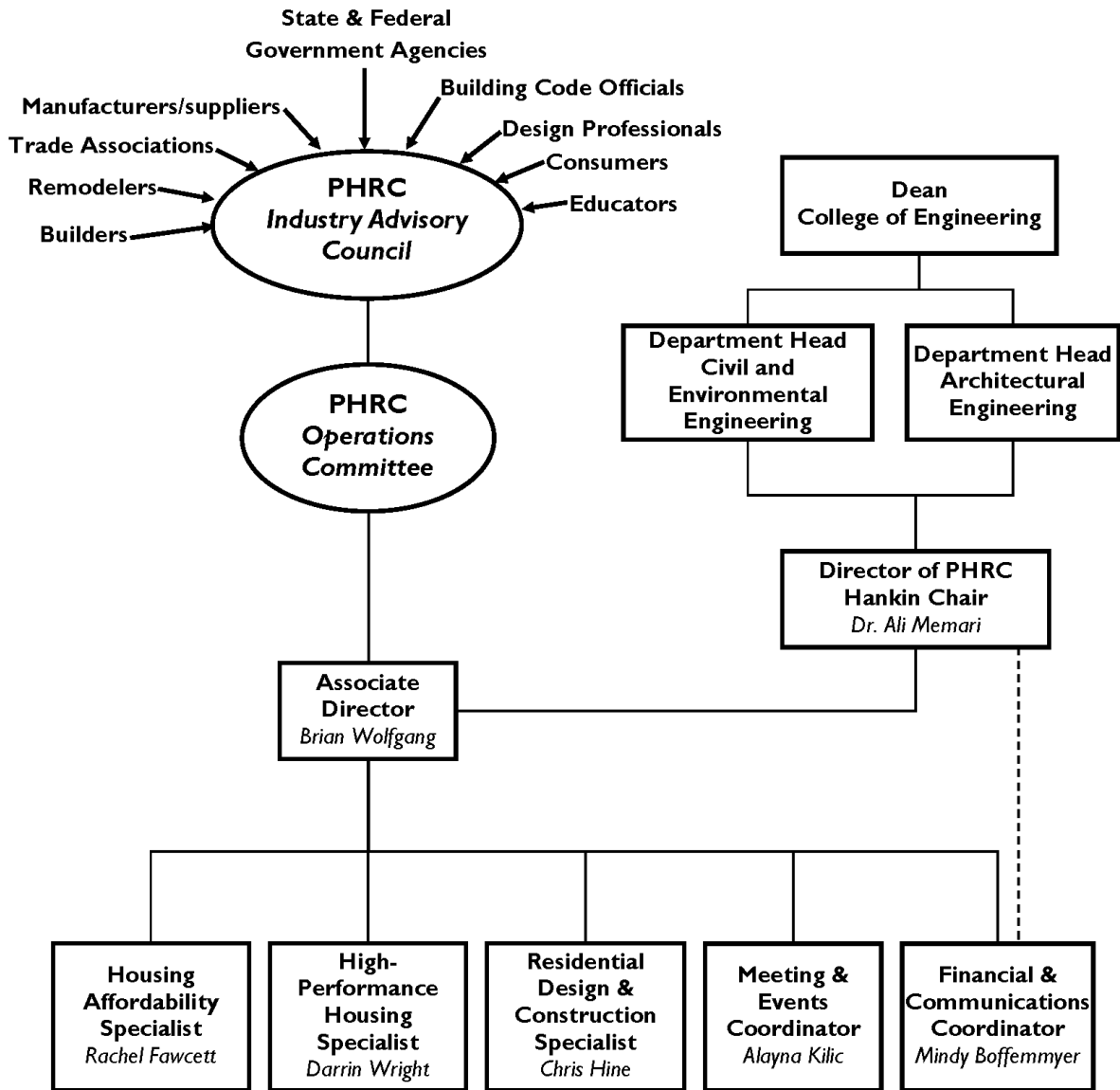


Figure 1. PHRC Organizational Chart

## B. PHRC Staff Changes

The PHRC staff experienced substantial changes since the publication of the 2023-24 Year in Review. To summarize these changes:

- Mindy Boffemmyer was hired as the Financial & Communications Coordinator in September 2023.
- Brian Wolfgang left as the Associate Director on April 26, 2024.
- Chris Hine was hired as the Associate Director on June 3, 2024.
- The PHRC is in the process of hiring a new Residential Design & Construction Specialist.

In addition to the staff changes, the PHRC offices have moved to a new, permanent location, due to building renovations and Penn State College of Engineering relocations. The PHRC offices will be in the Lidia Manson Building at 3127 Research Drive, State College, Pennsylvania, which is where most of our research laboratory facilities are located.

## II. Training, 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. The initiatives that are described below are in response to the recommendations from the PHRC's IAC and reflect the current needs within the industry.

Counting speaking engagements, workshops, the PHRC Housing Conference, webinars, and on-demand courses, the PHRC provided 58 educational programs to 2,331 individuals during this reporting period (see Table 1).

**Table 1. Summary of PHRC Training Programs for the 2023-24 Project Year**

PROGRAM	Activities for 2023-24	
	# of Events	# of Attendees
Speaking Engagements	14	675
Workshops	10	110
PHRC Housing Conference	Day 1	124
	Day 2	122
Webinars	11	1,209
On-Demand Courses	21	91
<b>TOTAL</b>	<b>58</b>	<b>2,331</b>

### A. Externally Hosted Training

**Description:** The PHRC has developed and maintains a wide array of training for many sectors of the construction industry with a focus on residential construction. These programs are intended to address technical issues facing the industry. The intended audience for these programs includes builders, remodelers, trade contractors, design professionals, educators, and building code officials. Additionally, the PHRC can customize programs to better meet the needs of an industry partner. As appropriate, AIA Learning Units (LUs) for architects, PA Labor & Industry contact hours and International Code Council (ICC) credit hours for code officials, NARI credits for remodelers, and PA Professional Development Hours (PDHs) for engineers are offered.

The PHRC seeks to partner with relevant outside organizations whenever possible. These industry partners may include trade associations such as the Pennsylvania Builders Association or their local associations, professional associations, building code associations, as well as the Pennsylvania Construction Codes Academy (PCCA). For externally hosted training, these partners groups and organizations request specific topics to be covered in a program that may vary in length from 30 minutes to full-day offerings.

To further differentiate between the types of externally hosted training that the PHRC offers, each program is classified as either a speaking engagement or a workshop. Both types of programs may be delivered in-person or online. These program categories are defined below:

- 1. Speaking Engagements:** The PHRC defines speaking engagements as externally hosted training programs that are two hours or less in length. These programs are generally based on existing content that can be modified slightly to meet the needs of the host organization. The PHRC will continue to offer one speaking engagement at no cost to groups and organizations within Pennsylvania during each calendar year. Subsequent speaking engagements typically involve an additional negotiated fee.

Occasionally, the PHRC team is invited to speak at conferences and symposia throughout the Commonwealth. These types of presentations are still considered speaking engagements, although they may involve additional content creation based on the specific event.

**Report:** During the 2023-24 project year, the PHRC team delivered 14 speaking engagements to 675 attendees. Table 2 shows a summary of these speaking engagements.

**Table 2. Speaking Engagements during the 2023-24 Project Year**

Organization	Topic(s)	Date	Attendees
Penn State AE 470	Construction Drawings	08/30/2023	71
CBO Conference	“A Comprehensive Deck Design from Footings to Guards: Learning from the Past”	09/14/2023	58
PENNBC	Selected Topics in Residential Construction	09/20/2023	20
Penn State AE 470	Building Science Intro	10/11/2023	71
Penn State CE 100S	Residential Construction at Penn State & Beyond	10/25/2023	25
Lawrence County Builders Association	Residential Energy in PA	11/08/2023	30
Lebanon County Builders Association	Moisture Control Layers and Materials	01/17/2024	9
PFS Corporation	Common Spray Foam Details in Residential Construction	01/19/2024	75
Penn State AE 497	Deep Dive into Building Science	01/29/2024	35
West Branch Susquehanna Builders Association	Double Stud Wall Frames	03/19/2024	16
Penn State CE 336	Wood as a Construction Material	04/12/2024	105
Penn State CE 336	Engineered Wood Products	04/15/2024	105
KSE Engineering	Residential Decks	04/17/2024	20
HBA of Metro Harrisburg	Changing the Way We Build: Hot Topics in the Building Enclosure	05/09/2024	35
<b>Total</b>		<b>14</b>	<b>675</b>

2. **Workshops:** The PHRC defines workshops as externally hosted training programs that are greater than two hours in length, up to a full day. These programs may be based on existing training content but often involve extensive content creation. Workshops typically involve a negotiated fee based on travel, accommodations, and the extent of content creation needed to prepare for the program.

**Report:** During the 2023-24 project year, the PHRC team delivered 10 workshops in partnership with the Pennsylvania Construction Codes Academy. Each workshop was delivered online via Zoom. Table 3 shows a summary of these workshops.

**Table 3. Workshops during the 2023-24 Project Year**

Organization	Topic(s)	Date	Attendees
Pennsylvania Construction Codes Academy (PCCA)	Residential Moisture Management: The 4 D's	11/15/2023	7
Pennsylvania Construction Codes Academy (PCCA)	Residential Energy in PA	11/16/2023	6
Pennsylvania Construction Codes Academy (PCCA)	Foundation Insulation: From Slabs to Walls	12/14/2023	5
Pennsylvania Construction Codes Academy (PCCA)	Residential Moisture Management: The 4 D's	01/29/2024	11
Pennsylvania Construction Codes Academy (PCCA)	Air Flow in Homes: Managing and Verifying Airtightness	03/05/2024	7
Pennsylvania Construction Codes Academy (PCCA)	Foundation Insulation: From Slabs to Walls	04/19/2024	13
Pennsylvania Construction Codes Academy (PCCA)	Basics of Residential Construction Drawings	04/29/2024	22
Pennsylvania Construction Codes Academy (PCCA)	Residential Energy in PA	05/28/2024	4
Pennsylvania Construction Codes Academy (PCCA)	Foundation Insulation: From Slabs to Walls	06/10/2024	4
Pennsylvania Construction Codes Academy (PCCA)	Basics of Residential Construction Drawings	06/20/2024	31
<b>Total</b>		<b>10</b>	<b>110</b>



## B. PHRC Hosted Training

**Description:** The PHRC hosts a variety of training activities, including online webinars, on-demand platforms for education, and in-person conferences. The scope of effort for these programs varies depending on the year as some programs are only offered every other year. In addition, external factors, such as changes to the Pennsylvania Uniform Construction Code, may increase activity in specific areas.

- PHRC Webinar Series:** The PHRC will continue its successful webinar series. Webinars are delivered live for continuing education credit, and they are archived for on-demand viewing without continuing education credit. Proposed topics are listed below. One PA Labor & Industry contact hour is offered for each webinar for PA code officials. As appropriate, AIA LUs for architects, ICC credit hours for code officials, NARI credits for remodelers, and PA PDHs for engineers are offered.

**Report:** During the 2023-24 project year, the PHRC team delivered 11 webinars to a total of 1,209 attendees. Table 3 shows a summary of the 2023-24 webinar season.

**Table 4. Webinars during the 2023-24 Project Year**

Organization	Date	Attendees
Building Enclosure Risk in the Codes	9/12/2023	109
Cathedral Ceiling Assemblies	10/10/2023	118
Double-Stud Wall Framing	10/26/2023	88
Pennsylvania Post Construction Stormwater Management Manual	11/14/2023	179
Understanding Tapes and Sealants	12/12/2023	125
Confined Spaces in Residential Construction	1/9/2024	97
Considerations for a Slab-on-Grade Foundation	2/13/2024	190
Zero Energy Ready Modular Housing for “Missing Teeth” Infill Projects	3/12/2024	83
Beyond Prescriptive: Evaluating Energy Code Compliance Paths	4/25/2024	101
Integrated Sheathing Systems	5/14/2024	92
Growing the Contractor Workforce	06/10/2024	27
<b>Total</b>	<b>11</b>	<b>1,209</b>

- PHRC On-Demand Courses for Continuing Education:** The PHRC continues to partner with Penn State Extension to offer recorded webinars in an on-demand format. This format utilizes knowledge checks and a final quiz to satisfy continuing education requirements and provides a certificate of continuing education upon completion for a fee. The PHRC team will continue to deploy webinars that are developed and delivered internally through this on-demand platform.

**Report:** The PHRC team worked with ODL to understand new accessibility guidelines from Penn State. This will require additional work to publish new on-demand courses. Additionally, the

College of Engineering is switching on-demand course platforms, so the PHRC is in ongoing testing to evaluate transitioning to this platform or staying with Penn State Extension. Building code officials are the primary audience completing the courses. On average, registrants complete six courses per year. During the 2023-24 project year, there were 91 course completions by 15 participants.

- 3. Annual PHRC Housing Conference:** The PHRC will continue to organize, promote, and hold the industry-focused conference. This conference has been held annually since 1992 and has established a reputation of being the premier program focusing on technical issues of housing and land development in Pennsylvania. The conference brings together the building community (builders, remodelers, design professionals, educators), regulators (planners, building code officials, township engineers, DEP and conservation district staff, etc.), and others involved in the residential construction industry.

**Report:** The 2024 PHRC Housing Conference was held on March 27-28, 2024, at The Penn State Hotel & Conference Center in State College, Pennsylvania. Both days included exhibitors during breaks to highlight products and services relevant to attendees.

**Day 1:** Day 1 of the PHRC Housing Conference started off with a keynote from Cal Beyer & Jeff Horwitz, SAFE Project, entitled “Shining Light on Workplace Health: Straight Talk for Leaders.”

The following tracks and sessions were offered:

- Codes & Construction
  - “Frame for Success” by Noah Humberston
  - “Basic Building Vocabulary” by Walt Schneider
  - “Introduction to Light-Frame Wood Roof Assemblies” by Matthew Hunter
- High-Performance Housing
  - “Understanding & Addressing Air Leakage in Residential Structures” by Craig Marden
  - “Practical Applications for Energy Retrofits: A Tale of Two Renos” by Chad Owens & Karis Taddei
  - “Introduction to High-Performance HVAC Design with VRF” by Josh Wharton
- The PHRC held a networking event titled “Networking on the Exhibit Floor” on the evening of March 27. This reception included conference speakers, attendees, and PHRC Staff and invited industry discussion on the day’s sessions. At this event, attendees could have productive discussions with industry exhibitors. Penn State students shared their impressive work from the NAHB Student Competition and the DOE Solar Decathlon Design Challenge.

**Day 2:** Day 2 of the PHRC Housing Conference included:

- Codes & Offsite Construction
  - “Building Resilient, Energy-Efficient Communities” by Jimmy Stecik
  - “Modular Construction: Transfer of Responsibilities from the Third-Party Agency to the Local Official” by Mike Moglia & Bob Gorleski
  - “Enabling Community Resiliency through FEMA Hazard Mitigation Projects and Funding” by Thomas Hughes
- Weatherization & Building Science

- “Fundamentals of Polyurethane Foams: Chemistry, Safety, and Applications” by Adam Broderick
- “Revitalizing the Ductwork: Bringing New Life to Old Duct Systems” by Rhett Major
- “Spray Foam Insulation for Unvented Attics: Proper Design and Application for Success” by Rick Duncan
- Land Development & Planning
  - “Sustainable Housing Development: It’s More than Just Good for the Environment” by Todd Poole
  - “Design and Construction Practices for Stormwater Control Measures” by Michael Snyder & Sharon Freiland
  - “Ways to Improve the Affordability and Availability of Housing” by Charlie Schmehl
  - “Overview of Environmental Soil Sampling and Environmental Due Diligence” by Collin Charnoff
- Day 2 concluded with a combined afternoon plenary titled “Taking it Outside: Adapting to Exterior Continuous Insulation” by Brian Wolfgang & Darrin Wright.

**Table 5. Attendees at the 2024 Annual PHRC Housing Conference**

Event	Attendees
Day 1 (March 27)	124
Day 2 (March 28)	122
Networking on the Exhibit Floor Reception	136

4. **Residential Building Design & Construction Conference (RBDCC):** The 2024 (7th) biennial Residential Building Design and Construction Conference (RBDCC) was held March 27-28, 2024. RBDCC presentations and posters are selected from abstract submissions, while full papers go through a peer review process and are published in the conference proceedings, available to download for free from the PHRC website (<https://bit.ly/RBDCC-Proceedings>). The 7th RBDCC included 55 presentations, 6 posters, and 59 full papers. The conference included a broad range of topics related to residential construction from building science to innovative materials and methods. The conference featured two keynote speakers: Vivian Loftness, Paul Mellon Chair in Carnegie Mellon University’s School of Architecture, who spoke on “Environmental Surfing at Home for a Resilient Future,” and Graham Finch, senior building science specialist at RDH Building Science, Inc., who spoke on “Lessons in the Development of Innovative Prefabricated Façades for Mass Timber Buildings.”
5. **PHRC Construction Summit:** The PHRC will organize, promote, and hold the student-focused PHRC Construction Summit or similar events at a frequency to be determined. This event is an effort to support secondary career and technology education programs through live in-person training, online training, and on-demand training. In past iterations, this event was hosted in 2020 and 2022 as a synchronous online offering with short technical presentations from external speakers and PHRC staff.

**Report:** The PHRC Construction Summit will be held in odd numbered years only, therefore, the PHRC Construction Summit was not held during the 2023-24 project plan year.

## C. Publications & Content Creation

**Description:** The PHRC will leverage the technical expertise of staff members along with the expertise of strategic external partners to continue to produce content for publication and future PHRC training programs. This initiative also includes the development and maintenance of online delivery platforms for article and video publication.

- 1. Written Content:** The PHRC will produce written publications as appropriate, including both internally and externally published work. Examples of internal publications include Builder Briefs, research reports, technical flyers, and future online articles. Examples of external publications include scholarly journal articles, conference proceedings, magazine and trade publication articles, and other general interest articles upon request.

This initiative includes the ongoing development and maintenance of the PHRC online article database that can be accessed through the PHRC website. This database allows for the PHRC team to publish a range of types of written work, including general industry announcements and technical articles.

**Report:** During the 2023-24 project year, the primary objective regarding written content was to prepare for the launch of the PHRC News site. This site, otherwise referred to as the online article database, was launched in September 2023 and will contain technical articles, PHRC announcements, and general industry news. Content relating to the following topics was developed ahead of this launch:

- a. Mechanical ventilation:** The PHRC worked with Rick Karg, a subject matter expert in the area of residential mechanical ventilation design and installation. Karg developed an eight-part series on mechanical ventilation which includes details on the technical background of indoor air quality, general ventilation strategies, as well as current code requirements for ventilation.
- 2. Video Content:** The PHRC will continue to increase internal capacity to develop video content from demonstrations, site visits, and other live events. This content will be captured, edited, and published in a manner that supports broader PHRC initiatives and future training programs. Example deliverables related to video creation include the publication of short “toolbox talks” for the building community, recording of presentations for secondary programs, and capturing construction processes through live demonstration.

**Report:** To increase our audience, the PHRC has created a YouTube channel for easy delivery of on-demand videos. These videos will be housed on this platform and then shared through other social media platforms.

- a. The PHRC team continued to increase the use of video capture and sharing for online and in-person content delivery.** Some examples of videos created in 2023-24 include safety glazing provision examples and using both iPad and document cameras during program delivery. This adds an additional layer experience for the attendees.

## D. Technical Assistance, Technology Transfer, & Outreach

**Description:** The PHRC continues to work to get technical information, resources, and publications to builders, remodelers, design professionals, building code officials, and others involved in the residential construction industry in new and innovative ways. This often involves leveraging existing and developing new relationships with other organizations in the residential construction industry.

1. **General Outreach Activities:** Through our general outreach initiatives, the PHRC pursues activities to keep industry professionals up to date on technical issues, as well as informed on the services and publications the PHRC provides. These activities may include email and social media campaigns, phone calls, and the PHRC’s website. Our general outreach also involves attending relevant industry meetings and serving as a technical resource to legislative committees as needed.

**Report:** The PHRC team continued to engage with the industry on various fronts, including through attendance at various organizations’ meetings and participation in a multitude of boards, councils, and committees in service to the residential construction industry. In addition, the lists below outline a portion of the scholarly efforts related to the residential construction industry through the guidance of the Hankin Chair and director of the PHRC.

### a. Journal Papers

- i. Duarte, G., Duarte, J. P., Brown, N., Memari, A. M., Gevaudan, J. P., (2023). “Design for Early Age Structural Performance of 3D Printed Concrete Structures: a Parametric Numerical Modeling Approach,” *Journal of Building Engineering*, Published Vol. 94, October 1, 2024. <https://doi.org/10.1016/j.jobbe.2024.109986>.
- ii. Azari, R., Kamel, E., and Memari, A. M., (2024). “Current Developments and Future Directions in Energy-Efficient Buildings from the Perspective of Building Construction Materials and Enclosure Systems,” *MDPI Buildings*, Special Issue Energy Efficiency and Carbon Neutrality in Buildings, 2024, 14, 1921, 19p., <https://doi.org/10.3390/buildings14071921>.
- iii. Aminpour, N. and Memari, A. M., (2024). “Capacity Evaluation of Composites with New Materials Based on Design Equations for Concrete and Masonry Walls,” *Taylor & Francis Mechanics Based Design of Structures and Machines*, Published online 04/01/2024; 26p., DOI: 10.1080/15397734.2024.2335204.
- iv. Kamel, E., Memari, A. M., and Habibi, S., (2024). “State of the Practice Review of Moisture Management in Residential Buildings through Sensors”, *Elsevier Structures*, Published January 2024, Vol. 59, 10P. 105698. <https://doi.org/10.1016/j.istruc.2023.105698>.
- v. Asghari, N. and Memari, A. M., (2024). “State of the Art Review of Attributes and Mechanical Properties of Hempcrete,” *MDPI Buildings*, Special Issue on Innovative Systems for Biomass Crop Production and Use, Published 02/02/24, Vol. 4, No. 1, pp. 65-91, <https://doi.org/10.3390/biomass4010004>.
- vi. Habibi, S., Kamel, E., and Memari, A. M., (2024). “Design Strategies for Addressing COVID Issues in Buildings”, *Elsevier, Energy*, Vol. 293, 16p, Published 04/15/2024. <https://doi.org/10.1016/j.energy.2024.130680>.

- vii. Abdelwahab, K., Memari, A., Griffin, C., and Lulo, L., (2024). "Small-Scale Testing of Air Barrier Systems Adhered to Sheathing Boards Under In-Plane Cyclic Loading Simulating a Seismic Event," Elsevier Case Studies in Construction Materials, published online 11/19/23; published Vol. 20, 2024, 18p., <https://doi.org/10.1016/j.cscm.2023.e02686>.
- viii. Kamel, E., Habibi, S., and Memari, A. M., (2024). "State of the Practice Review of Moisture Management in Residential Buildings through Sensors," Elsevier, Structures, Published online 12/11/23, Published Vol. 59, 10p., 105698; <https://doi.org/10.1016/j.istruc.2023.105698>.
- ix. Amini, M., and Memari, A. M., (2023). "CFD Evaluation of Regular and Irregular Breaking Waves on Elevated Coastal Buildings," Springer, International Journal of Civil Engineering, Vol. 22, Issue March 2024, Published October 8, 2023, 25p, <https://doi.org/10.1007/s40999-023-00898-2>.

**b. Conference Proceedings and Papers**

- i. Hojati, M., Sadeghi, R., Li, Z., Memari, A., Nazarian, S., Radlinska, A., and Duarte, J. P., (2024). "Flexural Strength of 3D Printed Concrete Beams: Exploring Barbed-Wire Reinforcement and Cross-sectional Area," Proceedings of the Digital Concrete Conference 2024 (4th RILEM International Conference on Concrete and Digital Fabrication), September 4-6, 2024, Munich, Germany, 9p.
- ii. Asadi, H. and Memari, A. M., and Asadi, B., (2024). "Integration of flexible photovoltaics into the tension fabric structures; potential, scope and challenges," Proceedings of the 7th Residential Building Design and Construction Conference, Editors: Ali M. Memari and Mindy Boffemmyer, The Pennsylvania Housing Research Center, Penn State University, University Park, PA, March 27-28, 2024, pp. 176-187.
- iii. Tong, W., Memari, A. M., and Griffin, C., (2024). "Tornado in Mississippi: Case Study on March 24, 2023," Proceedings of the 7th Residential Building Design and Construction Conference, Editors: Ali M. Memari and Mindy Boffemmyer, The Pennsylvania Housing Research Center, Penn State University, University Park, PA, March 27-28, 2024, pp. 415-424.
- iv. Tong, W., Memari, A. M., and Griffin, C., (2024). "State-of-the-Art Review of the Performance of Residential Structures under Tornado Effects," Proceedings of the 7th Residential Building Design and Construction Conference, Editors: Ali M. Memari and Mindy Boffemmyer, The Pennsylvania Housing Research Center, Penn State University, University Park, PA, March 27-28, 2024, pp. 403-413.
- v. Binega, E. and Memari, A. M., (2024). "Incorporating Carbon-Negative Hempcrete in 3D-Printed Eco-Friendly Residential Houses," Proceedings of the 7th Residential Building Design and Construction Conference, Editors: Ali M. Memari and Mindy Boffemmyer, The Pennsylvania Housing Research Center, Penn State University, University Park, PA, March 27-28, 2024, pp. 28-38.
- vi. Binega, E. and Memari, A. M., (2024). "3D Printing of "Clay-Hemp" Sustainable Structures for Residential Construction," Proceedings of the 7th Residential

Building Design and Construction Conference, Editors: Ali M. Memari and Mindy Boffemmyer, The Pennsylvania Housing Research Center, Penn State University, University Park, PA, March 27-28, 2024, pp. 12-25.

- vii. Aminpour, N. and Memari, A. M., (2024). "Effects of Expanded Polystyrene (EPS) Beads on Mechanical Properties of Concrete: A Comprehensive Study," Proceedings of the 7th Residential Building Design and Construction Conference, Editors: Ali M. Memari and Mindy Boffemmyer, The Pennsylvania Housing Research Center, Penn State University, University Park, PA, March 27-28, 2024, pp. 302-312.
- viii. Field, T. R. and Memari, A. M., (2024). "State of The Art Review of Log Home Construction from a Building Science Perspective," Proceedings of the 7th Residential Building Design and Construction Conference, Editors: Ali M. Memari and Mindy Boffemmyer, The Pennsylvania Housing Research Center, Penn State University, University Park, PA, March 27-28, 2024, 190-201.
- ix. Tayebani, B., Memari, A. M., and Said, A., (2024). "Characterization of Concrete Mixtures with Recycled Plastic Binder at the Micro Level Using SEM and EDS for Building Construction," Proceedings of the 7th Residential Building Design and Construction Conference, Editors: Ali M. Memari and Mindy Boffemmyer, The Pennsylvania Housing Research Center, Penn State University, University Park, PA, March 27-28, 2024, pp. 288-301.
- x. Wang, L. and Memari, A. M., (2024). "The State-of-the-art Review of BIPV Systems for Detached Single-family Homes," Proceedings of the 7th Residential Building Design and Construction Conference, Editors: Ali M. Memari and Mindy Boffemmyer, The Pennsylvania Housing Research Center, Penn State University, University Park, PA, March 27-28, 2024, pp. 254-265.
- xi. Lu, X. and Memari, A. M., (2024). "State of the Art Review of Recent Developments in Infrared Thermography Method for Thermal Resistance Measurement of Building Envelope Systems," Proceedings of the 7th Residential Building Design and Construction Conference, Editors: Ali M. Memari and Mindy Boffemmyer, The Pennsylvania Housing Research Center, Penn State University, University Park, PA, March 27-28, 2024, pp. 266-275.
- xii. Asghari, N. and Memari, A. M., (2024). "Study of Alternative Concepts to Enhance Compressive Strength of Hempcrete," Proceedings of the 7th Residential Building Design and Construction Conference, Editors: Ali M. Memari and Mindy Boffemmyer, The Pennsylvania Housing Research Center, Penn State University, University Park, PA, March 27-28, 2024, pp. 351-364.

2. **PCCA Symposium & Other Events:** The PHRC will work upon request with the PCCA to plan, develop, and deliver online and in-person events in support of PCCA initiatives.

**Report:** The PHRC has increased general collaborative activities with the PCCA staff, including discussions for future PCCA symposia. While these symposia were not offered during the 2023-



24 project year, the renewed emphasis on online workshop delivery has revived the relationship between both organizations.

- 3. Annual Magazine:** The PHRC annual magazine will be sent electronically to PHRC members and stakeholders to keep them up to date on recent PHRC activities and to promote upcoming events. Additionally, it is archived on the PHRC website for public viewing. For the 2024-25 project year, the PHRC intends to continue to have it delivered in the early fall to provide timely updating of the audience with the outcome of the previous year's projects and with what to expect in the coming year.

**Report:** The magazine was sent electronically to PHRC members and stakeholders to keep them updated on recent PHRC activities and to promote upcoming events. For the 2023-24 project year, the PHRC magazine was published in the fall to provide for a timely update with the outcome of the previous year's projects and with what to expect in the coming year.

- 4. Support of Secondary Career & Technology Education (CTE) Programs:** The PHRC will continue to support secondary education and CTE programs through a variety of outreach initiatives. Outreach activities are intentionally flexible based on the needs of these secondary programs but may include participation on occupational advisory committees, guest lectures in secondary program classrooms, development and promotion of video content for secondary students, and other activities as needed.

**Report:** The primary effort to support secondary CTE programs was highlighted in the PHRC hosted training portion of this report. PHRC staff continue to serve on various occupational advisory committees for local programs.

- 5. Professional Women in Building (PWB):** The PHRC, in alignment with its current strategic plan, prioritizes gender equity in the residential construction industry through involvement with the NAHB Professional Women in Building (PWB) activities and initiatives. This effort includes relationship building, sharing of resources, speaking at school events, leveraging resources and contacts to bring opportunities to students, and soliciting feedback from instructors and administrators to better address their needs.

**Report:** The success of this PWB initiative is demonstrated through the ongoing activities and success of the PWB council within the Builders Association of Central PA. PHRC staff continue to serve this initiative through event planning and support of other activities, such as career exploration events. Alayna Kilic attended three PWB events as the PHRC supports the mission of the PWB to encourage and support women in the building industry.

- 6. Support of the UCC RAC:** The PHRC will continue to support the Uniform Construction Code Review & Advisory Council (RAC) and the public by serving as a general technical resource upon request.

**Report:** The PHRC continued to be present at RAC meetings and supported the overall effort through promotion of deadlines as well as opportunities to contribute via public comment.

- 7. Support of Standards:** The PHRC has developed standards to respond to industry demand. Each of these standards requires training and timely technical assistance for local governments, builders/developers, design professionals, and contractors. All these standards are available electronically for free. Education on these standards will continue to be provided through

various training programs as requested and technical assistance will be provided through telephone and email support by the PHRC. The current PHRC standards include:

- 2021 Pennsylvania Alternative Residential Energy Provisions
  - Compliance Worksheet for the 2021 Pennsylvania Alternative Residential Energy Provisions
- Foundation Systems for Relocated Manufactured Housing

**Report:** The PHRC continued to provide training on the 2021 Pennsylvania Alternative Residential Energy Provisions through conference sessions and speaking engagements.

- 8. Strategic Partnerships:** The PHRC will continue to seek out new relationships and partnerships with peer organizations with activity in the residential construction industry. These partnerships are leveraged for the benefit of the PHRC audience and stakeholders. PHRC staff time will continue to be allocated in support of this overall initiative.

**Report:** The PHRC continued to experience success from ongoing networking and relationship building with other organizations, manufacturers, and companies. Examples of this ongoing effort include increase collaboration between the PHRC and the Clean Energy Center at Penn College through weatherization training.

### III. Applied Research

An important function of the PHRC is to undertake or stimulate research and development on materials, products, procedures, and processes. These efforts may have a longer-term or a more fundamental focus than other projects, and they are typically completed under the supervision of the PHRC director Ali Memari. Projects in this category foster partnerships and draw on the expertise and strengths of the people and facilities available at Penn State.

#### 1. Feasibility Study of Designing Homes Using Hemp Wood and Hempcrete

**Description:** Considering the strong desire to reduce carbon footprint of buildings, whether from building operation, e.g., HVAC system, or as it relates to the embodied energy associated with the construction materials and their fabrication and erection, we need to explore various new materials, components, and construction techniques toward more sustainable home building. One of the emerging construction materials is based on hemp fiber and hurd. A mixture of hemp fiber, hemp hurd, lime, and water, hempcrete has been shown to have potential in residential construction applications to improve the thermal insulation properties of walls, reduce the consumption of carbon-intensive concrete, and reduce the weight of cement-based structures. For the purpose of wood-frame home building, hempcrete can be cast, sprayed, or used as prefabricated blocks. However, given that industrial hemp is relatively newly reinstated, we do not have readily available design and construction guidelines for hempcrete homes. PHRC was involved in retrofit design and construction of the first PA hempcrete home in New Castle by performing thermal resistance measurement and energy performance evaluation of the house using in-situ testing and energy simulation. Involvement in the project from beginning to end provided the team with valuable experience and understanding of the shortcomings of constructing using hempcrete. This proposed project will look into developing state-of-the-art review of designing home using hemp wood and hempcrete. More specifically, we will evaluate the feasibility of using different forms of hempcrete, e.g., cast in place, spray in place, prefabricated blocks and other components, and incorporation of hemp wood for sheathing and framing, as appropriate. The feasibility study will provide some guidelines for design and construction of hemp-based homes relying on the current available technologies.

**Deliverables:** The result of this work will include a PHRC report.

**Report:** The study is currently ongoing with the objective of developing a report, which will provide a state-of-the-art review of the current status of hempcrete application for home building. The outline of the resulting report will include the following aspects: 1) introduction of hemp wood and hempcrete as new construction materials, 2) overview of typical application for residential construction, 3) review of design guidelines and code requirements, 4) understanding the non-loading bearing application of hempcrete and any evidence for load-bearing applications, 5) review any best practice guides for design and construction, 6) discuss various finish options, discuss durability aspects, including moisture management, service life, and maintenance.

## IV. 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 and amended by Act 36 of 2017. To fulfill PHRC’s annual mission, the organization must raise additional revenue outside of Act 157 funds to complete its annual project load.

Prior to October 25, 2018, Act 157 of 2006 funds were collected through a \$4 fee on every building permit issued in the Commonwealth and are dispersed through the Department of Community and Economic Development (DCED). PHRC received 50% of the collected permit fees minus a 7.5% administrative fee to DCED.

Beginning on October 25, 2018, Act 36 of 2017 amended building permit fees to be \$4.50 with PHRC being allocated 43.5% of the collected permit fee minus a 3% administrative fee to DCED. As of April 2020, DCED changed their fee collection process to only accept online payments by credit card or check for UCC permit fees, which allows for more expedient reporting to the PHRC.

Funds for the 2023-24 Project Year are based upon funds received from July 2022 through June 2023, which can be seen in Table 6 below. This was the highest total of Act 157 Funds received to date.

**Table 6. Summary of Act 157 Funds received during the 2022-23 FY (2023-24 PHRC Project Year)**

Collection Period	Amount Received
Q1: July 2022 - Sept 2022	\$161,221.19
Q2: Oct 2022 - Dec 2022	\$128,516.68
Q3: Jan 2023 - Mar 2023	\$122,706.44
Q4: April 2023 - June 2023	\$111,226.87
<b>Total</b>	<b>\$523,671.18</b>

Expenses for the Act 157 Account (\$419,052.06) were less than the revenues (\$523,671.18) for the 2023-24 project year. The PHRC continues to be fiscally conservative in adjusting to an ever-changing housing market and has increased strategic investments through various initiatives such as external content development and a broader investment in weatherization training. Additionally, PHRC had staff vacancies throughout the year accounting for lower than typical salaries and fringe benefits charged to the Act 157 funds. Table 7 shows a breakdown of PHRC expenses for the 2023-24 Project Year allocated to the Act 157 Account.

**Table 7. PHRC Expenses for the 2023-24 PHRC Project Year**

<b>Category</b>	<b>Act 157</b>
Total Salaries	\$271,721.19
Total Wages	\$0.00
Total Student Wages	\$3,600.00
Fringe Benefits	\$97,638.27
Supplies and Materials	\$1,003.61
Communications Services	\$1,322.69
Travel & Meetings	\$18,654.79
Publications	\$928.58
Maintenance	\$0.00
Consulting & Prof Svc	\$13,680.00
Copies and Photographic Services	\$232.00
Computer Services	\$0.00
Purchased Services	\$0.00
Equipment	\$1,070.98
Computer Equipment	\$5,838.00
Miscellaneous	\$3,361.95
<b>Total</b>	<b>\$419,052.06</b>