



The Pennsylvania Housing Research Center

PHRC Year in Review

July 2021 – June 2022

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Table of Contents

I. Introduction	1
A. PHRC Organizational Chart	2
B. Staff Changes	3
II. Training, Technical Assistance & Outreach	4
A. Program Development	5
1. Existing Program Updates & Maintenance.....	5
2. PHRC Continuing Education On-Demand	5
3. Stucco & Thin Stone Veneer Design & Installation Workshop Revamp	5
4. Full- or Partial-Day Code Update Workshop.....	6
B. PHRC Training Program Delivery	7
C. Webinar Development & Delivery.....	8
D. Builder Briefs & Other Publications.....	9
E. Technical Assistance, Technology Transfer, & Outreach	9
III. Applied Research	21
IV. Applied Projects	22
1. Energy Retrofits	22
2. Stucco & Stone Details.....	22
3. Code Update Video Series	22
4. PA Alternative Residential Energy Provisions	23
V. Proposals & Contracts	24
VI. Act 157 Funds	26

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, 2021 and June 30, 2022.

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 2021, 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 2021 – June 2022*," 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, 2021-2022" is submitted to meet the requirement of an annual report.

A. PHRC Organizational Chart

Figure 1 shows the current PHRC organizational chart.

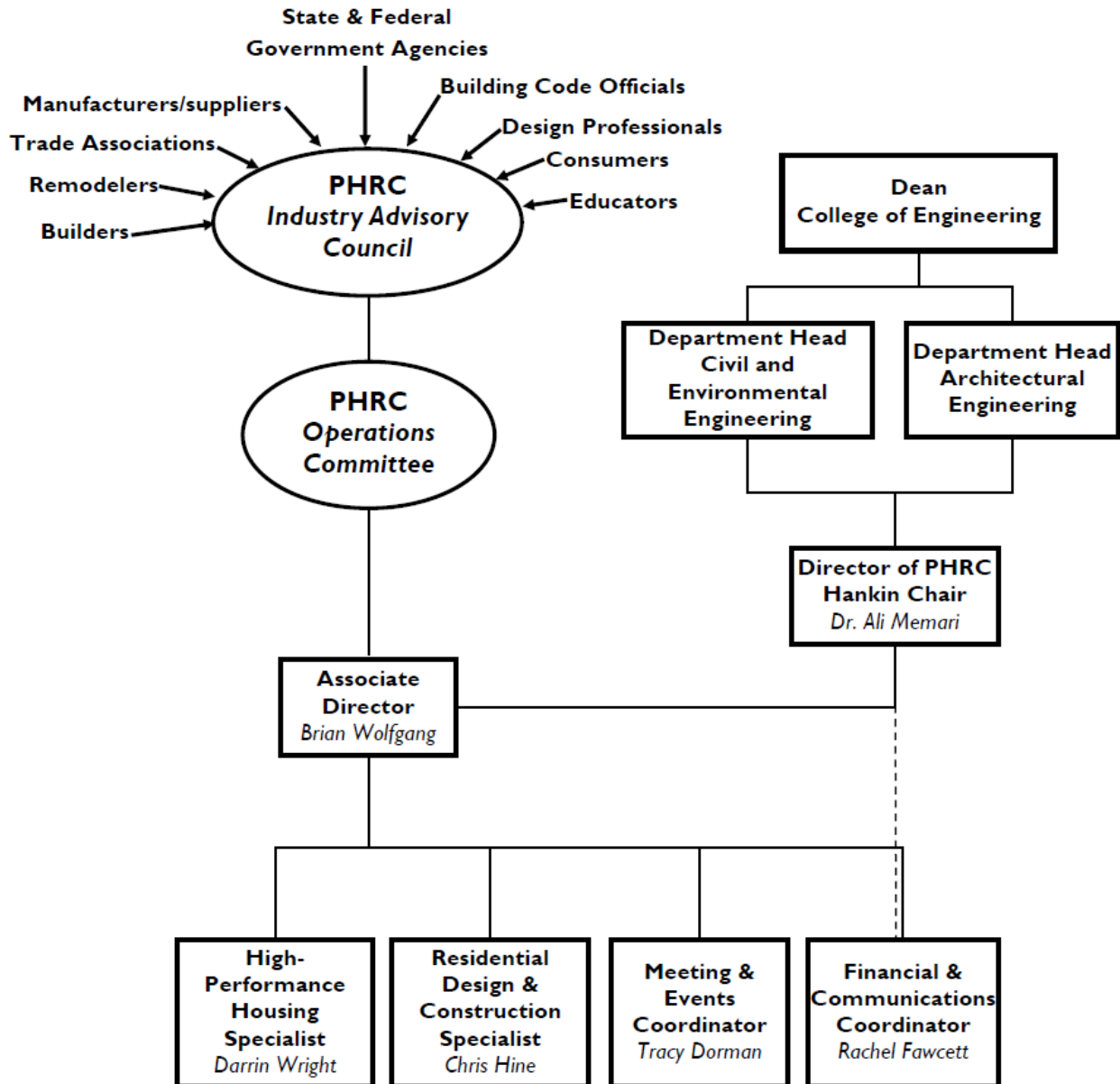


Figure 1. PHRC Organizational Chart

B. Staff Changes

During the spring of 2022, the PHRC team experienced the departure of long-time PHRC team member Sarah Klinetob Lowe. Sarah departed the PHRC team in March 2022 to pursue new opportunities elsewhere in the Penn State College of Engineering. PHRC leadership conducted an extensive search to fill the vacant High-Performance Housing Specialist position and successfully hired Darrin Wright to the PHRC team in July 2022. Darrin brings a substantial breadth of professional experience in the residential construction industry, including time as a commercial and residential building inspector, an extensive background in both residential and commercial project management and site supervision, and direct building experience. Additionally, he has taught secondary and post-secondary students in central Pennsylvania focused on a variety of residential-related topics including solar panel installation and other emerging energy systems.

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. To meet this expectation, 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 provided 53 educational programs to 2,865 individuals during this reporting period (see Table 1).

Table 1. Summary of PHRC Educational Programs for the 2021-2022 Project Year

PROGRAM	Activities for 2021-2022	
	# of Events	# of Attendees
Webinars	11	1,216
Speaking Engagements	39	1,361
PHRC Conference	Day 1	98
	Day 2	95
Residential Building Design & Construction Conference	1	86
TOTAL	53	2,865

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

- A. Program Development
- B. PHRC Training Program Delivery
- C. Webinar Development & Delivery
- D. Builder Briefs & Other Publications
- E. Technical Assistance, Technology Transfer, & Outreach

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. Program Development

The PHRC developed or updated the following training programs. These programs address issues challenging the residential construction industry (builders, developers, remodelers, building code officials, design professionals, materials suppliers, etc.).

1. Existing Program Updates & Maintenance

Description: For many PHRC workshops, there is a need to make minor course material updates based on instructor feedback throughout the year. Also, the PHRC will continue work to update and improve the photos in programs, incorporate more photos or videos as appropriate, and expand active learning exercises to increase learner participation and knowledge retention.

Manager/PI: C. Hine

Report: PHRC staff continued to update workshops to reflect administrative changes, technical additions, and other instructor-led requests.

2. PHRC Continuing Education On-Demand

Description: The PHRC team continues to work with the Office for Digital Learning (ODL) within the Penn State College of Engineering to utilize newly available software platforms for on-demand education. This effort will continue with the potential expansion to programs longer than one-hour recorded webinars. Note: this project began in the 2019-2020 project year and is ongoing.

Manager/PI: B. Wolfgang & R. Fawcett

Report: The PHRC team worked with ODL to develop seven on-demand courses through Penn State Extension bringing the course total to seventeen. Building code officials are the primary audience completing the courses. On average, registrants complete two courses per year.

3. Stucco & Thin Stone Veneer Design & Installation Workshop Revamp

Description: This workshop currently covers core building science principles, relevant exterior plaster code requirements, review proper flashing techniques, lath requirements, and treatment of joints between dissimilar materials. Due to anticipated code changes that will have a substantial impact on stucco and stone assemblies, this workshop will require some adjustments. Additionally, new construction details and mockups will aid in future instructional needs.

Manager/PI: B. Wolfgang

Report: The COVID-19 pandemic substantially altered the way the core PHRC audience consumes educational content. The topic of stucco and thin stone veneer, specifically as it relates to core changes in the PA Uniform Construction Code, was no different in that the PHRC staff and external instructors determined that the best delivery method for training was in short speaking engagements and online trainings. Content was developed in one- and two-hour modules that focused on building science principles, best practices, and new code provisions.

These modules were deployed in-person through invited speaking engagements, at the PHRC Housing Conference as a conference session, and through PHRC webinars. New details and photos were used in these training sessions.

4. Full- or Partial-Day Code Update Workshop

Description: The Pennsylvania Uniform Construction Code will update to the 2018 codes in the first quarter of 2022. The provisions impacted by these changes will be summarized in a full- or partial-day workshop, depending on the length of time needed to adequately cover the material. It is intended that this course will be delivered in-person, but online delivery will be considered when developing curriculum.

Manager/PI: C. Hine & B. Wolfgang

Report: The PHRC staff developed a module-based training program with a total of five one-hour modules available for delivery. These sessions were the primary training content focused on the updates to the PA Uniform Construction Code. The most common delivery method was through invited speaking engagements when external organizations would determine the content (modules) and length of training for their core audience. The PHRC team would travel and delivery this content in sessions ranging from one to six hours in length.

B. PHRC Training Program Delivery

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 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).

Report: During the 2021-2022 project year, the PHRC did not deliver full-day training programs. The primary reason for this shift in delivery mode was due to the fundamental change in the way that the PHRC audience consumes educational content. Due to an overheated housing market, ongoing pandemic-related concerns, and an interest in shorter training sessions, the PHRC team's focus shifted away from full-day in-person training to online training, including live and on-demand webinars, and invited speaking engagements.

C. Webinar Development & Delivery

Description: The PHRC will continue its successful monthly webinar series. Webinars are delivered live and are also archived for on-demand viewing. Proposed topics are listed below. One PA Labor & Industry contact hour is offered for each webinar for PA code officials. As appropriate, AIA Learning Units (LUs) for architects, ICC credits and ICC contact hours for code officials, NARI credits for remodelers, and Professional Development Hours (PDHs) for engineers in Pennsylvania are offered.

Report: The PHRC delivered 11 webinars during this reporting period to a total of 1,216 people. Due to the PHRC Housing Conference, no webinar was held in March. See Table 2 for the summary of webinars and attendees.

Table 2. 2021-2022 Webinar Series Titles and Number of Attendees

Webinar Series		
Date	Title/Topic	Attendees
9/14/2021	PA UCC Residential Code Update: Part 1	223
10/12/2021	PA UCC Residential Code Update: Part 2	161
10/28/2021	All-Electric New Homes in PA	84
11/9/2021	Adapting to Tighter Enclosures Scopes of Work	120
12/14/2021	2021 PA Alternative Residential Energy Provisions Update	140
1/11/2022	Research to Practice: What can I do to improve my BMP?	61
1/27/2022	Radon-Resistant New Construction Techniques	76
2/15/2022	Adapting Stucco & Stone Assemblies to Changing Codes	139
4/12/2022	The Benefits of Safety Plans on the Jobsite	34
4/28/2022	Why Passive House Design for Multifamily Affordable Housing	71
5/10/2022	Moisture-Control Layers and Materials	107
	Total	1,216

D. Builder Briefs & Other Publications

Description: The PHRC will produce publications as appropriate, including its series of short technical documents called Builder Briefs 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. Potential publication topics include:

- Stucco & Stone Details
- PA Alternative Residential Energy Provisions
- PA Alternative Residential Energy Provisions Worksheet

Manager/PI: B. Wolfgang

Report: The 2021 PA Alternative Residential Energy Provisions and associated worksheet were both published in fall 2021 and are available on the PHRC website for viewing and to download. Stucco and stone details were developed for the associated training content that was deployed in response to changes to the PA Uniform Construction Code. These details are available in session handouts.

E. Technical Assistance, Technology Transfer, & Outreach

Description: This initiative is a continuation or expansion of activities to get technical information, resources, and publications to builders, remodelers, design professionals, building code officials and others involved in the residential construction industry.

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

1. Annual PHRC Housing Conference
2. Residential Building Design & Construction Conference
3. PCCA Symposia
4. Speaking Engagements
5. General Outreach Activities
6. Annual Magazine
7. Educating the Next Generation of Tradespeople
8. Support of the UCC RAC
9. Support of Standards
10. Strategic Partnerships

- 1. Annual PHRC Housing Conference:** The PHRC will continue to organize, promote, and hold the 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) with regulators (planners, building code officials, township engineers, DEP and conservation district staff, etc.) and others involved in the residential construction industry.

Report: The 30th Annual PHRC Housing Conference was held on March 2-3, 2022 at The Penn Stater Hotel & Conference Center in State College, PA. 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 Joe Medosch, measureQuick, entitled “Who Holds the Keys to a Healthier Home? What Doors Are Open or Locked? Who Are the Key Makers?”

The following tracks and sessions were offered:

- High-Performance & Offsite Construction
 - “Panelized Building Envelopes: Velocity, Efficiency, and Sustainability” by Adam Eckley
 - “Air Sealing, the New PA Code, & Achieving Net Zero” by Paul Springer
 - “Carbon Smart and Healthy Homes: Design, Construction, & Building Code” by Ana Konopitskaya
- Codes & Construction
 - “The Countdown to 3 ACH50: Reviewing a Scope of Work to Achieve 3 ACH50 by the Time of Final Inspection” by Michael Arblaster
 - “Back to the Drawing Board: Diving into Stucco & Stone Details” by Brian Wolfgang, Steve Long & Bill Dare
 - “Modular Construction of a Net Zero Home in Pittsburgh” by Bill Spohn
- The PHRC held a networking event titled “Celebrate Reception” on the evening of March 2. This reception included conference speakers, attendees, and PHRC Staff and allowed for industry discussion on the day’s sessions. At this event, we celebrated innovative research, Professional Women in Building, and the next generation of industry professionals. Mollie Elkman held a book signing for “The House That She Built” with representatives from the local and state Professional Women in Building Councils to raise funds for student scholarships. 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:

- Weatherization & Building Science
 - “What’s the Real Focus: Energy Savings vs. Healthier Home? Can They Both Be the Focus & Converted into Marketing Strategies?” by Joe Medosch
 - “Industry Standards & Application Demonstrations for Flashing and Installation of Windows & Doors” by Jim Katsaros & Bill Dudek
 - “Residential Moisture Management: Durability” by Brian Wolfgang & Bill Dare
- Land Development & Planning
 - “High Intensity Soil Mapping for Land Development Planning” by Laurel Mueller
 - “Zoning Hot Topics: Keeping You Up to Speed on Trending Land Uses” by John Trant
 - “Pennsylvania Post-Construction Stormwater Management Manual Update” by Mark Bowen
- Day 2 concluded with a combined afternoon plenary titled “A Discussion on Workforce Challenges and Initiatives in the Construction & Weatherization Industries” by Alison Diehl & Carrie Boyer

Table 3. Attendees at the 30th Annual PHRC Housing Conference

Event	Attendees
Day 1 (March 2)	98
Day 2 (March 3)	95
Celebrate Reception	81

- 2. Residential Building Design & Construction Conference:** The PHRC will organize, promote, and hold the sixth Residential Building Design and Construction Conference (RBDCC), to be held in even numbered years. The RBDCC provides a unique forum for researchers, design professionals, manufacturers, and builders to keep up to date on the latest advancements and discuss their own findings, innovations, and projects related to residential buildings. RBDCC sessions will consist of technical paper presentations on recent research and innovations related to residential buildings. The RBDCC is focused on various types of residential buildings including single- and multi-family dwellings, mid-rise and high-rise structures, factory-built housing, dormitories, and hotels/motels. Full papers will be published in the conference proceedings.

Report: For the 2022 RBDCC, the PHRC kicked off the Call for Submissions in spring 2020 and received 118 abstracts. The 2022 RBDCC was held virtually on May 11-12, 2022, due to the COVID-19 pandemic and the international scope of the conference. Two keynote speakers presented, and they were Wil V. Srubar III from the University of Colorado Boulder and Rusty Smith from Auburn University. The online conference featured 60 presentations and 10 posters. The conference proceedings featuring 61 papers will be released in 2022 as a compilation of all submitted and reviewed papers.

- 3. PCCA Symposia:** The PHRC will work (as needed) with the Pennsylvania Construction Codes Academy (PCCA) to develop and deliver three 1-day programs (one in the central region of the Commonwealth in conjunction with the annual PHRC Housing Conference, one in the eastern part of the Commonwealth, and one in the western part). This annual event is intended to address technical issues being faced by building code officials.

Report: Due to personnel transitions at PCCA, these events were not held in 2021-2022.

- 4. Speaking Engagements:** The PHRC will hold and/or participate 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 regional, state, or national conferences.

Report: During the 2021-2022 project year, the PHRC team delivered 39 speaking engagements to a total of 1,361 attendees. The increase in frequency of speaking engagements is associated with the changes to the PA Uniform Construction Code.

Table 4. Speaking Engagements during the 2021-2022 Project Year

Organization	Topic(s)	Date	Attendees
Tri-State ASHI	Looking Ahead: Changing Building Codes and the Impact on the Future Housing Stock	9/24/2021	43
PA Manufactured Housing Association (PMHA)	2018 PA UCC Update: Part 1	9/30/2021	9
Pennsylvania Builders Association (PBA)	2018 PA UCC Update: Part 1	10/8/2021	16
Keystone ASHI	Changing Building Codes and the Impact on Building Enclosures	10/8/2021	110
Bureau Veritas	2018 PA UCC Update: Parts 1 & 2	10/13/2021	12
State College Design and Construction	2018 PA UCC Update: Parts 1 & 2	10/14/2021	10
Boral Stone Products/Westlake Company	Adapting Stucco & Stone	10/19/2021	19
PENNBOK	2018 IRC Program Update	10/20/2021	32
PA Manufactured Housing Association (PMHA)	2018 PA UCC Update: Part 2	10/21/2021	7
BIA of Lancaster	2018 PA UCC Update: Parts 1 & 2	10/26/2021	48
HBA of Bucks/Montgomery Counties	2018 PA UCC Update: Parts 1 & 2	10/29/2021	32
York County Builders Association	2018 PA UCC Update: Parts 1 & 2	11/2/2021	28
Wayne/Pike BIA	2018 PA UCC Update: Parts 1 & 2, Adapting to Tighter Enclosures, 2021 PA-Alt Update	11/2/2021	32
Indiana Armstrong Builders Association	2018 PA UCC Update: Parts 1 & 2	11/9/2021	31
Builders Association of Cambria County	2018 PA UCC Update: Parts 1 & 2	11/11/2021	46
HBA of Metro Harrisburg	2018 PA UCC Update: Parts 1 & 2	11/16/2021	24
Carbon Builders Association	2018 PA UCC Update: Parts 1 & 2, 2021 PA-Alt Update	11/18/2021	19
Pocono Builders Association	2018 PA UCC Update: Parts 1 & 2	12/7/2021	11
Lebanon County Builders Association	2018 PA UCC Update: Parts 1 & 2	12/8/2021	24
Lehigh Valley Builders Association	2018 PA UCC Update: Parts 1 & 2	12/15/2021	35
Lennar Home Builders	2018 PA UCC Update: Part 2, Adapting to Tighter Enclosures	12/16/2021	35
Lawrence County Builders Association	2018 PA UCC Update: Parts 1 & 2	1/12/2022	30
Central Keystone COG	2018 PA UCC Update: Parts 1 & 2, Adapting to Tighter Enclosures, 2021 PA-Alt Update	1/12/2022	76
PFS Corporation	PA Alternative and 2021 PA Alternative Energy Provisions	1/13/2022	68
HBA of Bucks/Montgomery Counties	Adapting to Tighter Enclosures, 2021 PA-Alt Update	1/18/2022	11
Builders Association of Metro Pittsburgh (BAMP)	Special extended version of 2018 PA UCC Update: Parts 1 & 2	1/25/2022	100
PennBoc Region 6	Special 6-hour version of 2018 PA UCC Residential Code Update	2/17/2022	70
Centre Region Code Administration	2018 PA UCC Residential Code Update	2/24/2022	77

Builders Association of Metro Pittsburgh (BAMP)	2018 PA UCC Residential Code Update	3/9/2022	50
Builders Association of Metro Pittsburgh (BAMP)	PA Alternative and 2021 PA Alternative Energy Provisions	3/9/2022	30
Builders Association of Metro Pittsburgh (BAMP)	Adapting Stucco & Stone Assemblies to Changing Codes	3/9/2022	30
Builders Association of Metro Pittsburgh (BAMP)	A Comprehensive Deck Design from Footings to Guards: Learning from the Past	3/9/2022	15
Pennsylvania Housing Research Center (PHRC)	Code Session - Air Sealing with AeroBarrier	3/24/2022	18
Pennsylvania Housing Research Center (PHRC)	Code Update - Air Sealing Session	3/29/2022	34
Envinity, Inc.	2018 PA UCC Update: Parts 1 & 2	4/12/2022	13
State College Rotary	PHRC and Building Code Overview	5/5/2022	25
West Branch Susquehanna Builders Association	2018 PA UCC Update: Parts 1 & 2	5/17/2022	23
PRO-ASHI	Residential Moisture Management - the 4D's, Adapting Stucco and Stone Assemblies to Changing Code	5/27/2022	32
PA Manufactured Housing Association (PMHA)	A Quick Look into Decks and Air Infiltration out of the 2018 IRC	6/7/2022	36
Total		39	1,361

5. **General Outreach Activities:** The general outreach activities of the PHRC include efforts to let builders know about the PHRC and the services and publications it provides. These activities may include creating PHRC mailings and promotional pamphlets; writing articles in research or trade journals; answering phone and email questions; and the maintenance of the PHRC’s website and social media, as well as relevant technical meetings attended by PHRC staff.

Publications

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

Journal Papers

- Hojati, M., Li, Z., Memari, A. M., Park, K., Zahabi, M., Nazarian, S., Duarte, J. P., and Radlinska, A., (2022). “3D-printable quaternary cementitious materials towards sustainable development: Mixture design and mechanical properties,” Submitted to Elsevier *Results in Engineering Journal*, Vol. 13, 10p. Published March 2022, <https://doi.org/10.1016/j.rineng.2022.100341>.
- Lu, X. and Memari, A. M., (2022). “Comparison of the Measurement Methods for Building Envelope Thermal Transmittance,” *Buildings*, Special Issue [Advanced Residential and Commercial Building Envelope Systems Evaluation](#), Vol. 12, Issue 3, 282, 15p., Published March 1, 2022, <https://doi.org/10.3390/buildings12030282>.
- Wu, Z., Memari, A. M., and Duarte, J. P., (2022). “State of the Art Review of Reinforcement Strategies and Technologies for 3D Printing of Concrete,” MDPI *Energies*, published 01/04/2022, Vol. 15(1), 360, 24 pages; <https://doi.org/10.3390/en15010360>.
- Lu, X. and Memari, A. M., (2022). “Comparison of the State-of-the-Art Measurement Methods for Building Envelope Thermal Transmittance, MDPI *Buildings*, published 03/01/2022, Vol. 12, No. 3, 15p., <https://doi.org/10.3390/buildings12030282>.
- Al-Qenaee, A. and Memari, A. M., (2022). “Experimental Study of 3D Printable Cob Mixtures, Elsevier *Journal of Construction and Building Materials*, published 02/09/22, Vol. 324, 126574, 19p. <https://doi.org/10.1016/j.conbuildmat.2022.126574>.
- Wu, Z., Memari, A. M., and Duarte, J. P., (2022). “State of the Art Review of Reinforcement Strategies and Technologies for 3D Printing of Concrete,” MDPI *Energies*, Published 01/04/2022, Vol. 15 (1), 360, 24 pages; <https://doi.org/10.3390/en15010360>.
- Amini, M., and Memari, A. M., (2021). “LES Simulations of Wind-induced Pressure on the Floor System Underside of Elevated Buildings, Techno Press *International Journal of Wind and Structures*, Published 11/5/21, Vol. 33, No. 5, November 2021, pp. 397-407. DOI: <https://doi.org/10.12989/was.2021.33.5.397>.
- Memari, A. M., Simmons, N. C. and Solnosky, R., (2021). “Derivation of Kinematic Equations Based on Full-scale Racking Tests for Seismic Performance Evaluation of Unitized Four-sided Structural Sealant Glazing Curtain Wall Systems,” MDPI *Buildings*, Published 11/28/21, Vol. 11, 593, 23p. <https://doi.org/10.3390/buildings11120593>.
- Memari, A. M., Simmons, N. C. and Solnosky, R., (2021). “Developing FEM Procedures for Four-Sided Structural Sealant Glazing Curtain Wall Systems with Reentrant Corners,” MDPI *Buildings*, Published 11/29/21. Vol. 11, 597, 30p. <https://doi.org/10.3390/buildings11120597>.

- Duarte, G., Duarte, J. P., Memari, A. M., and Brown, N., (2021). “Learning from Historical Structures under Compression for Concrete 3D Printing Construction,” Elsevier *Journal of Building Engineering*, Published 7/24/21, Vol. 43, 103009, pp. 1-19; <https://doi.org/10.1016/j.jobe.2021.103009>.
- Al-Qenaee, A., Memari, A. M., and Hojati, M., (2021). “Transition from Traditional Cob to 3D Printing of Clay Homes,” *Journal of Green Building*, Vol. 16, No. 4., pp. 3-28, Published Fall 2021. DOI:[10.3992/jgb.16.4.3](https://doi.org/10.3992/jgb.16.4.3).
- Amini, M. and Memari, A. M., (2021). “Comparative Review and Assessment of Various Flood Retrofit Methods for Low-Rise Residential Buildings in Coastal Areas,” *ASCE Natural Hazards Review*, Vol. 22, No. 3, August 2021, pp. 04021009-1-21; DOI: 10.1061/(ASCE)NH.1527-6996.0000464.
- Amini, M. and Memari, A. M., (2021). “CFD-Based Evaluation of Elevated Coastal Residential Buildings under Hurricane Wind Loads,” *ASCE Journal of Architectural Engineering*, Published September 2021, Vol. 27, No. 3, pp. 04021014-1-19. DOI: 10.1061/(ASCE)AE.1943-5568.0000472.
- Duan, Q., Hinkle, L., Wang, J., Zhang, E., and Memari, A., (2021). “Condensation Effect on Energy Performance of Building Window,” Elsevier, *Journal of Energy Reports*, Published November 2021, Vol. 7, pp. 7345-7357. <https://doi.org/10.1016/j.egy.2021.10.096>

Conference Proceedings Papers

- Wu, Z, Memari, A. M., and Duarte, J. P., (2022). “Practical Construction of 3D Printed Reinforced Concrete Members,” *Proceedings of the 6th Residential Building Design and Construction Conference*, Penn State University, University Park, PA, March 2-3, 2022, 10p.
- Wu, Z, Memari, A. M., and Duarte, J. P., (2022). “Review of Mechanical and Structural Testing for 3D Printed Concrete,” *Proceedings of the 6th Residential Building Design and Construction Conference*, Penn State University, University Park, PA, March 2-3, 2022, 10p.
- Yi, H., Griffin, C., and Memari, A. M., (2022). “Critical Review of the Characterization of Environmental and Mechanical Properties of Hemp hurd and Hempcrete,” *Proceedings of the 6th Residential Building Design and Construction Conference*, Penn State University, University Park, PA, March 2-3, 2022, 9p.
- Brown, N., Memari, A. M., Xiao, M., Duarte, G., Wu, Z., Duarte, J, Nazarian, S., (2022). “A comparison of thermal insulation strategies for 3D printed concrete structures in cold regions,” *Proceedings of the 6th Residential Building Design and Construction Conference*, Penn State University, University Park, PA, March 2-3, 2022, 10p.
- Xiao, M., Wang, Z.-Y., and Memari, A. M., (2022). “Design of Foundations in Permafrost for 3-D Printed Habitat in the Arctic,” *Proceedings of the 6th Residential Building Design and Construction Conference*, Penn State University, University Park, PA, March 2-3, 2022, 10p.

- Yadav, R. and Memari, A. M., (2022). “Case Study Finite Element Modeling and Analysis of a CLT Tornado Shelter,” *Proceedings of the 6th Residential Building Design and Construction Conference*, Penn State University, University Park, PA, March 2-3, 2022, 10p.
- Yadav, R. and Memari, A. M., (2022). “State of the Art Review of Tornado and Hurricane Shelters for Residential buildings,” *Proceedings of the 6th Residential Building Design and Construction Conference*, Penn State University, University Park, PA, March 2-3, 2022, 10p.
- Duarte, G., Wu, Z., Memari, A. M., Brown, N., and Duarte, J., (2022). “Structural Evaluation of a Proposed Habitat for 3D Concrete Printing in Remote Alaska,” *Proceedings of the 6th Residential Building Design and Construction Conference*, Penn State University, University Park, PA, March 2-3, 2022, 10p.
- Jellen, A. C. and Memari, A. M., (2022). “Structural Design of a Cross-Laminated Timber (CLT) Single-Family Home,” *Proceedings of the 6th Residential Building Design and Construction Conference*, Penn State University, University Park, PA, March 2-3, 2022, 10p.
- Duarte, G., Memari, A. M., Brown, N., and Duarte, J., (2022). “Structural optimization of overall shapes in 3D printing of concrete,” *Proceedings of the 6th Residential Building Design and Construction Conference*, Penn State University, University Park, PA, March 2-3, 2022, 10p.
- Erisman, C., Lulo, L., Abdelwahab, K., Griffin, C., and Memari, A. M., (2022). “Overview of common residential wall construction methods applied to achieve a continuous air barrier and their material properties,” *Proceedings of the 6th Residential Building Design and Construction Conference*, Penn State University, University Park, PA, March 2-3, 2022, 10p.
- Ulmer, B. and Memari, A. M., (2022). “State of the Art Review of Building Enclosure Use of Cross-Laminated Timber,” *Proceedings of the 6th Residential Building Design and Construction Conference*, Penn State University, University Park, PA, March 2-3, 2022, 9p.
- Mirzai, N. M. and Memari, A. M., (2022). “Review of Structural Load Resisting Systems for Cross-Laminated Timber Multi-story Residential Buildings,” *Proceedings of the 6th Residential Building Design and Construction Conference*, Penn State University, University Park, PA, March 2-3, 2022, 10p.
- Welch, S., Obonyo, E., and Memari, A. M., (2022). “Energy modeling to determine optimum order of component installation in stepwise retrofit towards EnerPHit standard,” *Proceedings of the 6th Residential Building Design and Construction Conference*, Penn State University, University Park, PA, March 2-3, 2022, 10p.
- Welch, S., Obonyo, E., and Memari, A. M., (2022). “Evaluation of Software Packages for Energy Modeling of Phased Deep Energy Retrofits to Passive House standards,” *Proceedings of the 6th Residential Building Design and Construction Conference*, Penn State University, University Park, PA, March 2-3, 2022, 10p.
- Abdelwahab, K., Griffin, C., Memari, A. M., and Lulo, L., (2022). “Small-Scale Testing of Air Barrier Systems Adhered on Sheathing Panels Under In-plane Relative Displacement

Simulating Seismic Effect,” *Proceedings of the 6th Residential Building Design and Construction Conference*, Penn State University, University Park, PA, March 2-3, 2022, 10p.

- Habibi, S. and Memari, A. M., (2022). “Use of Plastic Waste in Building Construction Industry,” *Proceedings of the 6th Residential Building Design and Construction Conference*, Penn State University, University Park, PA, March 2-3, 2022, 10p.

Conference Presentations

Oral Presentations

- Yi, H. (Presenter), Griffin, C., and Memari, A. M., (2022). “Critical Review of the Characterization of Environmental and Mechanical Properties of Hemp Hurd and Hempcrete,” *Virtual 6th Residential Building Design and Construction Conference*, Penn State University, University Park, PA, March 2-3, 2022.
- Brown, N. (Presenter), Memari, A. M., Xiao, M., Wu, Z., Duarte, J., Nazarian, S., (2022). “A Comparison of Thermal Insulation Strategies for 3D Printed Concrete Structures in Cold Regions,” *Virtual 6th Residential Building Design and Construction Conference*, Penn State University, University Park, PA, March 2-3, 2022.
- Duarte, G. (Presenter), Memari, A. M., Brown, N., Duarte, J., and Wu, Z., (2022). “Structural Evaluation of a Proposed Concrete 3D Printed Habitat in Remote Alaska,” *Virtual 6th Residential Building Design and Construction Conference*, Penn State University, University Park, PA, March 2-3, 2022.
- Jellen, A. C. (Presenter) and Memari, A. M., (2022). “Structural Design of a Cross-Laminated Timber (CLT) Single-Family Home,” *Virtual 6th Residential Building Design and Construction Conference*, Penn State University, University Park, PA, March 2-3, 2022.
- Welch, S. (Presenter), Obonyo, E., and Memari, A. M., (2022). “Energy modeling to determine optimum order of component installation in stepwise retrofit towards EnerPHit standard,” *Virtual 6th Residential Building Design and Construction Conference*, Penn State University, University Park, PA, March 2-3, 2022.
- Abdelwahab, K. (Presenter), Griffin, C., Memari, A. M., and Lulo, L., (2022). “Small-Scale Testing of Air Barrier Systems Adhered on Sheathing Panels Under In-plane Relative Displacement Simulating Seismic Effect,” *Virtual 6th Residential Building Design and Construction Conference*, Penn State University, University Park, PA, March 2-3, 2022.

Posters

- Abdelwahab, K., Griffin, C., Memari, A., and Lulo, L., (2022). “Small-scale Testing of Air Barrier Systems Adhered on Sheathing Panels under In-plane Relative Displacement Simulating Seismic Effect,” *Virtual Poster at the 6th Residential Building Design and Construction Conference*, Organized by the Pennsylvania Housing Research Center, Penn State University, University Park, PA, March 2-3, 2022.
- Habibi, S. and Memari, A. M., (2022). “On the Use of Plastic Waste in Building Construction Industry,” *Virtual Poster at the 6th Residential Building Design and Construction Conference*, Organized by the Pennsylvania Housing Research Center, Penn State University, University Park, PA, March 2-3, 2022.

Construction Conference, Organized by the Pennsylvania Housing Research Center, Penn State University, University Park, PA, March 2-3, 2022.

- Wu, Z., Memari, A. M., and Duarte, J. P., (2022). "Review of Mechanical and Structural Testing for 3D Printed Concrete," Virtual Poster at the *6th Residential Building Design and Construction Conference*, Organized by the Pennsylvania Housing Research Center, Penn State University, University Park, PA, March 2-3, 2022.
- Mirzai, N. and Memari, A., (2022). "Review of Structural Load Resisting Systems for Cross-Laminated Timber Multi-story Residential Buildings," Virtual Poster at the *6th Residential Building Design and Construction Conference*, Organized by the Pennsylvania Housing Research Center, Penn State University, University Park, PA, March 2-3, 2022.

Conferences/Meetings Attended

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

- Summer PBA Board Meetings, PHRC staff, Online, July 13-16, 2021.
- Fall PBA Board Meetings, Hine, C. and Wolfgang, B., Hershey, PA, October 8, 2021.
- Women in Residential Construction Conference, T., Dorman, Online, October 27-29, 2021
- 2021 Women in Residential Construction Conference, Dorman, T., Online, October 27-29, 2021
- 2021 National Land Bank Network Summit, Fawcett, R., Online, November 3, 2021.
- NAHB Student Competition, PHRC staff, Orlando, FL, February 7, 2022.
- International Builders Show, PHRC staff, Orlando, FL, February 8-10, 2022.
- NAHB Student Chapter Advisory Board Meeting, Wolfgang, B., Orlando, FL, February 9, 2022.
- Winter PBA Board Meetings, Wolfgang, B., Reading, PA, February 25, 2022.
- Solar Decathlon Design Challenge Student Competition, Klinetob Lowe, S., Golden, CO, April 22-24, 2022.
- Penn State Energy Days 2022, Wolfgang, B., State College, PA, May 26, 2022.
- NAHB Student Chapter Advisory Board Meeting, Wolfgang, B., Washington, D.C., June 15, 2022.
- Ci Live: Applied Building Science, Hine, C., Wolfgang, B. Denver, CO, June 21-22, 2022

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

- Dorman, T., Professional Women in Building Council of Central PA, Chair.
- Fawcett, R., Professional Women in Building Council of Central PA, Member.
- Wolfgang, B., Builders Association of Central PA, Board of Directors, Secretary.
- Wolfgang, B., Builders Association of Central PA, Education Committee Chair.
- Wolfgang, B., State College Area School District Building Construction Technology Program Occupational Advisory Committee Member.

National and International Committees and Organizations

- Memari, A.M., American Society of Civil Engineers, member.
- Memari, A.M., American Society of Civil Engineers, Editor-in-Chief, Journal of Architectural Engineering.
- Memari, A.M., American Society of Civil Engineers, Architectural Engineering Conferences, National Conference Steering Committee, member.
- Wolfgang, B., National Association of Home Builders Student Chapter Advisory Board member.

6. Annual Magazine: The PHRC Annual Magazine was sent electronically to PHRC members and stakeholders to keep them updated on recent PHRC activities and to promote upcoming events. For the 2021-2022 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.

7. 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 will consider 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. The PHRC also prioritizes gender equity in the residential construction industry through involvement with the NAHB Professional Women in Building (PWB) activities and initiatives. This project 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. Other outreach activities include trying to increase participation of vocational students and instructors in the PHRC Housing Conference, PCCA Symposia, and PHRC webinars.

Report: The PHRC Construction Summit is being planned for fall 2022 as a second edition of this event. Additionally, PHRC staff are involved with outreach through speaking to and interacting with various groups including students in other classes at Penn State, the State College Building

Construction Technology Program, and the Central PA Institute of Technology Carpentry Program.

8. **Support of the UCC RAC:** The PHRC continues to support the RAC and the public by serving as a general technical resource upon request and by sharing updates on RAC activities to the general PHRC audience.

Report: Throughout 2021-2022, PHRC staff attended each RAC meeting via Zoom.

9. **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.

Report: The PA Alternative Residential Energy Provisions were updated in alignment with changes to the PA Uniform Construction Code during the 2021 calendar year. Subsequent training, both in-person and online, was deployed to help inform the PHRC audience about the new provisions. More information can be found in the Applied Project report on the PA Alternative.

10. **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: PHRC staff continued to work with critical partners and stakeholders. These partnerships allowed for an expanded reach with marketing programs, the PHRC Housing Conference, and awareness of the PHRC overall.

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. Projects in this category foster partnerships and draw on the expertise and strengths of the people and facilities available at The Pennsylvania State University.

1. Light-Gauge Steel Framed Home Design

Description: Considering the recent significant increase in lumber prices, there is a need for alternative framing materials and systems. According to a February 2021 NAHB report, lumber shortage has caused an increase in average single-family home cost by \$24,000, mainly because of the approximately 180% increase in lumber price (since April 2020). Accordingly, this is mainly attributed to shut down of factories since March 2020 due to COVID 19 pandemic. However, there has also been an increased demand for single-family homes as working from home became a norm for millions, requiring more suitable working environment not available in their current residences. There is a definite need for alternative construction material, and light gauge steel stud seems to offer one such solution. However, since steel studs have been primarily used as non-load bearing partition walls and backup system for building envelope in commercial buildings, there is also a need to develop typical home design with such an alternative system. This project will develop the design calculations and typical details for an already designed conventional wood-frame single-family home and develop comparisons with regard to the cost of construction and various performance attributes of interest.

Manager/PI: Dr. Ali Memari

Report: This project is complete, and the report is being finalized. The outcome of the project is structural design of a single-family home using cold-formed steel (CFS) as an alternative building material. In the project report, potential users/designers of a CFS framing system for single-family residential construction are introduced to the typical CFS design methodology and can use the information presented to compare how the switch from conventional light-framed wood construction to CFS framing might affect their engineering design workflow. The structural design was performed on a model home provided by a local home builder (S&A Homes). Previously, a structural design was completed for this same residence using light-frame wood construction methods. The design was published in 2019 as a chapter titled “Structural Design of a Typical American Wood-Framed Single-Family Home” in the book titled, “Timber Buildings and Sustainability.” This report is intended as a follow-up to the original design report to present the design of the same residence using an alternative structural system. The alternative CFS design was conducted using prescriptive methods found in AISI S230. For comparison, the main structural members and shear walls were designed in RISA 3D.

IV. Applied Projects

The Applied Project category refers to projects that are application-oriented and have a direct need by the residential construction industry. This may also include longer term initiatives.

1. Energy Retrofits

Description: Nearly 80% of Pennsylvania’s existing housing stock was built before modern building codes, resulting in higher than necessary energy bills and occupant comfort issues. This project focuses on studying the potential impacts and challenges associated with energy retrofits through local case studies. Data extracted through this project will lead to future webinars and conference presentations. Note: this project began in the 2019-2020 project year and is ongoing due to COVID-19 restrictions.

Manager/PI: S. Klinetob Lowe

Report: The pilot Energy+ initiative tied to an external grant with the project partners was completed in April 2022 to design, implement, and evaluate residential energy efficiency-focused capital improvements in the State College area. An open house event was held with posters and a presentation to highlight the various retrofits completed on townhouses, duplexes, and single-family homes. The project partners continue to seek additional external funding to work on homes beyond the initial fifteen retrofits.

2. Stucco & Stone Details

Description: The existing stucco & stone workshop currently covers core building science principles, relevant exterior plaster code requirements, review proper flashing techniques, lath requirements, and treatment of joints between dissimilar materials. Due to anticipated code changes that will have a substantial impact on stucco and stone assemblies, new construction details would be helpful in illustrating the impact and sequence of some of the changes directly relating to rainscreen gaps in these assemblies.

Manager/PI: B. Wolfgang

Report: Stucco and stone details, including traditional constructions details, 3D graphics, and isometrics, were developed for the associated training content that was deployed in response to changes to the PA Uniform Construction Code. These details are available in session handouts.

3. Code Update Video Series

Description: With the Pennsylvania Uniform Construction Code update planned for the first quarter of 2022, the PHRC audience will need additional information in order to adapt to these new code provisions. Based on evolving methods for learning and content distribution, it would be helpful for many industry professionals to have access to more visual and video-based content. This project will task the PHRC with partnering with stakeholders to film on-site footage that illustrates key code provisions that will impact the residential construction industry.

Manager/PI: C. Hine, R. Fawcett, and B. Wolfgang

Report: The initiative to capture on-site videos will be converted into a long-term PHRC activity with the goal being to capture content when the opportunity arises. Various examples of this project were successful over the past year, including the development of a short blower door operation video that was intended to demonstrate the way building airtightness was quantified.

4. PA Alternative Residential Energy Provisions

Description: With the Pennsylvania Uniform Construction Code update planned for the first quarter of 2022, the PHRC will need to address the necessary changes to the PA Alternative. This process will include formation of a subcommittee of the PHRC Industry Advisory Council, solicitation of public comment, modeling of proposed changes to the PA Alternative, and publication of a revised version of the standard. This project will also include an update to the PA Alternative Residential Energy Provisions worksheet.

Manager/PI: C. Hine, R. Fawcett, and B. Wolfgang

Report: The PHRC team collaborated with the PHRC Industry Advisory Council to proceed with a multi-phase process to update the PA Alternative Residential Energy Provisions. This included the solicitation of public comments, drafting of changes to trade-offs and energy enhancement options, extensive energy modeling of all scenarios, and ultimately the development and approval of the final document. The final version of the PA-Alt was accepted by the PA Department of Labor & Industry to meet the need for an alternative energy code compliance pathway in the Uniform Construction Code.

As a supplemental resource to the PA-Alt, the PHRC team also published a two-page PA-Alt worksheet that builders and code officials can use to verify their intent to comply with the new provisions. Both the 2021 PA Alternative Residential Energy Provisions and the associated worksheet are available for download on the PHRC website at <https://bit.ly/PHRCStandards>.

V. 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 during the 2021-2022 project year. Several other smaller proposals were also submitted, and some are under review/negotiation but those are not reported here.

The following research proposals were submitted during this reporting period:

- Date: June 2020-December 2021
Title: PA Hemp Home
Sponsor: DON Services funded by PA Department of Agriculture, Commonwealth Specialty Crop Program
Amount: PSU share \$39,000 [funded]
(PI: Memari; Co-PIs: Corey Griffin, Hojae Yi)
- Date: February 2021-May 2022
Title: “Analyses of concrete samples with ingredients and engineering analysis of concrete 3D printed box shaped housing structure”
Sponsor: Alaska Housing Finance Corporation via Xtreme Habitat Institute
Amount: \$54,000 [funded]
(PI: Memari, Co-PIs: Jose Duarte, Shadi Nazarian, Ming Xiao, Nathan Brown, Aleksandra Radlinska, Sven Bilen)
- Date: August 2021-July 2022
Title: “An Open-Source Design and Build-It-Together Sustainable Housing System”
Sponsor: Pennsylvania State University – Department of Architecture, Stuckeman Center for Design Computing
Amount: \$6,000 [funded]
(Co-PI: Memari, PI: Benay Gursoy)
- Date: June 2021-May 2022
Title: “Framework for Application of Machine Learning in Multi-Objective Design Optimization of Coastal Residential Buildings Under Multiple Natural Hazards”
Sponsor: Institute for Computational and Data Sciences Seed Grant 2021-22
Amount: \$25,000 [funded]
(PI: Memari, Co-PI: Nathan Brown)
- Date: May 2022-August 2023 [Submitted 12/06/21]
Title: “Next Generation Insulated Concrete Form Home Building with Recycled or Waste Materials”
Sponsor: MRI
Amount: \$50,000 (Candidate’s share of funding – 40%) [Funded]
(PI: Memari, Co-PI: Benay Gursoy, Aleksandra Radlinska, Bryan Vogt)

- Date: 7/1/2022-6/30/2025 [Submitted 03/21/22]
Title: “Carbon-negative Ready-mix Concrete Building Components through Direct Air Capture”
Sponsor: DOE – ARPA-E -- Harnessing Emissions into Structures Taking Inputs from the Atmosphere (HESTIA) - DE-FOA-0002625
Amount: \$2,300,000 (Candidate’s share of funding – 15%) [Funded]
(Co-PI: Memari & Co-PI Farshad Rajabipour (PSU); PI: Robert Anex & Co-PI: Bu Wang (U. Wisconsin, Madison); and Co-PI Meenesh Singh (U. Illinois, Chicago))
- Date: 08/01/2022 – 07/31/2024 [Submitted 06/30/22]
Title: “Demonstration of Technical Feasibility and Cost Effectiveness of 3D Concrete Printing as an Alternative to Conventional Construction for Affordable Housing in Alaska’s Sub-Arctic Region”
Sponsor: US Housing and Urban Development (HUD)
Amount: Total incl. match \$2,000,000 (included 100% match), PSU’s share: \$800,000 (Candidate’s share of \$800,000: 18%)
(PI: Memari, Co-PIs: Aleksandra Radlinska, Nathan Brown, Ming Xiao, Sven Bilen, Jose Duarte, Shadi Nazarian, Rahman Azari)

VI. 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 2021-2022 Project Year are based upon funds received from July 2020 through June 2021, which can be seen in Table 6 below.

Table 5. Summary of Act 157 Funds received during the 2020-2021 FY (2021-2022 PHRC Project Year)

Collection Period	Amount Received
Q3: July 2020 - September 2020	\$77,811.80
Q4 October 2020 - December 2020	\$120,613.99
Q1: January 2021 - March 2021	\$101,664.21
Q2: April 2021 - June 2021	\$143,549.29
Total	\$443,639.29

Expenses for the Act 157 Account (\$398,0305.78) were less than the revenues (\$443,639.29) for the 2021-2022 project year. The PHRC began to limit spending and was restricted in travel beginning in March 2020 due to the COVID-19 pandemic. Unsure of the long-term effects of the pandemic on the residential construction industry in Pennsylvania, the PHRC continued to be fiscally conservative but began to shift to more typical financial patterns throughout 2021-2022 as the industry began to stabilize. Additionally, the PHRC experienced staffing changes in this project year and had 4.5 months without one full-time staff person. Table 6 shows a breakdown of PHRC expenses for the 2021-2022 Project Year allocated to the Act 157 Account.

Table 6. PHRC Expenses for the 2021-2022 PHRC Project Year

Category	Act 157
Total Salaries	\$264,755.85
Total Wages	\$0.00
Total Student Wages	\$2,780.80
Fringe Benefits	\$92,504.78
Supplies and Materials	\$3,448.42
Communications Services	\$1,049.60
Travel & Meetings	\$12,251.45
Publications	\$720.00
Maintenance	\$0.00
Consulting & Prof Svc	\$16,235.00
Copies and Photographic Services	\$105.00
Computer Services	\$89.88
Purchased Services	\$1,315.00
Equipment	\$0.00
Computer Equipment	\$0.00
Miscellaneous	\$2,990.00
Total	\$398,305.78