

The Hankin Legacy

**The Pennsylvania State University
and Housing: 1988 to 2005**

*Eric F. P. Burnett
July 2005*

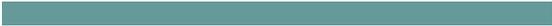


Table of Contents

Foreword	
Background.....	1
Hankin Responsibilities.....	3
Financial Support.....	5
What we do.....	9
Education.....	9
Training.....	9
Research, Development and Demonstration (R,D and D).....	15
Technology Transfer.....	21
Process and Service.....	23
The People.....	24
Beyond Pennsylvania.....	30
Concluding Commentary.....	33
Directions for the Future.....	34
Appendix: Hankin and PHRC Products.....	35

Foreword

The built environment involves two infrastructures: the civil or “constructed” infrastructure, and the built facility or “built” infrastructure. The latter can, in turn, be divided into engineered (commercial, industrial, educational, institutional, medical, etc.) and “non-engineered” (low-rise housing, small industrial and farm buildings, etc.) buildings. In most engineering faculties at most North American universities, the “non-engineered” built facilities, especially housing, are almost totally ignored. Since low-rise residential building constitutes nearly two-thirds of the building business and since this industry has largely sustained the US economy for the last ten years, this is an astonishing situation: economically, politically, socially, and educationally.

The late Mr. Bernard Hankin, to his eternal credit, saw this paradox and sought to do something about it. For the Pennsylvania State University and the Commonwealth of Pennsylvania, the endowment of the Bernard and Henrietta Hankin Chair in Residential Construction was an initiative of considerable foresight. It has been my privilege to have held the Hankin Chair for nearly ten years. I decided that some of the consequences of the Hankins’ foresight should be documented.

Without the endowment there would no Hankin Chair, no PHRC, and no Hankin legacy to write about. This short publication, *The Hankin Legacy*, seeks to acknowledge Bernie Hankin’s vision and to honor his contribution. A record of what has been accomplished over the past decade, *The Hankin Legacy* also provides an opportunity to acknowledge all those who have helped to support, facilitate, and expand on Bernie Hankin’s intentions and to put what has been achieved into perspective. As my own retirement approaches, I am aware that some of these intentions have yet to be realized; I also know that many have been successfully accomplished.

Many people have had a hand in the development of the PHRC. There are three persons, in particular, to whom I wish to express special thanks:

- Roger Glunt for his clear-sighted, eloquent and vigilant support of Bernie’s vision;
- Don DeLess for his wise counsel and sound advice; and
- Scott Cannon for his enthusiastic support, his leadership, his energy, his faith, his passion and his example.



Eric Burnett
Hankin Chair
July, 2005

Background

The Bernard Hankin Professorship in Residential Building Construction was established at the Pennsylvania State University in 1979. In 1988, this position became the Bernard and Henrietta Hankin Chair in Residential Building Construction. The chair was initially funded by a \$1,000,000 endowment: testimony to the farsightedness of Mr. Bernard (Bernie) Hankin and the generosity of the Hankin family.

Dr. Jack Willenbrock of the Civil and Environmental Engineering Department at Penn State was the first incumbent of both positions. Dr. Willenbrock held the latter position until his retirement in August 1995. Dr. Eric Burnett was appointed to the Chair in 1995 and he started at Penn State in January 1996.

Dr. Willenbrock initiated the Housing Research Center (HRC) at Penn State in 1988. Dr. Burnett took over as Director of the HRC in January 1996. Dr. Harvey Manbeck of the Agricultural and Biological Engineering Department acted as interim Director between August and December 1995.

In 1997, the HRC was reconstituted as the Pennsylvania Housing Research/Resource Center (PHRC) and, at the same time, a formal partnership with the Pennsylvania College of Technology was created. The PHRC's mission is to serve the housing industry in Pennsylvania, and this partnership was intended to foster a synergistic combination of research, training and technology transfer.

The table below summarizes the growth of the PHRC in terms of full-time personnel. Milestones to note include the appointment of Mark Fortney as full-time Director of the PHRC, with the Hankin Chair becoming the ex-officio Director of Research. Ken Sagan joined the PHRC as training and education development specialist; Scott Brown was subsequently hired for his expertise in land use and development. In 2003, Penn College was awarded a Ben Franklin grant that enabled Rick Terry to take up the position of Director of Factory Built Housing. Michelle McMullen and Tracy DeSoto are the administrative anchors for the PHRC.

As Director of Research of the PHRC, the Hankin Chair is responsible, through the head of the Civil and Environmental Engineering Department (CEE), to the Dean of the College of Engineering, for all of the activities of the PHRC. The PHRC is well on its way to becoming a full-service housing resource center (as outlined in the Business Plan of 1999, the PHRC Organizational Manual, and the 2002 Position Paper for a Network of Full-Service Housing Resource Centers). Upon joining Penn State, Dr. Burnett chose to be cross-appointed to both the Civil and Environmental Engineering and



Bernard & Henrietta Hankin

Architectural Engineering (AE) Departments. The Hankin Chair and the PHRC are physically located in the CEE Department, and both administratively report to the head of this department.

Each November the Hankin Chair formally reports to the Hankin Advisory Committee. The committee currently consists of Mrs. Henrietta Hankin, Mr. Richard Hankin, Mr. Robert Hankin, and Mr. Sam Hankin; Mr. Roger Glunt, President, Glunt Development Co.; Mr. David Martin, Executive Vice President, Pennsylvania Builders Association; the Heads of the CEE and AE Departments, and the Dean of Engineering or the Dean's appointee. In addition, Mr. Bruce Silver,

President and CEO of the National Housing Endowment (NHE) of the National Association of Home Builders (NAHB), has been a member of the Hankin Committee since 2003. The National Housing Endowment contributes in a number of ways to the Housing program at Penn State (Glunt endowment at NHE, and both the scholarship and the travel award programs).

Responsible parties and the growth of responsibilities

Year	Hankin Chair	Director of HRC/PHRC	Full-time Staff	Penn College
1988/90	J. Willenbrock	J. Willenbrock		
1989/94				
1994/95				
Aug/Dec		H. Manbeck		
Jan 1996	E. Burnett	E. Burnett	M McMullen/Dec. 95	
1996/97				
1997/98			M. Fortney/June 1998	Partnership
1998/99				
1999/00				
2000/01			T. DeSoto/Nov. 2000	
2001/02		K. Sagan / Jan. 2002		
2002/03		S. Brown /July 2002		
2003/04		M. Fortney		R. Terry
2004/05				

Hankin Responsibilities

The responsibilities of the Hankin Chair were explicitly stated in the job description and may be categorized as follows:

Courses: To ensure that, each academic year, at least two senior-level undergraduate courses are provided: one on residential subdivision design and construction and the other on house design and construction. In fact, three courses have been provided each academic year:

Residential Building Design and Construction (Spring semester—about 26 students per year)

Sustainable Residential Subdivision Design (Fall semester—about 23 students per year)

Building Enclosure Science and Design (Fall semester—7 to 8 students per year); introduced by E. Burnett

NAHB Student Chapter: To be Faculty Advisor to, and thereby to maintain, an active National Association of Home Builders (NAHB) Student Chapter at Penn State. Funds for scholarships and for travel to the annual NAHB convention are collected and disbursed each year. To date some 67 scholarships (totaling about \$55,500) and 55 travel grants (totaling about \$47,600) have been awarded. These funds have been provided by the Pennsylvania Builders Association (PBA), the NAHB, the Builders Association of Central PA, the Glunt endowments at Penn State and the National Housing Endowment, the Hankin family, and companies such as Winchester Homes, Toll Brothers, Ryland Homes, and Ryan Homes. The NAHB Student Chapter participates in local Habitat for Humanity initiatives. On average there are about 33 student members per year.

PBA Liaison: To develop and maintain good relations with the Pennsylvania Builders Association. One formal way to accomplish this is through membership of the following PBA committees:

Housing Research Committee (PBA/PHRC Committee)

Workforce Development Committee

Editorial Review Board

Land Development Task Force

Housing Finance Committee

The following responsibilities have been added since 1996:

Glunt Fellowship and related National Housing Endowment Funds:

The Hankin Chair administers this annual award to a graduate student doing housing-related research at Penn State. Since January 1994, an endowment has been used to fund the annual J. Roger Glunt Graduate Fellowship in Residential Construction. Since 2001 the annual revenue from the Glunt endowment that is maintained at the NAHB by the National Housing Endowment has been used to supplement the Glunt Fellowship and to sustain the National Housing Endowment/Glunt undergraduate scholarship. The Glunt Fellows are listed in the appendix.

Certificate Program in Housing: The proposal for a four-course (12 credit) housing certificate was formally approved by Penn State's Senate Committee on Curricular Affairs on October 5, 2004. Students who accumulate sufficient credits have been eligible for the certificate since the Fall session of 2004.

Over and above these specific responsibilities, there are at least three more general responsibilities: to foster among engineering students an awareness of and an interest in housing, to improve the quality and extent of housing-related education (and training), and to conduct research and development.

Financial Support

The activities of the Hankin Chair and the other members of the PHRC may be broadly described as follows:

Education: Conducting formal courses at an undergraduate and a graduate level for university or professional credit.

Training: Presenting short courses, workshops, and seminars at a variety of levels (professional, trades, building official, inspector, etc.) usually delivered off campus and ranging in length from half a day to two or more days.

Research, Development and Demonstration (R, D and D): Conducting R, D and D of a more technical nature with some emphasis on materials, building science, and the building enclosure.

Technology Transfer: Supplying information and assistance on relevant topics to the various constituencies within the housing community by formal means (builder briefs, talks, papers, presentations, etc.) and less formal means (telephone and e-mail communication).

Process and Service: Providing liaison, administration, leadership and cooperation: responding to requests and RFPs; providing reviews, sitting on professional committees; answering questions and providing assistance to consumers and businesses; and serving as a proactive resource.

How are the Hankin funds spent? As shown in the table, most of these funds have gone to support graduate students doing R, D and D. However, the Hankin funds are especially valuable because the money can be spent at the Chair's discretion. Hankin funds have, for instance, been used to pay for prizes in design competitions (e.g., Habitat for Humanity, Sustainability), to subsidize site visits (e.g., Eagle View, Falling Water, Architectural Testing Inc.), and to pay expenses for invited speakers and scholars. No Hankin money is spent on training, but some is allocated to teaching, service and process.

Disposition of Hankin Funds

<i>Activity</i>	<i>Support</i>	Hankin Endowment
Education		*
Training		
R, D and D		***
Tech. Transfer		
Process/Service		*

A table is provided to illustrate some of the realities of funding. Because it is direct, non-political and almost guaranteed, the Hankin support is our key funding. The Penn State support is largely indirect (salaries, office and laboratory space, and facilities). This institutional commitment is vital because it enables the Chair and the PHRC to function. Although we do not directly receive money from the housing industry, the industry's efforts (under PBA leadership) are largely responsible for the financial support provided by the Commonwealth through a line item in the Governor's budget. These funds are administered by the Department of Community and Economic Development (DCED). State support, especially if it provides a significant and stable level of base funding, is absolutely essential if the PHRC is to function properly. I would like to acknowledge the faith and goodwill demonstrated towards the PHRC by Governor Ridge and Governor Rendell, the Legislature, and our local representatives. In this regard the PBA, both its leadership and many of its members, have been very effective supporters of the PHRC and the Hankin Chair.

Annual State support through DCED went from zero in 1996 to \$600,000 in 2001/02. For 2002/03 this base funding was cut to \$438,000, and in 2003/04 it was reduced again to \$238,000. We received \$388,000 for 2004/05 and are hoping for the same allocation for 2005/06. For the continuity of this base funding we are indebted to the home-building community in Pennsylvania and the leadership of the PBA. The uncertainties about base funding, the amount and its timing, continue to be an issue.

The Main Sources of Financial Support

<i>Activity</i>	<i>Type</i>	PSU	State	Industry	Endowed
		#2	#4	#3	#1
Education		***			*
Training		*	***		
R, D and D		**	*		***
Technology Transfer		*	*		
Process/Service		*	*		*

PHRC training efforts are also supported from other governmental sources (the Department of Energy and the Department of Labor and Industry): the PHRC received \$325,000 in 2001/02, \$118,750 for 2002/03, \$110,000 for 2003/04, and we are expecting to receive \$90,000 for 2004/05. In addition, we have established a good relationship with the Pennsylvania Housing Finance Agency and are currently involved in two projects funded by the PHFA.

Until 2005, our technical R, D and D efforts were funded at about \$200,000 per year. Projects were funded by ASHRAE, NSF, industry and, to a very limited extent, support from DCED. The Building Enclosure Test Laboratory (BeTL) has been relocated, rebuilt and expanded at Cato Park in State College. This laboratory is probably the only facility devoted to Building Enclosures at a university in the entire country and represents a unique working asset. This resource was funded largely by Penn State with contributions from a variety of other sources.

A third funding table shows all the major sources of funds and provides some idea of the amount and variation in this support over the last few years. Currently, our group at Penn State has an annual operational cost of between 1 and 1.25 million dollars per year. Also note that the leverage we obtain from each contributor is significant; for instance, the multiplier on Hankin, State and Industry funding is of the order of 12, 3 and 20 respectively. In fiscal terms, we operate both efficiently and effectively.

Funding Sources and the Disposition of these funds

	PSU	State	State ¹	Federal ²	Industry ²	Industry	Endowed
	<i>Indirect</i>	<i>DCED</i>	<i>Other</i>		<i>Direct</i>	<i>Indirect</i>	<i>Direct</i>
Education	***				*		*
Training	*	***	*	*	**		
R, D and D	**	*	*	**	**		***
Technology Transfer	*	*					
Process/Service	*	*			*		*
Annual \$ max/min.	250	600/250	250/0	150/0	100/30	60/32	100
Leverage	5	2-3	>8	>8	>12	>20	12

1. Department of Environmental Protection, Department of Labor and Industry, Department of Education, Pennsylvania Housing Finance Agency, Ben Franklin Technology Center, PennDOT, Water Environment Research Foundation, Pennsylvania College of Technology.
2. Department of Energy, HUD/PATH, National Science Foundation, USDA, Brick Industry Association, Pennsylvania Concrete Masonry Association, ASHRAE, Superior Walls of America, NCMA, Trus Joist, West Penn Power SEF, Pennsylvania Builders Association.

What We Do

Educational activities are covered above under *Hankin Responsibilities*. While a listing of our products is provided in the Appendix, the sections that follow attempt to briefly highlight the nature and worth of what has been done in relation to the other four categories of Hankin and PHRC endeavor.

Training

The PHRC has developed into a major provider of training to the home building industry in Pennsylvania. The main reason for this has been the mandated adoption (for the first time) of a state-wide building code. In November 1999, the Uniform Construction Code Act 45 was signed into law. The code selected was the new International Residential Building Code (IRC 2003). As shown in the table and the two related graphs, nearly 10,000 persons have received training of some sort over the last seven years. We believe that the PHRC has been responsible for the most ambitious and effective program of building-related training ever conducted in Pennsylvania. In addition to the programs directed at the home building community, a number of training programs have been designed and delivered to professional engineers and architects and to the insurance and restoration industries. Programs have been developed for the Concrete Masonry industry and, in response to requests from professional and insurance groups, a number of moisture control workshops have been provided.

Training is only a partial solution to the larger issue of education for the residential building business. This would embrace the whole education system from high school to vo-tech programs to community colleges and universities. The PHRC has a stake in the educational process and is well positioned to play both a leadership and a delivery role in this field. The breadth of its efforts is evident from some of the PHRC's initiatives:

Code Training Consortium: The PHRC put together a consortium of interested organizations, associations and state agencies that either provide building-code training or represent groups that need access to training. Interest in membership in the consortium is increasing as the group comes together.

PA Construction Code Academy: The PHRC has partnered with the DCED's Governor's Center for Local Government Services, the Pennsylvania State Association of Township Supervisors and the Pennsylvania State Association of Boroughs to provide training

for the Pennsylvania Construction Code Academy (PCCA). The PCCA is the Commonwealth's mechanism to provide building-code-related training to local government officials and employees.

Career and Technical Educators Technical Development Program: A proposal was submitted to the PA Department of Education for a five-year program to develop and deliver a series of training and educational programs and to provide ongoing technical assistance, outreach and liaison to CTEs. The proposal is still pending.

Train-the-trainers: One very important by-product of the PHRC's commitment to training is the fact that we have trained and developed at least 20 Pennsylvanians who are knowledgeable of the Code and capable of teaching this material. Photographs and the names of some of the trainers appear later.

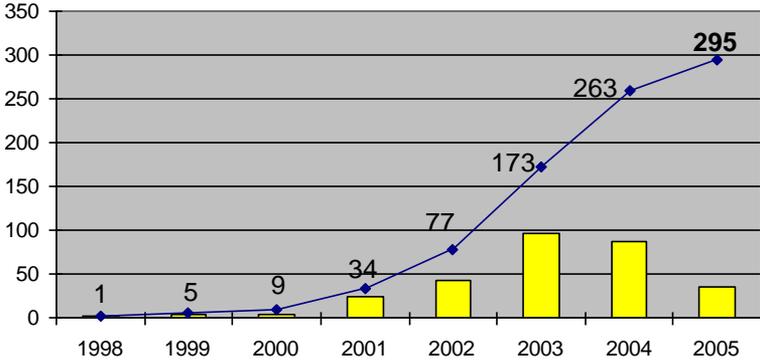
Stormwater Control: The PHRC has provided leadership at a time of turmoil and change in the state stormwater regulatory environment. The PHRC has developed and presented numerous workshops and training sessions for design professionals, regulators, builders, and developers. To date, over 600 people have attended PHRC-sponsored training events on stormwater control. We provide a valuable resource for builders and design professionals seeking assistance in resolving stormwater issues.

Factory Built Housing: A successful proposal was submitted to the Ben Franklin Partnership by the PHRC at Penn College. This grant enabled the College to appoint a full-time Director. The Factory Built Housing Center is charged with leading, developing, and growing educational and research initiatives, including the expansion of the training programs for the Modular Housing Training Institute (MHTI) and the Manufactured Housing Resource Center (MHRC).

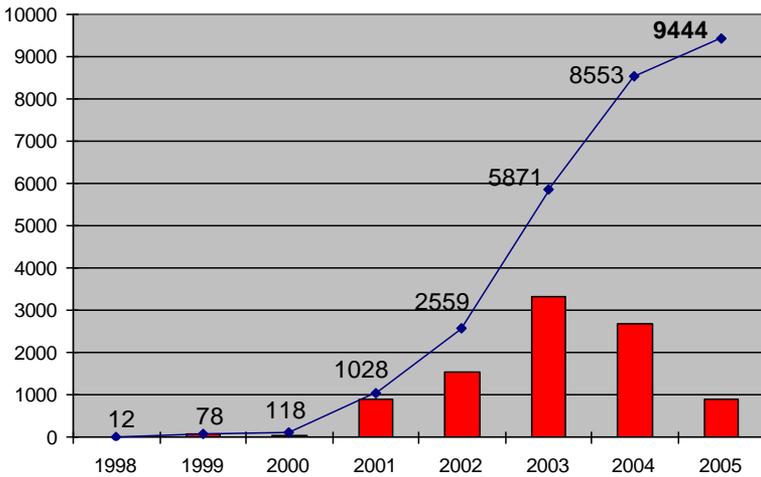
Training Programs Delivered by the PHRC

PROGRAM	Total from 1/1/1998 – 6/30/2005	
	No. of Programs	No. of Attendees
Comprehensive IRC Program for Code Officials	21	497
IRC's Plumbing Requirements for Code Officials	14	302
IRC's Mechanical Requirements for Code Officials	14	280
PA's New Energy Requirements for Code Officials	21	492
Administering and Enforcing PA's New Energy Code	1	12
Comprehensive IRC Program	104	3,836
CABO to BOCA Transition Program	16	612
Overview of the IRC's Plumbing Requirements	10	270
Overview of the IRC's Mechanical Requirements	23	709
PA's New Energy Requirements	19	629
IRC Update Program	2	56
Moisture Control	6	229
Comprehensive IRC's Masonry-Related Requirements	18	670
International Building Code for Concrete Masonry	7	226
Stormwater Management in PA – A New Approach	5	318
Custom Programs	14	306
Total programs delivered	295	9,444

Number of Programs Delivered Each Year



Individuals Trained



Instructors: A Training Resource



Bob Buddenbohn



Don Forry



Lee Milligan



Don Surrena



Dave Buskirk



Ned Liggett



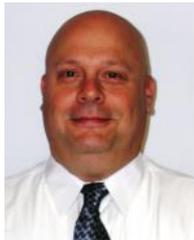
Merle Musick



Bob Smith



Robert Cartwright



Matt Light



Jim Royer



Cindy Davis



Jim Matscherz



Rodney Sarver

Mark Fortney Delivering Training



Research, Development and Demonstration

The reports, papers and presentations listed in the Appendix provide a good indication of the nature, extent and quality of our efforts in this area of endeavor. Much of this work is of a technical nature. Some projects, however, have been more important, technically or politically, than others; and the following projects deserve special mention.

Pennsylvania's Alternative Residential Energy Provisions:

In late 1999, legislation was passed to adopt a statewide building code—for housing the IRC 2000 was selected. The passage of the Uniform Construction Code (Act 45 of 1999) required the Pennsylvania Department of Labor and Industry (DLI) to promulgate regulations for prescriptive methods to implement energy requirements that take account of the various climatic regions in the Commonwealth. The PHRC was asked to provide a document that was simpler, more flexible, and focused on and better suited to Pennsylvania. Over a period of five months, the PHRC put a great deal of effort into developing and justifying an alternative, prescriptive energy code for Pennsylvania. The PHRC then submitted to the Department of Labor and Industry a draft code titled **Pennsylvania's Alternative Residential Energy Provisions** (The PHRC Alternative to Chapter 11, *Energy Efficiency*, of the International Residential Code (IRC) for use in Pennsylvania). This code was then formally adopted. It simplified the climate zones for PA and introduced trade-offs for airtightness and energy-efficient appliances. On average, 40 - 45,000 new homes are built in the Commonwealth each year. The PA-Alternative will impact much of this new housing but this code has also had considerable influence outside the state.

Membranes on the Exterior Sheathing — Conducted field investigations, laboratory testing and analysis of various housewraps and building papers to evaluate in-place performance, especially their effectiveness as an air barrier in residential wall assemblies.

Steel Framing Systems — Analysis (computer modeling) and simulation of exterior wall systems to assess the performance of steel stud framing in relation to the control of heat, air and moisture.

Ventilation Drying of Walls — The PHRC recently completed two inter-related R and D projects. One was funded by ASHRAE and the other by NSF. Both relate to the contribution of ventilation drying to the performance of above-grade enclosure wall systems with screen type cladding, e.g., siding, masonry veneer, etc. One objective was to develop and publish practical guidelines for design and construction. This work will have a bearing on the choice and installation of sheathing membranes (housewraps and/or building paper), the sizing of drainage and ventilation capabilities, the choice of cladding, and the provision of weeps and vents. This multi-year research project work was conducted in partnership with the Oak Ridge National Laboratory (ORNL) in Tennessee and the University of Waterloo in Waterloo, Ontario, Canada. The project was successfully completed at the end of 2004. Thirteen reports have been submitted to ASHRAE. Since completing this work, we have been asked to do complementary work for the brick industry; this project will be completed by September 2005.

Wood Research — Largely under Dr Manbeck's leadership, a number of projects were partially funded by the PHRC. The two main projects were the "Properties of Wood Composite Materials and Structural Response of Wood I-Joists" and "Moment Capacity of Metal Truss Plate Connectors."

"Visitability" — The PHRC is participating in a project to review the costs and benefits of Visitability Guidelines for Pennsylvania. This Pennsylvania Housing Finance Agency (PHFA) funded project is a partnership between Life and Independence for Today and the PHRC. The PHRC has assisted in the identification of six suitable builders and the building of 13 visitable houses across Pennsylvania. A series of four reports on the advantages, disadvantages, technical and developmental considerations, and costs and benefits have been prepared for distribution by the PHFA. The PHRC received a **Certificate of Meritorious Service** on October 14, 2004, from PHFA for its research project to evaluate Visitability in PA.

BeTL—Building Enclosure Test Laboratory

The unique facility for testing walls, roofs, membrane, sheathing, etc., has been assembled over the last six or seven years. The laboratory contains an all-purpose (hot and cold, rain, air pressure differential) testing frame commonly found in a good enclosure testing facility. It also contains a climate chamber designed and built specifically for BeTL. The photograph of this chamber under construction shows three research assistants, Chris Schumacher, Xing Shi, and Joe Piñon, and a technician, Bill Splain. The climate chamber can model any climate and, using lamps, can model any day and any orientation, i.e., solar intensity, temperature and relative humidity. The photographs provide some idea of the equipment available.



Climate Chamber Under Construction



All Purpose (Δ_t , Δ_p , rain) Test Rack



Test Set-up: Airflow Chamber

The facility has been and still is being used for a comprehensive program of research on the performance of above-grade enclosure wall systems. Of particular interest are sheathing membranes (housewraps, building papers), cladding (brick veneer, metal, vinyl, etc.) and the potential for ventilation drying. Research projects have been funded by ASHRAE, the NSF, private industry and state and PHRC funds. At present, testing is being funded by

the Brick Industry Association. In equipping, setting up, designing, operating the lab, the contributions of the following need to be acknowledged:

Brennan Glantz, Tony Chamra, Ed Bosack, Chris Schumacher, Bill Splain, Xing Shi, John deGraauw, Stacy Worley, Joseph Piñon, Ken Sagan, Chuck Farrell, Clark Colborn and the Office of Physical Plant at Penn State University, and Royal Building Systems for help during construction as well as for equipment.



Ventilation Drying Test



Climate Chamber and Data Acquisition

Land Development Activities

Land development issues have a significant impact on the delivery of residential housing within the Commonwealth. The most pressing site development needs are for updated and consistent residential site development standards, and resolving issues related to recent changes in the State's stormwater management policy and the implementation of NPDES II requirements.

In the late 1990's, the PHRC conducted an investigation into how local government was applying the subdivision and land development provisions of the State's Municipal Planning Code. In 1999, a report was produced that found significant inconsistency in the application of residential site development standards. Most municipal standards are outdated and, in many instances, are in conflict with sustainable or "best practice" development techniques. The report identified the need to develop model land development standards for the Commonwealth. A second conclusion identified the need to form a coalition of representatives from local government, state regulatory agencies, builders, developers, architects, landscape architects, planners, engineers, environmentalists, and other stake-holder groups interested in improved residential site development. The purpose of this group would be to support and participate in the development of the model residential site development standards.

For more than two years, the PHRC has sought funding and initiated efforts to produce the needed model standards. The Land Development Consortium was formed and had their first meeting in July 2004. (See Figure for stakeholder groups represented.)

By the summer of 2004, the PHRC had received partial support for the development of model residential development guideline standards. Some initial seed funding was also received from the Pennsylvania Builders Association and this was followed by a grant from the Pennsylvania Housing Finance Agency. In June 2005, a grant was received from the Water Environment Research Foundation, bringing the total funding for the project to the 65% level.

The residential site development guidelines will include site design, streets, parking, stormwater management, sanitary sewer systems, potable water systems, site and lot grading, and other utility considerations. Completion of the street standards is anticipated by fall of 2005, and completion of all sections of the model standards by early 2007.



The PHRC has also been active in influencing state stormwater policy. Scott Brown is a member of the oversight committee for the development of a Stormwater Best Management Practices Manual for Pennsylvania. He has taken a leadership role in an attempt to ensure that the recommended procedures and practices are reasonable, science based, and appropriate for the residential building industry in Pennsylvania.

In the future, we intend to augment our current efforts with research to address stormwater management issues and to assess and develop impact mitigation strategies for residential development.

The Land Development Consortium

State Agencies

DEP
PennDOT
DCED
Governors Policy Office

Local Government

Townships
Boroughs
Cities
Municipal Engineers

Attorneys / Solicitors

Design Professionals

Engineers
Landscape Architects
Architects
Planners
Surveyors

Environmental Groups

10,000 Friends
Pa. Environmental Council

Construction Community

Builders
Developers
Site Contractors

Technology Transfer

In one sense, all of the training the PHRC does could be viewed as technology transfer; so, for that matter, could all the talks and presentations we deliver. In addition, the reports and publications listed in the appendix are an integral part of our program to transfer technology to the various groups interested in residential construction. The following are supplementary initiatives:

Annual PA Housing Conference — In fact, the PHRC holds two simultaneous conferences at two different locations. By holding these meetings at two strategic locations, we have attracted well over 300 attendees. The PHRC held its 13th Annual Housing Conference in Allentown (125 attendees) and Pittsburgh (91 attendees). The morning program consisted of four primary sessions: Common Building Failures, Visitability in Pennsylvania, Ventilation Drying in Walls, and UCC Update. The afternoon started with seven roundtable sessions; then the program split into three different tracks: Flashing for Windows, Doors and Decks; Concrete Performance; and Common Code Violations and How to Avoid Them.

The 2nd Annual Land Development Conference was held in conjunction with the PA Housing Conference. At the Allentown location, there were 86 attendees and the Pittsburgh location had 49 attendees. The morning program consisted of five sessions: Legislative Update; Stormwater Management—Where are we?; Planning for Residential Developments...Today's Vision, Tomorrow's Trends; Lot Design...Thinking Outside the Box; and Road Standards...Optimizing for Function and Cost. The four afternoon sessions were: The Impact of Topography and Soils on Site Development; Infiltration: Understanding the Process and Limitations; Soil Testing and Site Investigation...How Much is Enough; and Panel Discussion—Site Selection and Infiltration Issues.

The PHRC has submitted a proposal to the Pennsylvania Department of Education, Bureau of Career and Technical Education (CTE) for the technical training of vocational building construction teachers. The goal of this program is to create a mechanism to keep educators up-to-date on new and emerging technologies, construction methodologies, and building codes. The program will incorporate this information into curriculum and teaching.

The PHRC will provide the CTE subcommittee with input and guidance on the activities that will be pursued under this multi-year initiative. The subcommittee will consist of the PA Department of Education, industry representatives, CTE educators and administrators, and PHRC members. The proposal is pending.

Briefs — The PHRC has developed and distributed a series of Builder Briefs, Technical Briefs and Research Briefs. These are short (4 pages or less) reports that focus on a single topic in a manner appropriate to the intended audience.

PHRC Newsletter — The PHRC produces two to three newsletters each year to report on the PHRC's projects, recent reports, and other resources that are available to the housing industry in Pennsylvania.

Internet Site — The PHRC continues to improve its web site (www.engr.psu.edu/phrc) to help disseminate information. An executive summary from each of the reports as well as builder, research and technical briefs are available on-line.

Given its limited resources, the PHRC still needs to resolve two related issues. First, how much of the relevant technology should it develop, and how much should it borrow? The internet is by far the most effective and cheapest means of transferring technology, so the second issue is how best to serve Pennsylvania's needs without unnecessarily duplicating or competing with other websites.

Process and Service

Significant resources—both time and money—are consumed in dealing with the agencies, both governmental and academic, with which we interact. The proposal submission and tracking process, plus the accounting and management procedures, are onerous.

The PHRC is relatively well known and, as a result, staff have to respond to the many questions (often from the public both within and outside Pennsylvania) that arrive by telephone, e-mail, or mail. Mold is an issue that has generated many questions. Both the Hankin Chair and the PHRC have a responsibility to liaise with and provide assistance to the housing industry. In particular, we attempt to stimulate and encourage innovation and enterprise. As a consequence, we meet with individuals and companies, evaluate products, provide assistance to agencies (both local and national) and review proposals, etc. This is a much needed and valuable service for which the PHRC receives little funding.

As a service to the home building and remodeling industry in Pennsylvania, the PHRC offers a speaker service to local and regional associations.

PHRC staff liaise with the PBA and also provide short articles or items of information for the two PBA publications, the *Keystone Builder* and the *Pennsylvania Builder*. The PHRC newsletter and web page are also vehicles for communicating with the builder community and housing consumers.

As the PHRC grows and becomes even better known, the cost of process and service will increase. The R in PHRC stands for Resource as well as for Research and, as the resource role expands, the PHRC will need to find some way of properly funding this important aspect of its mission. It needs to be stressed that this degree of consumer interaction is not customarily expected from a university engineering center. A 15% administration charge on contracts does not cover the cost of many of the services the PHRC is asked to provide.

The People



The PHRC Crew

(Top left: Tracy DeSoto, Michelle McMullen; Center: Nittany Lion;
Bottom left: Eric Burnett, Scott Brown, Mark Fortney & Ken Sagan)



*Eric Burnett
Hankin Chair & Director of Research, PHRC*

Dr. Burnett is a structural engineer with specialist competence in the broad areas of building science and technology, building performance and structural concrete. He has extensive experience of the building industry, having been involved in the design and construction of buildings on three continents. He has worked with and consulted to a number of R and D agencies in the U.S., Canada and elsewhere.

Dr. Burnett holds the Bernard and Henrietta Hankin Chair at the Pennsylvania State University. He is cross-appointed to the Departments of Civil and Environmental Engineering and Architectural Engineering. He is currently Director of Research for the Pennsylvania Housing Research/Resource Center.

Both as an educator and a researcher, Dr. Burnett was associated with the University of Waterloo in Canada for more than 25 years. He founded and was Director of the Building Engineering Group, as well as being a Professor of Civil Engineering. In addition, as senior Consultant and Technical Director for Building Science and Rehabilitation, he was involved with Trow Consulting Engineers Ltd. for more than ten years. For more than two years he was the first Manager of Building Research for the Canada Mortgage and Housing Corporation in Ottawa, Canada.

Dr. Burnett's current research interests are directed at the performance of building enclosures, i.e., wall systems, roofs, etc., and the integration of support, finish and control (heat, air, moisture) functions.



*Mark Fortney
Director, PHRC*

Mark Fortney has been with the PHRC since 1998. As Director of the PHRC, he is responsible for the day-to-day operation of the center as well as overseeing numerous contracts and grants.

His professional background includes over 25 years of experience relating to energy efficiency and residential and commercial construction. This includes positions at the Bureau of Sustainable Development, Pennsylvania Energy Office, and Energy Engineer in the Office of Pollution Prevention, Pennsylvania Department of Environmental Protection, as well as positions in the private sector. Mark holds a BS in Structural Design and Construction Management and an AET in Solar Engineering from the Pennsylvania State University.

He coauthored the Pennsylvania Alternative Energy Provisions for Residential Construction. This document was adopted by the Commonwealth of Pennsylvania as part of the State's building code and is expected to save the residents of Pennsylvania hundreds of millions of dollars.

Mark was responsible for the development of an infrastructure that has trained over 8,500 builders, design professionals, code officials, teachers and others involved in the residential construction industry. This included the development of over 20 training programs and the involvement of instructors from Penn State and from industry. Most of these programs have been delivered through partnerships with trade and professional associations, and the Commonwealth of Pennsylvania, as well as individual corporations.

He also initiated the Pennsylvania Code Training Consortium (PA-CTC). The CTC was established to create a forum for training providers and those who need training to share information and to coordinate efforts.

He is also responsible for the development and management of the annual Pennsylvania Housing Conference. This technical conference draws upon expertise at Penn State and throughout the industry to address technical challenges facing the housing industry.



*Scott Brown, P.E.
Land Use and Development Specialist*

Since July 2002, Scott has been the Land Use and Development Specialist for the Pennsylvania Housing Research Center. He has over 25 years of experience as a licensed professional civil engineer, and has unique expertise in residential and commercial site development, urban drainage, stormwater management, and river and watershed engineering.

Scott received his post-secondary education at the Pennsylvania State University where he was awarded his Bachelor of Science and Master of Science degrees in Civil Engineering in 1977 and 1979 respectively.

Early in his career, Scott was selected to manage the Federal Highway Administration's hydraulics laboratory in McLean, VA. Research areas included investigations of bridge waterway hydraulics, culvert hydraulics, and storm inlet hydraulics. In the mid 1980's, Scott became involved in land use and land development activities in the Washington, D.C. area. In 1991, Scott's career took him to Western New York where he served as the director of land development activities for an engineering consulting firm. In addition, he managed a team of 26 professionals working on the design of a project on the New York State thruway, which included all environmental clearances and the widening and rehabilitation of 11 ramp and main-line bridges.

From 1993 – 1995, while continuing to oversee land development activities, Scott served as principal investigator and primary author of a manual on urban drainage for the Federal Highway Administration. This technical design manual of more than 700 pages was published in 1996 as the Federal Highway Administration Hydraulic Engineering Circular No. 22, and continues to be used as a reference for drainage design nationally.

In 1996, Scott returned to Central Pennsylvania to work in the residential and commercial land development industry. Over a period of six years, Scott oversaw the engineering design of a significant portion of the expansion of residential and commercial properties in the State College Area.



Kenneth Sagan
Training, Education & Development Specialist

Before joining the PHRC in January 2002, Ken served as a partner in a Harrisburg, PA engineering firm that specialized in the design of plumbing and HVAC systems. He is a certified Master Plumber and also holds several International Residential Code (IRC) certifications. Ken has more than 35 years of experience in the construction industry.

Ken holds a BS in Workforce Education and Development and is currently working on his Master's degree with an emphasis in post-secondary and industrial training. As a McNair Scholar at Penn State, Ken studied the decline in the number of tradespeople and the gap between and employers' expectations of young people entering the building trades and their education.

As the Training and Education Development Specialist for the PHRC, Ken is responsible for the planning and administration of most training programs. He has developed and held training sessions for builders, remodelers, building code officials, design professionals, teachers, home inspectors, realtors, bankers and other professionals in the residential construction industry. His other responsibilities include overseeing the development of marketing, identifying presenters, and assuring the overall quality of the programs.

Ken and his wife, Deb, recently designed and built their own energy-efficient home in Bellefonte. This house has been recognized by the National Association of Home Builders (NAHB) as a model for their "Green Building" program. The construction of their house was filmed by NAHB and the film shown at the annual Green Building Conference in Atlanta in April 2004. The entire project is scheduled to be shown on Home and Garden TV (HGTV).



*Michelle McMullen
Administrative Assistant*

Ever since she graduated from the South Hills School of Business some 14 years ago, Michelle McMullen has been employed at the Pennsylvania State University. She joined the PHRC in December 1995, and works closely with both the Hankin Chair as well as the other employees of the Housing Research Center. Michelle was the first fulltime staff member and continues to be the longest serving member of the PHRC.

As the Administrative Assistant of the PHRC, Michelle plays a crucial role in PHRC's administration. Over the last nine years her responsibilities have increased, as has her work load. She works closely with both the Hankin Chair (about 33% of her time) and the PHRC (67% of her time).

Among other things, she produces (or oversees the production of) the PHRC's many publications, interacts with and assists undergraduate and graduate students, and keeps the administrative side of the PHRC and its various activities functioning smoothly



*Tracy DeSoto
Staff Assistant*

Tracy DeSoto has been working at Penn State for about 15 years. She joined the PHRC in November 2000. Her official title is Staff Assistant, which does not do justice to what she actually does for the PHRC. She works closely with the Administrative Assistant to facilitate operation of the PHRC. She also works with both the Director and the Training Education and Development Specialist to coordinate PHRC's many training programs.

Tracy is the primary point of contact for industry partners to schedule training, answer questions about the PHRC, and channel technical questions to appropriate PHRC staff or faculty. It is her responsibility to meet the needs of not only the PHRC but also the industry organizations that sponsor the training programs.

Tracy is the PHRC's main contact person with the industry, especially the Pennsylvania Builders Association and the executive officers of the various Local Builders Associations across Pennsylvania, as well as local, regional and state agencies, consultants, code inspectors, builders, and the general public.

Beyond Pennsylvania

Liaison and involvement with the housing community extends far beyond PA. Over the past nine years, my position as the Hankin Chair has enabled me to take, or promote, initiatives that have national implications. I believe these activities are very much in line with Bernie Hankin's vision for strengthening the residential construction industry. Some of these activities are listed below.

BETEC (Building Environment and Thermal Envelope Council, recently revised to the Building Enclosure Technology and Environment Council): I have been a Board member of BETEC since 1996 and was Vice-chair in 2001/02. In 2001, I was invited to serve as Chair. I relinquished this chairmanship in January 2005. The following are some of the initiatives that I encouraged, or took part in:

- To change the name, but not the acronym, to the Building Enclosure Technology and Environment Council to better reflect the focus of BETEC.
- BETEC is now the national representative to the International Association of Building Physics.
- I participated in both the first international conference held in Eindhoven, Holland, and was on the International Scientific Committee for the second conference held in Belgium in September, 2003. I am on the Scientific Committee for the third conference, to be held in Montreal in 2006.
- The Government Services Administration (GSA) is pursuing the development of comprehensive guidelines for the design and performance of building enclosures through BETEC. A total of \$600,000 was committed (mainly by GSA, FEMA, and DOD) to this task, which will have far-reaching effects. I have been, and will continue to be, involved in the management of this project.
- Because of the dearth of education and R and D in the area of building enclosures and the extent of problems and attendant litigation, BETEC is taking on the lead role for education and information transfer. One initiative was the holding of the first WUFI (Hygrothermal Analysis Software) workshop in the US, which took place in June 2002 at Penn State. This was a joint venture sponsored by the PHRC, the Fraunhofer Institute from Germany, and Oak Ridge National Laboratory in Tennessee. These workshops are now being conducted nation-wide.

- The setting up and promotion of BETEC/AIA Building Enclosure Councils (BECs) in cities across the country. This is an attempt to foster the formation of multi-disciplinary groups to provide a local focal point for discussion, promotion, and improvement in regard to the performance of building enclosures. The AIA has given formal support to this initiative and, to date, BECs have been started in Boston, Philadelphia, Pittsburgh, Dallas, Washington, D.C., and Seattle.
- In June 2004, Theresa Weston of DuPont and I convened a two-day workshop on “Membranes in Walls” in Crystal City just outside Washington, D.C. This BETEC-sponsored workshop was directed at the contribution of membranes (paints, housewraps, building papers, etc.) to the performance of wall systems and also attempted to address the confusion concerning the need for vapor retarders, air barriers and water barriers.

National Consortium of Housing Research Centers: Board member since 1996. Chair for 2000 and 2001. As Chair, I volunteered to write a position paper addressing the future of this consortium. This report, entitled *The Concept of a Network of Full Service Housing Resource Centers*, was distributed in February 2002. The report is also a roadmap for the growth of housing-related education and R and D within a participating university. In February of this year, NSF and HUD/PATH jointly sponsored a workshop on the research needs of the housing industry. I led the focus group addressing the building enclosure and authored the group report.

National Institute for Building Sciences (NIBS): As Chair of BETEC, I am invited to attend board meetings of the National Institute for Building Sciences. I am also on the Consultative Council to NIBS. NIBS is concerned with national policy, federal funding, and priorities relating to the built environment. With four presidential appointees, NIBS is the only engineering/construction related agency that has a mandate to report to the President and Congress each year.

Concluding Commentary

The years I have been privileged to spend as the Hankin Chair have been busy, interesting and rewarding. Mark Fortney, the Director of the PHRC, has made it possible for me to spend more time on my teaching, research, and leadership responsibilities. His activities have significantly raised the profile of both the PHRC and the housing program at Penn State. Having joined the PHRC as the Education, Training and Development Specialist, Ken Sagan has taken on a lead role in initiating and delivering training programs. Scott Brown's appointment represents a milestone. He has taken over the Land Development course and is expanding the PHRC's commitment to the land development area. The assistance provided by Michelle McMullen, our Administrative Assistant, is invaluable. She has an excellent rapport with the students and plays an important role in the NAHB student chapter. Tracy DeSoto is a tremendous help with all the training programs.

I believe that what we have done and are doing is fully consistent with Bernie Hankin's intent. A considerable amount has been accomplished over the past nine years. The Hankin endowment makes the activities of the Chair, and thus the PHRC, possible.

The support that the Hankin Chair and the PHRC has received, in particular the support from outside the University, has been most encouraging. The debt we owe to the PBA, its executive and its members, is considerable. Both the PHRC and Penn State are greatly indebted to individuals such as Scott Cannon, Don DeLess, Roger Glunt, Richard Hankin, David Martin and others who have given unstintingly of their time and advice in support of housing at this University.

The groundwork has been laid to make Penn State a national center of excellence for the residential housing industry. To move forward to the next level of development, at least one and preferably two junior faculty members need to be appointed to work in the areas of housing, especially development and building enclosures. These appointments would bring three main benefits. First, they would give the Chair the committed academic support that is needed; second, three faculty members would constitute a viable academic group and facilitate the getting and doing of housing-related R and D; and third, the workload of both the Hankin Chair and the Director of the PHRC would be reduced to a reasonable level. This is the most important recommendation I can make at this time. I believe it would fulfill Bernie Hankin's vision, and I believe that the housing industry deserves no less.

Directions for the Future

My experiences over the past nine years, as well as the qualifications and experience I brought to the Hankin chair when I accepted my appointment, have led me to some conclusions that I wish to share. I believe strongly that there are clear paths that need to be taken, and I have laid them out here in the hope that they will be given thoughtful consideration.

1. Housing has not received the attention it deserves from the Engineering faculties at our universities. The industry is too important for this situation to be allowed to persist. The housing industry must get actively involved in making the case for the right things to be done at the right places by the right people.
2. For the reasons noted earlier, there should be at least three full-time faculty members whose primary focus should be the delivery (development, design, construction, and operation of residential built facilities) of appropriate housing.
3. The PHRC is too valuable a resource to be so heavily dependent on state and local politics. At the state level, the PBA should continue with its support for the PHRC and attempt to establish a reasonably secure but appropriate level of base funding for the PHRC. At the national level, the NAHB and the NHE need to promote the development of six or seven full-service (education, training, R and D, and technology transfer) Housing Research/Resource Centers.
4. The main need at present is for energetic, active, knowledgeable, and committed faculty members. Land-grant institutions with large engineering, architectural engineering and architecture programs are the appropriate institutions at which to establish full-service housing research centers.
5. The largest educational gap exists in the area of building enclosures and the related building science. Both Engineering and Architectural schools need to come to grips with the notion that the building enclosure, as the environmental separator, is a vital component of any built facility. Most of the performance problems with modern buildings involve the building enclosure, and much of the blame for this situation can be attributed to the lack of appropriate education.

If it were not for Bernie Hankin and the Hankin Chair, neither Penn State nor the Commonwealth of Pennsylvania would be responding to any of the issues mentioned above. That, perhaps, is the most significant legacy of the Hankin endowment to Penn State, the Commonwealth, and the nation.

Products 1996 to 2005

Books:

Straube, J.F. and E.F.P. Burnett, "Building Science for Building Enclosure Design," Building Science Press, Publication September, 2005.

Straube, J.F. and E.F.P. Burnett, "Chapter 5: Overview of Hygrothermal (HAM) Analysis Methods," ASTM Publication, MNL40, *Moisture Analysis and Condensation Control in Building Envelopes*, 2001, pp. 81-89.

Willenbrock, J. W., H. B. Manbeck and M. Suchar, "Residential Building Design and Construction," Prentice Hall: New York. 1997.

Codes and Standards:

Burnett, E.F.P. and M.R. Fortney, "Code for the Conservation of Space Conditioning Energy for Housing in Pennsylvania: The PHRC Alternative to Chapter 11, Energy Efficiency, in the International Residential Code (IRC) 2000, for use in Pennsylvania," May 2001, 13p.

Position Papers:

Burnett, E.F.P., "Building Enclosures: A Strategy for NSF Support," *Proceedings of the NSF and HUD/PATH Housing Research Agenda Workshop*. Orlando, Florida, February, 2004, pp. 48-65.

Burnett, E.F.P., "The Concept of a Network of Full Service Housing Resource Centers," a report prepared for the Consortium of Housing Research Centers, State College, PA, PHRC Report No. 78, February 2002, 85p.

Manbeck, H. M., "Wood Structural Systems and the PHRC: A Strategic Plan for Collaborative Industry/PHRC Education and Research Programming In Wood Structural Systems," PHRC Research Series: Report No. 67, December 1999.

Burnett, E.F.P., "The PHRC Business Plan," PHRC Report, June, 1999, 31p.

Burnett, E.F.P., "Identifying a Vision for the PHRC," PHRC Report No. 57, December, 1998, 18p.

Conference Proceedings:

1. M.R. Fortney, *Proceedings of the 13th Annual Pennsylvania Housing Conference*, The Pennsylvania Housing Research Center, Allentown, February 24 and Pittsburgh, March 10, 2005,
2. Weston, Theresa, and Eric Burnett, "Membranes in Enclosure Wall Systems," *Proceedings and Program Handbook*, BETEC 2004 Spring Symposium, Arlington, VA, 10-11 June, 2004, Conveners and Editors.
3. Burnett, E.F.P. and M.R. Fortney, *Proceedings of the 12th Annual Pennsylvania Housing Conference*, The Pennsylvania Housing Research Center, Harrisburg, March 6, 2004,
4. Burnett, E.F.P. and M.R. Fortney, *Proceedings of the 11th Annual Pennsylvania Housing Conference*, The Pennsylvania Housing Research Center, Harrisburg, March 6, 2003, 178p.
5. Burnett, E.F.P., "Wall Structures," *Proceedings of the 37th Meeting of the CIB*, State College, PA, PHRC Research Series: Report No. 80, 2002, 133p., Convener and Editor.
6. Burnett, E.F.P. and M.R. Fortney, *Proceedings of the 10th Annual Pennsylvania Housing Conference*, The Pennsylvania Housing Research Center, University Park, PA, Monroeville, February 20, Philadelphia, February 28 and State College, March 7, 2002, 199p.
7. Burnett, E.F.P., "Housing Innovation-The University Housing Research Centers and the Building Codes," *Proceedings of a session sponsored by the National Consortium of Housing Research Centers at the International Builders' Show*, Atlanta, GA, PHRC Report #77, February 2002, 36p., Editor.
8. Burnett, E.F.P., "Housing Innovation-Healthy Environments for Living and Learning," *Proceedings of a session sponsored by the National Consortium of Housing Research Centers at the International Builders' Show*, Atlanta, GA, PHRC Report #74, February 2001, Editor.
9. Burnett, E.F.P. and M.R. Fortney, "The New Statewide Building Conference When~What~How", *Proceedings of the 9th Annual Pennsylvania Housing Conference*, The Pennsylvania Housing Research Center, University Park, PA, Monroeville, February 28, Harrisburg, March 8, New Cumberland, March 15, 2001.

10. Burnett, E.F.P. and M.R. Fortney, "Home Building for the 21st Century," *Proceedings of the 8th Annual Pennsylvania Housing Conference*, The Pennsylvania Housing Research Center, University Park, PA, Monroeville, February 29 and Valley Forge, March 1, 2000.
11. Burnett, E.F.P. and M.R. Fortney, "Innovation Without Headaches," *Proceedings of the 7th Annual Pennsylvania Housing Conference*, The Pennsylvania Housing Research Center, University Park, PA, State College, February 26, 1999.
12. Burnett, E.F.P. and M.R. Fortney, "Moisture Concerns: Problems and Solutions," *Proceedings of the 6th Annual Pennsylvania Housing Conference*, The Pennsylvania Housing Research Center, University Park, PA, State College, February 20 and 21, 1998.
13. Burnett, E.F.P. and M.R. Fortney, *Proceedings of the 5th Annual Pennsylvania Housing Conference*, The Pennsylvania Housing Research Center, University Park, PA, State College, February 19-20, 1997.
14. Burnett, E.F.P., *Proceedings of the 4th Annual Pennsylvania Housing Conference*, The Pennsylvania Housing Research Center, University Park, PA, State College, March 27-28, 1996.

Technical Reports:

Straube, J., R. VanStraaten, E.F.P. Burnett, and Schumacher, C., "Review of Literature and Theory," a report prepared for ASHRAE, Report #1, Sept., 2004.

Shi, X., C. Schumacher, and E.F.P. Burnett, "Ventilation Drying in Screened Wall Systems: a Physical Demonstration," a report prepared for ASHRAE, Report #3, Sept., 2004.

VanStraaten, R., and J.F. Straube, "Characterization of Airflow Behind Vinyl Siding," a report prepared for ASHRAE, Report #4, Sept., 2004.

Piñon, J., D. Davidovic, E.F.P. Burnett and J. Srebric, "Characterization of Ventilation Airflow in Screened Wall Systems," a report prepared for ASHRAE, Report #5, Sept., 2004.

Shi, X., C. Schumacher, and E.F.P. Burnett, "Ventilation Drying under Simulated Climate Conditions," a report prepared for the ASHRAE, PHRC/PSU, Report #7, Sept., 2004.

R. VanStraaten, J. Straube, C. Schumacher and E.F.P. Burnett, "Ventilation Drying under Natural Exposure Conditions," a report prepared for ASHRAE, Report #8, Sept., 2004.

Burnett E.F.P., J. Straube, and A. Karagiozis, "Synthesis Report and Guidelines," a report prepared for ASHRAE, Report # 12, Sept., 2004.

Memari, A.M. and E.F.P Burnett, "Seismic Evaluation of and Recommendations for Superior Walls Foundation Wall Systems for use in Seismic Regions," a proprietary report for Superior Walls of America, Ltd., PHRC Research Series: Report No. 79, March 2002, 80p.

Burnett, E.F.P., M.R. Fortney, and S. Bentz, "Glazing Proportions for New Housing in Pennsylvania," PHRC Research Series: Report No. 68, The Pennsylvania Housing Research Center, University Park, PA (May 2000, Revised August 2001), 27p.

Burnett, E.F.P. and M.R. Fortney, "Climatic Zones for Energy Conservation in Pennsylvania," PHRC Research Series: Report No. 69, The Pennsylvania Housing Research Center, University Park, PA (May 2000, Revised August 2001), 11p.

Fortney, M.R., A.S. Lau and E.F.P Burnett, "Evaluation of Energy Code Trade-offs for Pennsylvania," PHRC Research Series: Report No. 71, The Pennsylvania Housing Research Center, University Park, PA (May 2000, Revised August 2001), 19p.

Burnett, E.F.P. and M.R. Fortney, "Moisture Related Concerns, A confidential report prepared for the Housing Authority of Dauphin County," PHRC Report #76, The Pennsylvania Housing Research Center, University Park, PA (May 2001), 5p.

Fortney, M.R. and E.F.P. Burnett, "Thermal Envelope Assessment of Energy Code Provisions for Pennsylvania," PHRC Research Series: Report No. 70, The Pennsylvania Housing Research Center, University Park, PA (May 2000), 45p.

Burnett, E.F.P., "Energy Code Provisions for the Use of Light-Gauge, Cold Formed Steel Framing," PHRC Research Series: Report No. 72, The Pennsylvania Housing Research Center, University Park, PA (May 2000), 25p.

Straube, J.F. and E.F.P. Burnett, "Structural Performance of the Blok-Lok Helical Tie Dry-Set in Normal Weight Concrete Block, Brick and Mortar," a proprietary report prepared for Blok-Lok Ltd. December 1999, 24p.

Mendygral, J., and E.F.P. Burnett, "Tensile and Compressive Load-Displacement Characteristics of Blok-Lok Helical Ties," a proprietary report prepared for Blok-Lok, Ltd. October 1999, 27p.

Newsome, W. R., "Residential Site Improvement and Subdivision Design Standards: A Review," PHRC Research Series: Report No. 66, July 1999.

Buddenbohn, Jr., R.J. and E.F.P. Burnett, "House Building Industry: Educational Needs Assessment," PHRC Research Series: Report No. 65, The Pennsylvania Housing Research Center, University Park, PA, July 1999, 228p.

Bombino, R. and E.F.P. Burnett, "Design Issues with Steel-stud-framed Wall Systems," PHRC Research Series: Report No. 58, The Pennsylvania Housing Research Center, University Park, PA, May 1999, 44p.

Straube, J.F., J. Timusk and E.F.P. Burnett, "The Royal Building System: Thermal Performance, Energy Consumption and Codes," a proprietary report prepared for Royal Building Systems (Can) Ltd., February 1999, 22p.

Burnett, E.F.P., "Marketing Modular," PHRC Report No. 62, January 1999.

Balliet, K. and E.F.P. Burnett, "The Importance of Modular Housing in Pennsylvania," PHRC Research Series: Report No 56, The Pennsylvania Housing Research Center, University Park, PA, January 1999, 37p.

Bosack, III, E. J., and E.F.P. Burnett, "The Use of Housewrap in Walls: Installation, Performance and Implications," PHRC Research Series: Report No. 59, The Pennsylvania Housing Research Center, University Park, PA, December 1998, 47p.

Straube, J.F., C. Schumacher, and E.F.P. Burnett, "Good Crawlspace Construction Practices for Canadian Wood-Framed Housing in Japan," Building Engineering Group report for Natural Resources Canada, (December 1998), 26 pages + appendices.

Fortney, M. R. and R.J. Buddenbohn, Jr., "Building Code Training Needs in Pennsylvania," PHRC Report No. 61, 1998.

deGrauw, J. and E.F.P. Burnett, "Foundation Wall Systems for Houses," PHRC Research Series: Report No. 50, The Pennsylvania Housing Research Center, University Park, PA, December 1997, 70p.

deGraauw, J. and E.F.P. Burnett, "Below Grade Construction: Issues and Needs," PHRC Research Series: Report No. 51, The Pennsylvania Housing Research Center, University Park, PA, December 1997, 63p.

Straube, J.F. and E.F.P. Burnett, "In-Service Performance of Enclosure Walls: Summary Final Report (Volume 1)," Building Engineering Group report for URIF corporate partners, December, 1997, 125 pages + appendices.

Balliet, K. and E.F.P. Burnett, "A Builder's Guide to Modular Housing," PHRC Research Series: Report No. 52, The Pennsylvania Housing Research Center, University Park, PA, June 1997, 37p.

Straube, J.F., J. deGraauw and E.F.P. Burnett, "Design and Testing of GFRP-Reinforced Polymer Concrete Beams," Building Engineering Group report for Canadian Construction Controls Ltd., March 1996, 33 p. + appendices.

Published Papers:

Karagiozis A., J. F. Straube and E.F.P. Burnett, "The Hygrothermal Performance of Ventilated and Non-vented Brick and Vinyl Wall Claddings," Proceedings of the 10th Canadian Conference on Building Science and Technology, May 12-13, 2005, Ottawa, Ontario, Canada, pp. 102-115.

Burnett E.F.P., "9/11 and the Structural Hereafter," *Proceedings of the 2005 Structures Congress*, ASCE Conference Metropolis and Beyond, New York, NY, 20-25 April, 2004.

Straube, J.F., R. VanStraaten and E.F.P. Burnett, "Field Studies of Ventilation Drying," *Proceedings of the ASHRAE Buildings IX International Conference*, Clearwater Beach, December, 2004. 13p.

Pinon, J.P., D. Davidovic, E.F.P. Burnett and Srebric J., "The Airflow Characteristics of Ventilated Cavities in Screen-type Enclosure Wall Systems," *Proceedings of the ASHRAE Buildings IX International Conference*, Clearwater Beach, December, 2004. 15p.

Shi, X., and E.F.P. Burnett, "Mechanics of 2D Flexible Membranes," *Proceedings of the Second International Mechanics Conference*, Cape Town, July, 2004.

Burnett, E.F.P., "Ventilation Drying in Enclosure Wall Systems," Presented at NSF Housing Workshop, Orlando, Florida, February, 2004.

Burnett, E.F.P., "Roofing Systems Categorization," 2003 Building Envelope Technology Symposium, Roofing Consultants Institute, Dallas, 6-7 November, 2003, 22 p.

Burnett, E.F.P., "Whose Needs, Expectations and Performance?" Invited Presentation at the Global Policy Summit on the Role of Performance-based Regulations in addressing Societal Expectations, International Policy and Local Needs, National Research Council, Washington, D.C., November 3-5, 2003.

Burnett, E.F.P., "Envelopes and Reservoirs," *Energy Design Update*, October, 2003.

Schumacher, C., X. Shi, X., D. Davidovich, E.F.P. Burnett and J.F. Straube, "Ventilation Drying in Wall Systems," *Proceedings of the Second International Conference on Building Physics*, 14-19 September, 2003, Leuven, Belgium, pp 479-486.

Burnett, E.F.P., C. Schumacher, J. Straube and A. Karagiozis, "Ventilation for Enclosure Systems," Westford Symposium, Westford, Mass., 3-6 August, 2003.

Burnett, E.F.P., "Building Enclosure Categorization, etc.," Westford Symposium, Westford, Mass., 3-6 August, 2003.

Burnett, E.F.P., "Membranes and Their Functions," BETEC (Building Energy and Thermal Envelope Council), Spring Symposium, Washington, D.C., June 2003.

Burnett, E.F.P., "Weather-Resistive Membranes," *Energy Design Update*, April, 2003.

Burnett, E.F.P., "Below-grade Enclosure Construction: Characterization and Categorization," *Proceedings of the Ninth Canadian Conference on Building Science and Technology*, Vancouver, British Columbia, February 27 and 28, 2003, pp 238-249.

Masser, J. E., H. B. Manbeck and J. J. Janowiak, "Moment Capacity of Metal-Truss-Plate Connectors," ASAE Paper No. 03-4003. St. Joseph, MI. 2003.

Hindman, D. P., H. B. Manbeck and J. J. Janowiak, "Torsional Rigidity and Lateral Stability of SCL and I-Joist Beams," ASAE Paper No. 03-4001. St. Joseph, MI, 2003.

Wisniewski, B. and H. B. Manbeck, "Residential Floor Systems: Wood I-Joist Creep Behavior," *Journal of Architectural Engineering* (ASCE) 9(1):41-45, 2003.

Memari, A.M., E.F.P. Burnett and B.M. Kozy, "Seismic Performance of Masonry Ties Used in Brick Veneer Walls," *Construction and Building Material Journal*, Volume 16, Issue 7, October 2002, pp. 397-407.

Memari, A.M. and D. Getz, "Seismic Performance of Autoclaved Aerated Concrete (AAC) Cladding Panels," *Proceedings, 12th European Conference on Earthquake Engineering*, September 9-13, 2002, London, UK, CD-ROM, pp. 1-10.

Burnett, Eric F.P. and Mark Fortney, "Development of an Alternative to Chapter 11 of the IRC 2000 for use in Pennsylvania," *Proceedings of the Consortium of Housing Research Centers – Educational Seminar "Housing Innovation-The University Housing Research Centers and the Building Codes"* presented at the National Association of Home Builders Convention, Atlanta, GA, February 6, 2002, 12p.

Hindman, D.P., H.B. Manbeck and J.J. Janowiak, "Test Method Effects on Shear Moduli of Wood and Wood Products," ASAE Paper No. 02-4004. St. Joseph, Michigan., 7p., 2002.

Roeder, R.W. Jr., H.B. Manbeck and J.J. Janowiak, "Creep Behavior of Solid-Sawn and Wood I-Joist Floors," ASAE Paper No. 02-4005. St. Joseph, MI. 12p., 2002.

Lau, A., M. Fortney, W. Bahnfleth and E.F.P. Burnett, "Evaluation of Energy Code Trade-offs," *Proceedings of the Performance of the Exterior Envelopes of Whole Buildings VIII Conference*, Clearwater Beach, FL, December 2-7, 2001, 16p.

Burnett, E.F. P. and R. Bombino, "Heat and Moisture Control Considerations with Steel Framing in Low-rise Residential Construction," *Proceedings of the Performance of the Exterior Envelopes of Whole Buildings VIII Conference*, Clearwater Beach, FL, December 2-7, 2001, 14p.

Burnett, E.F. P. and M.R. Fortney, "The Development of an Alternative to Chapter 11 of the IRC 2000 for use in Pennsylvania," *Proceedings of the Performance of the Exterior Envelopes of Whole Buildings VIII Conference*, Clearwater Beach, FL, December 2-7, 2001, 13p.

Memari, A.M., E.F.P. Burnett and B.M. Kozy, "Seismic Response of a New Type of Masonry Tie Used in Veneer Walls," *Conference on Structural Faults and Repair 2001*, London, June 2001.

Burnett, E.F.P., X. Shi and T. Chamra, "The Functions of the Exterior Sheathing Membrane in Screen Type Enclosure Wall Systems," *Proceedings of the International Conference on Building Envelope Systems and Technologies (ICBEST)*, Ottawa, Canada, June, 2001, pp. 59-65.

Burnett E.F.P., "The Performance of Exterior Sheathing Membranes in Enclosure Wall Systems," *8th Conference on Building Science and Technology*, Toronto, Ontario, February 2001.

Burnett, E.F.P. and A. Arenja, "Housing Innovations-Healthy Environments for Living and Learning," *Proceedings of a Session Sponsored by the National Consortium of Housing Research Centers at the International Builders' Show*, Atlanta, GA, PHRC Report #74, February 2001, 51p.

Straube, J.F. and E.F.P. Burnett, "Simplified Prediction of Rain on Buildings," *Proceedings of the Thermal International Building Physics Conference*, Eindhoven, Holland, September 18-21, 2000.

Wisniewski, B., H.B. Manbeck and J.J. Janowiak, "Creep Response of Engineered Wood I-Joist and Oriented Strand Board (OSB) Floor Systems," Presented at the Forest Products Society in Lake Tahoe, June 2000, 8p.

Bosack, III, E.J. and E.F.P. Burnett, "The Durability of Wall Systems Containing Housewrap," *Proceedings of the CIB Conference on Durability of Building Materials and Components (8dbmc)*, Vancouver, Canada, May-June 1999, pp. 959-969.

Mendygral, J.E., E.F.P. Burnett, T.E. Boothby, and S. Burns, "The Mechanical Properties of Stainless Steel Helical Ties," *Proceedings of the Eighth North American Masonry Conference*, Austin, Texas, June 6-9, 1999, pp.

Straube, J.F. and E.F.P. Burnett, "Rain Control and Design Strategies," *Thermal Envelope and Building Science*, Volume 23, July, 1999, pp. 41-56.

Bosak, E. J., and E.F.P. Burnett, "Durability of Wall Systems Containing Housewrap," *Proceedings of the Conference on the Durability of Building Materials and Components*, Vancouver, Canada, May, 1999, pp. 959-969.

E.F.P. Burnett, "Housing Innovation – Management, Business and Marketing Practices," a session sponsored by the Consortium of Housing Research Centers at the NAHB International Builders Show, 1999, PHRC Report No. 60.

Straube, J.F. and E.F.P. Burnett, "Drainage, Ventilation Drying, and Enclosure Performance," *Proceedings of the Thermal Performance of Building Envelopes VII*, Clearwater Beach Florida, December 4-7, 1998, pp. 194-207.

Bahnfleth, W., C. Cogil, and G. Yuill, "Three-dimensional Modeling of Conditioned and Unconditioned Basement Thermal Performance," *Presented at the Thermal Performance of the Exterior Envelopes of Buildings VII*. Clearwater Beach, Florida, December 4-7, 1998.

Taylor, S.B., H. B. Manbeck, and J.J. Janowiak, "Structural Insulated Panel (SIP) Fractional Creep Deflection," *Proceedings of the 1998 World Congress on Timber Engineering*. Lausanne, Switzerland. August 17-20, 1998.

Worley, S. K., H. B. Manbeck and J. J. Janowiak, "Analysis and Modeling of Static and Dynamic Behavior of I-joist Floor Systems: A Progress Report." ASAE Paper No. 98-4013. St. Joseph, MI., July 13-15, 1998.

Straube, J.F. and E.F.P. Burnett, "Vents, Ventilation and Masonry Veneer Wall Systems," *Proceedings of the Eight Canadian Masonry Symposium*, Jasper, Alta., Canada, May 31 – June 3, 1998, pp. 194-207.

Straube, J.F. and E.F.P. Burnett, "Field Measurements of Masonry Veneer Exposure Conditions," *Proceedings of the Eight Canadian Masonry Symposium*, Jasper, Alta., Canada, May 31 – June 3, 1998, pp. 208-221.

Hindman, D. P., H. B. Manbeck and J. J. Janowiak, "Elastic Constants of Structural Composite Lumber (SCL)." ASAE Paper No. 98-4011. St. Joseph, MI. 1998.

Showalter, J. H. and H. B. Manbeck, "LRFD vs. ASD for Wood Design," ASAE Paper No. 98-4006. St. Joseph, MI. 1998.

Riegel, T. W. and H. B. Manbeck, "Post-frame Design Using LRFD", *Frame Building News*, November/December, 1997, 13(1):101-109.

Burnett, E.F.P., A. Arenja, and L. Holroyd, "An Innovative Housing System," *Proceedings of ASCE Construction Congress V*, Minneapolis, Minnesota, October 1997, pp. 894-902.

Gowda, P. and H. El-Bibany, "Builders' Perceptions towards the Use of Modular Building Technology," *Proceedings of the Construction Congress V*, Minneapolis, Minnesota, October 5-8, 1997, pp. 848-855.

Straube, J.F. and Burnett, E.F.P., "Driving Rain and Building Facades," *Proceedings of Clima 2000*, Brussels, Belgium, August 30 – September 2, 1997.

Straube, J.F., M. Gamble, R. Crowne and E.F.P. Burnett, "Polymer Concrete Beams Reinforced with GFRP Rods," *Proceedings of CSCE/JSCE Int. Conference on Eng. Material*, Ottawa, June 8-12, 1997, pp. 579-592.

Straube, J.F. and E.F.P. Burnett, "Field Testing of Filled-Cavity Wall Systems," International Conference on Building Envelope Science and Technology, 1997, Bath, UK, April 15-17, 1997, pp. 429 – 434.

Straube, J.F. and E.F.P. Burnett, "Rain Control and Screened Wall Systems," *Proceedings of the Seventh Building Science and Technology Conference*, Toronto, March 20-21, 1997, pp. 17-37.

Straube, J.F. and E.F.P. Burnett, "Masonry Veneers and Driving Rain," Presented at ASTM Symposium on Water Leakage Through Building Facades, Orlando, Florida, March 17, 1996. Published in Special Technical Publication: *Water Leakage Through Building Facades, ASTM STP 1314*, R.J. Kudder and J.L. Erdly, Eds., ASTM, Philadelphia, 1997, pp. 73-87.

Arenja A., L. Holroyd L. and E.F.P. Burnett, "An Innovative Housing System," *Proceedings of the Fourth Materials Engineering Conference*, Washington, D.C., November 1996, pp. 545-554.

Taylor, S. B., H. B. Manbeck, J. J. Janowiak, and D. R. Hiltunen, "Modeling Structural Insulated Panel (SIP) Creep Deflection," *Journal of Structural Engineering (ASCE)*. 1997. 123(12):1658-1665.

Janowiak, J. J., H. B. Manbeck, R. Hernandez and R. C. Moody, "Red Maple Lumber Resources for Glued-laminated Timber Beams," *Forest Products Journal*. 1997. 47(4):55-64.

Burnett, E.F.P., A. Arenja, L. Holroyd, "An Innovative Plastic Housing System," *Proceedings of the Fourth Materials Engineering Conference*, Washington, D.C., November 10-14, 1996, pp. 545-554.

J.F. Straube and E.F.P. Burnett, "Driving Rain and Masonry Veneer," *Proceedings of an ASTM Symposium on Water Leakage Through Building Facades*, Orlando, Florida, March 17, 1996, STP 1314, pp. 73-87.

Keener, J. D. and H. B. Manbeck, "A Simplified Model for Predicting the Behavior of Metal-clad, Wood-framed Diaphragms," *Transactions of the ASAE*. 1996. 39(3):1113-1122.

Keener, J. D. and H. B. Manbeck, "Effect of Corrugation Length on Effective Shear Modulus," *Transactions of ASAE*. 1996. 39(5):1817-1824.

Taylor, S. B., H. B. Manbeck and J. J. Janowiak, "Creep Performance of Composite Structural Insulated Panels," *Proceedings of the International Wood Engineering Conference '96*. 1996. Vol. 4:397-404.

Manbeck, H. B., J. J. Janowiak, R. C. Moody, P. R. Blankenhorn and P. Labosky, Jr., "Efficient Hardwood Glued-laminated Beams," *Proceedings of the International Wood Engineering Conference '96*. 1996. Volume 1: 283-290.

Shedlauskas, J. P., H. B. Manbeck, J. J. Janowiak, R. Hernandez, R. C. Moody, P.R. Blankenhorn and P. Labosky, Jr., "Efficient Use of Red Oak for Glued-laminated Beams," *Transactions of the ASAE*. 1996. 39 (1):203-209.

BRIEFS:

Builder Briefs:

BB0502—Air Leakage in Recessed Lighting, PHRC Builder Brief.

BB0402—So You Want to Become a Construction Code Official.

BB0301—Mold and Buildings, PHRC Builder Brief.

BB0201—Blower Door Testing, PHRC Builder Brief.

BB0200—Wood I-Joist/OSB Residential Floors.

BB0199—New and Improved Basement Wall Systems.

Technical Briefs:

TB0302—Window Technology.

TB0201—Site Design Considerations for Manufactured Housing.

TB0101—Soil Freeze Depth Guide for Manufactured Housing in PA.

Research Briefs:

RB0199—Composite Action and Floor System Stiffness.

Training Manuals:

Pennsylvania's Uniform Construction Code (UCC) (ACT 45 of 1999) and the 2003 International Residential Code (IRC) ~ *"Just tell me what I need to know!"*

Comprehensive International Residential Code

IRC's Plumbing Requirements

IRC's Mechanical Requirements

PA's New Energy Requirements

IRC Refresher and 2003 Update

Comprehensive IRC for Code Officials

IRC's Plumbing Requirements for Code Officials

IRC's Mechanical Requirements for Code Officials

PA's New Energy Requirements for Code Officials

Administering and Enforcing Pennsylvania's New Energy Code for Code Officials

Comprehensive IRC's Masonry Related Requirements

International Building Code Program for Concrete Masonry

Wood Frame Design - NDS Based (Harvey Manbeck)

Stormwater Management in PA (Scott Brown)

Moisture Control (Eric Burnett)

Some Representative Presentations:

PennBOC Conference: Mark Fortney presented a talk entitled "Masonry Requirements of the IRC and Updating to the 2003 IRC Program," Hidden Valley, PA, October 2003.

Affordable Comfort Conference: Mark Fortney presented a session "Building Codes and Building Science: Is There a Link?" 2003.

Pennsylvania State Association of Township Supervisors Conference: Scott Brown delivered a presentation on "Site Level Hydraulic Process" to over 55 township engineers, 2003.

Pennsylvania State Association of Township Supervisors Conference: Scott Brown delivered a presentation on “Management Practices for Post Construction Stormwater Control” to over 105 township officials, 2003.

2003 Pennsylvania Stormwater Symposium: Scott Brown presented a session on DEP’s SWM Manual Oversight Committee, 2003.

2003 Your Building & Remodeling Show: Ken Sagan presented sessions on “Uniform Pennsylvania Building Code and How the New Uniform Code will impact your business,” 2003.

Pennsylvania Independent Living Conference: “The New IRC and its Impacts on Home Accessibility and Overview of Pennsylvania’s Uniform Construction Code (UCC),” Mark Fortney, Harrisburg, October 2001.

PA State Weatherization Conference: “Overview of the State Building Code and Possible Implications for Weatherization Programs,” Mark Fortney, Williamsport, PA, March 2001.

DOE State Energy Code Conference: “Industry Partnerships to Promote Effective Energy Codes,” Mark Fortney, Burlington VT, July 2001.

NAHB International Builders Show: “Innovation—Disconnects and Diligence: Housewraps and their Installation,” Eric Burnett, Dallas, January 2000.

PHFA Housing from the Ground Up Conference: “Houses for a Lifetime, New Synergies in Construction and Energy Efficiency in Housing,” Eric Burnett, Hershey, PA, February 2000.

Energy Efficient Builders Association (EEBA) Excellence in Building Conference: “Short Course on Heat, Air and Moisture Control: Principles and Cases, Baltimore,” November 1999.

Durability and Disaster Mitigation in Wood Frame Housing—PATH Conference: “Rain Penetration in Walls, Madison, WI,” November 1999.

Homes for Life Forum: “Housing for a Lifetime,” Philadelphia, PA, September 1999.

Hankin Theses

Name	Degree	Dept.	Year	Title
Brian Kozy	M. ENG	CEE	1996	Seismic Performance of Masonry Ties
John deGraauw	MS*	CE	1997	Simplified Hygrothermal Analysis – Methodology for Wall Enclosures
Brennan Glantz	MS	CEE	1998	Design and Construction of a Performance Test Facility for Building Enclosures
John Straube	Ph.D.*	CE	1998	Moisture Control and Enclosure Wall Systems
Edward Bosack	MS	AE	1999	Evaluation of Housewrap Performance in Buildings
Robert Bombino	MS	AE	1999	Hygrothermal Design Issues with Steel-Framed Enclosure Wall Systems
James Mendygral	MS	AE	1999	Structural Considerations for the Use of Helical Reinforcement in Masonry Assemblies
Anthony Chamra	MS	AE	2001	The Structural Performance of Housewrap in Enclosure Systems
Danko Davidovic	MS	AE	2004	Characterization of Ventilation Airflow in Screen-Type Wall Systems
Xing Shi	Ph.D.	CEE	2005	Ventilation Drying and Performance of the Exterior Membrane in Building Enclosure Systems
Fred Peters	MS	A E	2005	Visitability for New Housing in Pennsylvania

* At the University of Waterloo.

Glunt Fellows

Year(s)	Fellow	Department	Supervisor
1995/96	Brennan Glantz	CEE	Eric Burnett
1996/97	Brennan Glantz	CEE	Eric Burnett
1997/98	Edward Bosack, III	CEE	Eric Burnett
1998/99	Edward Bosack, III	CEE	Eric Burnett
1999/00	Benjamin Wisniewski	ABE	Harvey Manbeck
2000/01	Steven Bentz	AE	Eric Burnett
2001/02	Julie Masser	ABE	Harvey Manbeck
2002/03	Joseph Piñon	AE	Eric Burnett
2003/04	Xing Shi	CEE	Eric Burnett
2004/05	Jesse Burow	ABE	Harvey Manbeck

Products prior to 1996:

Reports:

McIntyre, C., M.K. Parfitt, and J.H. Willenbrock, "A Technology Transfer Program in Computer Aided-Design for the Residential Building and Construction Industry," PHRC Research Series: Report No. 45, The Pennsylvania State University, University Park, PA, December 1995.

Taylor, S.B. and H.B. Manbeck, "Creep Behavior of Composite Structural Insulated Panels," PHRC Research Series: Report No. 41, The Pennsylvania State University, University Park, PA, September 1995.

McIntyre, C. and M.K. Parfitt, "The Framework for an Integrated CAD-Based Information Management System for the Residential Land Development Industry," PHRC Research Series: Report No. 42, The Pennsylvania State University, University Park, PA, September 1995.

Yuill, G. and J. Rioux, "The Energy Cost Optimized Modular House," PHRC Research Series: Report No. 43, The Pennsylvania State University, University Park, PA, August 1995.

Yuill, G. and A. Musser, "Evaluation of Duct Sealing Effectiveness," PHRC Research Series: Report No. 40, The Pennsylvania State University, University Park, PA, July 1995.

Adams, P. F., "Building Healthy Homes: A Builder's Reference Guide," PHRC Research Series: Report No. 33, The Pennsylvania State University, University Park, PA, November 1994.

Willenbrock, J. H., "Management Guidelines for Growth Oriented Homebuilding Firms," PHRC Research Series: Report No. 37, The Pennsylvania State University, University Park, PA, October 1994.

Willenbrock, J. H., "Course Manual for Management Guidelines for Growth Oriented Homebuilding Firms," PHRC Research Series: Report No. 38, The Pennsylvania State University, University Park, PA, October 1994.

Julo, J. A., "Comparative Analysis of State Mandated Contractor Licensing Examinations," PHRC Research Series, Technical Support Series: Document No. 5, The Pennsylvania State University, University Park, PA, October 1994.

Julo, J., J. H. Willenbrock, "Suggested Competency Standards for the Pennsylvania Builders Association State-Wide Builder Certification Program," PHRC Research Series: Report No. 35, The Pennsylvania State University, University Park, PA, August 1994.

Adams, P. F., "A Manufacturer's Reference Guide to the Design and Optimization of Energy Efficient HVAC Systems for Modular Houses," PHRC Research Series: Report No. 36, The Pennsylvania State University, University Park, PA, August 1994.

McIntyre, C., M. K. Parfitt and J. H. Willenbrock, "A Residential Land Development Model (Phase I of a Continuing Study Concerning the Land Development Process)," PHRC Research Series: Report No. 28, The Pennsylvania State University, University Park, PA, August 1994.

Werling, E. D. and G. Yuill, "Design and Optimization of Energy Efficient HVAC Systems for Modular Houses," PHRC Research Series: Report No. 27, The Pennsylvania State University, University Park, PA, July 1994.

Julo, J. and J. H. Willenbrock, "Course Manual for Computer-Based Cost Estimating," PHRC Research Series: Report No. 32, The Pennsylvania State University, University Park, PA, May 1994.

Julo, J., J.H. Willenbrock, S. Taylor and M. Syal, "Technology Transfer Manual for Computer-Based Cost Estimating: Edition 2," PHRC Research

Series: Report No. 26. The Pennsylvania State University, University Park, PA, May 1994.

McIntyre, C., "Applications of Softdesk Software in the Areas of Water Resources and Structural Engineering within the Department of Civil and Environmental Engineering," PHRC Research Series, Technical Support Series: Document No. 4, The Pennsylvania State University, University Park, PA, April 1994.

Taylor, S. B. and H. B. Manbeck, "A Review of Selected Alternative Wood Framing Systems for Residential and Light Commercial Construction," PHRC Research Series: Report No. 31. The Pennsylvania State University, University Park, PA, September 1993.

McIntyre, C., C. D'Amico and J. H. Willenbrock, "Technology Transfer Program for PA DER Approved Spray Irrigation Systems: Small Flow Sewage Treatment Facilities," PHRC Research Series: Report No. 24, The Pennsylvania State University, University Park, PA, August 1993.

Willenbrock, J. H., "Critical Evaluation of the Class Manual for the Revised GBI Scheduling Course," PHRC Research Series, Technical Support Series: Document No. 2A. The Pennsylvania State University, University Park, PA, August 1993.

Willenbrock, J. H. "Critical Evaluation of the Instructor's Guide for the Revised GBI Scheduling Course," PHRC Research Series, Technical Support Series: Document No. 2B. The Pennsylvania State University, University Park, PA, August 1993.

Suchar, M. G., G. K. Yuill, H. B. Manbeck, J. H. Willenbrock and H. E. Carr, Jr., "An Optimization Analysis of Residential Energy Systems," PHRC Research Series: Report No. 25. The Pennsylvania State University, University Park, PA, August 1993.

Parfitt, M. K., C. McIntyre and J. H. Willenbrock, "Development of a Customized CAD-Based Design Production System for Residential Builders," PHRC Research Series: Report No. 29. The Pennsylvania State University, University Park, PA, August 1993.

Willenbrock, J.H., "Summary of the Sabbatical Year of Dr. Jack H. Willenbrock as the First "Scholar in Residence" at the National Association of Home Builders and of the NAHB Research Center (August 24, 1992 to

June 30, 1993), PHRC Research Series Report #B4, The Pennsylvania State University, University Park, PA, July 1993.

Adams-Barner, P., "Builders' Perceived Need for Continuing Education. A Focus Group Research Project conducted for the Pennsylvania Builders Association Education Committee," PHRC Research Series: Report No. 30. The Pennsylvania State University, University Park, PA, June 1993.

McIntyre, C., G. Aron and J. H. Willenbrock, "Groundwater Infiltration Pits," HRC Research Series, Technical Support Series: Document No. 1. The Pennsylvania State University, University Park, PA, June 1993.

McIntyre, C. and J. H. Willenbrock, "Civil Engineering Software Applications within the Curriculum of the Department of Civil and Environmental Engineering and the Department of Architectural Engineering," HRC Research Series, Technical Support Series: Document No. 3, The Pennsylvania State University, University Park, PA, January 1993.

McIntyre, C. and G. Aron, "Analysis of Flow Through Porous Media as Applied to Gabion Dams Concerning the Storage and Release of Stormwater Runoff," PHRC Research Series: Report No. 10, The Pennsylvania State University, University Park, PA, August 1992.

Syal, M. G., "Construction Process Knowledge Model to Assist Method Selection in Project Planning," PHRC Research Series: Report No. 23, The Pennsylvania State University, University Park, PA, May 1992.

McIntyre, C., G. Aron and J. H. Willenbrock, "A Comparison of Methodologies Used to Estimate Storm Water Runoff and Detention Basin Volume on a Sample Watershed," PHRC Research Series: Report No. 8. The Pennsylvania State University, University Park, PA, May 1992.

Staib, J. R., G. Yuill, J. H. Willenbrock and H. Edward Carr, Jr., "Analysis of Envelope Performance and Energy Utilization in Residential Construction: Edition 2," PHRC Research Series: Report No. 22, The Pennsylvania State University, University Park, PA, March 1992.

Willenbrock, J. H., "An Overview of Opportunities/Needs for Residential Building Code Training for Pennsylvania Building Code Officials and Inspectors," PHRC Research Series: Report No. 19, The Pennsylvania State University, University Park, PA, November 1991.

Willenbrock, J. H., T. B. Brown and H. Burd, "Participant Manual for the Residential Building Code Training Program for Pennsylvania Code Officials and Inspectors, Volumes I and II," PHRC Research Series: Report No. 17, The Pennsylvania State University, University Park, PA, October 1991.

Willenbrock, J. H., T. B. Brown and H. Burd, "Instructor Manual for the Residential Building Code Training Program for Pennsylvania Code Officials and Inspectors, Volumes I and II," PHRC Research Series: Report No. 18, The Pennsylvania State University, University Park, PA, October 1991.

Staib, J. R., G. Yuill and J. H. Willenbrock, "Analysis of Envelope Performance and Energy Utilization in Residential Construction," PHRC Research Series: Report No. 9, The Pennsylvania State University, University Park, PA, October 1991.

Syal, M. G., M. K. Parfitt and J. H. Willenbrock, "Computer-Integrated Design Drawing, Cost Estimating and Construction Scheduling," PHRC Research Series: Report No. 11, The Pennsylvania State University, University Park, PA, September 1991.

Adams, P., B. and D. Prowler, "A Consumer Guide to Factory Built Housing," PHRC Research Series Report #B2, The Pennsylvania State University, University Park, PA, September 1991.

Mason, D. J., F. Grobler and J. H. Willenbrock, "An Analysis of Quality in the Modular Housing Industry," PHRC Research Series No. 13, The Pennsylvania State University, University Park, PA, August 1991.

Angell, J. A. and J. H. Willenbrock, "Analysis of Direct and Indirect Impact Costs Attributed to the Wetlands Regulatory Programs of the Local, State, and Federal Governments of the United States," PHRC Research Series: Report No. 14, The Pennsylvania State University, University Park, PA, August 1991.

Manbeck, H. and S. B. Taylor, "Structural Evaluation of the MURUS Stress-Skin Urethane Sandwich Panel," PHRC Research Series: Report No. 15, The Pennsylvania State University, University Park, PA, August 1991.

Aron, G., C. McIntyre and J. H. Willenbrock, "Analysis of the Policies and Procedures of Stormwater Management," PHRC Research Series Report No. 7, The Pennsylvania State University, University Park, PA, March 1991.

Willenbrock, J. H., H. B. Manbeck and S. B. Taylor, "Structural Evaluation of the MURUS Stress-Skin Urethane Sandwich Panel: Phase I Report," PHRC Research Series: Report No. 6, The Pennsylvania State University, University Park, PA, August 1990. *Proprietary research report.*

Willenbrock, J. H., T. B. Brown, M. G. Syal and J. R. Staib, "Technology Concept for the TEAHouse (Technologically Efficient Affordable House)," PHRC Research Series: Report No. 5, The Pennsylvania State University, University Park, PA, July 1990.

Showan, P.S. and G. R. Smith, "Analysis of Engineering Design and Drafting Time in the Modular Housing Industry," PHRC Research Series: Report No. 3, The Pennsylvania State University, University Park, PA, July 1990. *Proprietary research report.*

Gass, M. and G. R. Smith, "Analysis of Penn Lyon Homes Quality Program," PHRC Research Series: Report No. 2, The Pennsylvania State University, University Park, PA, July 1990. *Proprietary research report.*

Smith, G. R., "Modular Home Production Study for Penn Lyon Homes Inc.," PHRC Research Series: Report No. 1, The Pennsylvania State University, University Park, PA, July 1990. *Proprietary research report.*

Willenbrock, J. H., M. G. Syal and J. R. Staib, "Building Systems for the TEAHouse (Technologically Efficient Affordable House)," PHRC Research Series: Report No. 4, The Pennsylvania State University, University Park, PA, May 1990.

Proceedings:

Willenbrock, J. H., *Proceedings: Stormwater Runoff and Quality Management Symposium*, Technology Transfer Program #C6, September 1994.

Taylor, S. B., "Selling More Houses through Energy Efficient Construction: The Second Annual Housing and Energy Conference," Technology Transfer Program #C5 (Summary Document), October 1993.

McIntyre, C., *Proceedings: Guidelines for Meeting Energy Efficiency Requirements in Housing in the '90s*, PHRC Research Series Report #C3, The Pennsylvania State University, University Park, PA, March 1992

Long, D. A., J. H. Willenbrock and C. McIntyre, *Proceedings: On-Site Wastewater Treatment and Disposal Systems Research Workshop*, PHRC Research Series: Report No. 20, The Pennsylvania State University, University Park, PA, December 1991.

McIntyre, C., *Proceedings: 1991 Storm Water Management/ Wetlands/ Floodplain Symposium*, Technology Transfer Program #C2, September 1991.

Willenbrock, J. H., *Proceedings: First Annual Symposium - Modular Housing: The Trend for the '90s*, Technology Transfer Program #C1, April 1989.

