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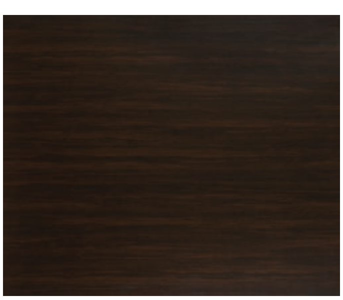
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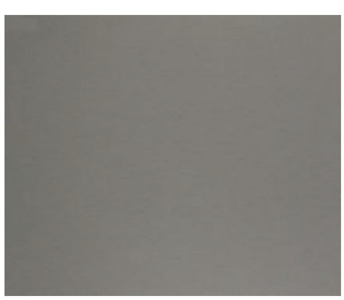
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FEATURES

DEPARTMENTS

Samer Daibess,
President,
BCBEC

Thank you for supporting *BCBEC Elements* magazine

I would like to welcome you all to this issue. Our volunteer board members work tirelessly to bring you cutting edge technical content that is of value to all readers of *BCBEC Elements*.

BCBEC Elements is the official bi-annual publication of the British Columbia Building Envelope Council (BCBEC). It is BCBEC's commitment to encourage learning and promote education related to the building envelope industry. The response to the first three issues of *BCBEC Elements* magazine since its inception in 2015 has been very positive, in large part due to our readership and advertising partners. *BCBEC Elements* boasts a readership that include a large segment of the construction industry, such as architects, engineers, government agencies, product manufacturers, contractors, construction associations and educators. The purpose of the magazine is not only to stress learning from the technical content provided by the articles and contributors of the publication, but also through information provided by our advertisers. I would like to extend our appreciation to our advertising partners for their essential financial support and endorsement of this initiative.

There are ever-changing challenges that face the building envelope industry in British Columbia. Our BCBEC team collaborates with stakeholders in the building envelope industry to share, discuss and understand these challenges in the hope of bringing clarity to the issues.

In the spirit of BCBEC's mandate to promote education in the building envelope field, our team has put together this fourth edition of *BCBEC Elements,* which features a discussion on indoor air quality; condensation risk assessments of window wall facades; whether bed bugs and other infestations are considered workplace hazards; along with a personal profile of Dr. Eric Burnett.

Our BCBEC directors and volunteers are now working on many exciting initiatives to add value to our current membership. Our first premier event is the annual All Day Conference and AGM. This year's event is scheduled for Wednesday, September 14 at the Fairmont Hotel Vancouver. We are also privileged to host the 15th Canadian Conference on Building Science and Technology in fall 2017. In addition to this publication, we will hold our regular luncheon presentations, half-day seminars in collaboration with the Homeowner Protection Office and Association of Professional Engineers and Geoscientists of BC, and continue our support of local building research efforts through the Building Research Committee.

We welcome ideas for technical content, articles of interest, upcoming events and personal profiles specific to the building envelope industry for our upcoming issues. Also, please feel free to reach out to the BCBEC board members for volunteer opportunities. Thank you and I hope you enjoy this issue.

Samer (Sam) Daibess, P.Eng.
BCBEC President
Co-founder and Principal, LDR Engineering Group

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Integrated Design Illiteracy:

The Root of All Evil in Architecture

By Robert Bean, R.E.T., P.L. (Eng.)

The only significant contribution I can make to building science that would have an immediate and positive impact on integrated studies in architecture, indoor environmental quality (IEQ) and energy efficiency is to get the "powers that be" to replace one word in one repeating sentence found in Building Codes. That's it. If those who take responsibility for writing codes would replace one word then we could change the world of architecture.

That word (drum roll please), is "air."

Stay with me on this. Take the following sentence found in various forms in building codes everywhere:

"…at the outside winter design temperature, required heating facilities shall be capable of maintaining an indoor *air* temperature of not less than 22°C…"

Now replace the word "air" with "mean radiant" and read it again.

"…at the outside winter design temperature, required heating facilities shall be capable of maintaining an indoor *mean radiant* temperature of not less than 22°C…"

This will mean absolutely nothing to many design professionals because they don't have the vocabulary to understand the significance. Let me explain; air temperature in codes relates to the space or, more specifically, to the space where the thermostat is located. This is not explicitly stated but when code compliance is cited the thermostat reading stands as witness. On the other hand mean radiant temperature (MRT) relates specifically to the person; i.e., where the person goes so goes the MRT. Together dry bulb (air) with MRT are defined under thermal comfort standards as "operative temperature." Ergo, where the person goes, so goes the operative temperature.[1]

A complete understanding of thermal comfort is part of my litmus test for professional literacy within the world of integrated design. If you are one of the chosen ones with an intimate understanding of building physics, energy and human physiology you will see the industry-altering implication of replacing the word "air" with "radiant" or "operative." For the rest, read on and blame an architectural culture based on segregation of design responsibilities.

THE CHALLENGE

The first step to recovery is to admit we have a problem, in fact several. The dominant assumption is that building codes establish environments which people can sense and perceive thermal comfort in a positive way. For this to be true, codes would require compliance to a thermal comfort standard but they don't. The codes work with risk and the short strokes are: if the occupants won't become ill at 22°C due to thermal discomfort, the space will be in compliance (Figure 1). It matters not if the space is muggy, hot, cold, drafty, etc. (Figure 2). Occupants can complain all day long and if the air-based thermostat says 22°C there are few ears (except maybe those belonging to the engineer) willing

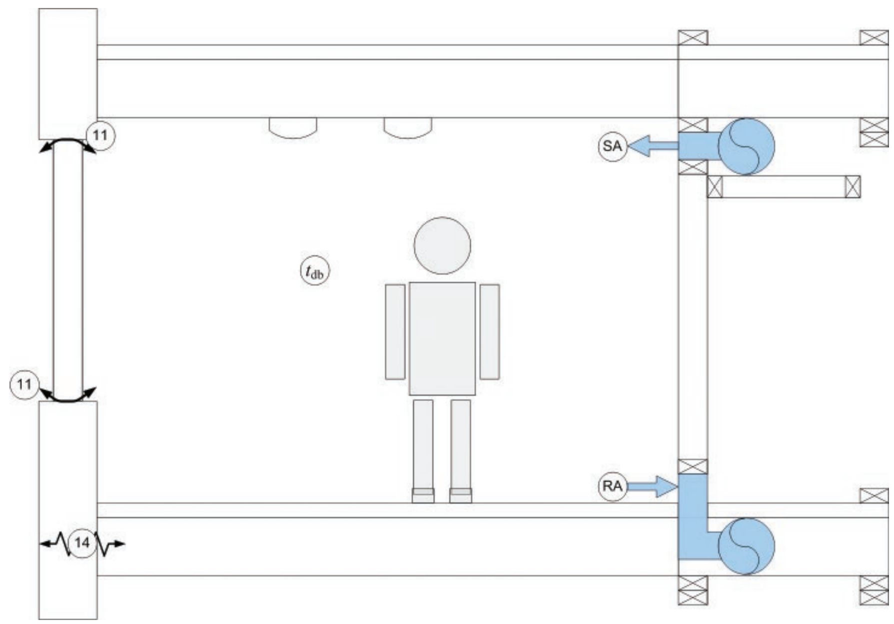


FIGURE 1: THIS IS HOW INDUSTRY TREATS CONDITIONING PEOPLE AND SPACES. AIR GOES OUT, AIR COMES, KEEP IT INSIDE AT 22°C. IF NO ONE GETS SICK DUE TO THERMAL DISCOMFORT THE SPACE IS IN COMPLIANCE WITH BUILDING CODES.[2]

to hear the pain. Canada's Mr. Wonderful and building codes have much in common in that there is no sympathy or empathy when it comes to discomfort complaints. Building enclosures can fix this. So let's start with the basics of thermal comfort, enclosure performance, an introduction to ANSI/ASHRAE Standard 55 – Thermal Environmental Conditions for Human Occupancy, and how this all fits into energy conservation and the world of integrated design.

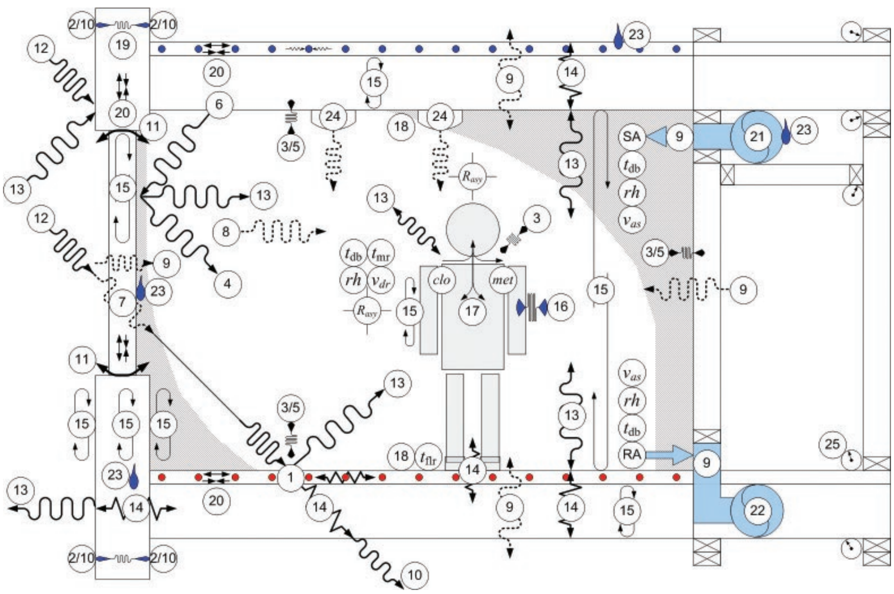


FIGURE 2: THIS IS ACTUALLY WHAT OCCURS. GOOD ENCLOSURES FIX A LOT OF WHAT REALLY HAPPENS WITH INDOOR CLIMATES.[3]

THERMAL COMFORT

Thermal comfort sits nicely within the human sciences. It should be considered as important as any other metric within the study of ergonomics and human factor design.[4] To value this principle one must appreciate the elegance, sophistication and simplicity of the physiological and psychological systems enabling people to sense and perceive their surroundings (aka the enclosure).

The Coles Notes version is: each of us have well over 150,000 thermal receptors in our skin (and some in the brain) forming part of what is called the somatosensory system.[5] Based on rates of temperature change sensed in the dermis layer, these receptors send a DNA programmed signal synapsed through our nervous system to our thalamus and hypothalamus. The former your very own biological "air traffic controller," the latter your personal pharmacist dispensing chemical relays in the form of hormones – an integral part of the endocrine system.

When we sense temperature it is done below consciousness but perceived consciously in the parietal lobe within the brain's cerebrum. It is here where you have, for example, the thought, "I feel cold." Conscious responses of the adaptive nature include putting on more clothes, increasing your activity level, reducing your exposure, etc. Below consciousness your hypothalamus releases a thyroid releasing hormone (TRH) to your pituitary gland, which then releases a thyroid stimulating hormone (TSH), which tells the thyroid gland to release T2 and T3 hormones. These two hormones activate receptor cells associated with metabolic processes (i.e., muscles, digestion and respiration) including the contraction of blood vessels in the skin (a heat retention strategy). In extreme cases of cold sensation it is this system which causes us to develop goosebumps and shiver. In overheating this system controls the opening of pores, production of sweat and dilation of blood vessels in the skin. Dilation brings warmer internal blood to an expanded surface area thus raising the skin's surface temperature, which increases heat loss (put that thought away for a moment). This below conscious response is part of the autonomic nervous system.[6] In HVAC terms the pituitary is your thermostat and thyroid the gas valve and the hypothalamus the operator. For those that understand control logic you can debate whether it falls into the PID camp of fuzzy logic. I see it this way… we're humans and not The Borg; ergo, with comfort the grayness of fuzzy makes more sense than the world of ones and zeros. This combination of conscious and below conscious controlled responses enables our body to return to a place called homeostasis. The consequences of falling in and out of homeostasis is the study of alliesthesia.

OK, that's the short version, so now let's look at how the human sciences fit with the building sciences and enclosure performance.

ENCLOSURE PERFORMANCE AND THERMAL COMFORT

Despite what you read in HVAC literature, the human body's sensible thermal relationship with the environment in conditioned spaces at normal activity levels is dominated by radiation and not convection (Figure 3). This will come as a shock to most but ASHRAE Handbooks, human factor manuals and medical textbooks are congruent with this "not so minor" detail.[7] It has been an epic disservice to the world of architecture to use air temperature as an exclusive proxy

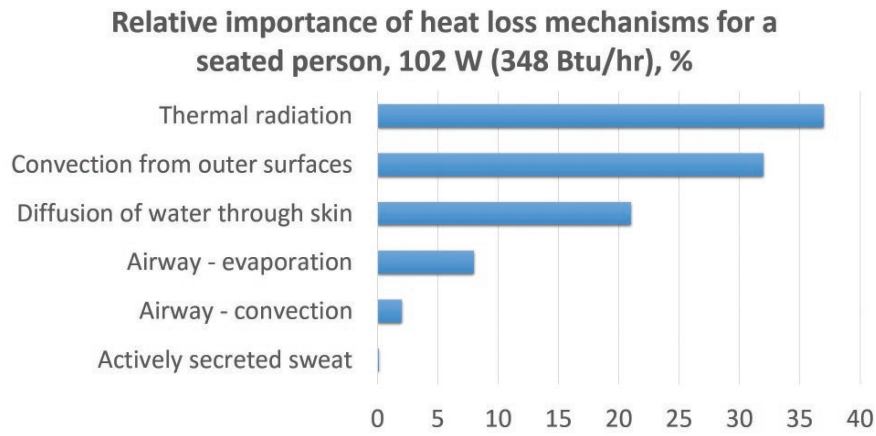


FIGURE 3: RELATIVE IMPORTANCE OF HEAT LOSS MECHANISM FOR A SEATED PERSON (IN %), BASED ON 102 W (348 BTU/HR)[8]

for conditioning people when thermal radiation plays a dominant role.

Once you get your head around this principle you can appreciate how the inside surface temperatures of a room, a function of its enclosure performance, controls the rate of radiant energy exchange and thus heat loss from the human body.

Courtesy of dead men like William Herschel, and later Josef Stefan and Ludwig Boltzmann, we understand the net exchange of radiative heat ($Q_{rad,}$ Watts) between two surfaces with:

$$Q_{rad} = esA(\Delta T^4)$$

Where,

e = surface emissivity

A = area, m^2

s = Stefan-Boltzmann constant (5.6704×10^{-8} W/m^2 K^4)

Povl Ole Fanger based a good part of his now famous PhD thesis on thermal comfort using this knowledge in developing the formulas for calculating angle factors and the mean radiant temperature experienced by a person in a space.[9]

What it all boils down to is this: in winter bad building enclosures have interior surfaces much cooler than the skin temperature and therefore extract energy via radiation from your body faster than you can internally produce it. The results: you feel cold even when the thermostat is meeting the code requirement of 22°C.

Bad buildings in summer have surface temperatures near, at or above your skin temperature and thus supress energy transfer via radiation. As a result, you can't shed heat fast enough so you feel hot even when the thermostat says 25°C or cooler.

This is important stuff because when you get it, you get that it is not that the building feels hot or cold, it's you that feels hot or cold. It's the energy leaving your body (or not) that causes the discomfort sensation and not even the zippiest air-based thermostat can serve as a proper proxy for this human experience inside buildings.

Thus why we ought to give it the old college effort to replace air with radiant or operative because where the person goes, so goes the MRT. If we're going to state a control point in codes it ought to be where the person is, n'es pas? Such an accomplishment would then require design teams to develop a language around people and comfort. This new literacy would result in better enclosures, energy conservation, improved IEQ and generally better architecture. What's not to like about this?

ANSI/ASHRAE STANDARD 55 – THERMAL ENVIRONMENTAL CONDITIONS FOR HUMAN OCCUPANCY

Standard 55 establishes the indoor environmental conditions for a given metabolic rate and clothing value that would lead to a higher probability of thermally acceptable environments. That being a predicted mean vote (PMV) between -0.5 and +0.5 and corresponding predicted percentage dissatisfied (PPD) of 10 per cent or less. Consider that 75 per cent of the environmental factors contributing to the PMV are a function of the enclosure performance.

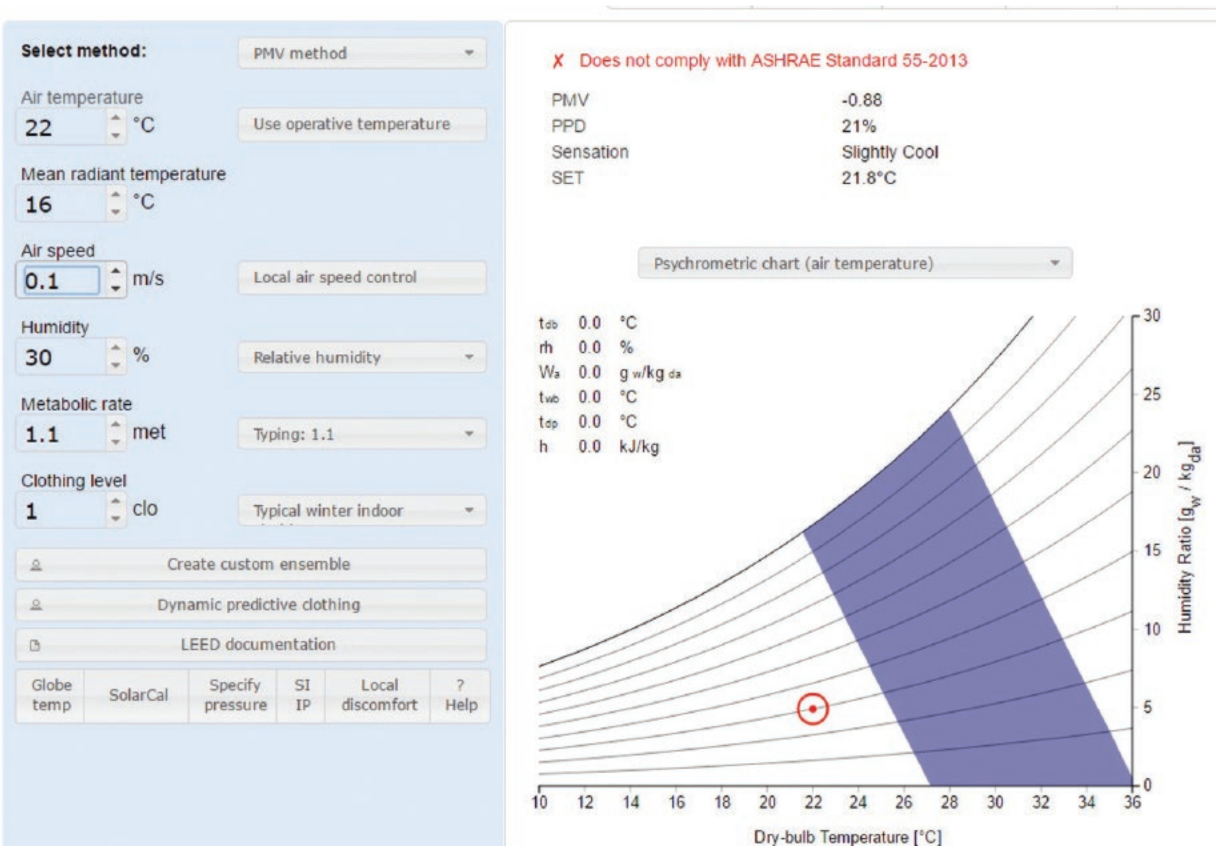
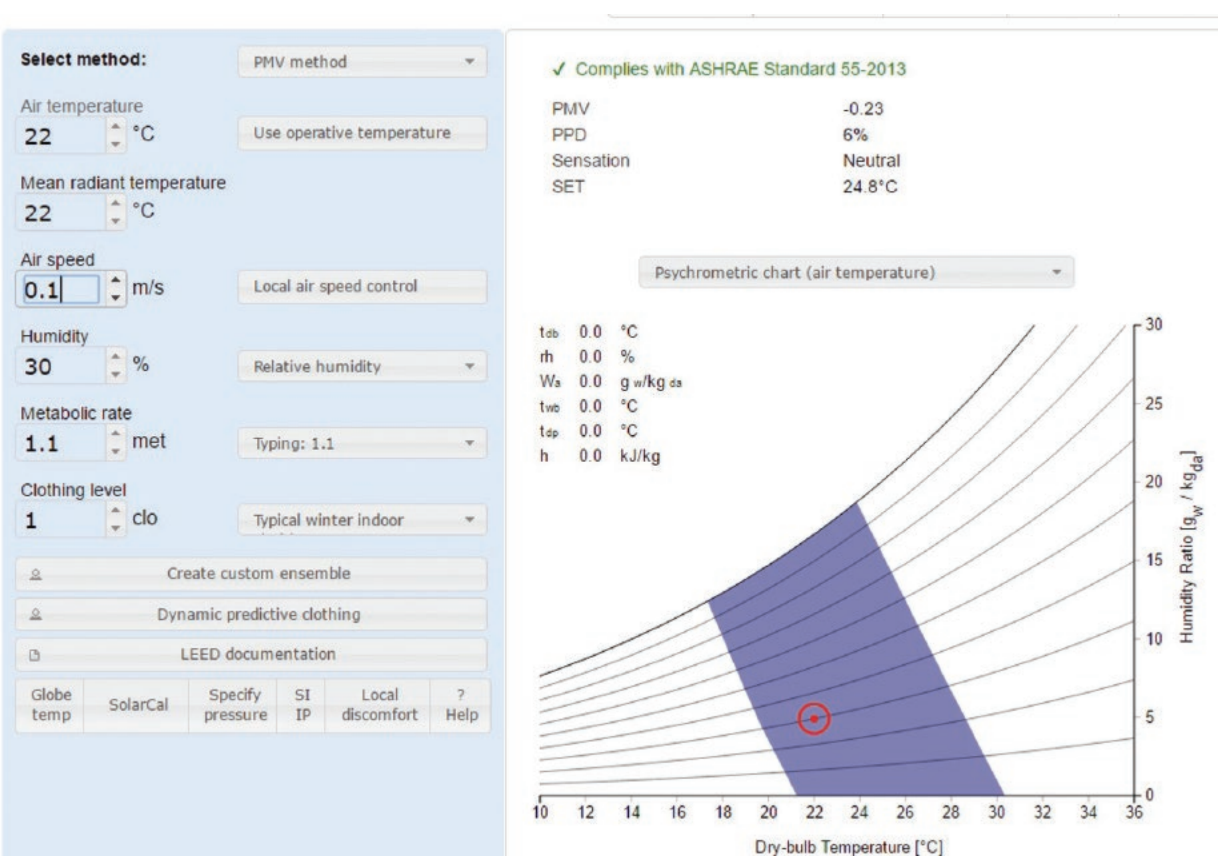


FIGURE 4: BAD BUILDING (ABOVE) AND NON-COMPLIANT WITH STANDARD 55. GOOD BUILDING (BELOW) AND COMPLIANT WITH STANDARD 55



Images provided by Robert Bean

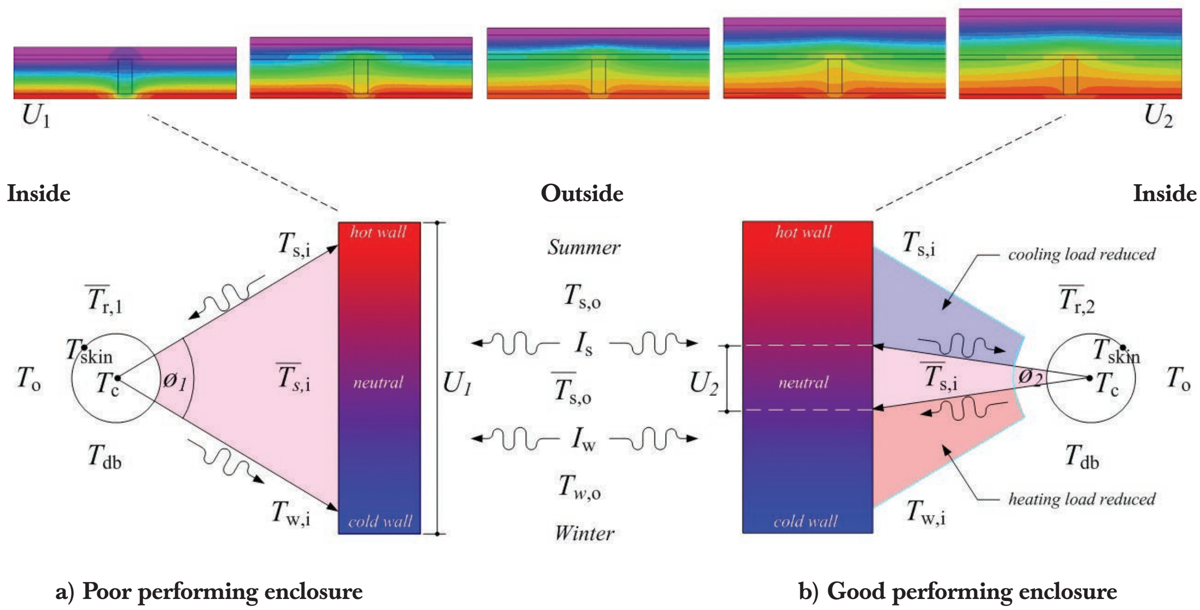


FIGURE 5: THE RELATIONSHIP BETWEEN ENCLOSURE PERFORMANCE, MEAN RADIANT TEMPERATURE, THERMAL COMFORT AND ENERGY CONSERVATION[12]

These are the main metrics:

TABLE 1. FACTORS AFFECTING THERMAL COMFORT[10]	
GENERAL ENVIRONMENTAL FACTORS	**LOCALIZED FACTORS**
Dry Bulb Temperature	Vertical Air Temperature Differences
Mean Radiant Temperature	Radiant Temperature Asymmetry
Humidity	Floor Temperature
Air Speed	Drafts
PERSONAL FACTORS	
Metabolic Rate	Clothing

Using the Center for the Built Environment's Thermal Comfort Tool we can see the effect of MRT on compliance in two spaces: a bad building (above) and a good building (below) (Figure 4).[11] This would be typical for a space with an aggressive window-to-wall ratio, poor glazing choices and extensive thermal bridging versus one with a conservative ratio, better glazing and detailed to reduce bridging.

ENERGY CONSERVATION

The effect of enclosure performance on comfort and energy can be illustrated with FEA modelling. This example looks at increasing values of exterior insulation on the inside surface temperature ($T_{s,i}$) (Figure 5). In the bad building (left) the seasonal swings in outdoor temperature ($T_{s,o} \rightarrow T_{wo}$) will be experienced as aggressive swings in the MRT ($T_{r,1}$) But in the good building the swings are supressed, resulting in conservative swings in the MRT ($T_{r,2}$), even though in both cases the air temperature is held at 22°C (T_{db}). The energy required in the former indicated by $Ø_1$ will be significantly greater than $Ø_2$ in the latter. The difference is energy conservation.

So there you go, an essay on integrated design using MRT and thermal comfort as a means to energy conservation through improvements in enclosures. My spidey senses tell me without building code support in replacing "air" with "radiant" or "operative," the use of 22°C air temperature as a minimum requirement will continue to be interpreted as maximum in practice. Meaning we will continue to solve comfort problems with mechanical and electrical solutions rather than letting the enclosure do the heavy lifting. Such practice is not congruent with the philosophies of sustainability preached by industry, including code regulators. ■

(ENDNOTES)

1. For the snipers in the crowd I would accept the word "operative" in lieu of "air"
2. Bean, R, 2014. Integrated Design Course. HeatSpring Institute
3. ibid
4. Hedge, A. 2007. Indoor Environmental Ergonomics, Cornell University
5. Marsh, A., 2004, Thermal Comfort. Square One Research
6. Gutton and Hall, Textbook of Medical Physiology, 12th Edition
7. (as an example) see Table 1, Representative Rates at Which Heat and Moisture are Given Off by Human Beings in Different States of Activity. 2013. ASHRAE Fundamentals Handbook.
8. Achieving the Desired Indoor Climate, Energy Efficiency Aspects of System Design. Fig. 3.1. Editor Per Erik Nilsson, Studentlitteratur, The Commtech Group. 2003
9. Fanger, P.O., 1970. Thermal Comfort, Danish Technical Press
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11. http://comfort.cbe.berkeley.edu/
12. Bean, R, 2016. Thermal Comfort and Building Energy Lecture.

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PEOPLE POWER:

Q&A With Eric Burnett

By Matthew Bradford

It's been some years since Dr. Eric Burnett exited B.C.'s building science and building enclosures community, yet his contributions to the field continue to drive advancements both in North America and beyond.

Initially a structural engineer, Eric devoted 25 years of his professional career working on the performance of building enclosures and sharing his expertise through his teaching, research and consulting projects. That career began shortly after graduating in 1958 from the University of Cape Town, when he went to work with a large construction company in South Africa. In 1960, he was awarded a Shell International scholarship and later headed overseas to gain a DIC, an M.Sc., and eventually a PhD in structural engineering from Imperial College in London, England.

In 1963, Eric moved to Canada where he spent two years with M.S. Yolles and Associates in Toronto. Two years after, he was invited to join the Civil Engineering faculty of the University of Waterloo, where he was employed for nearly 30 years.

Throughout the decades, Eric has conducted research for the National Institutes of Science, was the first manager of building research for the Canada Mortgage and Housing Corporation's new research division, has been a board member with the National Institute of Building Sciences (NIBS), founded Waterloo's Building Engineering Group, and served on the board of the Ontario Building Envelope Council, among other accomplishments. He also maintained a 10-year part-time relationship with Brampton's Trow Consulting Engineers Ltd., and was invited to assume the Bernard and Henrietta Hankin Chair at Pennsylvania State University, where he became director of research for the Pennsylvania Housing Research Centre. He served two five-year terms before retiring from Penn State in 2005. That year, Burnett and co-author John Straube published a textbook called *Building Science for Building Enclosures* directed at architects, engineers and others in the building profession.

Industry professionals spoke to *BCBEC Elements* on Burnett's contributions to the field. "Back in the day we called Dr. Burnett the 'Pope of Building Science' because he was infallible as shepherd and teacher of all building scientists," says Joe Lstiburek, principal at Building Science Corporation. "I first met Dr. Burnett in 1979. I was a young builder with an engineering degree and I thought I knew stuff. He was gentle with me – but firm – and I have been learning from him ever since."

"ERIC IS ONE OF THE PIONEERS OF BUILDING SCIENCE IN NORTH AMERICA. HIS INVOLVEMENT AT CMHC, UNIVERSITY OF WATERLOO AND PENN STATE HAS HELPED TO ESTABLISH BUILDING SCIENCE AS AN INTEGRAL PART OF THE BUILDING INDUSTRY. I HAVE HAD THE HONOUR OF WORKING DIRECTLY WITH ERIC IN HIS SEMI-RETIREMENT YEARS AND OUR FIRM HAS BENEFITTED GREATLY FROM THE BUILDING SCIENCE TRADITION HE BEGAN AT WATERLOO AND PENN STATE. I APPRECIATE HIS PASSION AND INTELLECT FOR BUILDING SCIENCE, AS WELL AS HIS LOVE OF TEACHING."

– DAVE RICKETTS, SENIOR SPECIALIST,
RDH BUILDING SCIENCE INC.

While his knowledge, expertise and experience in the industry are difficult to capture in one interview, *BCBEC Elements* spoke with Burnett about the highlights and insights from his impactful career.

BCBEC Elements: Why did you choose building enclosures as your focus?

Eric Burnett: It's a field that caught my attention many years ago. When I started, apart from the excellent work being done at the Division of Building Research (at the National Research Council of Canada) in Ottawa, very little relevant research was being conducted in Canada or in the U.S. at the time. For example, the significance – and the influence of – new building materials on building enclosure performance was not widely understood. As well, the enclosures of large and small buildings were failing, and the health and cost impacts of those failures on residents and owners were forcing engineers, architects and builders (to) sit up and pay attention.

BE: What specific areas of building enclosures did you focus on most?

EB: Moisture, or the control of water and water vapour, within walls was initially most critical.

BE: How would you characterize the growth of the building enclosures field throughout your career?

EB: It was initially slow and somewhat hit and miss, but in more recent years its expansion has been phenomenal – especially in Canada and the U.S. Although the building enclosure field is still not recognized professionally as a distinct specialty area, we now have the infrastructure in place to support related research and work. We also have the Building Envelope Councils (BECs) in Canada and the Building Enclosure Councils in the U.S., which have become much larger and more influential than ever before.

BE: What about the technolog y? How has that evolved?

EB: That's also come a very long way, especially with regard to advances in materials and building design. Greater use is being made of climate maps. NIBS has a number of projects in place that address related topics such as WBDG (Whole Building Design Guide), BIM (Building Information Management), etc. You now see buildings that are energy- or LEED-rated; and below-grade construction has been improved by design and with the use of insulation. Roof design has also improved, with attention paid to airflow, control of water and water vapour flow, ventilation or not, etc. Walls are outfitted with window controls and other systems that greatly improve the performance of enclosures, and the whole management process for energy, water runoff, sun use and shading, etc., has become much more important.

There has been a significant evolution and it's far from complete. We are going to see enormous change in the next 20 years given the emerging effects of climate change. There's still a lot to be done.

BE: You've spent some time within the B.C. building science community. How have you seen that evolve?

EB: B.C. is very fortunate in that it is home to a number of design and remediation firms. I moved to B.C. 10 years ago, and I found it to be one of the places in Canada where I could continue my work. BCIT is playing a role with courses and a laboratory facility for Building Science and Enclosures. It has an active research committee that provides guidance and advice. Unfortunately, none of B.C.'s universities has made a significant contribution. However, (BCBEC) is stepping up to the plate by hosting the 2017 Conference of BECs from Canada and the U.S. with DOE.

> **"TREES ARE OFTEN VALUED BY THE FRUITS THEY PRODUCE; ACADEMICS BY THE PAPERS THEY PUBLISH. ANOTHER MEASURE MUST APPLY TO DR. BURNETT. THE HARVEST OFFERED TO US BY DR. BURNETT CONSISTS OF RELEVANT RESEARCH AND SOME OF THE GREATEST MINDS IN BUILDING SCIENCE TODAY. BY EDUCATING OUR YOUTH, DR. BURNETT HAS COMMUNICATED HIS VISION TO A NEW GENERATION THAT IS MAKING OUR WORLD A BETTER PLACE."**
>
> – PIERRE-MICHEL BUSQUE, PRESIDENT, BUSQUE ENGINEERING

BE: Where does Canada stand?

EB: Canada is at the leading edge of enclosure performance because of all the people who are involved. The Canadian climate helps. Europe may be better with the building science (or physics) largely because they have been studying it for longer and also at the university level. However, with regard to current building-enclosure performance, the U.S. is right up there and Canada is not far behind.

BE: Where do you see the "gaps" in the field?

EB: Generally, the gaps are in the education and training of members of the building industry. Some engineers, some architects, and others who work in the building industry don't pay enough attention to issues affecting building enclosures. There are, however, many local firms in B.C. seeking to turn that around; it's just that building enclosures and the related science does not have as high a profile as the study of structural engineering.

BE: Reflecting on your own career, what do you consider your proudest achievement?

EB: I'm proudest of the success of my former students, especially my graduate students in Canada, the U.S., and China. Working with them to find and solve problems has been most gratifying. I'm also proud of the contribution I made in providing training to the building industry in Pennsylvania. I have felt proud of many of the projects in which I've been involved, but generally it's teaching that has been the most rewarding facet of my career.

BE: What is keeping you busy these days?

EB: I retired about 10 years ago (following a stroke) so I'm not that involved in the industry anymore. Now, it's about spending time with my family and pursuing personal interests such as playing bridge and doing some travelling. ■

WHEN PESTS COME TO WORK

Are bed bugs and other infestations considered workplace hazards?

By Kelly Parker

Remedial enclosure projects, in particular and by definition, often require working in an occupied building, and sometimes those buildings (usually residences) involve poor hygiene conditions where bed bugs or other pest infestations may be present. The project team's assessment of the possible hazards in advance of the start of the work includes recognizing this potential. The questions that rise are, are they simply a nuisance or are they a work hazard? What about the health safety implications? What regulations govern these situations and what should the contractor and consultant be doing to mitigate them?

The goal is always to prevent infestations from happening in the first place. The primary responsibility there lies with the owners. BC Housing, for example, has a pest control team of six staff members who monitor bed bug infestations and other pests. Coast Mental Health (CMH), which provides housing and other services to people recovering from serious mental illnesses, is diligent as well. "We run into bed bugs and cockroaches. Bed bugs are a big issue," notes CMH senior building operator Ismail Patel, "especially when it comes to high volatility individuals that we bring through the facility. The best thing we can do in dealing with those kinds of things is do regular suite inspections – monthly is best, but quarterly at least – and once we find a problem, we have to deal with it ASAP, and it has to be scheduled in a manner that is expedited."

When those infestations take hold and consultants are required to enter the infested spaces, that's when it gets complicated. Jim McKay, president of general and abatement contractor JLK Projects Ltd., emphasizes, "They're a significant concern. We're doing a few low-income housing units right now that have a bed bug infestation, so my guys refuse to go in. I've been (trying to) get them to fumigate. I guess they have a program in place where they do fumigate, but there are some there, and I've had a few employees who have just refused to go in. They have children at home, and one has a small baby, and they just can't take the risk of having a couple of these things go home with them on their bodies."

While bed bugs are the major concern, cockroaches can also be a problem – but being highly visible, perhaps less so. McKay says that his crew was set to enter a room in a building in the Gastown area of Vancouver that had just been fumigated for bed bugs. They didn't expect any problems, although they were given instructions to look at all cracks and door jambs for cockroaches. "You don't want one falling onto your jacket or into your shirt and taking it home," notes McKay, "because they are impossible to get rid of. Sure enough, the very first one we went through – an empty unit – they opened the door and there [the cockroaches] were; they actually had to look up, and then jump through the doorway into the unit!"

McKay sees cockroaches as a necessary evil, insofar as they can't be eliminated, "so they are kind of an evil that we have to work around. You have to be reasonable, because the work has to get done and the owners can only do so much. Whenever we know there are pests involved, my guys suit up as though they are going in to do mould, lead or asbestos abatement, meaning the Tyvek suits and the booties, but still, some guys just refuse."

When they do, McKay says he has to respect their decision. "I'm not about to send somebody in who is uncomfortable with this," he says, "especially someone who has kids at home. The last thing I need is to have one of my workers look at me and say, 'Really? You made me go in there and to this and now look at what's happened'."

When there hasn't been a notification from the landlord up front that there are bed bugs, but they're subsequently found by crews entering the space, the owners are immediately notified that the space must be fumigated before work continues. As McKay correctly points out, "generally speaking, WCB regulations dictate that the owners have to give us a safe work environment, and pests are one of those things that they have to take care of before we go in."

The question remains: are these nasty critters simply a workplace nuisance, or are they a workplace hazard? As defined by WorkSafeBC, they are a nuisance and not an occupational health and safety issue for one simple reason: bed bugs and cockroaches, as vile as they are, are not known to transmit diseases in British Columbia.

WorkSafeBC regulations include a section on biological toxins, which could include insect and snake venoms and even plant toxins. If workers are working around any of those elements and there is a risk of exposure, a control plan must be developed that would typically involve some kind of personal protective equipment.

"I entered one space," details Geoffrey Clark, senior occupational hygienist with WorkSafeBC, "where it looked like there was a mist or fog about six inches off the floor that turned out to be fleas. When I got out of there, I was covered right up to the ankles, and we were quite aggressive in getting them off. We know that fleas carry bacteria, but that's not the case here in B.C. as far as we've heard, and it's the same with bed bugs because as far as we're aware, they are a nuisance, as opposed to being a public health risk." Therefore, they don't fall under the purview of WorkSafeBC regulations, and because they're not a hazard in terms of occupational disease, WorkSafeBC can't force the owner to reveal the details about it.

Even so, WorkSafeBC does provide detailed bulletins on its website offering advice on how to approach these various pests. "Even though our regulations don't necessarily cover these kinds of cases," notes Clark, "a lot of us put out information anyway just to inform people of things they can do, so we're not leaving them in a vacuum." ■

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7:00 – 8:00 am	REGISTRATION, BREAKFAST & TRADESHOW	
8:00 – 8:15 am	WELCOME DELEGATES	
Opening Session 8:15 – 9:00 am	**Osmosis and Blistering of Liquid Applied Waterproofing Membranes – What We Have Learned in the Past Decade**	Graham Finch RDH Building Engineering Ltd.
9:00 – 9:15 am	**BCIT Master Students' Poster Presentation**	
Second Session 9:15 – 10:00 am	**Stretch Codes and the Climate Leadership Plan**	Lee Nicol Building & Safety Standards Branch
10:00 – 10:30 am	MORNING BREAK & TRADESHOW	
Third Session 10:30 – 11:15 am	**How to Build A Glass House**	Leonard Pianalto Read Jones Christoffersen Ltd.
Fourth Session 11:15 – 12:00 pm	**Breaking Glass**	Mark Brook BVDA Façade Engineering Ltd.
12:00 – 1:00 pm	AGM, TRADESHOW & LUNCH	
Keynote Speaker 1:00 – 1:40 pm	**Just Eat It: A Food Waste Story**	Jenny Rustemeyer & Grant Baldwin Peg Leg Films
1:40 – 1:55 pm	NETWORKING	
Fifth Session 1:55 – 2:35 pm	**BEC Talks – Roof Insulation** **Drainage Capabilities & Heat Loss of Different Inverted Roof Assemblies** **Design Considerations – Roof Insulations**	 Matthew Pel Morrison Hershfield Ltd. Josh Jensen JRS Engineering
Sixth Session 2:35 – 3:20 pm	**A Case Study: Studio Bell, Home of the National Music Centre**	Nicole Parsons & Scott Baxter WSP Canada Inc.
3:20 – 3:50 pm	AFTERNOON BREAK & TRADESHOW	
Seventh Session 3:50 – 4:35 pm	**The Envelope and Passive House: An Architect's Visual Design Process**	Joseph Kardum & Herman Kao Koka Architecture + Design Inc.
4:35 –4:45 pm	CLOSING REMARKS	

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HYDROTECH

CONDENSATION RISK ASSESSMENT OF WINDOW-WALL FACADES UNDER THE EFFECT OF VARIOUS HEATING SYSTEMS

By Derek Kin Fung Yan, M.Eng., Building Science Consultant, LDR Engineering Group; and Rodrigo Mora, Ph.D., P.Eng., Faculty, British Columbia Institute of Technology

INTRODUCTION

In northern coastal climates, surface condensation often occurs in fenestration systems during winter. The most common contributors of this phenomenon are air leakage, thermal bridging, local convection and radiation (i.e. boundary conditions). Researchers and industry experts typically focus on improving designs of fenestration and developing different strategies to deal with air leakage and thermal bridging. However, the effects of local convection and radiation on window condensation are often overlooked. This project focuses on investigating the ways different heating systems interact with window-wall systems via convection and radiation heat exchanges, and their effects on surface condensation. The three most common heating systems for multi-unit residential building (MURB) are considered: electric baseboard, hydronic radiant floor and forced air system. Each heating system provides vastly different indoor conditions due to differences in thermal stratification, room air distribution and location of heat sources. These differences have direct impacts on window performance and potentially increase risk of condensation.

In this project, the following questions are investigated: How significant is impact of room air flow on condensation risk in window-wall systems? Are empirical film coefficients sufficient for predicting condensation risk of window-wall units? What are the differences between each of the heating systems on condensation risk? This project designed a methodology in an attempt to better understand and predict these physical phenomena and will hopefully guide further efforts to better characterize the effect of different heating systems in window condensation risk analysis.

WHY IS CONDENSATION ON WINDOWS AN ISSUE?

Surface condensation often occurs on fenestration systems in buildings due to changes in humidity and temperature. It happens on a window when the temperature of part of a glazing unit drops below the dew point temperature. Dew point temperature depends on the surface relative humidity and temperature and is highly influenced by indoor and outdoor boundary conditions (i.e. local convection and radiation). Surface condensation accelerates deterioration of different building elements around the window frame. It leads to durability issues such as corrosion of metal components and/or potential of mould growth in wood components. Furthermore, surface condensation in window panes is not

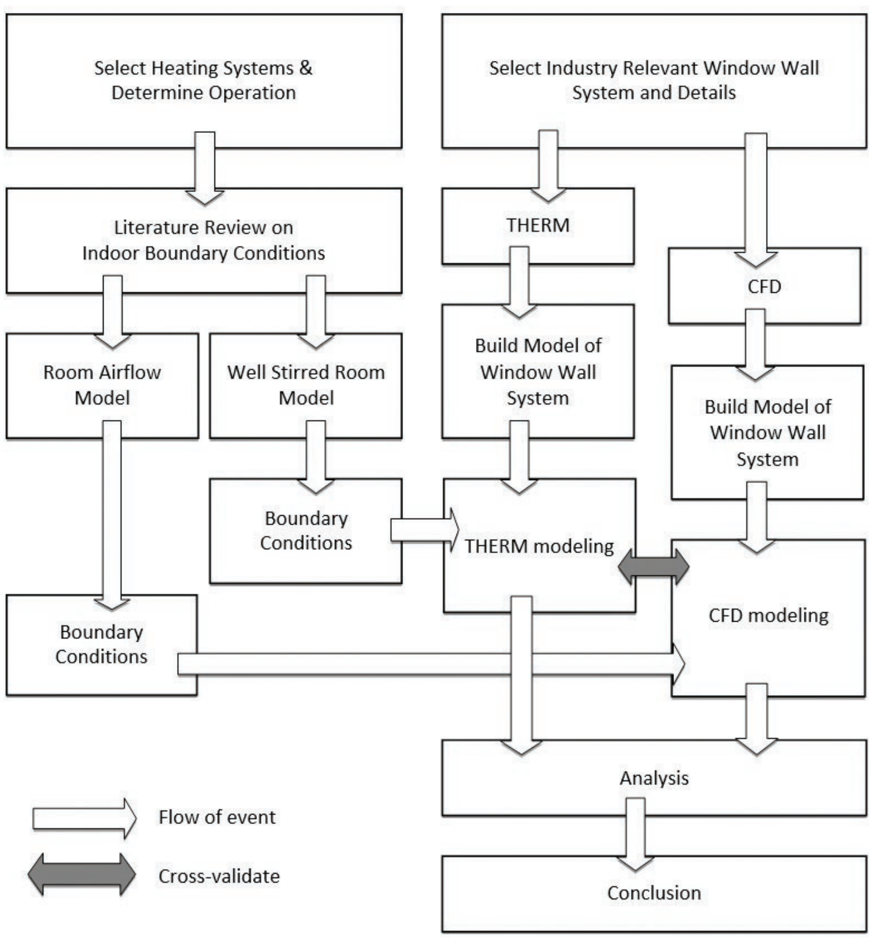

FIGURE 1: METHODOLOGY FLOW CHART OF THE PROJECT

aesthetically pleasing. This phenomenon is a significant issue under North American moderate coastal climate condition, where interior relative humidity is high in winter and exterior temperature is moderately low.

METHODOLOGY

In order to investigate the effects of heating systems, it is important to understand each of the heat transfer mechanisms involved, i.e. conduction, convection and radiation. While conduction and radiation can be modelled accurately via the use of heat transfer simulation software, it is not the case for convection because convective heat transfer is highly sensitive to buoyant and mechanically induced air movements.

There are two available methods to model convection coefficients in building simulation: 1) empirical coefficients obtained from laboratory experiments; 2) computational fluid dynamics (CFD) simulation. In this project, these two methods were explored and were used to model the selected window-wall details. Simulation software such as THERM and Autodesk Simulation CFD were utilized to simulate the condensation risk of typical glazing units with different heating systems.

THERM was used to model the two-dimensional (2D) heat transfer through envelope details. THERM uses the finite element method (FEM) based on well-stirred (or well-mixed) room air assumption: boundary conditions such as convective and radiation heat transfer coefficients are used to model heat transfer between surfaces and the room air.

CFD was used to predict the air flow patterns induced by the heating systems. CFD uses the fluid (air flow) and heat transfer finite control model based on the room air flow model assumption: simulation allows prediction of local heat flow patterns, thermal stratification and air distribution.

This project designed a methodology as illustrated in Figure 1. Window-wall details from the local industry were selected. Boundary conditions data from past research literatures were used for window detail (THERM) and room air flow models (CFD). 2D heat transfer models were built in THERM and room air flow models in CFD for the window details. These steady state models were simulated with representative boundary conditions for each heating system under typical winter conditions of Vancouver.

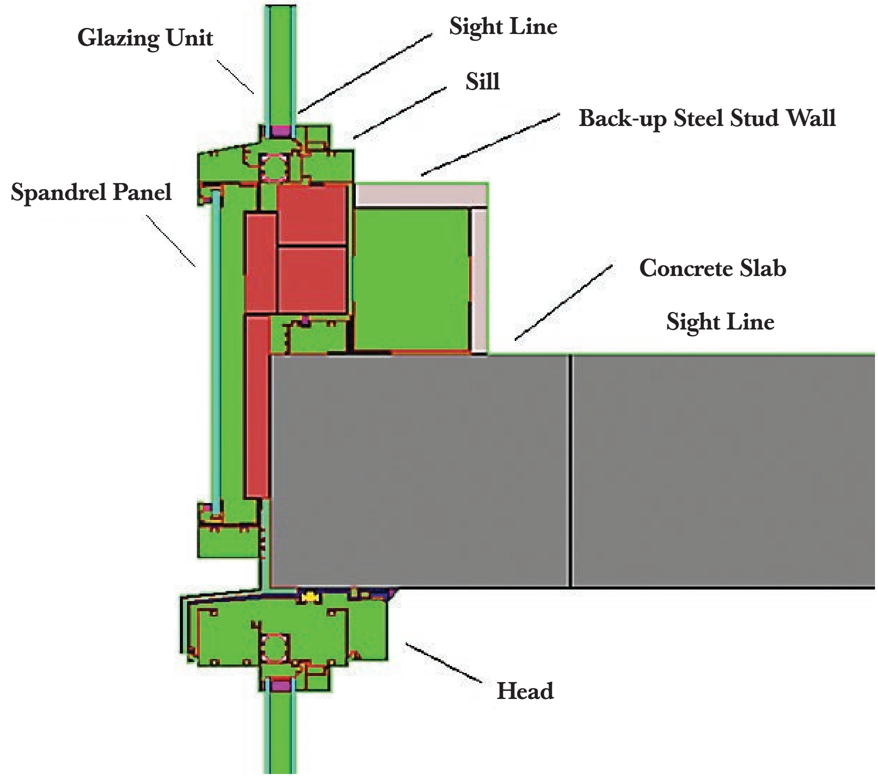

FIGURE 2: THERM MODELS ON BYPASS DETAIL AND EXTENDED SLAB EDGE DETAIL

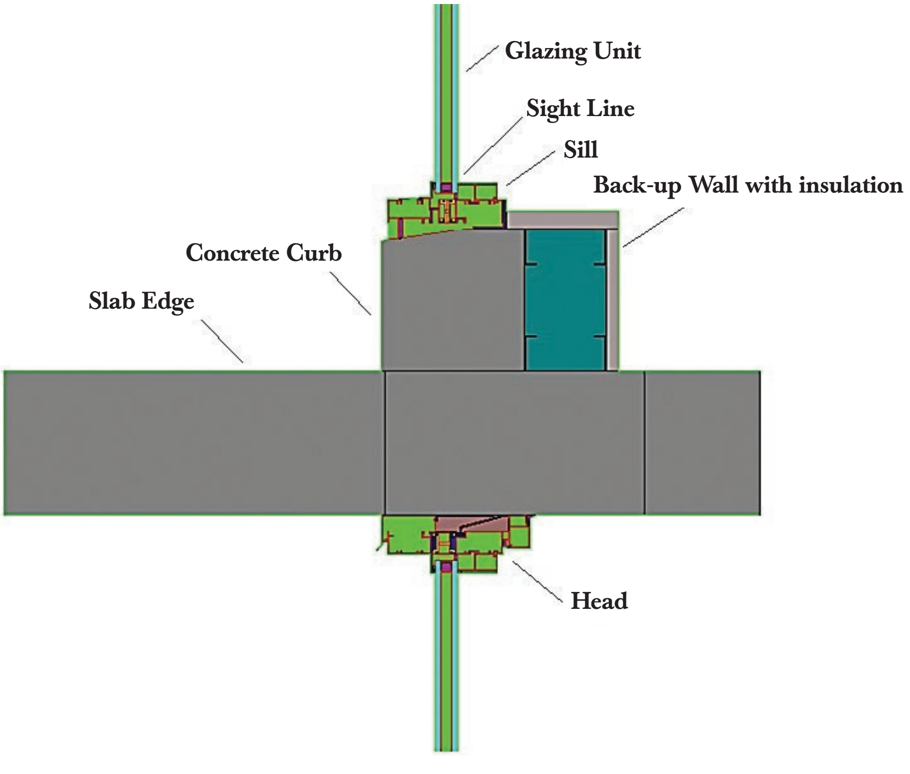

TABLE 1: LIST OF CONVECTIVE HEAT TRANSFER COEFFICIENTS USED IN THERM

DETAIL	HEATING SYSTEM	SOURCE	HC	REFERENCE TEMPERATURE
Slab Edge/Bypass	Reference	ASHRAE (2009)	6.8 (Fixed)	Average room air temperature
Slab Edge/Bypass	Electric baseboard	Khalifa, et al (1990)	hc = 8.07*ΔT ^0.11	Average room air temperature
Slab Edge/Bypass	Radiant Floor	Khalifa, et al (1990)	hc = 7.61*ΔT ^0.06	Average room air temperature
Slab Edge/Bypass	Forced Air	Goldstein, et al (2010)	hc = 0.103(V/L)0.8	Supply air temperature

THERM MODELLING

Two common multi-unit residential building window-wall details were selected for the project: window-wall assembly with bypass spandrel glass panel, and window-wall assembly with extended slab edge. THERM models were built to determine surface temperatures at the critical window-wall details when condensation is expected to occur. Some of the models implemented in THERM are shown in Figure 2.

In THERM models, indoor boundary conditions are described by heat transfer coefficients of window assembly surfaces. The effects of each heating system were modelled using convective and radiation heat transfer coefficients, which were drawn from the previous research literatures. Some of the heat transfer coefficients are shown in Table 1.

Radiation was modelled with the use of a view-factor-based radiation model in THERM. Conduction was modelled for each heating system based on manufacturers' product data sheet

COMPUTATIONAL FLUID DYNAMICS (CFD) MODELLING

CFD models were built for each of the heating systems, using the window-wall bypass and extended slab edge details.

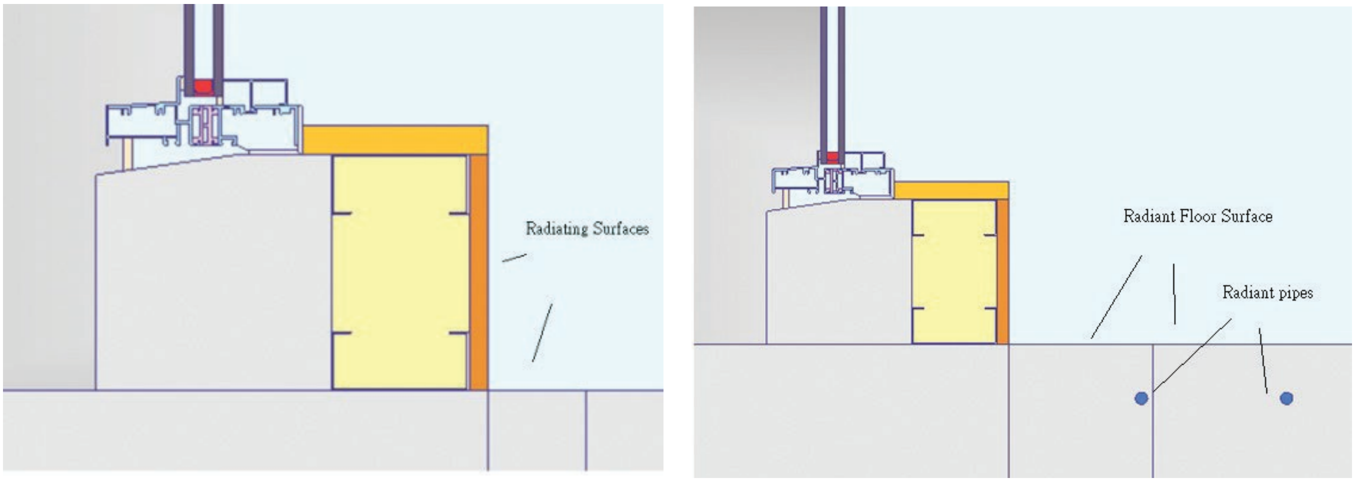

FIGURE 3: CFD ELECTRIC BASEBOARD (LEFT) AND RADIANT FLOOR (RIGHT) MODEL

Conduction was modelled similar to the THERM models (Figure 3). Convection and radiation were simulated by dynamic fluid flow in the CFP models.

DATA COLLECTING

Surface temperatures data were collected at each THERM and CFD models and the data were plotted under one graph. To plot a graph of surface temperatures against locations on the glazing unit, an origin point was set at the location where the window glass and the frame met at the sill section, which is named the "Sight Line." Positive sight line distance values are for points on the window frame below the sight line and vice versa. Y-axis represented surface temperature in °C. The dew point threshold of 21°C and both 50 per cent and 60 per cent relative humidity were plotted to assess condensation risk of each model. A graph for comparison between THERM and CFD models is included in Figure 4.

CFD: AIR FLOW PATTERNS AND TEMPERATURE DISTRIBUTIONS

CFD models generated graphical simulation results on air distribution and thermal stratification of the window detail and the room model for each heating system model. The colour differences reflect temperature differences. The arrows represent the direction of air flow and the size of arrow represents the speed of the air flow.

ELECTRIC BASEBOARD MODELS

The electrical baseboard model shows that there was an upward convective heat flow at the window sill due to the baseboard heater at the base of wall (Figure 5). The electric baseboard heater was able to distribute heat evenly at the centre of the room model (Figure 6).

RADIANT FLOOR MODELS

The radiant floor model shows a downward air flow at the window sill (Figure 7). The radiant floor system was able to distribute heat uniformly within the room; however, there is a cold corner at the window sill (Figure 8).

FORCED AIR MODELS

The forced air model shows an air flow carried by upward momentum travelling along the fenestration unit and towards the window sill (Figure 9). However, this air flow does not provide sufficient heat at the corners, as illustrated by the temperature gradient. The forced air system creates

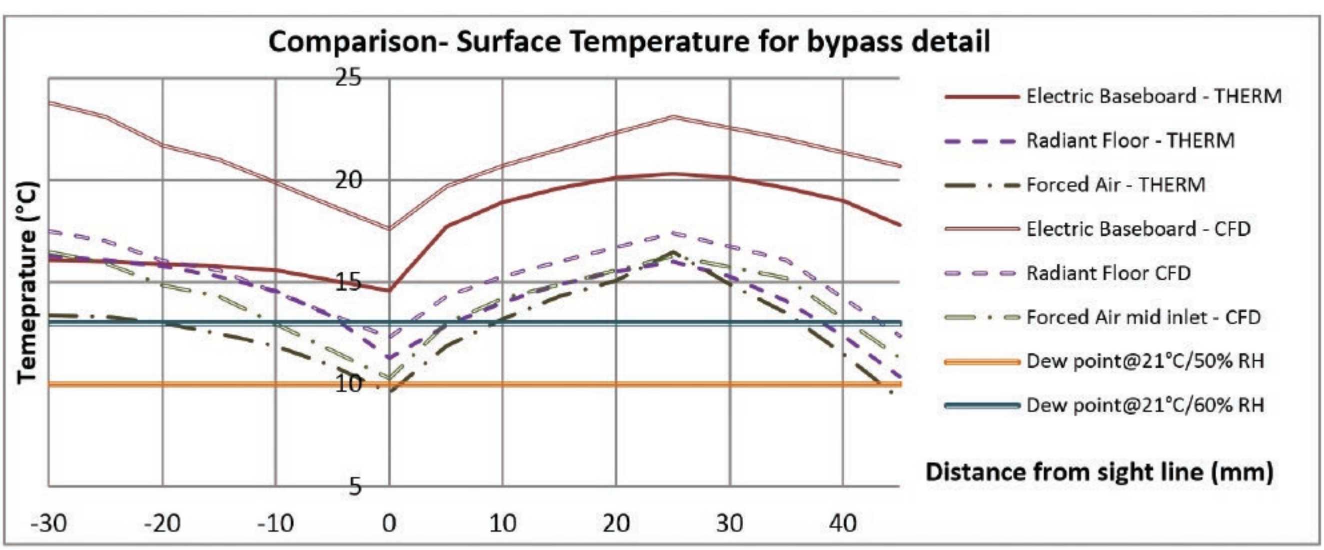

FIGURE 4: COMPARISON BETWEEN CPD AND THERM MODELS FOR BYPASS DETAIL

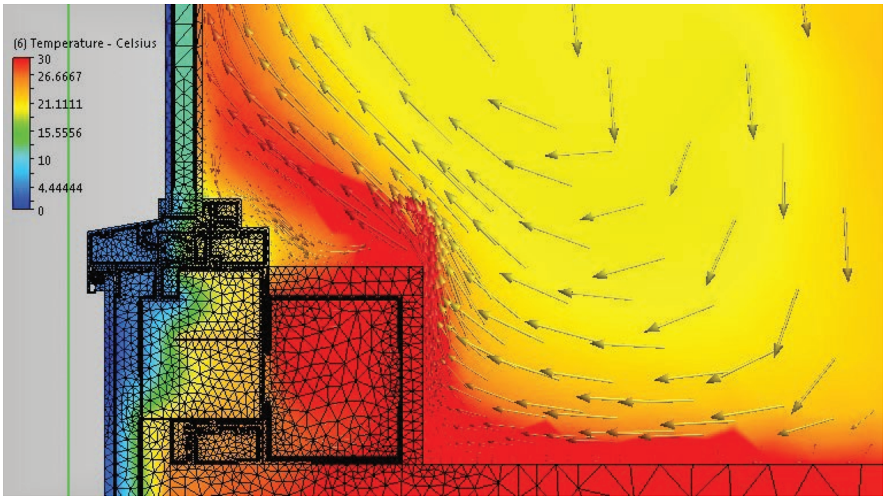

FIGURE 5: AIR FLOW PATTERNS – WINDOW SILL OF ELECTRIC BASEBOARD MODEL

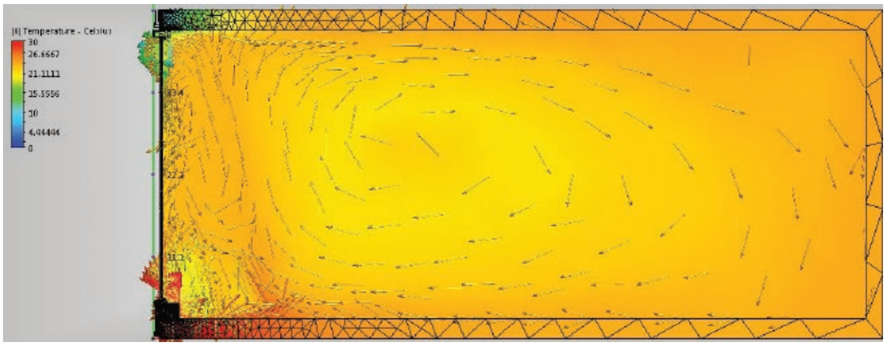
FIGURE 6: AIR FLOW PATTERNS – ROOM OF ELECTRIC BASEBOARD MODEL

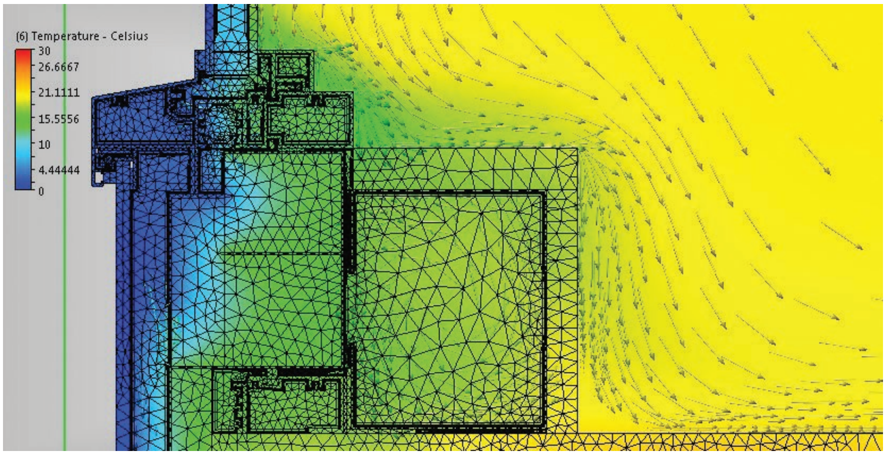

FIGURE 7: AIR FLOW PATTERNS – WINDOW SILL OF RADIANT FLOOR MODEL

multiple convective air loops within the room model (Figure 10). The forced air system does not distribute air as evenly as the radiant floor system and recirculation zones appear at cold corners.

RESEARCH FINDINGS

Based on the simulation results and analysis, the following comments were made:

- The electric baseboard system was less susceptible to condensation risk than radiant floor and forced air heating systems. The location of heating sources had a significant effect on heat distribution in a room and window condensation risk. For example, with a forced air heating system where the heating source was located far from the windows, the condensation risk was considerably higher than in other simulation models.
- The extended slab edge window detail performed worse than the bypass window detail due to thermal bridging, which is expected based on fundamental building science principles.
- CFD models appear to generate more realistic results than THERM models. It demonstrated that the use of constant convective coefficients in thermal simulation was not sufficient in characterizing indoor boundary conditions (e.g. convection, radiation, heat distribution, air flow, etc.) in some cases.

CONCLUSION AND FURTHER WORK

The research findings confirmed the hypothesis that the type of heating system has a significant impact on window condensation risk. The major finding in this project is that to simulate window condensation risk in computational models, the use of a fixed interior boundary coefficient is not sufficient in characterizing the indoor boundary condition, especially when the effects of different heating systems were considered. Each heating system provides vastly different indoor conditions due to differences in thermal stratification, air distribution in the room and location of the heating source. These differences have direct impacts on window performance and affect the risk of condensation. An accurate implementation of indoor boundary conditions is required to accurately assess condensation risk of window assemblies. In addition, CFD simulation provided meaningful insights into how air flow affects condensation risk in window assemblies.

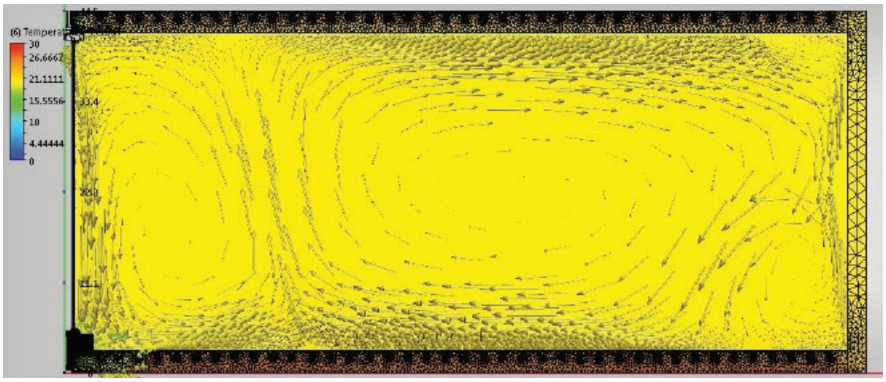

FIGURE 8: AIR FLOW PATTERNS – ROOM OF RADIANT FLOOR MODEL

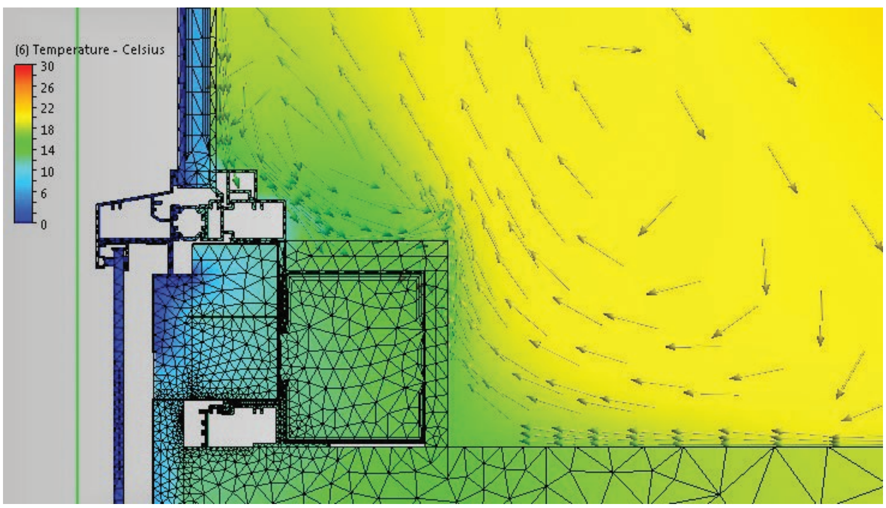

FIGURE 9: AIR FLOW PATTERNS – WINDOW SILL OF FORCED AIR MID INLET MODEL

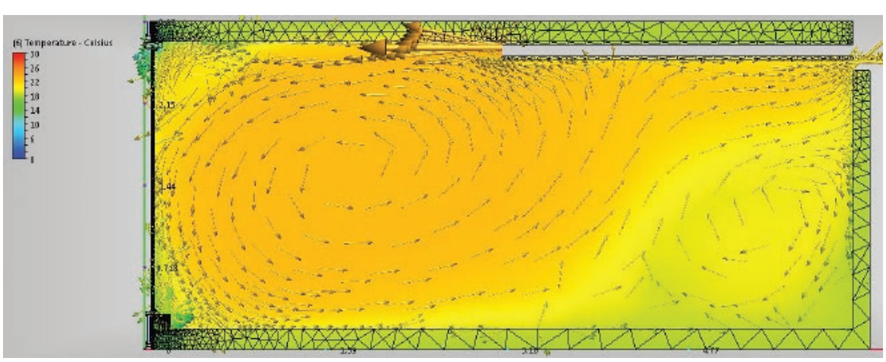

FIGURE 10: AIR FLOW PATTERNS – ROOM OF FORCED AIR MID INLET MODEL

Future work may include developing three dimensional (3D) CFD models to achieve more accurate simulations. Other parameters that affect condensation risk can be considered, such as the presence of furniture and blinds. More importantly, future work on this topic should seek to calibrate the simulation models through field measurements and exploring solutions to reduce the risk of condensation. ■

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THE ABSTRACTS ARE TO BE SUBMITTED ONLINE AT CCBST2017.CA

BCBEC FOUNDATION AWARDS PROFILE: Rosa Lin

By Matthew Bradford

In 2013, Rosa Lin received $1,000 from BCBEC's Tom Morstead Education Foundation in recognition of her high academic success within the Master of Applied Science in Building Science program at the British Columbia Institute of Technology. After becoming the first to graduate the program, she became research analyst at the BCIT Centre for Architectural Ecology, where she continues to learn and contribute to many aspects of building science.

BCBEC Elements caught up with Rosa to learn more about her career and her post-graduate successes.

BCBEC Elements: What have you been up to since winning BCBEC Foundation's award?

Rosa Lin: A lot! I've since completed and defended my Master's research thesis on the acoustical environmental quality of Vancouver's laneway housing and graduated with distinction – particularly as the first MASc from BCIT's Master of Building Science/Building Engineering program.

Immediately after graduation, I started working at BCIT's Centre for Architectural Ecology as a research analyst. I support operations at the Acoustics Lab and the Living Architecture Lab, conducting research and infrastructure development projects that mostly focus on building and environmental acoustics, and students' studies and projects. I have also presented various aspects of my work at the Canadian Acoustical Association and the Acoustical Society of America conferences, all with great feedback from industry peers and leaders.

BE: Please tell us more about your experience at the BCIT Centre.

RL: I support the work of centre director Dr. Maureen Connelly, graduate students in the Building Science graduate programs and undergraduate students from Architectural Science. Many of our projects are multidisciplinary and involve collaborations with industry, institutions and government.

Research topics I have been supporting and assisting include graduate thesis and graduate course projects on acoustics; for example, the performance of window attachments and fixtures on outdoor-to-indoor noise reduction, development of high-performance noise reduction partitions for specific industrial uses, and the validation of research methods, such as using sound intensity method to determine transmission loss of a building partition assembly or element.

Other interesting topics include acoustical properties of living walls and green fences, the effectiveness and use of sound masking systems in offices, anechoic chamber design and construction, architectural technologies to reduce or isolate high-intensity industrial noise emissions, wall assembly systems, speech intelligibility in classrooms and important collaborative meeting spaces, and many other aspects of improving acoustical environments.

Personally, my areas of interest include acoustical challenges of smaller footprint and lightweight "sustainable" architecture, concert hall and outdoor concert acoustics, and using architectural materials to improve acoustical performance of construction assemblies.

BE: Where do you hope to see yourself in the industry three years from now?

RL: A senior-level consultant working on interesting projects, possibly teaching a class, and perhaps even working on a PhD. Either way, I will be advocating for healthier, better-designed and better-built environments.

BE: How has the BCBEC Foundation award supported your career?

RL: The award really gave me the encouragement and moral support I needed – particularly in the steep, challenging upstream parts of my studies and my early career journey.

BE: How have you benefitted from being part of the BCBEC community?

RL: I really enjoy the camaraderie and peer support – "industry morale" – of the BCBEC community. It is encouraging, reassuring and exciting to know that there are at least a few hundred brilliant people in the Lower Mainland who are passionate about building science and about advancing construction technology! It's also encouraging to know there is a larger group of professionals, veterans and mentors who have walked the path and overcome difficulties from whom I can learn. Meanwhile, this is a potential area for my professional contribution to others.

BE: What advice would you give to students who are starting their involvement with BCBEC?

RL: Continue your BCBEC membership! Keep going to industry events to learn about your industry, stay on top of it, and – more importantly – meet people. Give them your contact card with a brief description of your unique strengths or points of interests regarding building construction practice, technology, or sciences, and persevere! When you become a veteran, pass on the benefit; mentor and be kind to new members and students. ■

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