ABSTRACTS

THEORY 1

SUSTAINING MODERNITY: AN ANALYSIS OF A MODERN MASTERPIECE, THE GROPIUS HOUSE

Simi Hoque, Carl Fiocchi

This paper presents a method and initial studies to evaluate the energy performance of the Gropius House, a Modernist icon. The objective is to quantify energy intensity of the house by creating and optimizing a parametric computer energy model. The procedure described in this paper provides a detailed outline of the energy modeling process with accompanying results. The goal is to advance the understanding of the performance of Modernist icons, offering insight into sustainable building strategies in use before the advent of contemporary technologies.

The present study is part of a larger project to create a knowledge base of the environmental performance of iconic homes. In addition to adding knowledge to the two disciplines, Building Science and Architecture, analytical studies using the digital model are intended to aid property administrators in evaluating the economic realities of retrofitting and upgrading opportunities as well as provide information about energy saving characteristics and shading technique designs. Furthermore, by outlining a protocol and methodology, improvements in the building industry's energy performance analysis methods may be developed.

TOWARD SUSTAINABILITY: PRIORITIZING RETROFIT OPTIONS FOR TORONTO'S SINGLE-FAMILY HOMES

Kasia Blaszak

This study proposes and investigates a framework for ranking retrofit options for single-family homes on the basis of net environmental effect. Four archetype homes developed to represent Toronto's existing housing stock were modeled in HOT2000 to calculate the operational energy requirements for base and retrofit cases. The embodied effects of selected retrofit options were then calculated using the ATHENA Impact Estimator and a list of environmental summary measures produced. A method of combining the operational and embodied effects based on these eight summary measures was proposed and tested on a selection of retrofit cases. The method incorporates two factors, a weighting factor and Durability Reduction Factor, both of which require further research. Analysis of the modeling results allowed generalizations to be made about energy performance and for retrofit recommendations to be prioritized for each archetype house. Increasing wall insulation is a priority for Century and 70s OBC archetype homes. Wartime homes need insulated foundation walls and slabs. Window replacements are the most pressing building envelope retrofit in the Modern archetype. In most retrofit cases operational energy effects dominate, however, the ranking equation shows the potential for certain conditions in which the embodied effects determine the ranking of a retrofit.

CODIFYING THE UNVENTED ATTIC ASSEMBLY IN CANADA

Paul Duffy

The quest for greater energy efficiency in buildings has led to increasing interest in (and need for) higher levels of insulation, improvements in HVAC equipment, more airtight construction, new materials and assemblies. Code changes however, are often painstakingly slow, conservative processes that stand in the way of innovation and result in little change from the status quo. In this paper, the author argues that significant performance improvement could be made in a great number of buildings if a set of parameters could be put into the National Building Code Part 9 / Residential Buildings (and by extension the provincial Codes) to set out the method by which unvented attic assemblies could be constructed in Canada.

ENERGY RETROFITTING AN HISTORIC 1870'S SOLID MASONRY HOME USING NESTED THERMAL ENVELOPE DESIGN™

Marianne Touchie, Kim Pressnail, Erin Dixon, Russell Richman

Given the growing environmental and economic need to use energy more efficiently, we must improve the energy performance of our buildings. Renewal of existing building stock by new construction is slow and some buildings, due to their historic value, cannot merely be torn down and replaced. Furthermore, in Toronto, as in other major cities across Canada, many homes contain little or no thermal insulation and therefore need to be retrofitted to reduce the environmental burden associated with their energy use.

Research is underway at the University of Toronto and Ryerson University to adapt an innovative design approach known as Nested Thermal Envelope Design™ (NTED™) to existing and historic buildings. The authors are testing this innovative design concept by retrofitting an 1879 historic, solid masonry home in Toronto to demonstrate the energy saving potential. The approach involves constructing a "building within a building" by delineating "core" and "perimeter" zones each with an independent thermal envelope that can control heat, moisture, and air movement.

In applying NTED™ to a historic building, this paper describes the energy savings that can be expected by using this design approach. For comparison purposes, NTED™ is measured against a base case retrofit that just meets the present energy standards of the Ontario Building Code (OBC). Modelling results show that, by applying NTED™ to an existing building, it is possible to reduce energy demand by more than 70% over an OBC home. These energy savings are achieved through the reduced heating loads associated with only fully conditioning the core of the building. Further energy savings are attained by using a heat pump system to recover core heat losses and passive solar gains from the perimeter. This paper leads to the conclusion that the Nested Thermal Envelope Design™ is a viable and effective option for energy retrofitting existing buildings.

THEORY 2

ENERGY CONSUMPTION IN MID- TO HIGH-RISE RESIDENTIAL BUILDINGS BOTH BEFORE AND AFTER ENCLOSURE REHABILITATION – A TOP-DOWN APPROACH

Eric Burnett, Warren Knowles, Graham Finch, Marcus Dell

In completing a major study of energy use in mid- to high-rise multi-unit residential buildings (MURBs) in BC, it was noted that there were a number of unexpected or unusual aspects to energy usage in this type of building. For example, energy data that was provided by the electrical and gas utility contained anomalies. On roughly a monthly cycle the following energy data was provided: the suites' electrical consumption (all suites together as one reading), the common areas electrical consumption (all common areas are provided as one reading), and gas consumption (usually from one meter reading). This data was correlated, normalized and then standardized in order to assemble annual and monthly records that were subjected to statistical analysis.
Six building are presented as case studies, each having a minimum of two years of energy data both before and after a full-scale building enclosure rehabilitation (replacement of exterior wall, window and roof assemblies to address moisture related deterioration). They are compared from the standpoint of energy use – site energy only. These buildings were extracted from a larger study of 62 buildings. It is important to note that reducing energy consumption was not one of the primary design criteria for the rehabilitation. Rather, the primary design criteria were water penetration resistance and durability of the assemblies.
In doing a top-down assessment of each building the total energy use is known (as opposed to a bottomup approach where one has to know, assume or guess the consumption of each and every appliance or piece of equipment). Avoiding any assumption, one can arrive at monthly and annual estimates of suite electricity, common area electricity (elevators and other equipment, lighting, heating, etc.), and gas consumption (conditioning of ventilation air, domestic hot water, fireplaces, etc.). At the very least, a baseline amount and a variable amount of energy can be derived for each yearly period. This energy is for groups of end-uses and can be plotted against degree days or any other time or weather related axis.
This paper presents an alternate energy analysis technique, and a number of conclusions can be drawn, some of them quite surprising when analyzing energy use in this manner. The analysis presented here complements the findings from the larger study where several alternate energy analysis techniques were used to analyze energy consumption end-use for each of the MURBs. This paper is best read in conjunction with the larger study report (RDH 2011).

AIR LEAKAGE DATA COLLECTION ACCURACY AND REPEATABILITY

Colin Genge, Jamee Desimone

Air leakage measurements are performed at elevated building pressures in order to determine the leakage rate of these enclosures. Pre-existing pressures across the enclosure that are typically due to wind and/or stack (and sometimes active HVAC), are referred to as "baseline pressures". Typically, air leakage results acquired when baseline pressures are small, are stable and repeatable; but as baseline pressures increase, results destabilize and begin to vary over a wide range. Standards such as ASTM E779 and ISO 9972 require that tests be performed at wind velocities below 5 mph and inside the temperature range of 45 to 95 F, but this is typically not possible or practical (especially on larger buildings) where the weather conditions may not fall within acceptable bounds for much of the year. These standards were originally designed for residential houses where baseline pressures would typically be much lower due to less exposure to wind and less stack-producing height. Clearly, a large building testing standard and modified residential testing standards are required that would allow testing under higher baseline pressures and over a wider range of environmental conditions. This paper is dedicated to providing guidance to testing standard committees on how to handle baseline pressures with the goal of producing a more robust air leakage testing standard that can be used within weather conditions that would occur 95% of the time.

ENERGY EFFICIENT RETROFITS FOR RESIDENTIAL BUILDING ENVELOPES

Alex McGowan, Ben Acton

This paper describes a research project conducted for CMHC, resulting in the development of a series of fact-sheets on cost-effective energy retrofits for building envelopes. This was achieved by considering the effects of various envelope upgrades on the energy consumption of archetypal residential buildings in various climates. Real-life examples of cost-effective details are to be reflected in the fact-sheets, and estimated costs and energy savings are to be provided. Environmental benefits of various measures are also to be discussed in the finished publications. The project considers four residential archetypes (1½-storey "Victory Home", semi-detached housing, two-storey residence, and split-level or raised bungalow) in eight Canadian climates, and describes envelope retrofits designed to improve the energy performance of the residence by 10% and by 25% over the MNECH.

The results of the project are intended to address the various aspects of building science and environmental considerations that affect the retrofit choices appropriate in each situation, including: Reduced energy consumption (by reducing heat transfer and air leakage); Increased resistance to moisture-related problems such as surface and interstitial condensation and resistance to wind-driven rain; Constructability, and ease of maintenance and renewals; and Used of environmentally appropriate and sustainable materials.

THEORY 3

SIMULATION OF A CONVECTIVE LOOP FOR THE NTED LOW ENERGY HOUSE

Ian Stahlbrand, Russell Richman

Buildings represent a great opportunity for reducing energy consumption without compromising occupant comfort or functionality. The Nested Thermal Envelope Design (NTED™) is an innovative low energy house design that incorporates two nested thermal envelopes. A three-season perimeter space acts as a thermal buffer zone, where heat loss from the core and solar gain in the perimeter is recovered via an inter-zone heat pump. In order to i) optimize heat recovery from the perimeter, ii) capitalize on passive solar gains, and iii) maintain minimal temperature stratification, a complete loop is formed around the core living space, through which air may flow in a convective cycle. The loop acts as a complex thermosiphon driven by buoyant forces where solar heat gains in the south perimeter space and heat loss in the north perimeter tend to drive the flow in a circular loop. A simplified convective loop was modelled with a commercial CFD software package to examine the effectiveness of passively driven flow. Preliminary simulations indicate the convective loop acts to moderate the temperature distribution in the perimeter, reducing stratification. It was shown that modifying the loop geometry can optimize flow rates in the cavity. It is expected minimal forced circulation may be required to optimize heat recovery. Future work focused on optimizing the performance of the convective loop in the NTED™ house is outlined.

NTED™: APPLICABILITY OF AN INNOVATIVE LOW-ENERGY HOME DESIGN TO NORTHERN CLIMATES

Erin Dixon, Russell Richman, Kim Pressnail, Marianne Touchie

Residential energy use accounts for approximately 19% of the total energy use in Canada. Space heating represents the largest portion of this with percentages varying according to climatic region. For example, space heating accounts for 60% of home energy use in Toronto Ontario and increases to 83% in the northern city of Yellowknife, Northwest Territories. As a result, technologies that decrease residential space heating energy requirements have the potential to make a significant contribution to reduce residential energy use and consequently, total Canadian energy use.

While the higher percentages of space heating energy in northern regions provides the potential for greater overall energy use reductions, these areas provide unique challenges for energy efficient home design. Extreme winter temperatures coupled with limited solar availability result in a greater need for heating energy and remote locations can prove challenging for fuel supply. Furthermore, in very cold weather, even high-performance insulating glazing units can ice up, and concealed condensation and icing can occur within envelope assemblies due to air leakage. Traditional design approaches often do not perform well under such extreme conditions.

This paper presents a design alternative to the more traditional approach of super-insulated homes for northern climates. Known as Nested Thermal Envelope Design™ (NTED™) it is an innovative concept that optimizes building heat gains and losses through the use of nested thermal envelopes. The design incorporates one insulated building inside another to control heat, air and moisture transfer. A seasonal perimeter area acts as a thermal buffer and heat recovery zone, while a core area is conditioned year-round as necessary. Preliminary studies comparing this design to an R-2000 home located in Toronto, Ontario have shown an 85% reduction in heating energy use. While the extreme northern climate of Yellowknife, Northwest Territories results in more modest energy savings, simulation results show that reductions of up to 55% in heating energy use are possible. In addition to saving energy, building performance can also be improved since this approach provides designers with increased control over moisture and moisture movement, thereby reducing the likelihood of condensation in very cold weather.

MATERIAL INNOVATIONS IN BUILDING ENVELOPES OF HIGH PERFORMANCE HOMES

Franca Trubiano

The successful design and construction of the building envelope is an essential feature of high performance buildings. Yet very little new technology has been brought to bear on the design of building skins for residential buildings. The home building industry remains highly conservative in all matters of applied technology, particularly in what concerns the choice of building materials. Moreover, during the past two centuries, architects have been consumed with an all-encompassing desire to dematerialize that of which the building is made; a quest recognizable at widely differing scales and across vastly disparate cultures. Designs whose degree of transparency reduces to a minimum the material interface between inhabitant and environment are of ever-greater interest. This most ubiquitous of pursuits continues to lie at the heart of architectural invention, fascinating architects and clients alike. As a result, many new materials have been invented to facilitate transparency. The research question at the center of this paper asks, therefore: "how the energy profile of architectural materials can best be evaluated when the nature of high performance, ultra-engineered materials is to be weightless, airy, nearly transparent and invisible; that is, immaterial?" Its answer lies in the knowledge that the thermal value of architectural materials has been radicalized during the past two decades. The proliferation of new and emergent materials that increase the energy responsiveness of buildings has vastly altered the terrain upon which materials are assessed for optimal performance. The availability of aerogels, thin film technologies and building integrated photovoltaics makes possible a radical rethinking of the traditional relationship between materiality and thermal performance; and this most particularly in the field of high performance homes.

USE OF VACUUM INSULATION PANEL IN BUILDING ENVELOPE CONSTRUCTION: ADVANTAGES AND CHALLENGES

Phalguni Mukhopadhyaya, Kumar Kumaran, Fang Ping, Nicole Normandin

In Canada, and elsewhere in the world, highly insulated building envelopes are being seen as a potential solution to bring down energy demand for space heating and cooling requirement of built environment. Quite naturally, this has intensified the search for high performance thermal insulation in an unprecedented manner. One of the most promising thermal insulation that can make building envelopes, both new construction and renovation, highly energy efficient is vacuum insulation panel (VIP). Furthermore, use of VIP can generate more living space using less material. The thermal conductivity of VIP is less than one tenth of the same for traditional thermal insulations used in building envelope construction industry. In terms of thermal performance, as indicated by R-value per inch, VIP is undoubtedly the best available thermal insulation. However, for a number of real or perceived reasons, both economic and technical, use of VIP in building construction industry is a rare example at this moment.

This paper will outline the construction and basic physics of vacuum insulation technology, and economic and technical challenges which are keeping VIP away from the building envelope construction industry. At the same time, ongoing activities in Canada and around the world to bring VIP much closer to building construction industry will also be highlighted.

THEORY 4

BRUTE FORCE OPTIMIZATION: COMBINING MASS ENERGY SIMULATION AND LIFE CYCLE ANALYSIS TO OPTIMIZE BUILDING DESIGN

Stuart Fix, Russell Richman

The lack of whole-building design optimization resources available to building designers has led to uncertainty in design decisions involved with building highly sustainable or 'Green' buildings. This uncertainty can be removed using Brute Force Optimization: the process of conducting a massive number of building energy simulations, and combining this predicted operational data with life cycle analysis metrics to optimize building design. This method has been executed over the scope of 1 080 000 single detached home designs under Toronto climate conditions by automating EnergyPlus simulations within Amazon's Elastic Compute Cloud. A lifetime energy consumption analysis was performed using data from Athena's Impact Estimator. Sample analysis shows parameters such as total building size, sub-grade floor area, window U-value, and air infiltration level have the greatest effect on total lifetime energy consumption. Future research is to include more rigorous database analysis and the inclusion of other relevant optimization metrics.

NUMERICAL INVESTIGATION OF THERMAL RESPONSE OF BASEMENT WALL SYSTEMS WITH LOW EMISSIVITY MATERIAL AND FURRED AIRSPACE

Hamed Saber, Wahid Maref, Michael Swinton

In basement wall systems, airspaces can contribute in obtaining a higher thermal resistance, if a reflective material such as reflective foil is installed on one side or the other of a furred-airspace. In this paper, the hygIRC-C model was used to investigate the steady-state and transient thermal performance of a basement wall system that incorporate foil bonded to expanded polystyrene (EPS) foam in a furred-assembly having airspace next to the foil. The furring was installed horizontally. The external layer of this wall is a poured-in-place concrete. Walls with and without Furred-Airspace Assembly (FAA) were considered in this study. Also, consideration was given to investigate the effect the above- and below-grade portions of the wall on the thermal performance when these walls were subjected to a Canadian climate. Results showed that the effective thermal resistance of a wall with FAA at steady-state condition depends on the soil, outdoor and indoor temperatures. Additionally, a wall with FAA and low foil emissivity (0.04) bonded to EPS foam resulted in an energy saving of 17.7% compared to a wall without FAA when these walls are subjected to the same climate condition.

DEVELOPMENT OF AN OPEN SOURCE HOURLY BUILDING ENERGY MODELING SOFTWARE TOOL

Brittany Hanam, John Straube

Computer building energy simulations are an important tool in the design of low-energy buildings. Building energy modeling is used to predict annual energy consumption, determine peak loads for sizing equipment, complete cost-payback analysis to select appropriate energy efficiency measures, and show compliance with standards. While energy modeling is a cost effective tool to assist in design, there are a number of challenges in the current building energy modeling industry. Most energy modeling programs are too technical to be used by architects, and too complex for early design when many mechanical system parameters are not known. Programs that are easy to use lack accuracy and the ability to model new, innovative systems. Programs that allow the simulation of new systems are very complex and have a high learning curve.

A computer program to model building energy loads and energy consumption of mechanical systems has been developed. The program, titled "Building Energy and Loads Analysis" or BELA, has a transparent, open architecture to allow additions and changes, and facilitates the simulation of both simple early design and detailed later design. BELA is currently a simple, single-zone model but could be expanded in accuracy and in its range of capabilities.

This paper presents the theory and calculations used in the BELA program. To demonstrate the application of this program, a group of sample office buildings are modeled in both BELA and eQuest, a popular energy modeling program. The annual energy consumption calculated by each program for the sample group of buildings is compared, and it is seen that there is between 5% and 15% difference between the total energy consumption results of the BELA and eQuest programs.

EXPERIMENTAL INVESTIGATION TO ESTIMATE EFFECTIVE MODULUS OF ELASTICITY AND SHEAR MODULUS FOR BRICK MASONRY WALL IN FLEXURE

Taohida Parvin Akhi, Aftab Mufti, Fariborz Hashemian, Leslie Jaeger

Most of the historic and old masonry buildings are constructed of load bearing unreinforced brick units. As masonry is a non-homogeneous and anisotropic material, its behavior in shear and compressive load is different compared to those of homogeneous and isotropic materials. The tensile strength of masonry is lower than its compressive strength. As a result, masonry structures are more vulnerable to failure under lateral load than vertical load. Heritage and old masonry buildings have not been designed to resist lateral earthquake forces but mainly to resist vertical loads. Hence, upgrading of masonry structures in seismic areas is critical to achieve continuous satisfactory performance. For any rehabilitation techniques it is essential to accurately predict the behavior of masonry materials and masonry wall specially modulus of elasticity (E) and share modulus (G).

This paper presents the experimental program to investigate E and G values of masonry wall under lateral load. Three unreinforced brick masonry walls were constructed and tested by applying in plane horizontal load to study uncracked flexural behavior. This paper presents the experimental result and finite element analysis of one of the three masonry walls. The proposed method of research will be significant since it gives new approach for determining E and G values which are related to the performance of masonry under in plane lateral load.

THEORY 5

DYNAMIC WATER VAPOR PERMEANCE OF BUILDING MATERIALS AND THE BENEFITS TO BUILDINGS

Marysusan Couturier, Craig Boucher

Knowledge of building materials water vapor transmission properties is critical to proper building design. However, using the standard ASTM E96 test method, does not fully describe water vapor transmission properties of air barriers. ASTM E96 only provides two data points for an air barrier. The data obtained does not provide sufficient information to determine an air barrier's response to in situ conditions where the relative humidity will change throughout the day and year. This paper will describe simple modifications to the current standard which allows for measurement of water vapor permeance over a range of relative humidity. Depending on the chemistry of the material, a linear or exponential response can be obtained. Use of this data in hydrothermal modeling allows for more accurate predictions on mold and corrosion within a structure.
The paper will also provide information on the benefits of air barriers that have a variable vapor permeance in typical exterior wall assemblies. As the relative humidity changes, the vapor permeance of an air barrier may fluctuate. This property can provide better performance of wall assemblies in terms of moisture control. The paper will provide examples of wall assemblies in various climate zones to help validate the benefits of variable vapor permeance when exposed to different relative humidity levels.

FIELD THERMAL MASS PERFORMANCE OF AN INSULATING CONCRETE FORM (ICF) WALL

Marianne Armstrong, Hamid Saber, Wahid Maref, Madeleine Rousseau, G. Ganapathy, Mike Swinton

Field monitoring of the dynamic heat transmission characteristics through Insulating Concrete Form (ICF) wall assemblies was undertaken in 2009-10 at National Research Council Canada's Institute for Research in Construction's (NRC-IRC) Field Exposure of Walls Facility (FEWF). The scope of work included the design of the experiments, the installation of test specimens, the commissioning of the instrumentation, the operation of the test facility, the monitoring, data collection & analysis. This research evaluated the dynamic heat transmission characteristics through an ICF wall assembly in FEWF for a one year cycle of exposure to outdoor natural weathering conditions. The monitored data confirmed that the concrete adds very little to the overall R-value of the wall assembly under steady-state conditions. During the transient conditions, the data showed that the concrete played a significant role in tempering heat loss to the exterior. The thermal mass of the concrete was shown to reduce the peak heat flux through the assembly during cold weather. This research is one of a series of projects that highlight direct and indirect impacts of thermal performance of the building Envelope technologies in houses. This paper provides valuable experimental data to be used for energy simulation models. This research is on-going. Future work including the cooling season performance and simulation results will be presented in later publications.

COMPARISON OF ENERGY CONSUMPTION FOR A WOOD FRAME BUILDING USING BATT INSULATION AND A FOIL BACKED EPS FOAM BOARD

Kathy Fedirchuk, Kris Dick

The fundamental objective of this research program was to obtain baseline data on the relative performance of a foil-backed EPS product compared to friction-fit fibreglass batt insulation for wood-frame residential buildings. Results from laboratory tests often lack ecological validity, particularly with a complex system such as a building envelope. Therefore, full-scale in-situ testing of the insulation materials is necessary to evaluate the performance of the new insulation product.

THEORY 6

BIO-BASED FOAM INSULATION FROM SODIUM CARBOXYMETHYLCELLULOSE AND KAOLIN

J-F. Masson, Peter Collins, Slađana Bundalo-Perc, Phalguni Mukhopadhyaya

Mounting environmental regulations combined with pressure on oil prices provide favourable conditions for the sustained development of eco-friendly insulation foams to be used in construction. Current synthetic insulation show both high thermal performance and high environmental footprints. In contrast, natural insulation like cellulose and perlite have a small environmental footprint but their thermal efficiency is lower. The goal of this work was to develop high performance biofoams thermal insulation that is both eco-friendly and show high thermal performance. It follows that biofoams were prepared from kaolin and 1%, 5%, and 10% (w/v) water solutions of sodium carboxymethylcellulose (Na-CMC). Biofoams were obtained from freeze-drying of solutions. Biofoam density, modulus, thermal stability, and thermal conductivity were measured as a function of composition. Results gave densities of 17 kg/m3 to 144 kg/m3 and moduli between 2 kPa and 1 MPa. In thermal stability tests, kaolin was found to reduce char combustion temperature, sometimes by 250ºC. Thermal conductivity values of some biofoams, as measured by ASTM E1952, are found to be close to those of commercial insulation materials.

THERMAL INDUCED STRESSES ON MODIFIED BITUMINOUS LOW-SLOPE ROOFING SYSTEMS

Suda Molleti, Bas Baskaran, Pascal Beaulieu

In Canada, where the design temperatures are below freezing, the modified bitumen roofing membrane are the most commonly used and are in practice since 1950's. The modified bituminous roof membrane system is a two-ply system comprising of a base sheet and a cap sheet. Existing literatures on the thermal induced stresses in the modified bitumen systems indicate that these systems have a history of problems such as blistering, rupturing, splitting and slippage, however, with the improvement in the manufacturing process and better system designs, these issues subsided with time. In the recent past, the issue of membrane ridging on low sloped modified bitumen systems was brought to the attention of National Research Council of Canada. Membrane ridging sometimes referred to wrinkling was a common failure mode observed on BUR systems over the past decade. However, this seems to be emerging on the two-ply mod-bit systems. The question is whether the ridging is the effect of any material or whole system performance. The present paper presents two case studies showing the membrane ridging and also discusses an experimental study that was conducted at the National research Council of Canada to understand the thermal induced stresses in modified bituminous roofing systems.

WOOD SORPTION, CAPILLARY CONDENSATION AND THEIR IMPLICATIONS FOR BUILDING ENVELOPES OF WOOD CONSTRUCTION

Jieying Wang, Phalguni Mukhopadhyaya, Paul Morris

This paper reviews the existing knowledge and a number of controversial issues concerning the relationship between wood and moisture, around basic concepts such as adsorption/desorption, capillary condensation, and the fiber saturation point. It starts with characteristics of wood micro-structure, with a focus on the pores in cell walls, followed by sorption in wood cell walls, the potential for vapour condensation at high relative humidity (RH) conditions, the measurement of wood equilibrium moisture content (EMC) at different RH levels and the concept of fiber saturation point. The discussion is then focused on the potential impact of a number of wood structure and use-related factors on the measurement of EMC under near-saturated RH conditions, particularly about the use of the pressure plate method for predicting the moisture content of low-permeance softwood species. Recommendations were provided on further studies on EMC measurement and EMC testing methods. The intent of the paper is to improve the understanding of wood properties and behaviour in building applications, and emphasise the importance of moisture management in building envelopes.

PRACTICE 1

CHALLENGES AND OPPORTUNITIES FROM DESIGN AND CONSTRUCTION OF DRAINED PRECAST WALL ASSEMBLY

Claude Louvouezo

Traditionally precast panel wall assemblies have been designed as face seal systems where the weather tightness relies on water repellence treatment of the panels and on the detailing of the panel joints, such as binary sealant joints. More recent designs have attempted to incorporate rainscreen principles in the design of precast panel wall assemblies. In a typical rainscreen construction, the back up wall is installed first and then weatherproofed prior to the cladding installation. Such sequence happens to be challenging or impractical when the precast panels are designed as curtain walls to be hung on the building structure. The authors have been involved in projects which addressed the need to install the precast panels first while incorporating a drainage path in the wall assembly. The drainage path was achieved by attaching a drain mat on the back side of the precast panels. This paper will present case studies and lessons learned from two projects recently completed in Vancouver, BC and Portland, OR.

DESIGN CONSIDERATIONS FOR OPEN JOINT RAINSCREEN CLADDING SYSTEMS

Stéphane Hoffman, José Estrada

Recent years have seen an increased trend towards rainscreen cladding system for the benefits they offer in terms of rain water management. These systems typically consist of an exterior cladding, a drainage cavity and a back-up weather resistive barrier. Traditionally in rainscreen cladding designs the joints in the exterior cladding are sealed to minimize the potential for water intrusion into the drainage cavity with the exceptions of weeps and pressure equalization vents which are generally sheltered from water ingress. However recent trends in the design of exterior claddings have seen an increase use of open jointed rainscreen cladding systems. In these systems the joints between the cladding elements are intentionally left open. This paper will discuss the implications of open joints for the performance of rainscreen systems. Various approaches to the design of open jointed rainscreen cladding systems will be discussed and a case study demonstrating the detailing of an open jointed cladding system will be presented

INTEGRATING A VENTED AIRSPACE INTO A SPRAY-FOAM INSULATED SOLID MASONRY HISTORIC BUILDING IN A COLD CLIMATE: A CASE STUDY

Ekaterina Tzekova, Kim Pressnail, Clarissa Binkley, Nastassja Pearson, Paul Pasqualini, Craig Aikin

Historic brick buildings can benefit from the addition of thermal insulation which was not included during the original construction. Such retrofits can reduce the operating energy while improving occupant comfort. However, heritage requirements often limit designers to the use of internal insulation which can lead to facades that are colder and hence less durable.

This paper evaluates an innovative Vented Masonry Retrofit (VMR) approach. When urethane foam insulation is applied to the interior of solid brick walls, a vented airspace is created by incorporated Mortairvent between the insulation and the masonry. To assess the ability of a vented airspace to reduce moisture and moisture-induced problems, modeling software was used to compare the hygrothermal performance of this new application of the vented airspace approach with that of a standard interior insulation retrofit.

Modeling was complemented with a field trial involving a three-storey heritage building. Side-by-side wall assemblies along the east and south facing walls were foam insulated using a Standard approach and the VMR approach. Temperature and relative humidity data were collected during the winter months. The field data showed that the drying capacity of the south–facing wall assembly was increased when a vented space was created; however, data also revealed that the addition of a vented airspace did not increase the drying capacity of the east-facing assembly. Additionally, while the incorporation of a vented airspace reduced the duration of freezing cycles, the number of freezing cycles increased.

A comparison of the field data with the modeling results revealed differences. The modeling predicted that using VMR assemblies would reduced the moisture content in both the east and south elevations as opposed to the field studies which showed an improvement only at the south façade. However, to examine the full potential of the VMR approach, it should be evaluated over a longer time period to assess more accurately the long-term performance and moisture content changes experienced by such historic brick structures.

DESIGNING NET-ZERO HOMES WITH ICF

Cooper Stewart

Since their inception Insulated Concrete Forms have been used across North America to build thousands of energy efficient, durable and comfortable homes and buildings of every shape and size. In the last decade we've witnessed the emergence of the rising Green Building tide which has changed the face of construction around the world. Construction methods have been revolutionized, building codes are becoming more stringent and, now, net-zero homes and buildings have emerged as the cutting edge of green building. Net-zero builders gravitate to ICF because they need durable super-energy efficient building envelopes that are quick and easy to build. Many net-zero homes have already been built using ICF. Although every home is different and every builder and designer has their own unique approach, along the way we've gained considerable insight into the best practices for net-zero building.

We've prepared this whitepaper for those building owners, designers and contractors who want to build cutting edge net-zero homes. This whitepaper contains guidelines and suggestions only. The contractor and designer of record assume full responsibility for the competent design and construction of the construction project. However, we would like you to benefit from the experiences and insights gained from the exciting net-zero projects that have already taken place.

PRACTICE 2

BUILDING EXTERIOR RETROFIT AND ITS IMPACT ON ENERGY PERFORMANCE - A CASE STUDY

Nick Trovato

The building envelope plays a key role in the energy performance of a building and the comfort of its occupants. Read Jones Christoffersen Ltd. (RJC) recently completed a major retrofit of an existing 1960's office building. This building had a very poorly performing building envelope. Water and air leakage was occurring, resulting in high energy consumption. The entire building was stripped to the structure and totally renovated. The building envelope was upgraded and a new mechanical system installed. The new mechanical system used "chilled beams" system – one of the first applications in Alberta.

This paper will discuss the improvements made to the building envelope and the mechanical system and how the integration of the two systems has significantly improved overall occupant comfort and reduced energy consumption. We will present a comparison of current energy consumption data with historical data obtained prior to the retrofit.

REMOTE MONITORING OF AIR MOVEMENT THROUGH A HIGH-RISE, BRICK VENEER AND STEEL-STUD WALL SYSTEM

Trisha Niemeyer, Gerald Genge

The growing availability of economical compact sensors and programmable data logging equipment has allowed for more thorough real-time trend analyses of occupied buildings. Whereas typical in-person building envelope investigations are generally limited to daytime hours and favourable (or simulated) weather conditions, remote monitoring equipment accumulates data during all hours and actual conditions, thereby providing a more complete picture of a building's in-service performance, while minimizing resident disturbance.

Remote monitoring equipment was installed across the exterior wall assembly of a high-rise apartment building in Ottawa, Ontario, Canada. The exterior wall construction consisted of brick veneer backed by an insulated, steel-stud framed wall. Outdoor to indoor air pressure difference was measured in total across the entire wall assembly and in series across the various components forming the wall. Temperature and air moisture content within the stud cavity and the building interior were also measured. Local airport weather records were used for outdoor conditions.

Monitoring locations were selected on both the predominant wind side (East Wall) and the opposite, leeward side (West Wall) of the building. Monitoring results, from data collected between November 2007 and June 2008, were compared to air pressure distribution and theoretical thermal prediction models in order to determine how the in-service walls are actually performing. While the collected pressure distribution data was limited overall by low wind pressures experienced during the study period, the presumed air barrier was clearly shown ineffective. Air leakage was also confirmed through a comparison between the collected temperature data and the theoretical thermal model.

Understanding the differences between actual and theoretical performance of the building envelope allows for more informed analysis and serves as a decision making tool for remedial work. This paper discusses the usability of monitoring outcomes for determining the in-service performance of buildings, identifies lessons learned during the process, and contemplates future considerations for building instrumentation as a diagnostic tool.

ENERGY OPTIMIZATION OF R-2000 UPGRADES

Gary Proskiw, Anil Parekh

A methodology has been developed for optimizing the design of the energy-related features of R-2000 houses based on the costs and energy benefits of various Energy Conservation Measures. Using three representative house types, in three representative climates (Vancouver, Winnipeg and Toronto) with two space heating fuels (electricity and natural gas), the "Value Index" (defined as the incremental cost of an ECM divided by its annual energy savings, $/kWhe/yr) was evaluated for over 46 ECM's for each house type/location/fuel combination. Using this information, a series of Design Guidelines were developed to aid the designer in selecting which ECM's should be included in the design of an R-2000 house.

PRACTICE 3

BUILDING WITH CLT PANELS – DURABILITY ISSUES

Constance Thivierge, Jieying Wang, Graham Finch

Cross-Laminated Timber (CLT) Panels have been manufactured and used in European design for over a decade and have demonstrated great structural performance as well as a good market opportunity for the forest industry. The use of CLT panels in North America is gaining a lot of interest in the construction industry as well as in the wood industry. Several local manufacturers are in the process of product and manufacturing evaluation or have already started pilot production.

In terms of durability, a lot of attention has been paid in Europe to protecting CLT panels from getting wet during construction by delivering the products just in time, minimizing construction time, and providing temporary shelters during construction. Due to the mass of wood in the product, there is a potential for slow drying from CLT once moisture gets into the panel. In addition, other components used in a CLT building enclosure such as insulation and membranes may also have an impact on the drying ability. Therefore, precautions should be taken during design and construction in order to prevent wetting and facilitate drying, particularly in areas with high moisture loads such as the west and east coasts of North America.

This paper focuses on strategies for insulation placement, vapour flow control, air-leakage, and rainwater penetration for the design of CLT building assemblies. Due to the short history of this construction system, more research is to be conducted, and durability performance in service is still to be assessed.

TAKING THE LABORATORY TO THE FIELD: ONSITE TESTING OF BUILDING ENVELOPE SYSTEMS

Kevin Knight, John Runkle, Bryan Boyle

Commissioning of building envelope systems on new and retrofit high-performance construction projects has become recognized as an essential means to ensure that the envelope, as designed and constructed, will function effectively over the desired life cycle of the building and that building performance will ultimately satisfy the Owner's Performance Requirements (OPR). To verify performance of individual assemblies or systems comprising the envelope, mockups are typically tested in a laboratory setting, most commonly for air-tightness, water-tightness, thermal performance and structural integrity, among others. However, given the myriad of potential variables during actual field installation – different installers or installation procedures, environmental conditions, site constraints, material substitutions, etc. – laboratory mockups are often not accurate representations of field installation and as such, there is no verification that the systems as installed will function per the design intent. While visual observation can provide a degree of assurance of system functionality, a comprehensive field testing protocol is required to provide a more accurate and, in most cases, quantifiable assessment of building envelope performance.

This paper will discuss common and not-so-common testing methods and procedures that can be conducted on site during the projects' Construction Phase to verify that the performance of installed systems is consistent with the benchmark performance levels achieved during Pre-Construction Phase laboratory or field mockup testing. Topics to be covered include the differences between laboratory and field mockup testing procedures and the challenges faced when testing on site, replicating mockup testing over the remainder of the project, proper analysis of test results and deciphering the meaning of those results, limitations of some commonly utilized testing procedures, understanding the functional layers of the building envelope (air, water, thermal, drainage) and how those functional layers shape testing protocols, specifying testing procedures and performance requirements, and sampling techniques.

GUIDELINES FOR THE PRACTICE OF BUILDING ENCLOSURE ENGINEERING

Mark Lawton, David Ricketts

The City of Vancouver introduced a requirement in Part 5 of the 1999 Vancouver Building Bylaw (VBBL) that a Building Envelope Professional undertake design review, "enhanced field review" and provide letters of assurance that the components and assemblies of the project substantially comply with the requirements of Part 5 of the VBBL and with the plans and specifications accepted by the City on application for building permit. This requirement applied to all multi-residential buildings and buildings of framed construction.

This action made the practice of building enclosure engineering (or building envelope engineering, or applied building science) a mandatory requirement in a major jurisdiction. This started a process of defining and formalizing the practice of building enclosure engineering in British Columbia. In 1999, the Council of the Association of Professional Engineers and Geoscientists of the Province of British Columbia (APEGBC) adopted the first version of "Guidelines for Professional Practice Building Envelope Professional Engineer".

More recently, members of the Building Envelope Committee of APEGBC reviewed the 1999 document and other relevant documents, such as AIBC's Bulletin 34, endorsed by APEGBC, and produced a document entitled Guidelines for Building Enclosure Engineering Services for Part 3 Building Project. APEGBC's Council is expected to formally adopt these guidelines in the near future. These guidelines set out the standards of practice that a Building Enclosure Engineer should follow and meet when providing building enclosure engineering services for building projects.

The guidelines reflect the current state of practice in jurisdictions where application of independent building science expertise is both mandatory and mature. The logic and contents of the guideline should be of interest to practitioners and building code authorities.

PUSHING THE LIMITS WITH GLASS DESIGN - CHALLENGES AND SOLUTIONS

Hamid Vossoughi, Vladimir Maleev

At a height of 971ft (296 m), the First Canadian Place (FCP) tower, constructed in 1975, is the tallest office tower in Canada. The tower's distinctive white exterior cladding was created with over 45,000 white Carrara marble stone veneer panels, covering about 400,000 square feet (37,000 square meters) of the façade. The owners are currently proceeding with recladding the marble façade to address durability and safety concerns with the deteriorated marble. The owner's consultation with the design team on various design issues and options led to a design that involves replacing the existing cladding with large, bright, white triple laminated glass panels on the primary elevations and bronze double laminated glass panels at the building corners.

This paper focuses on the glass design challenges and the balance between structural performance, durability, constructability, and future maintenance requirements with an awareness and sensitivity to the past performance. This is the largest recladding project in Canada and the largest use of triple laminated glass cladding in North America.

The design team included Bregman + Hamann (Architect of Record), Moed de Armas & Shannon (Design Architect), and Halsall Associates Limited (Preconstruction Engineers).

PRACTICE 4

METER CALIBRATED ENERGY SIMULATION OF HIGH RISE RESIDENTIAL BUILDINGS: LESSONS LEARNED

Brittany Hanam, Graham Finch, Curt Hepting

A study was undertaken to understand the total energy and space-heating energy consumption of mid- and high-rise multi-unit residential buildings (MURBs) in the Lower Mainland of British Columbia. To perform this study, detailed monthly energy consumption data was provided by the local gas and electric utility providers for over sixty MURBs constructed during the past 40 years. Detailed information including drawings, mechanical system specifications, and building history were collected for each building to understand the influence of different characteristics of a building on its overall energy performance. This initial selection of buildings was then narrowed to buildings that had previously undergone building enclosure rehabilitations to address moisture damage. These buildings provided the opportunity to directly compare pre- and post- building enclosure rehabilitation energy consumption and analyze potential energy savings from more thermally efficient and air-tight building enclosures. Whole building energy models of these buildings were created using detailed as-built enclosure Rvalues, air-tightness values from research and some field testing, mechanical information, and building operating conditions. Metered energy was then compared to simulated predictions and calibrations were performed to improve the accuracy of the models to better predict the actual energy consumption. Because information was available for both pre- and post-rehabilitation cases, it was possible to assess the ability of a pre-rehabilitation building model to predict the energy consumption of a corresponding postrehabilitation model. Additionally, common assumptions regarding high-rise residential building energy use were tested including the level of detail required to accurately simulate the thermal performance of a building enclosure. Using the knowledge gained through this energy simulation process, recommendations can be made to improve the accuracy of representative energy use patterns for retrofits and new construction of high-rise multi-unit residential buildings.

EVALUATING THE EFFECTIVENESS OF ENERGY-EFFICIENT RETROFITS ON MULTI-UNIT RESIDENTIAL BUILDINGS: TWO CASE STUDIES

Ekaterina Tzekova, Kim Pressnail, David De Rose, Kevin Day

In large cities like Toronto, there is a growing need to reduce the energy consumption of Multi-Unit Residential Buildings (MURBs). Residential towers in Toronto account for more than 700,000 tonnes of CO2e emissions annually and over 20% of the total energy used by all residential buildings in the city. Most of these towers were built during a time when energy was relatively inexpensive. As fossil-fuel prices continue to rise, the need to reduce the operational energy of these buildings continues to grow.
This paper examines two high rise residential buildings that have been energy retrofitted. Each of these buildings has had window, mechanical system, lighting, and air sealing upgrades. To determine the effect of these retrofit measures on energy savings, energy data was gathered and normalized to account for variations in heating demand related to weather. Further, the normalized data was incorporated into computer simulation models in order to predict energy savings. While modeling results varied, this study found that energy savings from retrofit measures could be reasonably predicted. Taken together, the actual energy use data and the modelling results reveal that energy retrofit measures can be effective. By replacing the windows, boilers, and make-up-air (MUA) units, as well as installing a Building Automated System (BAS) and implementing air sealing measures in a gas-heated building, natural gas savings of up to 40% and electricity savings of 18% were achieved. For an electrically heated building, savings of 18% for natural gas and 42% for electricity were found.

RETROFITTING AND MODERNIZATION OF EXISTING STRUCTURE USING LESSONS FROM OUR PAST

Paul Totten

Before retrofitting or upgrading an existing building enclosure, the designer should examine how the structure and the building enclosure performs including air and moisture transport, acoustics and fire control, as well as how the mechanical system heats and cools the building, delivers ventilation air, and controls relative humidity. We can then determine what effect we will have on the building by changing the level of insulation, air tightness and other building enclosure parameters. This paper will utilize case study examples:

- to show a modernization solution for reinsulating a building
- and a review of the history and type of the structure in the process of solving water infiltration and moisture problems

A DESIGN APPROACH TO ENVELOPE REMEDIATION OF HERITAGE BUILDINGS: FIELD MONITORING OF SALT BUILDING

Hamid Heidarali, Sophie Mercier

The Salt Building is a significant landmark in the Southeast False Creek neighborhood of Vancouver, B.C. The heavy timber industrial structure was built circa 1930 to refine raw salt. Now considered a heritage building, the Salt Building recently underwent a major rehabilitation to be transformed into a commercial building, with restaurant, bakery and cafe.

With the rehabilitation, the interior operating conditions of the building changed from an unconditioned space to a conditioned space. The exterior wall assemblies, which consisted of dimensional lumber clad with horizontal cedar siding installed directly over diagonal shiplap sheathing, needed to be improved to provide adequate protection against rainwater and to incorporate an adequate level of thermal insulation, air barrier and vapour diffusion control. The absence of a moisture barrier in the existing wall assembly and the designation as a heritage building, where the cladding was considered a significant component that needed to be retained, made this a challenging project. Removal of the cladding and upgrading of the exterior portion of the wall was not a viable option.

This paper will discuss our innovative design approach to provide the exterior wall assemblies with the appropriate components to control heat, air and moisture flow with a focus on long-term durability. It will describe how the walls were upgraded from the inside using spray polyurethane foam and a drainage mat to create a vented air space inboard of the sheathing.

The hygrothermal performance of the remediated innovative wall assemblies was monitored by installing sensors to collect the temperature and moisture content of the wall sheathing and studs at specific locations on the four elevations of the building over a period of two years. This paper presents the monitoring results and discusses the performance implications of the applied strategy in dealing with similar envelope remediation of wood frame heritage buildings.

PRACTICE 5

HOUSING CONDITIONS AFFECTING INTERIOR MOISTURE LEVELS: LINKS TO MOULD GROWTH AND CHILDREN'S RESPIRATORY HEALTH

John Wells, Dimos Polyzois, Eleoussa Polyzoi

Understanding how respiratory health risks are associated with housing is essential to designing effective strategies to improve children's quality of life. A survey designed to determine the relationship between respiratory health and housing conditions was completed by 3,423 parents of grades-3 and -4 children in Winnipeg, Manitoba, Canada. Air samples were then taken in the homes of a subset of 715 parents—one in the child's bedroom and another in the basement—with an exterior neighborhood air sample as a control measure. Finally, an engineering audit of each of the 715 residences was conducted—including measurements of relative humidity, temperature, and moisture content of walls. This paper focuses on the results of the engineering audit (assessing variables such as the age of the home, condition of gutters, presence of caulking, age of windows, type of foundation, existence of a crawl space, presence of (Heat Recovery Ventilation (HRV), and presence of an attic). The goal was to assess how each of these variables affects the indoor humidity and building material moisture content of each home. Research has shown that high indoor moisture content promotes the growth of mould, which, in turn, affects the respiratory health of its occupants (Polyzois, Polyzoi, & Wells, 2008). Results from the current study confirm that routine maintenance, including keeping the home's exterior caulking, cladding, gutters/downspouts, and roof in good condition, can have a major impact on reducing interior moisture levels and, thus, stem the consequent potential biological growth (mould) which affects the respiratory health of children.

FIELD HYGROTHERMAL PERFORMANCE OF RETROFITTED WOOD-FRAME WALL ASSEMBLIES IN COLD CLIMATE

Wahid Maref, Marianne Armstrong, Madeleine Rousseau, Constance Thivierge, M. Nicholls, G. Ganapathy, W. Lei

At NRC-IRC's Field Exposure of Walls Facility (FEWF), a field monitoring study to compare the potential for wetting and drying in different wood-frame wall assemblies of different heat, air and vapour flow transmission characteristics was initiated in the Fall of 2008 and continued until the spring of 2009.

Two wall specimens consisted of R20thermal insulation in 2X6 wood-frame construction with an exterior wood-based sheathing, a sheathing membrane and vinyl lap siding. Of these two, one test specimen included a polyethylene air and vapour barrier on the interior side of the stud cavity, behind painted drywall, whereas the other test specimen did not include a polyethylene film. A third R20 2X6 wood-frame wall specimen included an R10 XPS insulating sheathing installed on the exterior of a wood-based sheathing panel and sheathing membrane, as well as a polyethylene air and vapour barrier on the interior side of the stud cavity.

Several factors could affect the wetting and drying of these wall assemblies: indoor relative humidity, air pressurization (depend on wind speed and direction), outdoor temperature and relative humidity, deficiencies that provide a path for air leakage as well as the HAM properties of each layer of the wall assemblies. The test specimens were subjected to a test protocol that permitted investigating the effects of these factors, From January to April 2009, the test specimens were challenged with exposure to outdoor wintertime weather of Ottawa (Canada) and different indoor relative humidity and air pressure levels, as well as incorporation of a "deficiency" (i.e., an opening) in the air and vapour barriers through which air might flow. Continuous monitoring of the relative humidity, temperature, pressure and liquid surface wetting took place at critical layers of the assemblies.

This paper presents and discusses the experimental findings obtained over the course of this study in terms of the hygrothermal response of the wall specimens in relation to their HAM properties, and conditions of exposure and to see the effect of retrofitting an existing wall by adding exterior insulation.

ANALYSIS OF CONDENSATION IN EXTERIOR WALL CLAD WITH PRECAST CONCRETE – A CASE STUDY

Medgar Merceau, Andy Lang

A recently constructed residential tower near Seattle, WA, experienced reports of water accumulation at the interior side of exterior walls clad with architectural precast concrete panels. Analysis confirmed that the source of water was condensation occurring on the interior side of the precast panels. This condensation occurred as a result of bulk air movement from convection, which allowed the interior air and moisture to bypass the interior vapor retarder and thermal insulation, where it condensed on the cold interior surface of the precast panels during the winter.

This paper will present the investigation of the reported moisture problems, including site investigation and monitoring of temperature and humidity conditions within the wall assembly, the unit interiors and the exterior. Hygrothermal modeling was undertaken using both default environmental conditions and actual measured data, to assess the risk of condensation based on the as-built assembly and to aid in verifying the suitability of proposed repairs.

This paper will discuss the specific exterior wall assembly and the detailing and conditions that contributed to the condensation problems. Initial dew point analysis that was undertaken during the design phase will also be presented, which predicted condensation occurring in the assembly if air leakage into or across the assembly was not controlled. Finally, this paper will outline the repair strategy executed to address the condensation problems.

PRACTICE 6

THE BRAVE NEW WORLD: NEW GENERATION BUILDING CONTROLS IN NEW ZEALAND

Chris Murphy

The continuing poor performance of the external building fabric in New Zealand buildings prompted the NZ Government in 2009 to set up a consultative process to once again review the New Zealand Building Act. This second review, following on from one in 2004, was prompted by increasing concern about ongoing weather tightness issues evident in buildings constructed since the initial performance based Building Act was passed in 1991.

The review reflected the Government's apprehension, hinted in a 2009 report, that despite lower failure rates since 2006, there is plenty of more bad news to come in the area of non-performing buildings! Whilst not wanting to take the 'foot off the accelerator' in terms of compliance for appropriately complex structures, the Government had concerns that the parts of the Act are now too cumbersome, too costly to administer and not achieving the outcomes required by the Act's key principles.

This paper monitors the progress of these changes as they wind their way into legislation. It will discuss the reasons for the Government's desire to yet again initiate amendments, particularly in areas related to the introduction of the licensed building practitioner regime, a scheme that will limit certain building work to registered licensed builders. The paper suggests that changes lessening the degree of oversight by Building Consent Authorities (BCAs) to building work should proceed cautiously, and then only after the appropriate back up legislative and educational systems have had time to coalesce and prove their effectiveness.

INTERPRETING THE INTERNATIONAL BUILDING AND RESIDENTIAL CODES REQUIREMENTS FOR DRAINAGE OF EXTERIOR WALL CLADDING SYSTEMS

Andy Lang

Chapter 14 of the International Building Code (IBC) and Chapter 7 of the International Residential Code (IRC) require that exterior walls must be designed with a water-resistive barrier and a means of draining any water that penetrates past the cladding to the exterior of the wall system. There are exceptions to the requirements for a water-resistive barrier and a means of drainage, which include exterior walls that are constructed of mass concrete or masonry, or for wall cladding systems that prevent water penetration when tested in accordance with ASTM E331. This paper focuses on the base requirements for incorporating a water-restive barrier and means of drainage in the wall cladding system, and will not discuss wall systems constructed based on the exceptions to these requirements.

The minimum requirements for the water-resistive barrier are defined in the codes. Minimum requirements for the drainage capacity of the cladding system to direct water to the exterior, however, are not defined in the IBC or IRC. In their adoption of the International Codes, a few jurisdictions have defined minimum drainage requirements. These jurisdictions include the City of Seattle (Seattle Building Code) and the State of Oregon (Oregon Residential Specialty Code), who have published different interpretations of the minimum drainage requirements. Most jurisdictions, however, have not published specific requirements or definitions pertaining to the means of drainage, and thus it remains open to interpretation and potential confusion.

This paper discusses the cladding drainage requirements of the IBC and IRC and the different interpretations that have been adopted by specific jurisdictions. This paper will also discuss means of defining drainage capacity and provide an opinion with respect to designing and constructing to these minimum code requirements.

A RAPID ROOF MODELING TOOL - THE MIT DESIGN ADVISOR ROOF MODULE

Stephen Ray, Leon Glicksman

Previous studies suggest potential for energy savings through cool and green roofs, but do not always consider the many factors that affect potential savings or the relative advantages of different technologies. To further investigate these factors, a tool has been developed and introduced into the existing MIT Design Advisor to allow architects the ability to quickly assess the energy-saving potential of different roof systems. A first principles heat transfer model has been developed for each of the roof technologies, with particular care for green roof heat and mass transfer. Experimental data from Japan and Florida validate the models by predicting roof surface temperature.

Example simulations are run with the tool to show that potential energy savings are highly sensitive to many parameters, particularly roof type, climate, and amount of insulation. To illustrate these dependencies, simulations show that a one-story building in Toronto with a modified-bitumen roof and 1 m2K/W roof insulation can save 24% in cooling and heating energy by adding 4 m2K/W insulation, whereas only 3% if a green roof with is installed instead. However, in Phoenix, the same additional amount of roof insulation to the same building results in 24% savings, while the installation of a green roof results in a 29% reduction.