IRUSE Workshop, June 24th 2013

Engineering Building
College of Engineering and Informatics and Ryan Institute
NUI Galway

Integrated modelling and performance of built environments

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9:30-9:40	**Sustainable buildings**	BRE Ireland	Ms. Amanda Gallagher	Technology Strategy Board Building Performance Evaluation
9:40-9:50		TCD	Dr. Oliver Kinnane	The Low Carbon Adaptable Home prototype project
9:50-10:00		NUI Galway	Mr. Alan Armstrong	Environmental life cycle assessment study of Irish residential buildings from an energy and carbon perspective
10:00-10:20		Discussion		
10:20-10:50	Coffee break			
10:50-11:00	**Ventilation & air quality**	NUI Galway	Dr. Harald Berresheim	The self-cleansing capacity of our atmosphere – limitations on local to global scales
11:00-11:10		TCD	Dr. Aonghus McNabola	Air pollution in buildings and how this relates to energy efficiency
11:10-11:20		NUI Galway	Mr. James McGrath	Development of a computational model to evaluate personal exposure to particulate matter in indoor microenvironments
11:20-11:30		UCD	Dr. Donal Finn	Investigation of the influence of external wind conditions on internal airflows in naturally ventilated spaces using CFD analysis
11:30-11:40		NUI Galway	Ms. Magdalena Hajdukiewicz	Numerical modelling of operating naturally ventilated indoor environments
11:40-11:50		UCD	Dr. Donal Finn	Indirect evaporative cooling potential in air–water systems in temperate climates
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12:10-12:20	**Building fabric properties**	WIT / TCD	Mr. Derek Sinnott	Measured airtightness of existing dwellings in Ireland
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14:00-14:10	**Building fabric properties**	Building Life Consultancy	Mr. Joseph Little	Managing moisture – the key to healthy internal wall insulation retrofits of solid walls
14:10-14:20		DIT	Mr. Lee Corcoran	A hygrothermal analysis of international timber frame wall assemblies tested under temperate maritime climatic conditions
14:20-14:30		NUI Galway	Mr. Des Dolan	Life Cycle Assessment (LCA) on timber construction products produced from Irish forests
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15:50-16:00	**Closing address**	NUI Galway	Dr. Jamie Goggins	
16:00-17:00	**Tour of the Engineering Building - the living laboratory**			

Session 1: Sustainable buildings

1. Technology Strategy Board Building Performance Evaluation

Amanda Gallagher
Building Research Establishment (BRE)

Building Performance Evaluation is an essential tool in closing the loop between design targets and actual performance in the built environment. There is typically a significant discrepancy between the predicted energy performance of a building (and hence its $C0_2$ emissions) and its measured performance. These discrepancies arise from a variety of sources, ranging from the design and modelling tools used in the design of the building, through buildability, build process and build quality, systems integration and commissioning, handover and operation, to the understanding, comfort and motivation of occupants. The UK Technology Strategy Board has committed £8 million to fund the costs of building performance evaluation studies on domestic and non-domestic buildings. Over 100 buildings are being evaluated using a variety of tools and testing methods including CIBSE TM22, DomEARM, Co-heating Tests, U-value Measurement, Thermography, Air Permeability Testing, BUS Surveys, Energy Surveys and Analysis, Air Quality and Environmental Monitoring and Energy Sub-metering. The research programme will run from 2010 until September 2014. Early findings are emerging and data will be available for analysis and research from TSB at the end of the programme. Northern Ireland currently has three projects in the research programme – the results of these studies will be discussed as well as early findings from other projects in the UK.

2. The Low Carbon Adaptable Home prototype project

Oliver Kinnane, Tom Grey, Jamie Reynolds & Mark Dyer
TrinityHaus School of Engineering, Trinity College Dublin, Dublin, Ireland

The Low Carbon Adaptable Home prototype (LCAH) is a collaborative design, build and research project supported by Enterprise Ireland and being undertaken by TrinityHaus Research Centre, with industry partner Glenbeigh Offsite Ltd.
The house is built using light-gauge steel offsite construction. It was designed around two concepts 1. low carbon operation and 2. adaptable form. The house is designed as a holistic residential product for the Irish domestic market and for export markets. To evaluate this novel housing-product, and the success of these concepts of low energy and adaptability extensive modelling and monitoring studies are being undertaken. Results of the modelling study of the LCAH are presented. Operational parameters such as energy consumption and occupant comfort are assessed via simulation for comparison to real monitored conditions. Design decisions are evaluated through analysis of overheating risk solar gain and thermal mass potential.

3. Environmental life cycle assessment study of Irish residential buildings from an energy and carbon perspective

Alan Armstrong & Jamie Goggins
Department of Civil Engineering, National University of Ireland Galway, Galway, Ireland

Residential construction activity has formed an integral component to Ireland's economy recently and hence contributed substantially to national greenhouse gas (GHG) emissions and energy consumption over this period. With Ireland wishing to reduce environmental damage attributed to the residential construction sector, quantification systems capable of identifying carbon hotspots requires attention. One methodology of carbon footprint quantification is environmental lifecycle assessment (LCA) of residential buildings from an energy and carbon perspective. As residential homes become increasingly energy efficient during its operational phase, more focus will switch towards sustainably sourcing building materials for future building projects. Total embodied energy and embodied carbon contributions for selected residential buildings are calculated between 16-27% and 23-34% respectively. Further analysis highlights favourable Irish building element scenarios from an environmental and economic perspective. Through utilising environmental LCA mechanisms in Ireland, an increasingly sustainable construction industry can significantly aid to achieve national environmental targets in the long term.

Session 2: Ventilation & air quality

4. The self-cleansing capacity of our atmosphere – limitations on local to global scales

Harald Berresheim
School of Physics and Centre for Climate and Air Pollution Studies, National University of Ireland Galway, Galway, Ireland

I will present a brief summary of my past and present research including: studies of volcanic emissions and their global contribution to sulfur pollution in comparison to anthropogenic emissions, oceanic phytoplankton emissions of sulfur and their potential relation to global climate, impacts of sulfur and nitrogen compounds, aerosol particles, and ozone on health and environment, aerosol particle formation from gaseous precursors and relation to cloud microphysics, role of hydroxyl radicals as the dominant "detergent" of the atmosphere and its limitations by pollution including long-term changes in methane and carbon monoxide levels.

5. Development and assessment of an energy efficient air pollution control system for building ventilation systems

Aonghus McNabola & Laurence Gill
Department of Civil, Structural & Environmental Engineering, Trinity College Dublin, Dublin, Ireland

An air pollution control device, designed to restrict the amount of particulate matter passing through it, was developed on the principle of aspiration efficiency. The performance of this new form of air pollution control was assessed in terms of its remediation efficiency for PM2.5 at the ventilation inlet of a medium sized office building. Physical prototypes and 3D computational fluid dynamics models were developed to i) prove the concept behind the device, ii) assess its long term energy saving performance, and iii) quantify the scalability of the device across the building sector.
The results of the investigation indicated that the device was capable of restricting the passage of 50% of PM2.5 into the ventilation inlet of the commercial building depending on average. The technology also demonstrated significant potential to reduce the operating costs of building ventilations systems by up to 20% as an add on to the ventilation inlet. Long term energy savings were achieved by reducing the particle loading rate and hence pressure drop across existing panel filters. Implementation of this new device in practise may significantly improve the sustainability of buildings.

6. Development of a computational model to evaluate personal exposure to particulate matter in indoor microenvironments

James McGrath & Miriam Byrne
Centre for Climate and Air pollution Studies (C-CAPS), School of Physics, National University of Ireland Galway, Galway, Ireland

In this presentation, the development of a computational model to determine concentrations of Particulate Matter (PM) in indoor microenvironments (e.g. home, office, car), will be summarised, and the process by which one can estimate the personal exposure of individuals who are moving through a series of microenvironments will be described. The model has the ability to simulate PM concentrations that are subject to one or several of the following processes: infiltration from outdoors, transport through a multizone enclosure, deposition, resuspension or indoor generation. Concentrations can be estimated on a timescale of minutes, so that the effect of short-term variations in air exchange (due, for example, to a door opening event) can be investigated. The model has potential for use by policy makers, as it allows accurate assessment of the success of (a) outdoor air pollution control interventions and (b) building air tightness interventions in improving building occupants' respiratory health.

7. Investigation of the influence of external wind conditions on internal airflows in naturally ventilated spaces using CFD analysis

Joseph Horan & Donal Finn
School of Mechanical and Materials Engineering, University College Dublin, Belfield, Dublin, Ireland

A key issue that arises in the use of natural ventilation is the assessment of building internal airflow conditions. Changes in the external microclimate may give rise to unpredictability of internal airflow, thereby leading to internal discomfort when certain (non-design) external conditions prevail. The current work is concerned with the influence of external wind conditions on internal airflows in naturally ventilated spaces. The work has been carried out using a combination of computational fluid dynamics (CFD) and experimental measurement on an instrumented naturally ventilated building. This research addresses the uncertainty associated with external wind conditions and internal airflows leading ultimately to the establishment of design knowledge. M work aims to quantify the effect of changes in external wind conditions on airflows induced in naturally ventilated spaces with the ultimate aim of developing insight that will assist architects and engineers engaged in design of naturally ventilated buildings.

8. Numerical modelling of operating naturally ventilated indoor environments

Magdalena Hajdukiewicz & Marcus M. Keane
IRUSE Galway, Department of Civil Engineering and Ryan Institute,
National University of Ireland Galway, Galway, Ireland

Computational fluid dynamics (CFD) is a robust tool for modelling interactions within and between fluids and solids. However, the accuracy of CFD predictions is a big concern. There is a need for robust computational models that accurately represent environmental conditions in operating naturally ventilated buildings.

This presentation examines the possibility of employing CFD to simulate, and potentially operate, naturally ventilated environments, considering the uncertainty of available data. In this research, calibrated 3D virtual models of two internal environments were developed. The CFD models were supported by physical field measurements from wireless sensors and a locally installed weather station. The numerical boundary conditions were analysed for their effect on model results and its accuracy, by utilising parametric and regression analysis. This provided a systematic and robust calibration process of CFD models that represented environmental conditions in operating buildings. Those calibrated models allowed then for ensuring satisfactory, in terms of thermal comfort, indoor conditions for the building occupants.

9. Indirect evaporative cooling potential in air–water systems in temperate climates

Mehdi Nasrabadi & Donal Finn
School of Mechanical and Materials Engineering, University College Dublin, Belfield, Dublin, Ireland

Recent developments have prompted a review of evaporative cooling technology as an effective means of cooling modern deep plan buildings. Prominent among these developments is the success of high temperature sensible cooling systems, particularly, chilled ceilings, which require a supply of cooling water at 14–18^{o}C. Crucial to the success of evaporative cooling technology, is the ability to generate cooling water, in an indirect circuit, at a temperature which closely approaches the ambient adiabatic saturation temperature (AST) or wet bulb temperature (WBT). Recent experimental research has demonstrated that it is technically viable to generate such cooling water at a temperature of 3 K above the ambient AST. The talk will examine results of experimental research into the achievement of low approach conditions in an evaporative and the energy performance of this test rig when generating cooling water, indirectly, at the temperatures required for chilled ceilings. In additional the talk will discuss some experimental research results into the thermal effectiveness of a water-side, open, indirect evaporative cooling test rig, designed to achieve low (1–4 K) approach conditions in the temperate maritime climate.

Session 3: Building fabric properties

10. Measured airtightness of existing dwellings in Ireland

Derek Sinnott
Waterford Institute of Technology, Waterford, Ireland

This study focuses on the quantitative data gathered from a small number of single family social housing units. The results show that the measured airtightness was often worse than the Dwelling Energy Assessment Procedure (DEAP) default. The study also explores why many of the newer dwellings exceeded the Part L airtightness standard and why some of the older dwellings were the most airtight.

Fabric upgrading of four dwellings included installation of passive and active ventilation, but did not involve improving airtightness - an obvious missed opportunity. However, post upgrading airtightness testing revealed a considerable reduction in building leakiness.

There is significant scope to improve the airtightness of existing dwellings in Ireland. The results underline the importance of including airtightness as part of a retrofitting strategy. Achieving improved airtightness is in effect governed by economics, good design, attention to detail, and rigorous on site controls.

11. Sustainable fire engineering

C. J. Walsh
Sustainable Design International Ltd. - Ireland & Italy

Fire Engineering ... involves much more than mere compliance with building regulations and codes ... whose fire safety objectives are limited, and whose performance requirements are sometimes inadequate and always minimal. More problematically ... a fundamental conflict is mushrooming between Sustainable Climate Resilient Building Design and Conventional Fire Consultancy Practice.

However ... **Sustainable Fire Engineering Design Solutions** are:

- Reliability-based ;
- Person-centred ; ... and ...
- Adapted to Local Conditions ... geography, climate (incl. change, variability and severity swings), social need, culture, and economy, etc.

This **Presentation** will discuss collaborative 'trans-disciplinary' research opportunities in the following areas ...

1. Fire-Induced Progressive Damage in Buildings
2. Human Behaviour and Abilities in a Fire Situation
3. Building Design for Firefighter Safety
4. Creative Fire Engineering Concepts and Building Systems
5. Computer Modelling, BIM & Fire Engineering

Output must be targeted at implementation in 'real' buildings!

12. Managing moisture – the key to healthy internal wall insulation retrofits of solid walls

Joseph Little & Beñat Arregi
Building Life Consultancy Dublin, Ireland

This study investigates the appropriateness of internally insulating solid walls to the Passivhaus standard. A number of variables are assessed using numerical hygrothermal simulation (under EN 15026) to check (1) associated risk of mould growth on original substrate and (2) if they result in a greater likelihood of timber decay at built-in joist ends.
We simulated 48 variations of a one-dimensional solid brick wall build-up in WUFI Pro and 18 two-dimensional variations of a built-in joist end detail in WUFI 2D. These cover variables such as exposure to driving rain, brick characteristics, type and amount of internal insulation (see Table 1). We deliberately focused on lower cost internal insulation options:

- Cellulose blown through a gauze, as representing a 'low-carbon' approach;
- Cellulose with an AVCL, as representing a 'best practice' approach;
- PIR with foil face taped, representing a 'commercial' approach.

13. A hygrothermal analysis of international timber frame wall assemblies tested under temperate maritime climatic conditions

Lee Corcoran
Dublin Institute of Technology, School of Architecture, Dublin Energy Lab, Dublin, Ireland

As the use of timber frame construction increases it is important that the assemblies specified have sufficient drying capacity to withstand any moisture loads that may occur over the life of the structure since decay is heavily dependent on the presence of moisture. The purpose of this study was to assess the hygrothermal performance of common timber frame wall assemblies under temperate maritime climatic conditions. Four timber frame wall assemblies were simulated using WUFI 2D. An additional moisture source was modelled to simulate wall performance under the presence of a construction defect. The results show that under normal conditions all four wall types behave in a similar manner. However once the moisture source is added, moisture contents in two of the wall types exceed thresholds above which the risks of mould growth are high. This effect is the result of the location of the OSB sheathing on the external side of the timber frame, which limits the escape of moisture from the wall assemblies. Wall types where the OSB is on the internal side have greater drying rates due to the increased rate of moisture mass transfer through the wall. This drying capacity is important in humid climates where the probabilities of high moisture loads are greater.

14. Life Cycle Assessment (LCA) on timber construction products produced from Irish forests

Des Dolan & Annette Harte
Department of Civil Engineering, National University of Ireland Galway, Galway, Ireland

Climate change is widely accepted as the greatest environmental challenge facing the world today. The increase of greenhouse gas emissions, especially CO_2, into the atmosphere is a major contributor to climate change. As buildings account for 36% of EU CO_2 emissions, the use of sustainable construction materials, such as wood, has a major role to play in the reducing our CO_2 emissions. In line with National and EU policy for sustainable development and resource efficiency, it is becoming accepted that a life-cycle approach to product development and construction must be adopted. In order to implement such strategies, it is essential that an accurate database is available on the whole-of-life greenhouse impacts of the materials used. The aim of this research is to quantify the carbon impacts associated with the wood construction products produced in Ireland over their whole life cycle using an environmental assessment technique known as Life Cycle Assessment.