Event 3: Sandpit

The aim of the sandpit event was to determine key research needs and identify opportunities for funding applications for cross-disciplinary projects, building on the outcomes of the previous activities. The sandpit was held on Tuesday 25th April 2017, at the Glasgow School of Art. The event was followed by the annual UK Indoor Environments Group conference on 'Indoor Environments and Health in Buildings', which is a networking event for a multidisciplinary audience of academics, policy makers and industry experts with an interest in improving indoor environments for health and wellbeing.

Six sandpit sessions were supported in total, following on from the outcomes of the workshop event and discussions during the steering group meeting, held in February 2017.

The purpose of the event was to refine proposals for multidisciplinary projects to be submitted as joint funding applications. Participants worked in small groups (<10 people) to brainstorm and refine ideas.

An informal agenda was devised, which covered the following activities:

- Introduction and overview
- Define the scope and the problem
- Ideas generation
- Identify aims and objectives
- Development of project proposal
- Outline of research bid
- Presentation development

At the end of the day, groups were asked to present their project ideas to participants for feedback, and submit a short summary of their research proposal with details of the research question, aims and objectives, and possible next steps. The event brought together 41 participants from the UK, Ireland, the Netherlands, China, Belgium, Austria, and Denmark.

The sandpit resulted in the development of six project proposals, which will now be taken forward by the groups and advanced as funding applications.

Sandpit Programme

10:30	Registration, tea and coffee
11:00	**Introduction and Overview**
11:30	Parallel Sandpit sessions
Session 1	Chair: **Jan Sundell** Cross Sectional Study of Children's Health and Homes
Session 2	Chairs: **Pawel Wargocki and Sani Dimitroulopoulou** Changing Nature of Pollutant Exposure in the Home Environment
Session 3	Chairs: **David Waddington and Jack Harvie-Clark** Ventilation Noise Levels and Occupant Perception in Airtight Homes
Session 4	Chair: **Tom Woolley** Chemical Emissions of UK Residential Construction Materials: Lessons from Europe
Session 5	Chairs: **Ian Mawditt and Mich Swainson** State of the Art of UK ventilation: RH as a metric for ventilation performance
Session 6	Chair: **Anthony Seaton and Tim Sharpe** Solutions / New Perspectives (Open call)
13:00	Lunch
14:00	**Parallel Sandpit Sessions (continued)**
16:10	Tea and coffee
16:30	**Research Proposal Presentations and Discussion**
17:30	Close

Photos from the sandpit event

Workshop session: Ventilation Noise Levels and Occupant Perception in Airtight Homes

Workshop session: Changing Nature of Pollutant Exposure in the Home Environment

Proposed research projects in development

1) *Cross sectional study of children's health and the home environment*

The UK has one of the highest prevalence of asthma sufferers in the world. In Scotland, 368,000 people are currently being treated for asthma, including 72,000 children. Last year, annual statistics from the National Records of Scotland revealed asthma death rates in Scotland were at their highest for more than a decade. Despite extensive research in this field, the aetiology of asthma and allergic disease is poorly understood; partially due to the lack of standardisation in methodology and case-definition in epidemiology studies, therefore limiting the value of temporal and spatial comparisons. Previous studies have identified a history of atopic disease within the family as a risk factor for asthma development. However the impact of environmental factors, particularly the home environment, is less understood.

The aim of this study is to explore the role of the home environment on the aetiology of childhood asthma in Scotland. The context of the proposed research is existing evidence of higher allergy levels in UK, Australia, and New Zealand; and a current impetus to address air pollution in the UK. The study will replicate a methodology employed by Prof Sundell and colleagues in previous studies in Sweden, USA, and China, using standardised questionnaires developed as part of the ISAAC study, to identify the prevalence and severity of asthma, rhinitis and eczema in children.

2) *Assessment of chemical emissions from UK residential construction materials*

This project considers indoor environment in the domestic sector and aims to investigate volatile organic compound (VOC) emissions from common building materials. The project includes the review of UK and European legislation and standards relating to indoor air pollution and an assessment of the relevant existing measurement methodologies and protocols. A number of dwellings representing a range of standard UK construction types will be selected for a monitoring pilot, to establish VOC concentrations and the potential health effects on the building occupants.

The study will identify methodologies, protocols and construction materials for a larger study to acquire data on typical UK construction and related in-situ emissions, which can then be translated into practical guidance for architects, designers and specifiers to facilitate identification and specification of low-emitting building materials.

3) *Influence of ventilation design on the prevalence of anti-microbial bacteria in homes*

This project (funded by the AHRC: AH/R00207X/1) will investigate how contemporary housing design affects the indoor microbiome, and what the effects of this might be on anti-microbial resistance. In the early 19th century, the way that houses were designed led to considerable improvements in public health, largely as a result of improvements in sanitation, but also access to fresh air and sunlight. In recent years however, commercial interests and building legislation have largely dictated design issues. During

this time the ways that buildings have been designed and constructed has changed significantly, mainly as a response to issues of climate change. Improved thermal performance and increasing airtightness has been able to isolate the building from the external environment. Whilst this will have benefits in terms of reduced carbon dioxide emissions, lower running costs and better comfort, it is becoming increasingly clear that levels of ventilation and consequent standards of indoor air quality (IAQ) are reducing and there is emerging evidence that this might have negative health impacts. Whilst there are a number of dimensions to IAQ, one area that has not been researched is the prevalence and nature of microorganisms. People - especially vulnerable groups such as the old and very young - spend a great deal of time in the home, and so any change to the indoor microbiome may significantly affect occupants' health. There is a concern that isolation from the outside environment may reduce diversity and result in proliferation of harmful microorganisms, including those that have antimicrobial resistance.

This study aims to close this gap in knowledge by undertaking an assessment of contemporary housing to determine the ventilation characteristics and relate this to the presence and nature of microorganisms in the home, with the specific aim of identifying factors that would impact on the presence and proliferation of anti-microbial resistant microorganisms. It anticipated that this could lead to changes in the way that we design buildings, in particular ventilation provision, and the project will aim to address this through a programme of academic, industry and public dissemination.

4) *Changing nature of pollutant exposure in the home environment: New-build versus retrofit home environments and risks*

Over the last decade, significant improvements have been made to the thermal performance of dwellings, particularly the airtightness of building envelopes. It is now well evidenced that increasing airtightness is likely to increase the concentration of air pollutants indoors. However much less is known regarding the changing nature of these pollutants in modern housing.

For instance, in modern airtight housing, tobacco smoke has been largely eradicated. There is also less influence of ambient pollution. The introduction of new chemicals in the indoor environment is exceeding the ability of regulators to effectively evaluate these in terms of their potential risk to human health. How might this new cocktail of pollutants influence the health of building occupants? Given that airtightness is continually improving in the UK, this information will be crucial to ensure the protection of occupant health in future housing.

This study will identify if/how the type of pollutant exposure in homes has changed, and investigate how this new cocktail of pollutants might influence occupant health. Are there any new pollutants emerging? What are the new risks? Is there a difference between pollutant levels in retrofitted and new-build homes? The study will benchmark exposure in new-build and traditional retrofitted dwellings, while establishing a mechanism to connect measured pollutants with associated sources and processes (e.g.

lifestyle, culture, materials etc.). The results can be used to propose solutions to manage the problem.

5) *Ventilation noise levels and occupant perception in airtight homes*

Noise can be a significant constraint to the use of modern ventilation systems, as there is a tendency for residents to turn off noisy equipment in their home, partly due to acoustic disruption but also linked with associated energy cost concerns. Without adequate ventilation in modern airtight dwellings, air quality can have a significantly adverse effect on the health of the occupants. This most often occurs at night time when people are settling to sleep, resulting in adverse impacts on IAQ.

The aim of this project is to overcome noise as a barrier to the use of mechanical ventilation systems in modern airtight homes. An initial pilot study will investigate occupant perception of ventilation noise in a social housing context, which will be followed by physical measurements in selected homes to inform a larger study. The aim of the larger study is to establish which noise characteristics of ventilation systems are best suited for sleep.

6) *State of the art of UK ventilation: moisture as a metric for ventilation performance*

The topic of IAQ and ventilation effectiveness in dwellings is very broad. Multiple pollutants and their associated sources, and the wide range of resident preferences/activities make assessment of IAQ complex. It is now common for metabolic CO_2 to be regarded as a general indicator for the quality of indoor air and ventilation effectiveness. Increasingly domestic ventilation systems offer demand control functions, modulating on RH and CO_2 amongst other inputs. But is this making things more complicated than they need be? Does it offer long term reliability, what is the longevity both in life and accuracy of small NDIR CO_2 sensors?

Bio effluents and moisture have, for some time, been considered the main pollutants in homes, and control of these pollutants remains to be the basis for established background ventilation rates in building performance standards. Controlling ventilation rates based on only CO_2 instead of moisture content (typically using relative humidity as the metric), may mask non-metabolic moisture generation. This approach is common in non-domestic buildings, but in dwellings may result in some spaces being ineffectively ventilated, possibly leading to potential health and building fabric problems.

The aim of this proposed study therefore is to understand what control inputs are needed for effective demand control and whether these can provide a robust means of achieving good IAQ in buildings. Is complex sensors required or can we effectively regulate systems based on RH and temperature (e.g. using indoor and outdoor vapour pressure data)? This will be achieved through a review of ventilation performance and effectiveness in domestic environments where data of CO_2 and moisture content can be compared and correlated with occupancy, activities and external conditions. Where

information is available for other indoor pollutants this will also be included in the assessment. The study will seek to determine whether CO_2 provides a useful proxy over and above moisture, or whether moisture content on its own is an adequate proxy for effective ventilation control throughout the year.

7) *A pilot investigation into relationships between ventilation and health status of people with chronic obstructive pulmonary disease (COPD) in contemporary airtight homes*

In the UK about 1 million people over the age of 60 have Chronic Obstructive Pulmonary Disease (COPD). Although the effects of outdoor air pollution on COPD are well established, the effects of indoor air pollution on COPD especially in the elderly remain unknown. There are increasing concerns that whilst new building regulations introduced to combat climate change make houses more airtight and thermally efficient, the construction materials and lack of ventilation may adversely affect indoor air quality and could be detrimental to the health of vulnerable groups, such as elderly people with COPD.

In this pilot study we will use a postal survey of elderly people (≥65years) with COPD to investigate associations between levels of ventilation predicated on building design and respiratory health. In a more detailed study of 50 elderly people with COPD, measurements will be made in the home of airtightness, ventilation provision, actual ventilation and indoor air pollution and related respiratory health.

8) Ventilation and house dust mite proliferation in high density student accommodation in Scotland

This study will investigate the impact of ventilation and resulting indoor environmental conditions on the levels of house dust mites in modern airtight high density, non-serviced student accommodation in Glasgow. The hypothesis is that modern, poorly ventilated student residences will have higher levels of moisture and more stable environmental conditions than well ventilated residences, resulting in higher levels of house dust mites and greater risk of adverse health effects. Student accommodation has been selected as a building typology with small room sizes and a tendency to be intensively occupied. Measurements of HDM levels and environmental conditions will be monitored simultaneously in selected accommodation over a 12-month period, to investigate the impact of seasonal and temporal changes in ventilation and environmental conditions on HDM proliferation. Occupant behaviour (particularly occupancy and cleaning and heating regimes) will be measured through use of an occupant diary.

The study will help to i) Establish concentrations of HDM in student accommodation in Glasgow, ii) Identify key design variables and risk factors associated with HDM proliferation, iii) Evaluate the impact of seasonal and temporal changes on HDM levels, iv) Identify associations between ventilation effectiveness and HDM levels. The findings will be used to develop strategies to improve the quality of the indoor environment in student accommodation and reduce the risk of HDM proliferation, while providing an

evidence base for future work to investigate the potential implications on occupant health.

9) *Bedroom ventilation and asthma exacerbation among school children*

It is known that there are diurnal changes in the physiology in asthma patients in which airways become constricted overnight, with a consequence of an increase in asthma attacks during this period. Sufferers are known to experience some relief through opening windows during asthma events. At the same time, there is increasing evidence of poor ventilation rates in bedrooms of modern airtight buildings with limited ventilation provision. The aim of the study is to compare ventilation rates and concomitant effects (moisture, temperature and pollutants), with the frequency of asthma events and lung function of children with asthma living in modern homes.

We know patients with asthma are susceptible to their environmental conditions and that poor ventilation is an important factor. The hypothesis is that improved levels of ventilation in bedrooms overnight will lead to reduced incidences of asthma and improved lung function rate. There are a number of components that determine levels of ventilation. However, window opening has the single biggest effect. Comparing windows open and closed gives a clear measure with which asthma events and lung function can be compared.

If you are interested in finding out more information about the proposed research projects, please contact the Session Chairs or the Network Organisers.