SEAHA CENTRE FOR DOCTORAL TRAINING IN SCIENCE AND ENGINEERING IN ARTS HERITAGE AND ARCHAEOLOGY

SEAHA Studentship:

Novel Retrofit Technology Incorporating Robots for Lower Energy Healthy Buildings

There are ~22.2 million dwellings in England. One in five (21%) dwellings were built before 1919. About three quarters of these older dwellings have been subject to at least some major alterations since they were built, mostly extensions or loft conversions. A further 17.9% of dwellings was built between 1919 and 1944 and further 18% from 1945 to 1964. Dwellings built after 1990 account for just 12% of the stock. A large proportion of English housing stock is thus considered as heritage.

Novel technologies for retrofit of our ageing stock would enable us to reduce its carbon emission and alleviate fuel poverty in a cost-effective way. This is essential for preservation of the heritage housing stock. The company Q-Bot has developed an innovative system for reducing heat loss through suspended timber floors that applies PU insulation from underneath. A robot is inserted into the floor void, surveys the void and condition of the floor, sprays insulation to the underside of the floor boards, and verifies the area and depth of insulation applied. This keeps the appearance of the floor (which could itself be considered as a heritage element) on the warm dry side, while maintaining ventilation within the floor void. Access can be made through an air vent in the outside wall, or through a small opening in the floor from within the property. This minimises disruption to residents and results in a typical install time of 1-2 days.

Initial 'in-house' experiments indicated that spraying insulation to suspended timber floors could reduce heat loss through the floor by 85%, reduce temperature stratification within the room, and reduce draughts in the property by up to 40%. This creates a warmer, comfortable home, and reduces energy bills. In older, solid wall properties the service is often the most cost effective way of improving the EPC rating.

Customers such as local authorities value the low-disruption energy performance improvement. However, an important question needs to be addressed: the PU foam itself and its impact on the indoor environment and occupants during the installation and afterwards. The currently used PU foam is sourced from BASF (Walltite) and it appears to contain ~30 Volatile Organic Compounds (VOCs), some with unknown effects on human health. This could potentially create a risk to inhabitants sue to exposure to chemicals that might, in the future, turn out to be (or have been) harmful.

This project aims to explore the impact of various PU foams (and other sprayable insulation materials) on environmental and energy performance of retrofitted historic houses.

Research questions

1. Following an in-depth literature review, can commercially available PU foams and other sprayable insulation materials be identified that could be used in historic building refurbishment?
2. Can emission rates of selected VOCs be determined under controlled conditions? What are the short, mid and long term impacts of VOCs on health and exposure thresholds in dwellings?
3. Can ventilation modelling be used to analyse the impact of various ventilation design options and ventilation rates on the concentration of selected VOCs? How can energy modelling be optimised to predict the overall effect on energy use?
4. Based on experimental and modelling work, can protocols to mitigate risks during the installation phase and building use be developed and validated in case studies?

The project will be supervised by Professor Mumovic, UCL Institute for Environmental Design and Engineering and Professor Matija Strlic, UCL Institute for Sustainable Heritage. The candidate will collaborate closely with Q-Bot (industrial sponsor) and Historic England (heritage partner).

Research methodology

Experimental methodology will be developed to measure emission rates. This will be based on quantitative measurements of VOCs in the headspace of the insulation materials after application, using gas chromatography with mass spectrometric detection preceded by sampling using thermal desorption tubes. The technique is well established and utilizes active sampling, i.e. the headspace is continuously purged and samples through an absorption tube.

A number of insulation materials will be analysed and both short-term emissions immediately after application (i.e. during the drying process) and long-term emissions (i.e. during the curing process) will be of interest. Following the determination of the dominant VOCs, the work will focus on the compounds highlighted by the literature review as potential health risks in order to determine the exposure thresholds. The experimental parameters will be explored that ensure that thresholds are not exceeded, such as rate of ventilation.

The airflow rates will be predicted by multi-zonal CONTAM model and the results will be validated with measured data collected in controlled environment. Fan pressurisation, smoke and tracer gas tests will be conducted to estimate the permeability of building envelope components, to locate cracks, and to determine the interzonal airflow rates between spaces.

Academic entry criteria

The successful candidate will have a good first degree in a relevant discipline such as engineering, science, physics, material science, conservation or heritage science.

This project is part of the EPSRC Centre for Doctoral Training in Science and Engineering in Arts, Heritage and Archaeology at University College London, University of Oxford and University of Brighton (www.seaha-cdt.ac.uk). As a SEAHA student, you will have unparalleled access to research infrastructure and expertise across three universities and more than 50 heritage, research and industrial partners. In addition to the university doctoral training requirements, SEAHA students take part in an exciting range of cohort activities, ranging from residential events and group projects, to conferences and careers events. Please visit the SEAHA website (www.seaha-cdt.ac.uk) for details.

The SEAHA Studentship will cover home fees and an enhanced stipend of up to £17,690 per year (to be confirmed at point of offer) for eligible applicants (http://www.seaha-cdt.ac.uk/opportunities/eligibility-criteria/), and a substantial budget for research, travel, and cohort activities.

To apply, submit your online application to study on the MRes Science and Engineering in Arts, Heritage and Archaeology, via http://www.ucl.ac.uk/prospective-students/graduate/taught/degrees/science-engineering-arts-heritage-archaeology-mres

As part of the application, please upload all the required elements, and in addition:

- A 2000 word project proposal for the 4-year PhD research, explaining a work plan that aims to answer the research questions, and which is based on the relevant literature.
- A covering letter clearly stating:
    - Your motivation and how the course will contribute to your career development

- Your residency status and eligibility for funding according to the information provided http://www.seaha-cdt.ac.uk/opportunities/eligibility-criteria/, or how you intend to sponsor your studies if not eligible for funding

You are encouraged to contact the SEAHA Manager (manager@seaha-cdt.ac.uk) or the project supervisor Professor Dejan Mumovic (d.mumovic@ucl.ac.uk) before producing the application.

Application deadline: 1st September 2016