Concrete Solutions for Sustainability in Buildings

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SCIENTIFIC SOCIAL ECONOMIC

TECHNOLOGICAL ACADEMIC ENVIRONMENTAL

SUMMARY

The built environment accounts for over one-third of the world's final energy. Traditional building skins, including those of concrete, are often a barrier to energy efficiency. In addition, making concrete, traditionally in high quantities with high levels of cement, results in high carbon emissions.

Dr Oliver Kinanne and research colleagues Dr Richard O'Hegarty and Dr Aidan Reilly at UCD College of Engineering & Architecture are researching and developing new forms of high-performance concretes to create novel, thin, ultra high-strength, thermally superior pre-fabricated skins for buildings, for new and retrofit applications.

Through collaborations with industry and as a principal investigator on the major European project IMPRESS, Dr Kinnane's work will make buildings more energy-efficient, more environmentally sustainable and more comfortable for the people within.

"Nationally we need to build houses, and to near zero energy building standards, while also retrofitting existing buildings with novel materials and technologies to make them more efficient in operation"

New Options for Energy Efficient Skins

Concrete is everywhere – from the skyscrapers of Manhattan to tiny dwellings in rural Vietnam and in all housing and commercial developments in the UK and Ireland. Used as a popular cladding material in the 1960s and 1970s, concrete facades are often thermally inefficient. Poorly performing building fabrics are partly why the built environment is responsible for almost 40% of global carbon emissions, requiring auxiliary heating energy, cooling and other services to compensate once the building is operational.

"Many existing buildings have been poorly designed for their local environments and are associated with high energy requirements" says Dr Oliver Kinnane, whose research at UCD College of Engineering & Architecture is figuring out new ways to reduce the environmental burden of buildings. "So, in general there is a move to improve the energy-efficiency of new builds, and to retrofit existing buildings with new materials and technologies so they become more efficient to operate."

Dr Kinnane is working with industry and academic partners to develop new high-performance pre-fabricated 'skins' for buildings that can help reduce their energy and carbon costs. By using materials such as cement replacements, textile and carbon fibre meshes (to replace steel reinforcement in concretes), vacuum insulation, bio-based aggregates and even Phase Change Materials (PCM) - that change their physical properties when they absorb and release heat - they are producing and testing thin and highly efficient façade cladding systems to improve building sustainability.

Monitoring energy usage is another key component in the sustainability jigsaw, and Dr Kinnane's research is measuring how newly built near Zero Energy Buildings (nZEB) are performing in the social housing sector.

Demolish Energy Consumption, not Buildings

A major area where Dr Kinnane sees his research having an impact is in enabling solutions that can help avoid the demolition of poorly-performing existing buildings. “Many of these buildings have good bones; it is the skin that is failing or flawed”, he explains.

“When these buildings were constructed, they embodied a lot of energy in them, the materials had to be made using energy intensive processes. The cement production for these buildings represents a huge investment, as producing cement alone is estimated to result in as much as 5-8% of global carbon dioxide emissions. Demolishing the buildings would not only result in the loss of their embodied energy, then the materials would have to be recycled or more commonly go to landfill, and the buildings would then have to be replaced – starting the same cycle again of the short-life building.”

Instead, Dr Kinnane’s research will help to provide new high-performing materials, systems and technologies to update the skins of such buildings, rendering them more efficient and avoiding the environmental cost of destroying, disposing and rebuilding. The Horizon 2020 IMPRESS project has built demonstration and validation units using its new pre-fab technologies to test their performance. “The ultra-high-performance concretes we develop for façade cladding will do a much better job with much less material, and enable more efficient, more comfortable and healthier buildings.”

Through his research, Dr Kinnane has built up relationships with industry partners. They include Irish heating company Firebird, with whom his lab has partnered to develop concrete skins that can harvest solar energy, and Irish company Techrete, a partner on IMPRESS, which produces architectural concrete cladding. He also works with a host of construction and energy management companies, architects and local authorities who are working to make Irish buildings more efficient.

As building designs improve to take sustainability into account, Dr Kinnane is keen to improve monitoring and feedback of building energy performance post-occupancy, and he has just been awarded funding from the Sustainable Energy Authority of Ireland (SEAI) for a project (nZEB_101) to monitor near zero energy buildings, which will augment his existing work in the area.

“By monitoring nZEB houses constructed by a developer for Wexford County Council and openly publishing the results, we are supplying data to show the thermal, indoor air and energy performance, and this is important for making future decisions about using such designs for social housing. These kinds of decisions are becoming more and more important in the context of climate change, particularly in Ireland where household carbon emissions are amongst the highest in Europe and fuel poverty is a consistent problem for large sections of the population.”

Research References

IMPRESS is a 16-partner project funded by the European Commission under Horizon 2020 to develop a new range of easy to install panels that reduce energy demand while preserving or improving the building aesthetics. http://www.project-impress.eu/

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