MIT professor Caitlin Mueller gave the keynote presentation at the IStructE Digital Design and Computation conference in May. Here, she tells Jackie Whitelaw how computer tools she’s developing will help structural engineers design for zero carbon.

‘Material reuse is a super important component of sustainability,’ she says. ‘I’m looking at algorithms for using found material in design, how you can reassign all those irregular shapes and come up with a structure that responds to the material you already have,’ she explains (Figure 1). ‘There is something very pleasing about the idea of taking a pile of stuff and turning it into a building. Material reuse has a long history – I have a colleague, Brandon Clifford, who calls it material cannibalism. My interest is how to do it at scale, using computation in a systematic way.’

Developing sustainability tools
Mueller and her Digital Structures team at MIT are also focusing on how to measure the impact of city planning and policy decisions on carbon in the urban environment. ‘We are all deeply concerned about climate change and are focused on coming up with new tools and methods for designing buildings that combine sustainable performance with good design,’ she says.

The Digital Structures research group has a track record in developing such innovative and exciting tools. Its stated aim is ‘to contribute new knowledge to empower the design and fabrication of innovative, creative and performative architectural structures’.

Its first interactive design tool was structureFIT, a free, web-based platform for exploring the structural design of planar trusses that allows designers to link geometric design variables with structural performance and then test design alternatives that assess structural material volume, stress and buckling.

At the moment, among many other things, the group is looking at an automatic path planning framework for robotic construction to overcome the issue of professionals working in the parametric design environment having to manually ‘plan’ for the robot – generating guiding curves for the robot to follow that avoid collisions with other objects on site. The project will overcome these limitations through an automated robotic path-planning software layer linking design geometry to robotic telepath code that will design out potential collisions and other issues.

Carbon-efficient designs
In her keynote presentation at the Institution of Structural Engineers Digital Design and Computation conference in May, Mueller shared some of this expertise, demonstrating how computational tools that have been developed for early-stage or conceptual design can allow buildings to be built efficiently and practically by optimising their geometry (Figure 2) and by digital planning for fabrication. And throughout, low carbon should be top priority (Figure 3).

‘Climate change should be the overriding priority for designers,’ Mueller says. ‘I would love engineers and architects to be creative in how we respond. It shouldn’t be just decarbonise the energy in a building and carry on as normal.’
This limits the ability of engineers and architects to use their design skills to think about the process of construction. But as fabrication processes develop, e.g. 3D printing, designers are going to need to understand the mechanics.’

Mueller can see tools being developed soon to allow for lightning-fast sketch iterations that could be converted into a quick shop drawing to test which option is best for manufacture and assembly. ‘That collapsing of design has a lot of potential,’ she says. ‘This wouldn’t be something fully automated, you’d still need all various professional skills to get things correct and you would still require the hand calculation skills to verify the soundness of design, but there is an opportunity for quick checks on ideas so you get to the most efficient solution.’

For the last two years, Mueller herself has been working on a programme that would link sketching and computer assessment of the drawn idea. ‘Basically, a designer would produce a sketch and the computer could read it, work out how it would perform in reality and suggest alternatives (Figure 4).’ I’m at the very early stages using narrow structural types such as trusses, blocks and curved frames, and the initial results are very exciting. But as with all our artificial intelligence tools, this needs data to learn on. We need to test on real-world problems.’

Real-world applications
To that end, Mueller and the Digital Structures team work with major practices to validate their more mature computer tools. They collaborated with SOM on a hotel tower to maximise the number of rooms in a tapering shape, for example. ‘I like the idea of working at the cutting edge with new ideas and then at a later stage taking them into an actual project,’ she says.

This is not surprising. Mueller trained first as an architect and then as a structural engineer and worked in practice for a couple of years. ‘I started during the 2008 recession and learned a huge amount working on some not hugely important buildings. But it was a very influential time for me.’

‘I was surprised how brittle the system was. I’d assumed we’d have all these modern tools, yet everyone was doing what was done 20, 30, 40 years ago. The need to develop new tools led me to MIT.’

Mueller’s main motivation is advancing knowledge and the MIT ethos is very philanthropic. ‘There is a strong belief in open source, we believe in ideas development and commercialising them might limit access.’ Some of her PhD students have gone on to join start-up companies.

Native English
There is a risk that computing can be embraced just for expanding possibilities rather than understanding constraints. We have to use them with constraints in mind, especially the impact on carbon and the climate.

companies that have been acquired by mainstream suppliers, nevertheless. She has a warning about reliance on computer design, however. ‘Computers, you could say, pose a problem because they enable designers to understand the building less – you can’t draw it and you can’t always explain how it works with hand calculations. On one hand, that is very exciting, but it is also part of the reason we see some destructiveness in terms of the cost of carbon in the built environment, because structures that seem impossible become possible even though they may not be the most sustainable.

‘There is a risk that computing can be embraced just for expanding possibilities rather than understanding constraints. We have to use them with constraints in mind, especially the impact on carbon and the climate.’

FIGURE 4: Computer assessment of sketches could lead to more efficient alternatives (with Bryan Ong)

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