Case study

A project reimagined: the questions I wished I had asked

Having attended the Institution's 'Net-zero structural design' course, Ruth Eve revisits a previous project to examine how her new understanding of the hierarchy of net-zero design could have unlocked carbon savings if the right questions had been asked at the right time.

Introduction

I like to think that as engineers we always strive to build clever: aiming for least weight (or 'use less stuff') is a basic design principle. I have always instinctively supported refurbishment projects, and aspired to find ways to use recycled and reclaimed materials where possible. As engineers, we also all know how to collaborate and support our clients and professional colleagues to achieve such technical requirements.

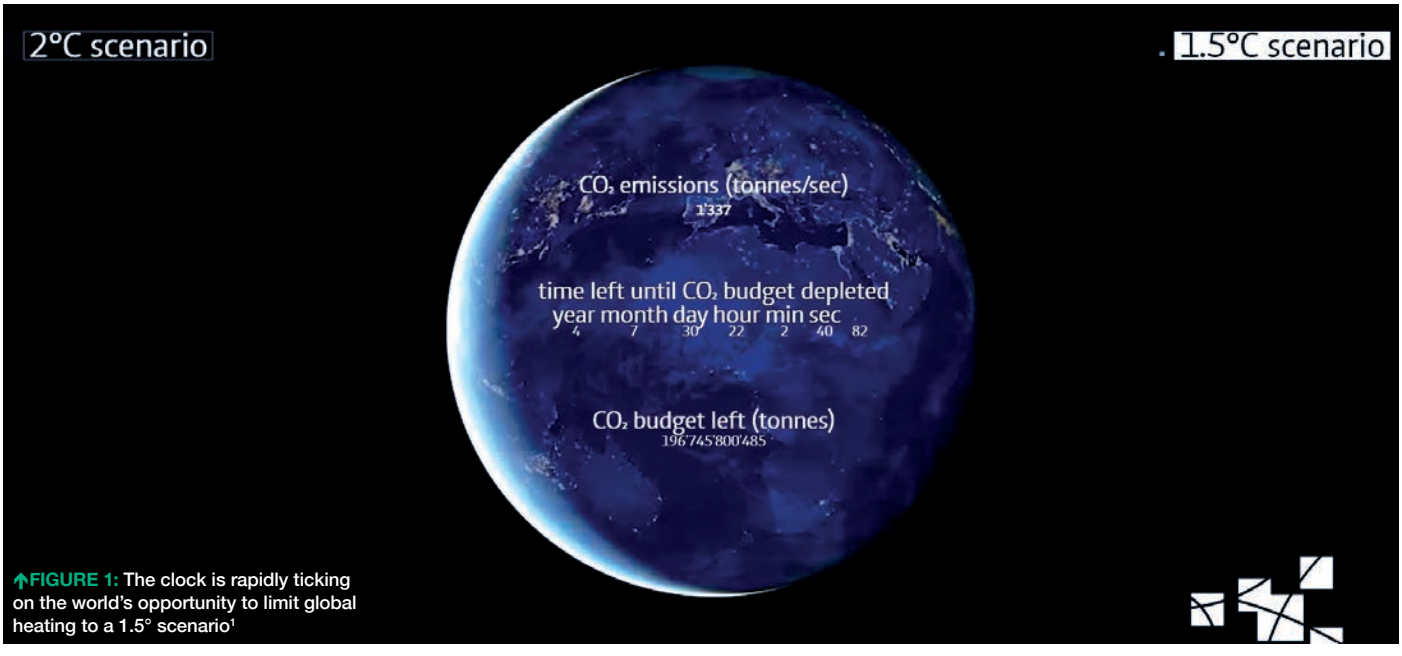
But as the depth and breadth of the climate emergency reveals itself to us all, and the carbon reduction clock runs down **(Figure 1)**[1], construction remains one of the world's most impactful industries, with more urgent action clearly needed. There is an abundance of guidance, technical papers and courses that can show us how to reduce the embodied carbon of our designs. But with so much guidance out there, where is the best place to start? And what if your project is already under way?

We now all recognise that, like safety, sustainability must be incorporated into our designs from inception. We know that working through schemes and materials options for projects, and 'doing the maths' on embodied carbon, is not only important, but is getting quicker and easier as we all become more familiar with the jargon. But while calculating and specifying low-impact options is important, it is a relatively small slice of the triangular-shaped pie **(Figure 2)**. Calculating carbon does not produce low-carbon solutions in of itself, but it does change our understanding as to whether or not a design is 'good'.

It's easy to feel a bit like the villain once we calculate our material volumes and carbon emissions. Even when we've developed our schemes in the least impactful way, we're still left responsible for the release of hundreds or thousands of tonnes of carbon each year (a single new house can emit between 50t and 100t of CO_2).

A wider perspective

When I recently attended the Institution's 'Net-zero structural design' training course (which I highly recommend; see www.istructe.org/events for details), I had something of an engineering epiphany. It came about when we applied the Institution's so-called



↑**FIGURE 1:** The clock is rapidly ticking on the world's opportunity to limit global heating to a 1.5° scenario[1]

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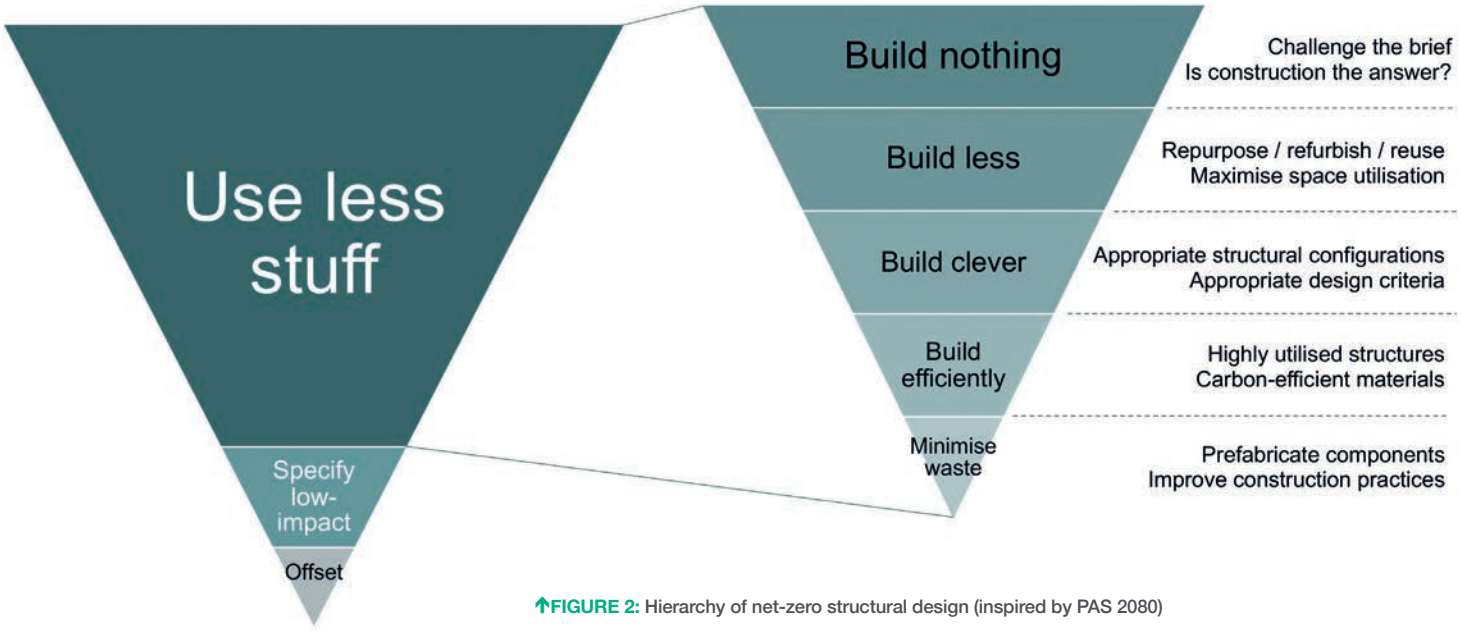

↑**FIGURE 2:** Hierarchy of net-zero structural design (inspired by PAS 2080)

'Hierarchy of net-zero design'[2] **(Fig. 2)** to elevate and reimagine projects in a more fundamental way by really getting under the skin of the brief. Pouring a project through the funnel-shaped net-zero hierarchy meant tapping into one of my favourite aspects of structural engineering – creativity.

As a thought experiment, putting to one side the usual constraints of project realities, we reimagined our projects to tease out the possible net-zero fractals of opportunity at each step, searching for opportunities high up the hierarchy with the greatest potential to reduce the overall impact of the design. For me, it was like some sort of chromatography of design, enabling us to separate, identify and purify our design elements and opportunities… with no maths required! We all had a go, and we all came up with some great ideas.

The case study presented (see panel) is based on an existing, in-use council building which I had been appointed to engineer a modest extension for, to rehouse and relocate the local library, and retain council office space. The wider project also incorporated an earlier mechanical, electrical and public health (MEP)-led decarbonisation phase for the building.

All the questions raised in the case study need to be asked in the context of the building being created. To quote Kate Raworth in taking sustainability to mean 'meeting the needs of all people within the means of the planet'[7], we can see the need for balance. The carbon emissions I am responsible for on this project will generate social value – and so the metric of 'value for carbon' becomes something I would want to consider when asking all these questions.

> **POURING A PROJECT THROUGH THE FUNNEL-SHAPED HIERARCHY MEANT TAPPING INTO ONE OF MY FAVOURITE ASPECTS OF STRUCTURAL ENGINEERING – CREATIVITY**

Can't see the wood for the trees?

I came up with the questions as homework given to attendees of the course between training sessions. As this was already a real-world project I knew well, this simple exercise only took about 20 minutes and quickly unlocked some new ideas.

For this particular project, many of these questions may well have already been asked and answered before our involvement – but perhaps I could have helped answer them better if I'd been involved. We have a mixed orderbook at our practice, and I chose a project that I knew I could make work for the homework I'd been set. Being forced to apply the hierarchy to this project resulted in something of an epiphany: I realised that I already knew all the questions to ask, I just hadn't been asking them, and hadn't understood their relative potential impacts. Awareness now unlocked, I will definitely be doing this exercise again on future projects.

We likely all have projects and clients that this can be applied to, giving our sustainability conversation a kickstart so we can contribute in an even more proactive and positive way. I realise how rarely I really take the time to fully unpick the basic premise of the brief to this extent and, of course, now I'm asking, 'why didn't I ask these questions earlier, could I have made a bigger difference, and would they have listened?' Too late now perhaps for this particular project, but I have plenty more projects coming up.

As a company, we know that we must stay relevant, hopefully even get ahead of the curve, realise the opportunity to advocate, demonstrate leadership and do the right thing. Soon it may even become a risk that we and our product are no longer relevant. In structural engineering, we see a groundswell of support, collaboration and learning across our governments and technical bodies, peers, collaborations, material and professional institutions. Articles in magazines, etc. show us what can be achieved, providing precedents that we can learn and share. If you're new to all this, the IStructE video asking, 'What are you going to do about it?' is a great place to start: www.istructe.org/resources/guidance/what-are-you-going-to-do-about-it/.

All clients (or their shareholders) do not share the same level of desire, or have the resources, to make big changes, and for a good proportion the cost plan is king. There is an awkward elephant in the room, asking me

Case study: reimagining the brief

This project involves an extension to a council building to rehouse the local library. The existing primary structure is a three-storey concrete frame with a basement car park (low headroom), supported by piled foundations. The proposed alterations include a new entrance atrium, along with covering one of the two existing inner courtyards in order to create more floor space. Works are to be phased so that the building can remain in use throughout.

Starting at the top of the net-zero hierarchy, here are some of the questions I now wish that I had asked earlier on in the project.

Build nothing[3]

Could the aims of the project be achieved without building anything? What are the council's wider aims for library facilities generally? Could these be met not through new construction, but by reorganisation of the existing internal spaces at this building or other buildings the council owns? Put another way, could the library sit within the existing building, rather than within an extension, if we could help the client use the building's space better? Why does the existing library need to be relocated at all? What other projects and buildings does the council own? What other building projects are planned?

Build less[4]

Assuming that the library does need relocating, and the existing building is not big enough, how could we minimise the amount of construction needed? The existing three-storey (plus basement) concrete frame likely has structural capacity for an extra floor: has this been investigated? If we extended upwards instead of outwards, would this involve less construction overall, and could it enable the proposed library to be accommodated on the ground floor? Could we run similar studies for other council buildings, to find a more suitable space?

Instead of using new materials, could materials be harvested from other council buildings and projects for reuse in our extension? Are there any materials that could be harvested from this building that aren't being used? Could the car park be reused as a heat sink? Reservoir? Data centre? Storage? Rhubarb farm? The proposed entrance colonnade and cladding are bespoke precast concrete. Can we use something reclaimed or upcycled? This could be an opportunity to use the bricks from the old library. Could the external steel frame be left unclad?

Build clever[5]

The new entrance atrium and covered courtyard have relatively long spans, and a heavy green roof. So can we introduce support columns? Or reduce the weight of the roof? Is a green roof really that useful – will anyone see it, and will nature appreciate it, in this town-centre location? Or could we lower the height of the new structures? The proposed 'minstrel's gallery' overlooking the atrium provides minimal functionality: what are the drivers for this element? What if we built the courtyard roof from ETFE – is this viable and could it help reduce structural sizes throughout the design?

Build efficiently[6]

Could the programme accommodate a pre-construction optimisation stage, so that once the structural configuration is set, contractor-designed items are incorporated and detailed design is fully complete, there would be a period of time to process design elements to maximise to 100% utilisation?

Are there opportunities to revisit the materials we will be building from, once we've achieved as much as we can in 'build clever' to reduce demands on the structure. For example, could previous rationalisation of the grid, avoiding of transfer beams, or changes to the green roof, all seek to now unlock a lightweight timber roof structure?

Could the level or build-up of the roof be adjusted to ensure we have enough depth allowances so that beam sizes can be as deep and light as possible? Would the client and architect consider this even if it compromised the interface with the existing brick arches at the building by partially concealing them?

If we need precast concrete, what are the options for further savings? Could early engagement with the supply chain demonstrate whether is it lower-carbon to have i) big elements made with low-strength concrete, or ii) smaller elements made from higher-strength concrete?

Minimise waste

Has the contractor considered off-site manufacturing? Which elements of the project do they expect to produce the most waste based on their experience? How does this overlap with our design and which elements could we adjust the to help minimise this? How can we detail the reinforcement to aid installation and avoid wastage?

how easy it is to actually ask these questions, particularly the more strategic aspects of build nothing and build less. I know that earlier in my career I would not have felt empowered enough to ask, and perhaps it feels a bit more than a little impolite to try and influence a client in this way with the risk of being deemed a little too 'draconian'. I ponder over how best to have these conversations supportively and to encourage our clients, project manager and construction manager colleagues to incorporate 'appropriate time and resources' to seeking sustainable outcomes, in the same way that they do for their duties to safety under the Construction (Design and Management) Regulations. The belief that green projects are more expensive could be only a lack of understanding about what is achievable. And the vagaries in assessing and measuring the wider benefits. And disadvantages such as impact to ecosystems. And perhaps a little bit of a lack of imagination.

I'm also still interested to see whether the planners I interact with will support such changes that explicitly target reducing carbon

> **I PONDER OVER HOW BEST TO HAVE THESE CONVERSATIONS SUPPORTIVELY**

– and will they usher them through with ease? Or will the mechanics of the process be too time-consuming? (And will anyone get paid for this?) Nonetheless, I'm still keen to test the theory, and perhaps have the conversation anyway to find out what might have been possible. I'm also excited to promote this quick method to my colleagues, internally and externally, because I know that great clients and design teams will respond positively if we can demonstrate an ability to tune into what they need at the right moment and show them what is possible. Maybe then on the next project with the same client, they will engage with us earlier in the decision-making process, allowing us to ask some key questions and make alternative proposals. While the biggest impact can typically be made at early design stages, whatever stage a project is at, there is scope to have a positive influence throughout the project.

Maybe a rhubarb factory in the basement is a wild idea… but perhaps with humility and curiosity we can all find space to ask some 'stupid' questions, and use our collective expertise and ingenuity to find new ideas that fundamentally change the shape of our projects for the better.

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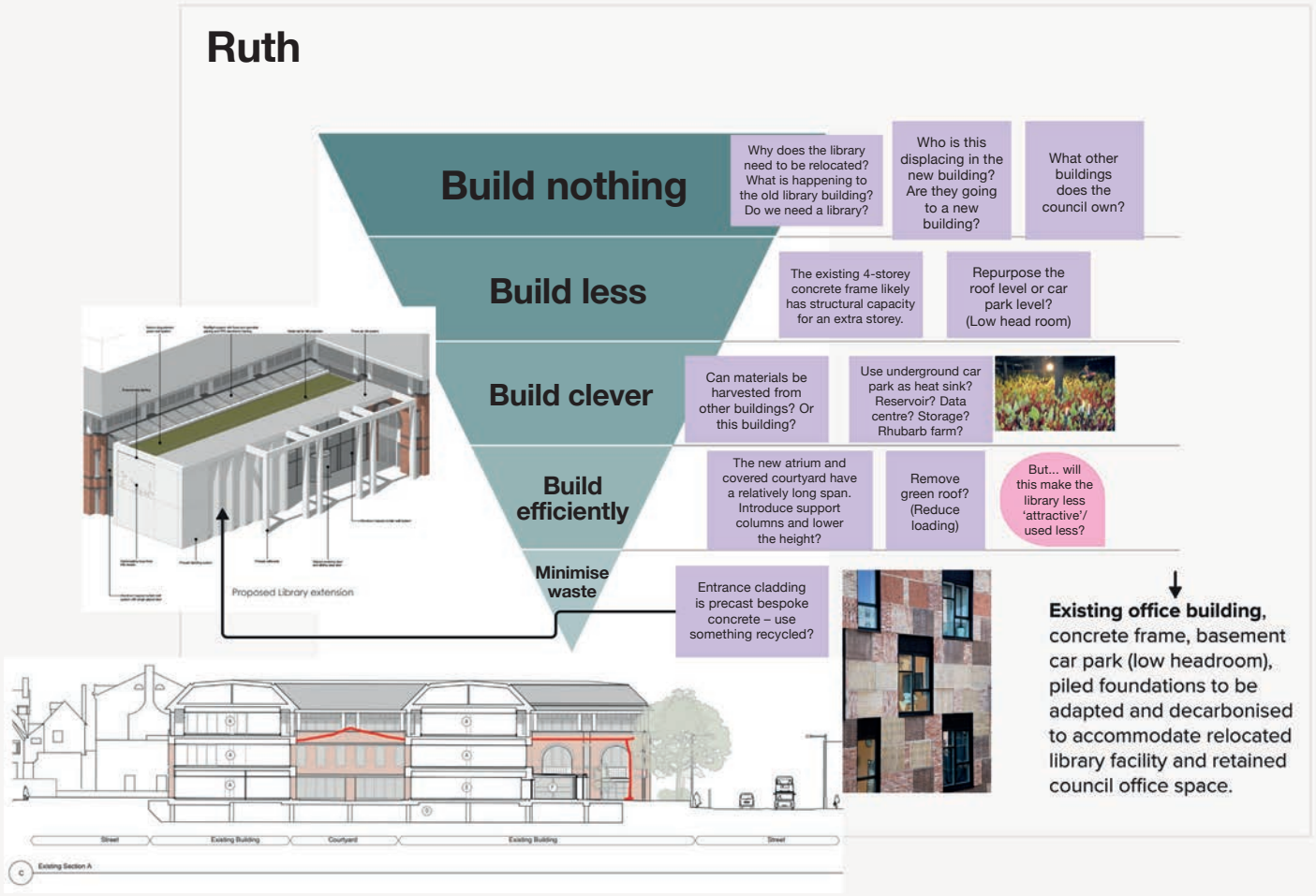
Ruth is a Director of Glanville Consultants in Didcot, UK. She is an experienced structural engineer leading a small team within a small to medium-sized multidisciplinary consultancy. Her goal is to develop and deliver more sustainable practices across all teams.



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