Putting the net-zero hierarchy into practice

Build efficiently

Muiris Moynihan summarises available guidance covering the fourth level of the Institution's hierarchy for net-zero design, which encourages engineers to 'build efficiently' by ensuring designs are highly utilised.

Building efficiently is ensuring that structures are highly utilised and use materials in an efficient manner. It is the fourth strategy down the net-zero hierarchy (**Figure 1**), coming after 'building clever' (which involves selecting appropriate structural configurations and design criteria). While the scope to reduce carbon is less than in the higher-up strategies, we must still strive to build efficiently because: a) these reductions are cumulative on top of build nothing/less/clever wins; b) build efficiently initiatives impact less on the wider design team, and hence can be more straightforward to implement.

One of the major ways that engineers at every level, from graduates to senior directors, can reduce material usage, and thereby reduce carbon emissions, is to ensure that their designs are highly utilised. Ian Poole summarises the research indicating that most structural designs use 'somewhere between 20–50% more material than necessary'[1], corroborated by Ben Gholam in a study of utilisation ratios of building structures that found 'a cumulative 40% under-utilisation in terms of material mass'[2].

To drive greater optimisation, Natasha Watson shares that 'target utilisations', which vary by design stage, can be used to drive greater optimisation as more information and detail becomes available[3]. As part of her 10-point lean design action plan, Natasha also makes the point that we should 'design for use *now*, and strengthen if use changes' – we should not be including redundancy at the outset which may never be needed, instead we should develop a strategy for the structure to be strengthened should extra capacity in fact be required.

Caroline Field expands on the perceived trade-off between a structure's optimisation and its resilience, concluding there is no inherent conflict as 'lean design focuses on maximising value; resilience focuses on protecting and enhancing value. There is a synergy here if the design is focused on

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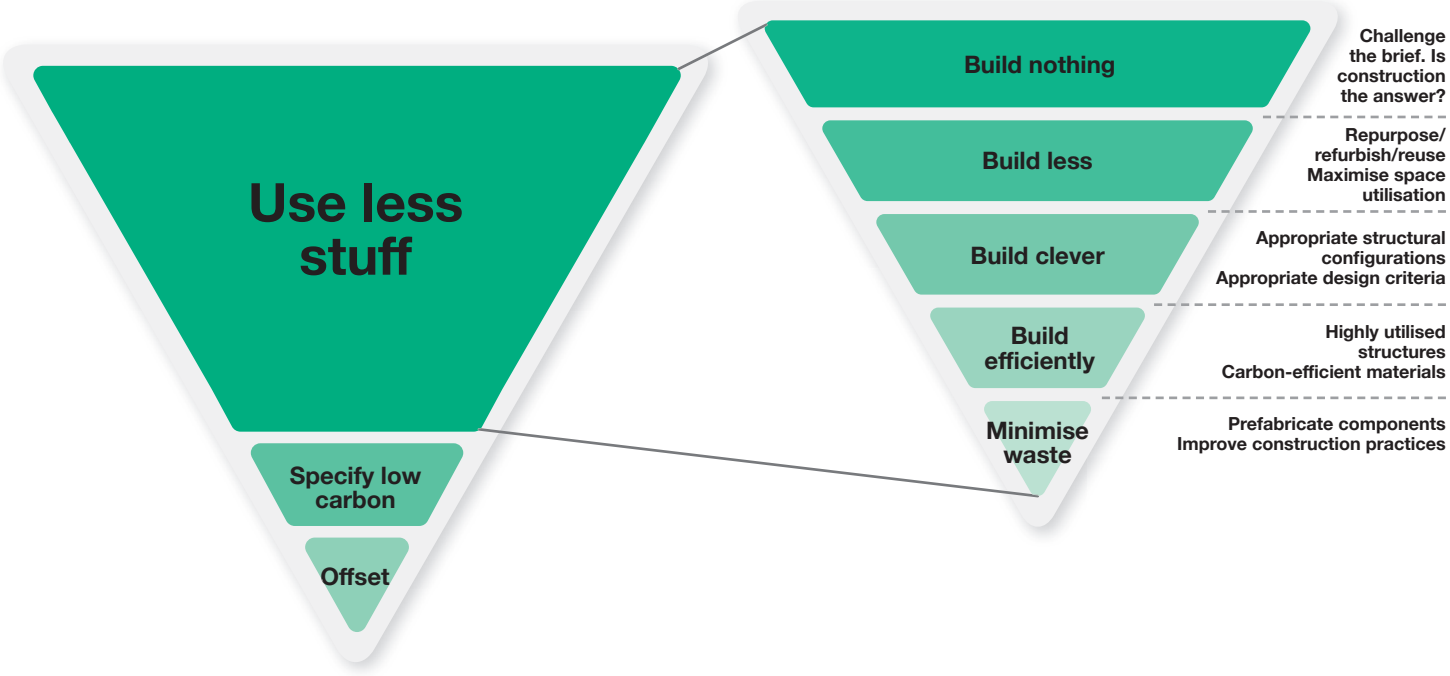

↑**FIGURE 1:** Hierarchy for net-zero structural design (inspired by PAS 2080)

delivering value to the client'[4]. She advocates that 'good design that is both lean and resilient (and therefore sustainable) must balance this – agreeing a level of resilience and then designing precise, optimal structures that meet (but do not exceed) this level'.

This approach is echoed by the Institution's Safety, Health and Wellbeing Panel, which also notes that over-stress is rarely a cause of failure but that there is a case for ensuring ample capacity at connections (at low additional carbon 'cost') where failures do more frequently occur[5]. Luke Bisby emphasises the need to deeply understand fire and other catastrophic scenarios while designing (lean or otherwise)[6].

There is significant scope for more efficient geotechnical design, as Andy Smith explains, where assumptions can be refined and updated with comprehensive site investigations and testing[7]. He notes that when such work is properly programmed to feed back data in a timely manner, it can result in optimised designs – or even avoiding piled foundations altogether. His article contains a useful list of geotechnical sustainability initiatives compiled from a literature review.

Many might think of timber as a low-carbon frame solution – which it certainly can be, as advised by Will Hawkins[8]. However, Will also notes that 'wasteful or inappropriate use of timber could readily have a greater impact than a more efficient concrete or steel alternative', stressing the importance of selecting the material (or combination) best suited to the requirements, and concluding that 'it is always better to use less of any material'. James Walker's guidance outlines scenarios amenable to efficient timber designs and how to deliver them, accounting for the differences between timber products (sawn, glulam, cross-laminated, etc.)[9]; while forester Jez Ralph lists wider sustainability considerations for timber[10].

In their lecture, Ryan Daniell and Oscar White discuss how composites are a way of utilising the strengths of both materials to reduce overall volumes; they also demonstrate the use of computer scripts to quickly optimise a design[11]. A counterpoint to this is steelwork fabricator John Callanan, who highlights there are opportunities for lean design on projects big and small if we use our engineering judgement rather than relying on idealised computer analyses: for instance, a nominally pinned connection can have considerable moment restraint in some configurations[12].

This circles us back to Ian Poole's article, where he examines reasons for inefficient designs and concludes that contractor involvement is key to challenging 'any assumption made in the design stage where rationalisation is adopted over optimisation, to ensure any assumed benefits are correct and to justify additional use of material and carbon'. John Callanan echoes this, confirming there is plenty of 'old-school arbitrary self-directed overdesign' still around, with significant opportunities to save material if the supply chain is engaged early to provide its knowledge and insights. He concludes, 'We have the tools and knowledge for lean design to become the norm… so let's start today'.

> **WE SHOULD DEVELOP A STRATEGY FOR THE STRUCTURE TO BE STRENGTHENED SHOULD EXTRA CAPACITY BE REQUIRED**

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SEE ALSO

→| **Halliwell E. (2024)** 'Putting the net-zero hierarchy into practice: Build nothing', *The Structural Engineer*, 102 (1), pp. 10–11; https://doi.org/10.56330/WSKW8501
→| **Hayes C. (2024)** 'Putting the net-zero hierarchy into practice: Build less', *The Structural Engineer*, 102 (2), pp. 18–19; https://doi.org/10.56330/MGEK3688
→| **Halliwell E. (2024)** 'Putting the net-zero hierarchy into practice: Build clever', *The Structural Engineer*, 102 (3), pp. 10–11; https://doi.org/10.56330/WZIY7163

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