Putting the net-zero hierarchy into practice

Minimise waste

Emily Halliwell concludes this series of notes signposting key resources at each level in the IStructE hierarchy of net-zero design by looking at how to 'minimise waste'.

In the net-zero hierarchy, minimising waste focuses on improving construction practices and prefabricating components. This relates both to new construction, but also the use of components from existing buildings. Using existing structures *in situ* will generally result in the least waste and the earlier 'Build less' note in this series signposts resources for assessing and reusing existing structures.

Off-site manufacture (OSM) potentially offers the opportunity to utilise highly controlled factory environments to improve efficiency and productivity. It is estimated that OSM can reduce material waste to 1–3%, compared with an average on site of 10%. This is achieved in a number of ways, including better production control, leading to higher quality and fewer defects, automated processes, which can reduce scope for human error, and utilising factory storage to avoid overordering. Despite these benefits, and a further opportunity to reduce transport movements by up to 60%, an OSM approach is often overlooked in favour of traditional construction processes.

In their article on 'Manufacturing buildings for people and profit'[1], Adrian Campbell, Matt Cooper and Andrew Waugh look at the barriers to adopting OSM, such as a desire for customisation which may be incompatible with mass production and a lack of awareness and understanding of the systems available. They advocate for better guidance for design methods for manufacture and the use of building information modelling (BIM) to simulate manufacturing and assembly. The use of BIM enables early clash detection with the aim of avoiding rework on site and the waste associated with remedial works.

Adrian Campbell, Robert Hairstans and Giulia Jones[2] repeat CIRIA's warning that potential environmental benefits of OSM are 'not always clearly substantiated' and they propose a model for how OSM might be refocused to maximise sustainability gains. They provide suggested construction-stage values for embodied carbon assessments and examples of how OSM can facilitate the reuse of existing buildings, through lightweight extensions, and enable demountability and reusability, through standardised components.

However, a modular approach is not limited to standard solutions. In his case study on One Sherwood Street, Matt Goold[3] shows how OSM led to less waste, a reduction in on-site working and temporary works, and a faster construction programme. Factory conditions not only offer increased

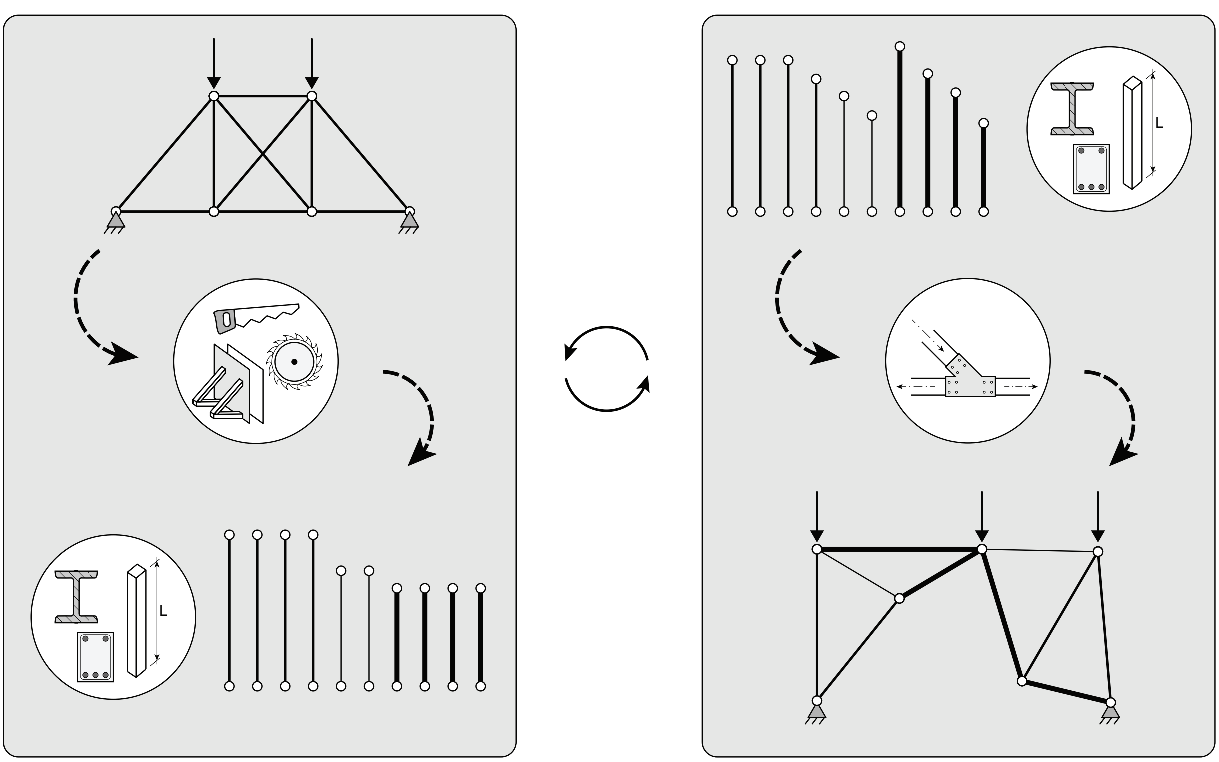

FIGURE 1: Repurposing elements from existing buildings requires a shift in engineers' approach to design[5]

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productivity, but enhance working conditions, providing sheltered, well-lit, ergonomic workspaces and significantly reducing high-risk activities, such as work at height.

It has also been shown that there is potential to achieve factory conditions *in situ* – Natalie Bowkett, Peter Goring and Des Mairs[4] share how a fully functioning factory was created on site, used to construct a concrete floor and then jacked up a week later to repeat the process. The Jump Factory represents an opportunity to significantly increase productivity, enabling faster, safer and more efficient construction.

Minimising waste is not merely a consideration during the initial construction phase – in their article on structural design for a circular economy, Corentin Fivet and Jan Brütting envisage a future where 'everything is reused'[5]. Construction and demolition waste accounts for approximately one-third of waste within the EU – the largest waste stream – and the article outlines how structural engineers can repurpose elements from existing structures. Challenges to the approach include identifying opportunities for reclaiming materials, e.g. from buildings due to be demolished, and shifting the design process to consider element characteristics, e.g. cross-sections, strengths and lengths, as the input and the geometry and layout as the output **(Figure 1)**.

The reclamation of steel sections offers opportunities to achieve carbon savings of up to 97% at product stage. Thomas Howarth's case study of City Place in London[6] describes the process of removing steel sections for reuse. The reclamation process includes detailed pre- and post-demolition surveys and cataloguing of each element. The use of recovered steel is covered further in Robert Mills' Holbein Gardens case study[7], which talks about how the reuse of steel elements, alongside reuse of an existing concrete frame and new cross-laminated timber (CLT) structure, enabled Grosvenor Properties to achieve its first net-zero-carbon project.

Concrete structures also offer an opportunity for reusing elements – ranging from small blocks to three-dimensional assemblies comprising a column and slab. Prototypes built by École Polytechnique Fédérale de Lausanne are outlined in Malena Bastien-Masse, Célia Küpfer and Corentin Fivet's article[8] to demonstrate the broad scope for reclaiming concrete elements.

As with reuse of steel elements, assessing the 'donor structure' is critical to determine what elements may be reclaimed, particularly as monolithic concrete structures may be saw-cut into a range of element types and sizes. Significant carbon savings are possible – a life-cycle analysis of the FLO:RE prototype, designed for typical office loadings, showed that if the reclaimed slab was used on the same site as the donor structure, carbon savings of 94% may be achieved.

Research is also ongoing into the use of recovered wood in mass timber products. Colin Rose and Phil Isaac[9] discuss how CLT and glued laminated timber (glulam) can incorporate wood from demolished structures. CLT and glulam make use of layering to achieve the necessary structural properties – this makes the inclusion of shorter pieces possible, such as those cut from existing frames, where connections or defects may need to be removed.

> **"OSM CAN FACILITATE THE REUSE OF EXISTING BUILDINGS, THROUGH LIGHTWEIGHT EXTENSIONS, AND ENABLE DEMOUNTABILITY AND REUSABILITY**

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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
- Moynihan M. (2024) 'Putting the net-zero hierarchy into practice: Build efficiently', *The Structural Engineer*, 102 (11), pp. 10-11; https://doi.org/10.56330/GSRU2454

KEY REFERENCES

1) Campbell A., Cooper M. and Waugh A. (2020) 'Manufacturing buildings for people and planet', *The Structural Engineer*, 98 (1), pp. 43–49; https://doi.org/10.56330/DVJY8722

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3) Goold M. (2023) 'One Sherwood Street: realising the benefits of a modular approach', *The Structural Engineer*, 101 (4), pp. 32–37; https://doi.org/10.56330/KGUV2466

4) Bowkett N., Goring P. and Mairs D. (2020) 'The Jump Factory – reaching new heights in construction productivity', *The Structural Engineer*, 98 (1), pp. 50–55; https://doi.org/10.56330/DXGY2297

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8) Bastien-Masse M., Küpfer C. and Fivet C. (2024) 'A concrete answer for circular construction: three prototypes reusing saw-cut elements', *The Structural Engineer*, 102 (4), pp. 32–37; https://doi.org/10.56330/ZMSY4716

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