## 4.Zero waste

# Enabling steel's circular economy potential

**Michal Drewniok discusses the principles of reusing steel elements and encourages structural engineers to consider this option over designing with new material.**

### Introduction

Half of all steel is used in construction and infrastructure, responsible for almost 4% of global greenhouse gas emissions[1]. Over the past two decades, global steel production has doubled, but with growing pressure on the construction industry to be more resource efficient and reduce waste, dramatic changes need to be made to the way we use this important material.

Steel has high recycling potential. When produced in an electric arc furnace (EAF) using recycled scrap (secondary steel production), it offers approx. 50% energy savings and 75% carbon savings over primary production from iron ore in a basic oxygen furnace (BOF)[2]. Nevertheless, to get even greater carbon reduction, reprocessing should be limited only to the products that cannot be reused directly (e.g. reinforcing steel recovered after demolition).

This article outlines ways in which practising structural engineers can make better use of the circular economy potential of structural steel in the UK. The principles discussed also apply internationally.

### Structural steel reuse today

In the past few years, several research projects have identified barriers to the reuse of structural steel[3–8]. Studies have clearly shown that low demand makes steel reuse uncommon. Unlike the reuse of entire structures, only approx. 7% of heavy structural sections and tubes, 15% of steel piles and 10% of profile steel cladding are reused[9,10]. It is more convenient to design, manufacture and build from new materials, mainly due to their availability.

The vast majority of steel scrap in the UK is sent for recycling[1] with few or no visible stocks of second-hand structural steel – although several companies in the UK (see 'Case studies') do offer surplus steel from previous projects or deconstruction.

The perception of a lack of available steel is also due to a lack of communication between the demolition contractor and the team involved in the new design[11]. The demolition contractor is appointed just before works begin, even if the building lies empty for several months before demolition. This makes it impossible to conduct a pre-demolition audit to identify elements for reuse, and as a result the default is to send the steel for recycling.

There have been attempts to develop a repository of steel from new projects that could facilitate future steel availability[7,12] (e.g. by uploading an IFC model from Tekla Structures or STRUMIS to an online database). A similar solution might be considered for further development under the EU-funded Circular Construction in Regenerative Cities (CIRCuIT) project[13].

Even with no specific standards, UK regulations simply require proof that a reused element 'is suitable for its intended purpose and use'[14]. And in 2019, the Steel Construction Institute published *Structural steel reuse: Assessment, testing and design principles*[15], which includes recommendations on data collection, inspection and testing to ensure that reclaimed structural steelwork can be reused with confidence.

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It should also be highlighted that the mechanical properties of structural steel do not degrade over time, and sections are robust and dimensionally stable[15]. Electrochemical steel corrosion (rust) leads only to a reduction in the cross-section[16]. Where steel has not been exposed to fire or fatigue, it can be successfully used again in new structures[15].

The long-term price differential (2000–16) between the cost of UK structural steel and scrap sections is over £300 per tonne, representing a substantial profit opportunity. And although there are costs involved with deconstruction, testing, storage and re-fabrication, structural steel reuse can provide an economical alternative to using new steel sections[8,9,15].

Structures made from reused elements will typically result in a higher mass and lower utilisation. Nevertheless, studies have shown carbon savings of 35% compared with new structures[17] and 56% compared with minimum-weight solutions for steel trusses made of new steel elements[18].

**TABLE 1:** Case studies of steel reuse in UK

| Year | Case study | Notes |
|---|---|---|
| 2020 | Wood Wharf, London | **Use** of 2220m surplus steel tubes |
| 2016 | UTC Leeds | **Reuse** (repurpose) of industrial building from 1900s into college |
| 2015 | 9 Cambridge Avenue (SEGRO) | **Relocation** of 3320m$^2$ building 1 mile away, **260t$CO_2$e savings** (56% less embodied carbon compared with comparative new build), 25% saving in costs compared with equivalent new build |
| 2015 | Skanska office, Doncaster | **Reuse** (repurpose) of 5000m$^2$ steel-framed paint shop from 1960s |
| 2013 | Kings Science Academy, Bradford | **Reuse** of existing industrial steel infrastructure (portal frames), project savings |
| 2012 | London Olympic Stadia | **Use** of 2500t of surplus unused oil and gas pipeline tubes |
| 2012 | Baldwin Terrace, London | **Reuse** (repurpose) of Victorian foundry building to office and studio space, **45t$CO_2$e steel savings** |
| 2008 | Carrwood Park, Leeds | **Reuse** of 82t of structural steel from old warehouse, **82t$CO_2$e steel savings** |
| 2005 | Honda plant, Swindon | **Relocation** of 927m$^2$ steel warehouse, built in 2001, dismantled in 2004, storage, erected in different location in 2005 |
| 2005 | Blue Steel building, Leeds | **Refurbishment/vertical extension** of 14 500m$^2$ Poundstretcher facility to Carlsberg facility |
| 2002 | BedZED, London | **Reuse** of steel from Brighton railway station for workshop area of building, **98t$CO_2$e steel savings** |

## Case studies

Benefits of steel reuse have been noticed by some fabricators and stockists[11], such as Cleveland Steel & Tubes and James Dunkerley Steels (steel elements) and Portal Power (pre-used steel-framed buildings). **Table 1** presents selected case studies where steel reuse occurred in various forms (reuse, relocation, repurpose).

Unsuccessful projects are not listed but are identified in Sansom *et al*.[12] Typical reasons preventing success included: client's restrictive procurement process; architect's vision to design with new elements or in concrete; cost consultant's reluctance for steel reuse ('unknown' cost of dismantling, cleaning and storing); and fabricator's refusal to accept second-hand steel (for already available structure).

## Structural engineers can make a difference

There is little difference between designing structures using new or reused steel sections. There are currently no technical barriers to structural steel reuse.

Today, however, it can be difficult for the steel fabricator to source designed elements, as the market for reclaimed steel elements is still in its infancy. Nevertheless, if the steel contractor is informed about the main design assumptions in advance, structural steel reuse is feasible. If an inventory of steel elements is available before starting design, the new structure can even respond to the available steel constraints (spans, bays). To support the design of structures from reused steel elements, computational methods[17,18] have been developed that also assess environmental benefits compared with best-practice new designs.

Structural engineers have an opportunity to communicate the environmental, cost and programme benefits of reused steel to the client or architect. This requires a broader knowledge and skillset than pure structural engineering – which can be easily learned through guidance documents, trainings and workshops. The structural engineer should also make clear that if a structure is made from a material that 'is suitable for its intended purpose and use', there is typically no obstacle to steelwork contractors or general contractors providing a warranty or insurance companies providing insurance.

The reuse of structural steel is often perceived as complicated and unviable. However, there are currently no technical barriers to structural steel reuse and the case studies presented show that this solution can be cost-effective. Awareness of the feasibility of steel structural steel reuse is the first step towards making it happen.

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## Key reading

**The following suggested reading will help readers to develop their understanding of the subject further:**

- →| *Optimum design of frame structures from a stock of reclaimed elements*[17]
- →| *Options to make steel reuse profitable: An analysis of cost and risk distribution across the UK construction value chain*[9]
- →| *Real and perceived barriers to steel reuse across the UK construction value chain*[11]
- →| *Can Material Passports lower financial barriers for structural steel re-use*[8]
- →| *P427: Structural steel reuse: Assessment, testing and design principles*[15]
- →| Allwood J., Cleaver C., Cabrera Serrenho A *et al*. (2020) *Unlocking Absolute Zero: Overcoming implementation barriers on the path to delivering zero emissions by 2050*; doi: https://doi.org/10.17863/CAM.57650

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