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Understanding and overcoming the barriers to structural steel reuse, a UK perspective

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ABSTRACT

To meet greenhouse gas emission targets, at global, national and sector level, reduction opportunities should be explored in both the embodied and operational carbon of the built environment. One underexploited option to reduce embodied carbon is the reuse of structural steel. However, in the UK, work by Sansom and Avery (2014) suggests a picture of declining levels of reuse. This paper explores why this is the case by identifying the practical barriers to structural steel reuse through a series of semi-structured interviews with UK construction industry members. Whilst there were many identified barriers, five practical barriers were prioritised as being most significant: cost, availability/storage, no client demand, traceability and supply chain gaps/lack of integration. These contrast with those most commonly identified in global literature: cost, supply chain gaps/integration, risk, jointing technique, composite construction and time for deconstruction; with only two overlaps: cost and supply chain gaps/integration. Many of the barriers from literature have a technical focus (reducing salvage yield rather than completely preventing reuse) differing from the largely systemic barriers that the interviews prioritised. These systemic barriers will need to be dealt with first to increase reuse rates. This will require a coordinated approach across the UK construction supply chain. Building on interview insights, this paper proposes four mechanisms to overcome these systemic barriers: (1) the creation of a database of suppliers/reused section availability, (2) a demonstration of client demand (3) technical guidance and education for the construction industry and (4) government leadership. Together these mechanisms would improve reuse rates in the UK, reduce the embodied emissions of the built environment and play a crucial role in meeting greenhouse gas emissions reduction targets.

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1. Introduction

Substantial changes are required across the construction sector, a significant user of energy and energy intensive materials, if the UK is to meet its greenhouse gas (GHG) emissions reduction target of 80% below 1990 levels by 2050 (Climate Change Act, 2008). This is recognised by the sector, whose Construction 2025 aims include a 50% GHG reduction, relative to 1990 levels, in the built environment by 2025 (HM Government, 2013). There is no restriction on when in the life cycle this reduction could occur, although the focus has traditionally been on buildings in-use. However, embodied emissions (those produced from the extraction, processing, manufacturing, transport of materials and construction of the built environment) are also significant, with Giesekam et al. (2014) estimating these at 63 $MtCO_2e$ in 2007 for the UK. This amounts to 9.5% of the UK's 2007 reported domestically produced GHG emissions (Webb et al., 2014); or 5.78% of the UK's reported consumption-based GHG emissions (DEFRA, 2015). Giesekam et al. (2014) also show that, on average, almost half of the embodied built environment emissions occur outside UK borders so will not count towards the UK's 2050 target. There has however been some recognition of the importance of embodied (or capital) carbon reduction. The Green Construction Board's (2013) Low Carbon Route-Map for the Built Environment recommends a 21% reduction in embodied carbon, relative to 2010 emissions by 2022, increasing to a cumulative 39% reduction on 2010 levels by 2050 to meet the UK's target. A benefit of targeting embodied emissions is the immediacy of the GHG reduction. Conversely, there is a time lag with in-use emissions reductions. Given the urgency of the climate change challenge, reducing embodied emissions should be an

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appealing strategy.

Material efficiency (which entails using less material, for longer, while delivering the same function) is a promising option for reducing embodied carbon in the built environment, as suggested by Allwood et al. (2012). The biggest emission reduction opportunities will likely be those focusing on energy intensive, bulk materials; such as steel and cement in the built environment. Globally, in 2008, 56% of steel and almost 100% of cement were used in the built environment, generating 3.2 $GTCO_2$ (Allwood et al., 2012).

Material reuse is one promising strategy for improving the material efficiency of the built environment. This entails reusing material across multiple construction projects over time, with minimal re-processing. Steel in particular lends itself to this approach, as a quick initial review can be conducted to identify deflections, distortions and corrosion and ascertain the potential suitability of reuse before demolition. However, steel reuse is not common practice in the UK, as shown by Sansom and Avery (2014); suggesting there are few drivers for reuse or that there are barriers along the supply chain preventing reuse. This paper offers an exploration into the barriers to structural steel reuse for different actors along the UK construction supply chain.

2. Defining steel reuse

Reuse is defined as the subsequent use of an object after its first life. The object may be repurposed, but its original form will be retained with only minor alterations. As a consequence, the re-occurring embodied carbon is minimal. For steel, the key distinction is that it is not re-melted. It differs from recycling, which is the most common practice at end of life in the UK (Sansom and Avery, 2014) and has a much larger impact on GHG emissions. Table 1, developed by the authors, characterises different types of reuse, distinguishing between in-situ reuse (on the same site) and relocated reuse (moved to another site), for whole buildings, component systems and individual elements. This framework is useful for categorising reuse case studies and for identifying common and differing barriers and drivers. In practice, the type of reuse selected the will depend on technical feasibility, environmental impacts and financial costs.

The decision to reuse steel may be made early in a project if the building is to be reused on-site, or decided at a later stage, during tendering for steelwork, if relocated element reuse. The design team, denoted by the shaded box in Fig. 1, is therefore critical in determining the reuse type. Fig. 1, shows the different possible procurement routes for obtaining reused steel. There are three possible options: sourcing directly from a demolition contractor (a departure from standard practice, which relies on an awareness of who might have reused steel available), sourcing from a traditional steel stockist or, with the emergence of a new stakeholder, procuring steel from a specialised reused steel stockist.

3. State of the Art

A number of studies have investigated different aspects of steel reuse, including: current reuse rates; case studies with assessments

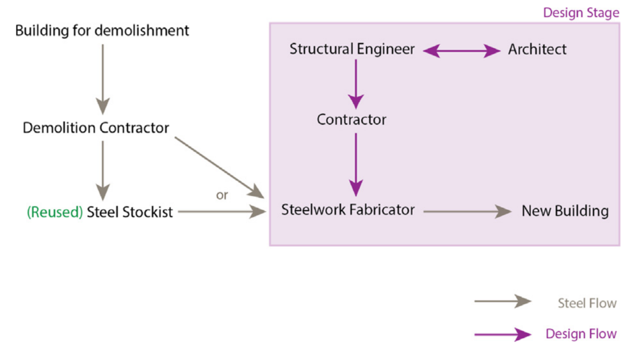

Fig. 1. Mapping steel reuse flows for relocated reuse.

of embodied emissions savings; barriers, and the potential costs or profits. This section summarises the key findings from this varied literature.

3.1. Current and potential reuse rates in the UK

Sansom and Avery (2014) surveyed demolition contractors to estimate what percentage of steel from demolition sites is reused, recycled and sent to landfill in the UK. The authors estimate that in 2007, 5% of light structural steel and 7% of heavy structural sections/tubes were reused, both in situ and relocated, from demolition sites. They show this is a 5% reduction in reuse rates relative to 2000 levels. However, it is challenging to accurately compare reuse rates across years due to differences in sample sizes, dictated by interviewee response rates and project types among demolition contractors. Cooper and Allwood (2012) suggest that it is possible to reuse 50% of cold formed sections, indicating significant technical potential to increase reuse rates.

3.2. Structural steel reuse case studies

Gorgolewski et al. (2006) document a series of relocated reuse case studies, predominately in Canada, where individual steel elements and components (roof trusses) had been reused. This shows barriers to reuse can be overcome under certain market conditions.

Pongiglione and Calderini (2014) conduct a study to explore the potential material savings by reusing steel in the theoretical development of a train station in Italy. The authors identify that steel could be sourced from a nearby industrial building, suited for deconstruction but unsuitable for renovation. The authors show that around 30% of the new steel could be replaced by reused steel with only a small modification to the station design. This equalled a reduction of approximately 2915 GJ and 138 TCO_2e in embodied energy and carbon respectively. The latter two estimates are highly dependent on the datasets used, making the material percentage saving of more interest. Although this study is useful in demonstrating the potential environmental benefit of reusing steel, it is largely theoretical and does not explore the practical barriers to achieving these savings.

Table 1
Characterising variants of reuse.

	In-Situ Reuse	Relocated Reuse
Building Reuse	Reuse of a significant portion of a building, e.g. entire structural frame, façade or envelope, in-situ	Deconstruction, and reassembly on a new site of a building frame/envelope
Component system Reuse	Reuse of a small part of a building in-situ, e.g. foundations	Reuse of system of components, e.g. steel truss, on a new site
Element Reuse	Deconstruction and reuse of elements in a new configuration	Reuse of individual elements, e.g steel section(s), on different sites

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