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Real and perceived barriers to steel reuse across the UK construction value chain

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ABSTRACT

Although steel reuse has been identified as an effective method to reduce the carbon and energy impact of construction, its occurrence is shrinking in the UK. This can be partly explained by the many barriers which have been identified in the literature, but a detailed analysis of how these barriers affect different parts of the supply chain is still lacking. We show that there is a contrast between perceived higher costs and time required to employ reused steel and the assessments of realised projects. Using a novel ranking method inspired from the field of information retrieval (tf-idf), we have analysed interviews of actors across the supply chain to determine the acuteness of the perception of each barrier. We show that demolition contractors, stockists, and fabricators face specific barriers which each need to be addressed at their level. This is in contrast with more generic barriers present throughout the value chain which we show are probably more perception than reality. Finally, we suggest how supply chain integration could facilitate reuse and make it economically viable at scale.

1. Introduction

Despite considerable environmental benefits, steel reuse is a rare occurrence in the UK (Cooper and Allwood, 2012), and is becoming less common (EUROFER, 2012; Sansom and Avery, 2014). There are a number of reasons for this: changes in the demolition practices, a more formalised certification process for the steel, and changing design practices (Densley Tingley et al., 2016). Nonetheless, a number of case studies show steel reuse is possible and can yield substantial benefits in terms of cost and time, beyond the carbon savings. Replicating these successes requires understanding the circumstances behind them. If they could be replicated, steel reuse could be pushed from a marginal possibility to common practice. In this document, we define 'steel reuse' as the use in a new construction of an element obtained from the deconstruction of an older building, typically after testing and reconditioning.

Most studies of the environmental impacts of buildings focus on operational carbon emissions, notably the energy required for heating, cooling and lighting (Choudhary, 2012; Ley and Samson, 2003). However, studying only the operational aspects of buildings is insufficient to provide a complete understanding of the impact of construction, as energy and emissions are also embodied in the building materials and construction. Strategies to reduce embodied energy and carbon depend on the material choice for the frame (Nadoushani and Akbarnezhad, 2015). Concrete framed buildings have relatively little scope for improvement, barring the introduction of novel substitution materials as the current production of supplementary materials is wholly exploited. Steel buildings by contrast offer an alternative route for carbon and energy savings: the steel elements of the building can be reused if the building is deconstructed rather than demolished. As the recycling of steel is an energetically expensive operation (Milford, 2010) even using the best currently available technology, the reuse route represents considerable savings over recycling (Milford et al., 2013). Indeed, steel reuse can play an important part of a global strategy for the efficient use of materials (Allwood et al., 2011; Allwood and Cullen, 2012) as the carbon and energy embodied in structural frames can represent up to 20–30% of the assumed 50 year life-time carbon footprint of a building (Nadoushani and Akbarnezhad, 2015; Dimoudi and Tompa, 2008). Studies on the benefits of steel reuse tend to be prospective, focussing on how design for deconstruction (thought to facilitate reuse) may reduce the carbon footprint from a whole life cycle analysis perspective (Densley Tingley and Davison, 2012). The consensus is that from the environmental point of view, steel reuse is a potentially excellent strategy (Cooper and Gutowski, 2015), and general guidance about the reuse process is available (Addis, 2012). Nonetheless, widespread reuse does not seem to occur.

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1.1. Steel reuse potential in the UK

In the UK, steel reuse is a marginal practice, representing between 8 and 11% of the steel arising from demolition (EUROFER, 2012; Sansom and Avery, 2014). Other construction materials, notably bricks are commonly reused because they are valuable, for example Cambridge white bricks are not produced any more and are highly sought after for façades. However, the vast majority of emissions associated with construction come from cement and steel production. Almost all of the steel which is not reused is sold as scrap to be remelted. The carbon intensity of the electric arc furnace (EAF) route – 0.36 kg CO_2/kg steel – is much lower than that of the production of new steel in the UK. The latter is dominated by blast furnaces, with an average intensity of 1.78 kg CO_2/kg steel according to the *Steel Statistical Yearbook* (Yearbook 2015) and the International Energy Agency (Carpenter, 2012). This saving represents 7% of the emissions from the UK steel industry, indicating constructional steel reuse could significantly participate in helping this industry reach its emissions reduction target, as defined in the COP21 (Serrenho et al., 2016; Report of the Conference, 2016). To establish more precisely what are the potential savings, we estimated the amount of steel from sections arising from demolitions. The National Federation of Demolition Contractors (NFDC) represents 80% of the market by value and has published in the last ten years a report indicating the total mass of metal in demolition arisings. Approximately 40% of the total is taken by larger sections which could be reused, consistent with the work of Milford and colleagues (Milford et al., 2013). We estimate thus that currently, between 40 and 80% of the needs of the market could be covered by these arisings, a proportion which is set to increase (Fig. 1).

Cooper and Gutowski wrote an extensive review of the qualities needed for a product to be most environmentally and economically suitable for reuse (Cooper and Gutowski, 2015). The products should be long-lived, substitute production – and thus not be the cause of more emissions through the rebound effect – and have high embodied carbon. All these properties are found in structural steel.

In conclusion, widespread reuse of construction steel would, in the UK context, significantly help the steel industry meet its emission targets.

1.2. Real and perceived barriers

Our study focuses on the UK design and build process only: construction practices are specific to each country as norms, industry structure and habits vary. Indeed, steel reuse in construction is a complex problem involving economic, sociological, technological, and legal considerations. In the UK, all actors of the construction supply chain experience specific barriers which deter them from steel reuse (Kuehlen et al., 2014). These barriers are summarised in the works of Vukotic (2013) and that of Densley Tingley et al. (2016) among others. International comparisons indicate common challenges. For example, the work of da Rocha and Sattler (2009) about steel reuse in Brazil attempts to cover all aspects. He identifies, in the Brazilian context, trust between actors about the quality of the steel to be a central problem. He further identifies logistical difficulties such as the quality of roads which may not be relevant to the UK. There is a body of work on practical experiences with steel reuse which analyses case studies, for example, Gorgolewski et al.'s collection of successful projects (Gorgolewski et al., 2006). These show that when there is strong integration in the supply chain, for example when the firm responsible for the design of a new building is also the owner of the building it replaces, then steel reuse is found to be practical and cost effective. An important factor found in all studies is lack of trust between actors, which translates to onerous contracts, deterring many potential reusers. All these studies therefore indicate the key barrier to steel reuse is the articulation of the supply chain, which would need to be reconfigured to form a supply loop as per Geyer and Jackson (Geyer and Jackson, 2004).

Indeed, an important unresolved question in published studies is the lack of distinction between 'barriers to steel reuse' and 'barriers the interviewee has personally experienced'. This distinction is particularly important as the construction supply chain in the UK is strongly compartmentalised and the barriers any actor interviewed believes are important across the supply chain may not apply specifically to themselves, and therefore could be a perceived barrier rather than real. In the current study, we have tried not only to understand the barriers to steel reuse, but also how each actor would introduce steel reuse in their usual work-flow. To this purpose, we have held interviews across the supply chain, to piece together where the barriers arise and how they affect each part of the supply chain in practice. We have used an analysis method inspired from information retrieval to derive an index which measures the acuteness of the concerns of the actors we interviewed.

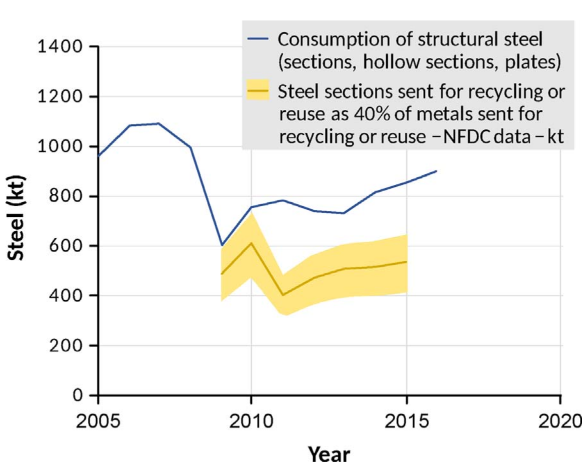

Fig. 1. Mass of steel elements used in construction compared to an estimation of elements sent for recycling and reuse. The large uncertainty in the steel arising is represented by a band. This band assumes that the proportion of metal suitable for reuse lies between 30 and 50%. Further, NFDC only represents 70–90% of the demolition market by value. Taken together, these ranges define the uncertainty band.

2. Methods

To establish how important each barrier to steel reuse is to each actor across the construction supply chain. We set up an on-line survey and conducted interviews. A novel analysis of the answers is used to rank the perceived importance of barriers across the supply chain. Both interviews and survey were conducted concurrently, and the same questions were asked in both, although the interviews covered topics in more depth.

2.1. On-line survey and interviews

A structured online survey was set up. It comprised of a standard set of questions plus specific ones depending on the actor's role. The survey was available online from January to May 2016. It was advertised at a 'circular economy' events and a number of the interviewees also completed the survey. Invitations for filling the survey were distributed by leaflets, e-mail, phone, and in person. People who were invited to take part in the survey had various levels of experience with steel reuse, but all of them were interested in the topic.

Following the start of the survey, 30 actors were interviewed (Table A1). Most interviews occurred in person, although some were by phone and some information was obtained from follow-up emails. Interviews were conducted in Cambridge (Department of Engineering), London (offices of ASBP) or at the offices of the interviewees. The information gathered from 80% of the interviews was verified by the interviewees who checked the post-interview reports. The interviews covered the themes of certification, cost, and programme. The interviewees all had