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Options to make steel reuse profitable: An analysis of cost and risk distribution 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, it is in effect only a marginal practice. A detailed analysis of the costs and risks of reuse in practice in the UK is lacking. We found that although there is a sufficient spread between the price of steel scrap and new steel, this difference cannot be captured by the demolition contractors. Rather, reused steel is somewhat more expensive than new elements, except in certain circumstances such as when the reused elements are available from a nearby site, or when testing elements can be avoided. Further, we show that neither the costs of steel reuse, nor the risks, nor its benefits are spread equitably throughout the construction industry supply chain: most of the substantial and capital-intensive changes required for the widespread adoption of steel reuse are concentrated on steelwork contractors and stockists. Based on this analysis, we suggest helping the emergence of a specialised stockist.

1. Introduction

The trends in ecologically-friendly construction aimed at reducing the impact of buildings have largely focused on the operational aspects: better insulation, better natural lighting, better ventilation. These have considerably lowered the carbon and energy footprints of newly-built or retrofitted buildings. Nonetheless, a large part of the whole-life carbon footprint of buildings is not associated to their use, but is embodied in the materials used for construction.

The study of operational emissions is thus insufficient to fully describe the impact of a construction (Ley and Samson, 2003; Choudhary, 2012). Moreover, current practices make it possible for constructions to be operationally carbon neutral. Further efforts should then look at the *embodied* carbon and energy required for building construction, materials production and forming, and material transportation. Depending on the material used for the frame, the strategies which have the highest mitigation potential are different (Nadoushani and Akbarnezhad, 2015).

Concrete framed buildings have relatively little scope for improvement, aside from the introduction of novel substitution cementitious materials (SCM) as the current production of SCM is almost wholly exploited (Snellings, 2016). Steel buildings, by contrast, offer an alternative route for carbon and energy savings: the steel elements of the building can be reused if buildings are deconstructed rather than demolished (Fujita, 2012). This is the case even when the elements have not been expressly designed for that purpose, a key focus of ongoing research (Durmisevic and Noort, 2003; Guy et al., 2006; Ness et al., 2015).

In this study, we concentrate on steel-framed buildings. Recycling steel only save approximately 50% of the energy and carbon over making new steel (Norgate et al., 2007), as the recycling of steel is an energetically expensive operation even using the best currently available technology (Milford, 2010). By contrast, steel reuse can play an important part in a global strategy for the efficient use of materials (Allwood et al., 2011; Allwood and Cullen, 2012; Zink et al., 2015). The carbon and energy embodied in structural frames can represent up to 29% of the life-time carbon footprint of commercial buildings (Nadoushani and Akbarnezhad, 2015; Dimoudi and Tompa, 2008). Although the embodied carbon for offices and dwelling is much lower, typically in the order of 8–13%, this fraction is set to increase as

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operationally carbon-neutral buildings are more commonly being constructed. Despite the consensus view of steel reuse as a potentially excellent strategy (Geyer and Jackson, 2004; Cooper and Gutowski, 2017), its practical implementation is fraught with difficulties. Thus, studies on the benefits of steel reuse tend to be prospective, focusing on *e.g.* the trade-off between design for deconstruction (Crowther, 2015) (thought to facilitate reuse) and carbon life cycle analysis (Densley Tingley and Davison, 2012). Indeed, the proportion by mass of elements reused from steel arising from demolition in the UK is low and declining (Sansom and Avery, 2014). This is due to a combination of factors, notably the decline of the reused steel market, now concentrated in a few niches such as farm animal sheds.

Studies of steel reuse practice tend to reflect the particular circumstances of the country where they are conducted, as in the work of Da Rocha about steel reuse in Brazil (da Rocha and Sattler, 2009), who identified steel quality to be a critical barrier. This barrier does not seem to the relevant to the UK, where the steel certification process is possibly *too* stringent. In Canada, Gorgolewski describes practical experiences with steel reuse and presents successful case studies (Gorgolewski et al., 2006). For example when the firm responsible for the design of a new building is also the owner of the building it replaces, keeping elements for reuse presents few difficulties. When there is strong integration in the supply chain, steel reuse is found to be practical, and most importantly cost effective. It is not clear this advice is generally applicable in the UK where the supply chain is highly fragmented.

Many previous studies of steel reuse in the UK list barriers extracted from interviews and establish a hierarchy (Vukotic, 2013; Kuehlen et al., 2014; Tingley et al., 2017). Cost and programme (the organisation and timing of the various operations in the design and build process) are always at the apex of barrier hierarchies, but there has not yet been a detailed reconstruction of the business case of steel reuse. A work from our team recently exposed the heterogeneity of the barriers to reuse felt across the supply chain (Dunant et al., 2017): the stockists and steelwork contractors are the ones whose operations have to change the most to accommodate steel reuse.

A business case for steel reuse in any country must fit in the context of the local construction value chain. This value chain is the added value from all the actors in construction as well as their share of the profit. In the context of this paper, we concentrate on the cumulative cost of a structural beam as it goes from semi-finished steel (or as deconstructed) to being erected on a construction site.

Suggesting effective steps to change the practice of the construction industry must be based on knowledge of the circumstances under which steel reuse can be profitable. In the particular case of the UK, using data acquired through interviews (Dunant et al., 2017), this paper attempts to demonstrate that:

1. In certain circumstances, steel reuse can be reliably shown to yield cost savings;
2. A general market for steel reuse has not arisen because the risks and benefits of it are not apportioned fairly among the actors of the supply chain;
3. There is an opportunity to introduce a specialised actor in the supply chain responsible for the acquisition, reconditioning and distribution of reused elements.

This is done by establishing a cost model describing how an erected steel beam is priced, and describing the risks faced by each actor when a construction project involves steel reuse.

2. Materials and methods

A quantitative survey of the costs of steel reuse is missing, in particular for the UK. Only scant published information is available on the pricing structure of new steel elements, even more so from reuse. This is in part because the information on the cost structure is fragmented across the supply chain, but also because such information is commercially sensitive. As part of a larger study on steel reuse, we have interviewed actors from across the chain about their experience of the topic, and have asked them to provide us what costing information they could disclose. By comparing the results, we were able to reconstruct the cost structure per tonne of fabricated and erected steel elements in the cases of new and reused steel.

2.1. Interviews

We interviewed 30 members of the value chain (Fig. 1): 10 client/advisers/architects, 4 main contractors, 12 structural

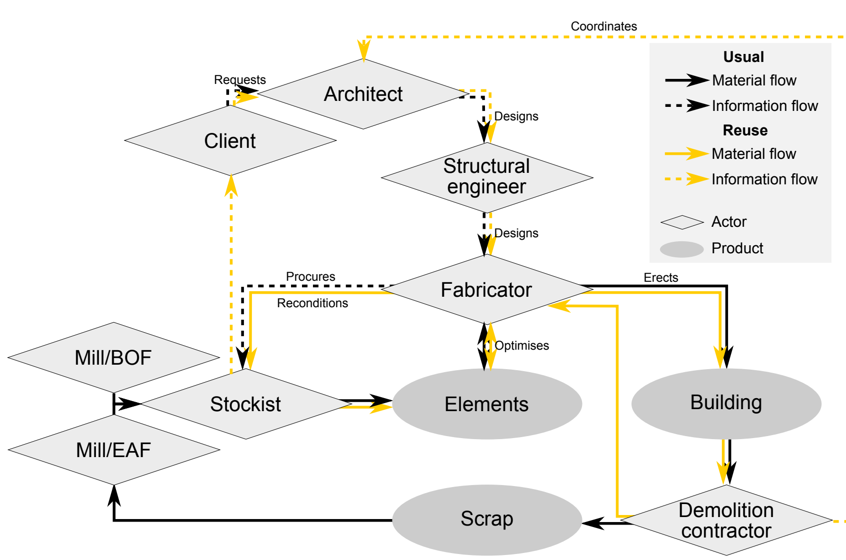

Fig. 1. How steel and information flow across the construction value chain. The central role of the fabricators and stockists is apparent. Figure adapted from Dunant et al. (2017).