Barriers to structural steel reuse and means of overcoming them

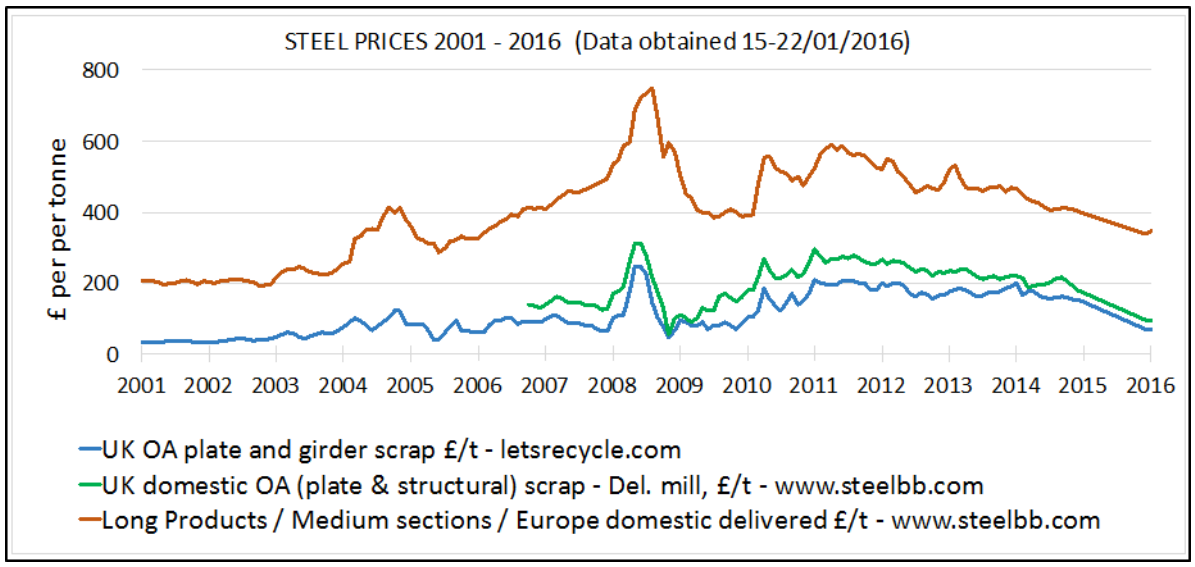
Consultation with the supply chain has identified the following main barriers to the reuse of hot-rolled structural steel recovered from the deconstruction of UK buildings. This is by no means a comprehensive list of barriers put forward by consultees but arguably, they are the main ones.

1. Economic barriers
2. Availability
3. Traceability and certification
4. Lack of demand/incentive
5. (Lack of) supply chain integration
6. Automation and health and safety.

In this section, these six barriers are explained and potential ways of overcoming them, based on the research, are suggested. It is noted that there is overlap and interrelationships between barriers and importantly, clear cut solutions have not been identified to all barriers.

Economic barriers

There is a perception that reusing reclaimed structural steel is more expensive than using new steel. This is not clear from the research. What we do know, with some certainty, is the differential in price between new steel and scrap steel (OA grade; the relevant grade for structural steel sections). Although new steel and scrap steel prices are volatile, as shown in the graph below, there is a price differential. Over the last 15 years, the price differential was never lower than £200/t; the highest was almost £520/t. The average difference was £280/t.



Comparison of new structural steel price and OS scrap price 2001 to 2016

It should also be noted that actual new steel prices are not necessarily the same as the steel prices published by the steel mills.

What is also apparent, is that there are additional costs that will be incurred as a consequence of using reclaimed structural steel. These include:

- Additional structural design cost as a consequence of designing using non-optimised sections, i.e. the designers will need to design the structure based on the available sections rather the full list of (new) universal sections
- Additional cost for deconstructing (as opposed to demolishing) steel frames
- Additional fabrication cost including grit/shot blasting to remove any coatings, removal of any fixtures and filling any holes, etc. in the reclaimed members. It is noted that many fabricators are moving to fully automated fabrication lines where the difficulties of working with previously used sections are exacerbated
- Additional transport and storage of the reclaimed sections
- Chemical and mechanical testing of the properties of the reclaimed sections.

It has not been possible to provide definitive cost information for these additional activities since they are highly variable and project dependent. A further complication is that pricing of structural steel is usually on a 'per tonne basis' whereas some activities, e.g. testing, are generally on a piece-basis. Nevertheless, the following additional costs are suggested on the basis of the consultations undertaken with the supply chain.

Activity	**£/t**	**Notes**
Additional design cost	-	Unknown - project specific
Additional deconstruction cost	161	Assumed 75% of erection cost
Additional fabrication cost	120	Additional 20% of fabrication cost
Additional transport and storage	34	
Testing	53	Assume average weight 38kg/m, 6m sections, testing 20% of beams £60 per test

Data based on typical costs for a typical, multi-storey commercial building

In terms of economic viability, what is clear is that any cost savings need to be equitably shared between all actors in the supply chain to make reuse happen.

It should also be noted that the economic viability has been considered in the context of today's (2016 Q2) costs only. Future scenarios in which, for example, material prices are much higher and/or environmental taxes are much greater, would significantly change the economic viability assessment.

Reuse case studies such as Bedzed and the Segro projects demonstrate that reuse can be cost neutral and should therefore be promoted more widely. If other aspects including carbon savings, social benefits and reputational advantage could be robustly quantified (economically) the case for reuse would be stronger.

Economies of scale also apply in that more widespread reuse would lead to greater availability, lower transport costs, lower unit test costs, etc.

There is no panacea to the cost barrier. Given the right incentives all actors in the reuse supply chain would use reclaimed sections if it made economic sense for them to do so.

Availability of reclaimed sections

Availability was cited as a barrier by many consultees who had experience of trying to design buildings using reclaimed structural steel sections. This is self-evident given the low volume of steel

sections currently reclaimed from UK demolition; estimated to be just 5% of those arising from demolition.

There are two aspects to overcoming this barrier:

1. Supply (demolition contractors) and demand (clients and their professional advisers) need to be encouraged to reuse structural steel; clearly an economic incentive is a prerequisite in the absence of legislative or other drivers.
2. Means of sharing information on the supply and demand of reclaimed steel sections need to be established.

Concerning the second point, the Innovate UK project under the Supply chain integration call (Supply chain integration for structural steel reuse) is specifically investigating the feasibility of sharing information along the supply chain and particularly between the two actors at either end of the supply chain, i.e. demolition contractors and designers.

This project is investigating the feasibility of developing a website portal for sharing information about structural steel reuse and also providing a material exchange, focussed on reclaimed structural steel, through which reclaimed steel sections can be sourced and traded.

Traceability and certification

For designers and steelwork contractors to design and fabricate reclaimed steel structures efficiently and safely, it is evident that information concerning the provenance of the reclaimed steel is known. This includes both mechanical and chemical properties. Certainty in material properties is also important in the context of warranting reclaimed steel structures and the professional indemnity insurance of the designers.

Traceability of new steel used today is relatively robust and it is relatively easy, using new and existing manufacturing and BIM software, to provide an audit trail of the structural steel used in buildings. Ultimately this trail should to lead to the inspection document relating to the manufacture of the steel which will include all relevant chemical and mechanical properties. Reuse today is different however; for most buildings of any age, information is generally not available to help the demolition contractor deconstruct the building or for the designers to make new designs using the reclaimed steel sections.

Solutions to overcoming this barrier <u>today</u> and in the <u>future</u> are therefore quite different.

Reuse today

Without detailed knowledge of the material properties of the reclaimed steel, testing will be required to facilitate subsequent reuse. Options for this include:

1. Destructive testing either in-situ or after the structure has been deconstructed. Sampling in-situ can be difficult particularly where the structure is not exposed and/or when the building is still occupied. It is also potentially costly although one consultee suggests that a full suite of chemical and mechanical testing, to derive the same set of parameters as included in a new steel mill test certificate, costs £60-70. In addition to a chemical analysis, this provides tensile and yield strength, elongation and hardness parameters. Testing each reclaimed steel member is unlikely to be economically viable and therefore appropriate sampling and testing protocols are required.

2. Non-destructive (ND) testing - ND testing of steel (and other metals) is well developed and there are many commercially available portable testers used by many parts of the steel

production, fabrication and scrap processing sectors. ND chemical testing using, for example, XRF (X-ray fluorescence) spectrometry is able to rapidly determine the chemical composition of the steel. ND testing of mechanical properties is more difficult, portable hardness testing equipment is available and this can be correlated to the strength of the steel although the accuracy of this approach is disputed.

3. Age of the steel - A third approach, is based on the age of the building, the steel within it, knowledge of the history of UK steel section production and engineering judgement. This approach, sometimes supplemented with some testing, appears to be the most common scenario for the steel reuse and refurbishment case studies identified though consultation.

   The process is:

   1. The age of the building is known or established and the age of the steel within the structure inferred from the age of the building.
   2. Using historical records including the BCSA and SCI publications – see below, dimensions and properties of the steel sections can be established.
   3. The age of the building will also determine the relevant codes likely to have been used in the design of the structure.
   4. Based on 2 and 3 and applying engineering judgment, usually making conservative property assumptions, experienced engineers can successfully design safe, new structures using reclaimed sections.

   It is possible that decision-support software could be developed to replicate and simplify this process this process.

Guidance on the appraisal of steel structures and information on the historical use of structural steel in the UK is provided in the following publications:

1. Historical Structural Steelwork Handbook (4th impression, 1991) BCSA
2. Appraisal of existing structures (third edition) 2010, The Institution of structural engineers
3. Appraisal of existing iron and steel structures, SCI P138, (1997).

CE Marking of reclaimed structural steel was identified as a significant barrier to reuse by many consultees.

Clearly, structural steel that was manufactured before the introduction of the Construction Products Regulation (CPR) will not be CE-Marked and is likely to have been manufactured to a (now withdrawn) national product standard.

We have investigated, with advice from steel certification experts, the requirements of the relevant harmonised standards for hot rolled structural steel products and fabricated steel structures (EN 10025 and EN 1090). Our conclusion is that under EN 1090-2 reclaimed structural steels do not need to be to the relevant product standard; in this case EN 10025-1, as long as their properties are specified. However, this view appears to be subject to interpretation of the relevant clauses in the relevant standards.

Whether real or perceived, certification of reclaimed structural steel is a significant barrier to their reuse. In terms of overcoming this barrier therefore we propose the following:

1. Obtain a more definitive interpretation of the standards concerning reclaimed structural steel (it is noted that both EN 1090 parts 1 and 2 are currently being redrafted).
2. Include a relevant clause(s) in the standards and the CPR that specifically address the requirements for reclaimed structural steel so that this option is proactively encouraged in line with the EU's circular economy strategy.

It is noted that although the focus of our work is structural steel, however it is likely that these issues also apply to other construction products.

As part of this project, we have discussed certification and use of reclaimed structural steel with BSI and as a consequence, produced a note on our understanding of the certification of previously used structural steel. BSI has circulated this note to the following BSI committees:

- CB/203 – Design and execution of steel structures
- ISE/103 - Structural steels other than reinforcements
- B/558 – Sustainability of construction works

With a request for comments specifically on:

- a definitive interpretation of EN 1090 with regard to use of reclaimed steel
- the possibility of revising EN 1090 to allow for the use of reclaimed steel
- any other comments on standardising for the use of reclaimed steel

The deadline for the receipt of comments is 1st August therefore we will include a summary of these comments in the final deliverables for the Innovate UK steel reuse projects.

Lack of demand or incentive

Ultimately, it is construction clients who will drive the reuse of structural steel; ideally to save construction cost. As outlined above however, cost savings though reuse, will be challenging to achieve in the current market. It should also be noted however that structural costs typically represent only around 15% of the total build cost of commercial, multi-storey buildings. Consequently costs savings achieved through reusing the structure represent a small proportion of the overall build cost.

There are other reasons for clients to pursue reusing structural steel these include, generally internal, targets and strategies to reduce embodied carbon and corporate and reputational benefits associated with 'doing the right thing'.

What is lacking is any legislative incentive to reuse structural steel. Several initiatives have been started to encourage greater reuse and recycling of construction products and materials (see examples below) but since the 2008 recession, successive UK Governments have, in general, reduced regulation on constructors and this has included the removal of several sustainability measures including the Code for Sustainable Homes, Site waste management plans, Zero carbon homes targets, etc. In general therefore, there is significantly fewer legislative incentives and drivers for sustainable construction in the UK, including measures to encourage building end-of-life recovery, recycling and reuse.

Measures developed over the last few years which were designed to encourage reuse and recycling include:

- Inclusion of credits for reuse within BREEAM (BRE rejected this on the basis that they did want to be seen as favouring certain material groups, in this case steel)
- WRAP reuse and recycled content targets
- Proposal to include embodied carbon within the Building Regulations (Approved Document Part L)
- Proposal to include embodied carbon reductions as an allowable solutions under the proposed zero carbon building targets.

Two successful fiscal measures which have undoubtedly had an impact on construction and demolition waste practice are:

1. The Landfill Tax, introduced in 1996 and currently £84.40 per tonne (standard rate) and £2.65 per tonne (lower rate) most uncontaminated demolition waste is defined as inert and generally attracts the lower rate.
2. The Aggregates Levy, introduced in 2000 to encourage the use of recycled and secondary aggregates in place of primary aggregates. The levy is currently £2 per tonne.

The 2020 target under the EU Waste Framework Directive (2008/98/EC) is for Member States to increase the recovery rate of non-hazardous construction and demolition waste to a minimum of 70% by weight. The latest Defra statistics on UK waste (December 2015) suggest that the average UK recovery rate of non-hazardous construction and demolition waste between 2010 and 2012 was 86.3%. It is clear that more challenging targets are required which not only divert waste from landfills but also encourage reuse, true recycling or upcycling, as opposed to downcycling which is common for most demolition waste streams.

In 2015, the EU adopted a circular economy package which includes revised legislative proposals on waste. Within the EU Action Plan (COM(2015) 614 final) it is stated that:

The Commission will take a series of actions to ensure recovery of valuable resources and adequate waste management in the construction and demolition sector, and to facilitate assessment of the environmental performance of buildings.

Specific actions relating to construction and demolition waste include the development of:

- Pre-demolition assessment **guidelines** for the construction sector 2017
- Voluntary industry-wide **recycling protocol** for construction and demolition waste
- **Core indicators** for the assessment of the lifecycle environmental performance of a building, and incentives for their use.

The UK planning system has an important and overarching role in delivering sustainable development. The aim of the planning system is to help ensure that development takes place in the public interest and in economically, socially and environmentally sustainable ways. It also has a role to play in helping to cut carbon emissions, protect the natural environment and deliver energy security.

The core elements of the planning system are development plan-making and development management. These activities are primarily undertaken at the local level.

The planning system in England requires each local planning authority to prepare a local development framework (LDF) which outlines how planning will be managed for that area. In determining planning applications, local planning authorities (usually the district or borough council) must have regard to their LDF.

Planning authorities are also responsible for development management. This includes statutory requirements on publicising, consulting on and determining most applications for planning permission, taking into account the opinions of local people and others.

The Department for Communities and Local Government supports plan-making and development management, principally through the provision of planning legislation, national planning policy and guidance.

The National Planning Policy Framework was published in March 2012 and effectively replaces all existing Planning Policy Statements (PPS). Proposed policy changes were published for consultation in 2015. The framework gives guidance to local councils in drawing up local plans and on making decisions on planning applications. It states that Local Plans should be based upon and reflect the presumption in favour of sustainable development, with clear policies that will guide how the presumption should be applied locally. Planning Policy Statement 10: Planning for sustainable waste management was published in 2005.

Most planning policy relates to relatively high level decision making such as where and if new development should be permitted. At the local level however, many planning authorities have prepared supplementary planning guidance (SPG) and supplementary planning documents (SPD) which provide more detailed guidance applicable at the individual project level; guidance can be either topic or site specific.

SPGs and SPDs are one of the 'material considerations' taken into account when determining planning applications. Most planning authorities are replacing SPG with SPDs which form part of the authorities' Local Development Framework. Many local planning authorities have prepared SPG/SPD that specifically address sustainable design and construction. In terms of scope these documents are often closely aligned with national assessment schemes such as BREEAM, however many documents vary significantly between different authorities and many include different issues and targets. In relation to construction and demolition waste management, the SPG/SPDs (where they exists) make reference to Site waste management plans and waste minimisation statements in addition to providing guidance on good waste management practice.

Better supply chain integration

Traditional construction supply chains are long and complex. In most construction projects the supply chain is generally considered to terminate at building completion/handover or shortly after. Following the building's useful life which can be 50 to 100 years of more, a demolition contractor is engaged to demolish or deconstruct the building.

In effect therefore we have a long, linear supply chain with the demolition contractor and the client (with their professional advisers) at either end. Circular economy principles involve bringing these two actors together so that, in the case of structural steel, information on supply (from deconstruction) can be shared with the demand from the designer.

Integration of the needs of designers and demolition contractors is the focus of the previously mentioned Innovate UK project focussed on supply chain integration and the provision of

information via a website portal. In addition to providing guidance on structural steel reuse, the proposed website will facilitate information exchange including:

- Posting information about buildings scheduled for demolition
- A platform where buyers and sellers of reclaimed steel sections can trade
- A facility to upload as-built BIM files so that in the future, a detailed inventory of steel sections within the building can automatically generated.

In addition to the specific objective of bringing together designers and demolition contractors, it is apparent that all actors in the steel construction supply chain need to be better integrated to facilitate structural steel reuse. Economic and legislative drivers (addressed above) are most likely to bring about improved supply chain integration.

Automation and health and safety

Time pressures associated with new build programmes and H&S issues associated with demolition work are cited by demolition contractors as major barriers to the recovery and reuse of structural steel from buildings. Many demolition contractors consulted sated that recovery and reuse was far more common in the past than it is today.

High-reach demolition equipment with shear, pulverising or universal attachments, allow demolition contractors to demolish buildings quickly and without operatives working at height and the associated H&S risk. Modern high-reach equipment can be used to demolish buildings up to 70m high.

Most demolition contractors consulted stated that there was generally no significant technical barriers to deconstructing buildings, with a view to recovering the steel sections for reuse, as long as:

- The programme allowed sufficient time to deconstruct the building
- It is economically viable to deconstruct the building; this could mean a higher fee for the developer and/or additional value achieved by recovering steel sections for reuse rather than just scrap value.

While it is recognised that demolition using high-reach equipment is the fastest and quickest demolition method for many buildings, there are many buildings which require more careful deconstruction using top down or floor-by-floor demolition which is more conducive to material recovery. Such situations include:

- City centres
- Near railway lines
- Tall buildings
- Adjacent to historic buildings.

In terms of technical developments that may facilitate reuse the only suggestion from demolition contractors, was a new twin-boom excavator developed in Japan. The arms of this machine could, in theory, allow the steel section to be held in place using one arm, while the other shears the ends of the section.

Hitachi ASTACO (Advanced System with Twin Arm for Complex Operation)

Increased automation was also cited as a barrier to reuse by steelwork fabricators. Many UK fabricators have or are currently investing in fully automated production lines that cut, drill and in some cases weld, structural steel members. Recovered sections will generally include holes/openings and plates, brackets, stiffeners, etc. welded to the main member. Automated fabrication lines will not cope well with these unforeseen additions and therefore manual removal of accessories will be required; incurring additional cost and impeding factory throughput.

In addition, fabricating reclaimed sections will generally mean greater variability in section types, sizes, qualities, etc. compared to using new steel. The need to 'clean up' reused sections before fabrication and to re-tool the cutting and drilling machinery is time consuming and hence expensive for the fabricator.