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Strategies for salvaging and repurposing timber elements from existing buildings

Sustainability scholarship 2021
The Worshipful Company of Constructors

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Executive summary

A circular economy approach within the construction industry is crucial for addressing the climate and biodiversity emergencies we are currently facing. The concepts of designing out waste and keeping materials in use for as long as possible are not new or complex to understand. However, integrating these into the current business model of the construction industry is not straightforward, as changes are needed at practical, technical, economic, and cultural levels.

Nearly 40% of the global carbon footprint emissions are due to buildings and the construction sector, from which 11% are associated with the manufacturing of conventional building materials such as steel and cement (United Nations Environment Programme, 2019). In addition, the construction, demolition and excavation waste (CD&E) represents 62% of the total annual UK waste (Department for Environment Food & Rural Affairs, 2020).

As a natural material, timber is one of the most promising sustainable construction materials that can help mitigate climate change. However, there is no guidance or route within the current business model to enable its circularity (i.e. recovery and repurposing) and assessment to guarantee that the material is fit for purpose. Unlike recycling, re-use enables to keep construction materials at their highest value while at the same time eliminating the need to source new materials. In addition, timber can be upcycled into engineered wood products (EWPs) like Cross-laminated timber (CLT) or Glulam, creating components with the potential to replace carbon intensive materials like concrete or steel.

This document summarises the main findings of the research project "*Strategies for salvaging and repurposing timber elements from existing buildings*." The aim of the research was to gain an understanding of the challenges and opportunities for salvaging structural timber during demolition activities and for reusing second hand or upcycled structural timber during construction activities. This was achieved by two interview series. The first was an interview programme targeted to demolition and main contractors. This consisted of semi-structured interviews with the aim of obtaining an understanding of the current practice, barriers, and opportunities of reclaiming and repurposing structural timber. The data collected from this interview programme was analysed using thematic analysis. The second consisted of elite interviews to obtain information and insight from experts in the field like TRADA, NFDC and Timber Development UK. Overall, the data collected was analysed via triangulation using the thematic analysis from the interview programme to demolition and main contractors, the elite interviews to different stakeholders and the available literature review. The scope of the research was limited to the reclamation of structural components consisting of softwood and hardwood and strategies applicable to the UK practice. A summary of the barriers and opportunities for salvaging and repurposing (reuse/upcycle) structural timber identified are presented. The strategies for timber reclamation and repurposing identified were mapped against the business-as-usual demolition and construction process. Recommendations of what we can do now to help us achieve reclamation and repurposing and pave the way for the development of a future "re-use" market for structural timber are outlined along with future work.

Acknowledgements

I would like to thank the people that have helped me during this year to complete this research project. First of all, I would like to thank my mentors Penny Gowler and Mike Nestor for their time, conversations and feedback during the past year, their support was invaluable.

Thank you also to Anna Koukoullis, Anjali Pindoria and Deborah Pullen for coordinating the programme and their constant support and encouragement. Thank you to Renuka Thakore and Donna Rourke-Houguez for sharing their expertise via the learning session series.

A very special thanks to all the interviewees, for taking the time and for sharing their knowledge and insight which form the basis of this research. And to all those that provided guidance at the early stages throughout conversations that helped me define the problem.

Finally, I would like to thank the Worshipful Company of Constructors, the Chartered Institute of Building (CIOB) and University College of Estate Management (UCEM) for their funding, and to Elliott Wood for the time and support that helped me to complete this project.

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Toureen Group

TRADA

Weald and Downland Museum

Westgreen Construction Ltd

Willmott Dixon

Contents

Definitions

The following are some key terms and definitions used throughout the report. Where applicable, these are in line with the key sustainability terms for engineers provided by Di Benedetto (2021).

Circular economy
"A circular economy is based on the principles of designing out waste and pollution, keeping products and materials in use, and regenerating natural systems" definition by Ellen MacArthur.

Structural timber
In this study, structural timber refers only to softwood and hardwood elements such as beams, joists and columns. It does not refer to engineered wood products.

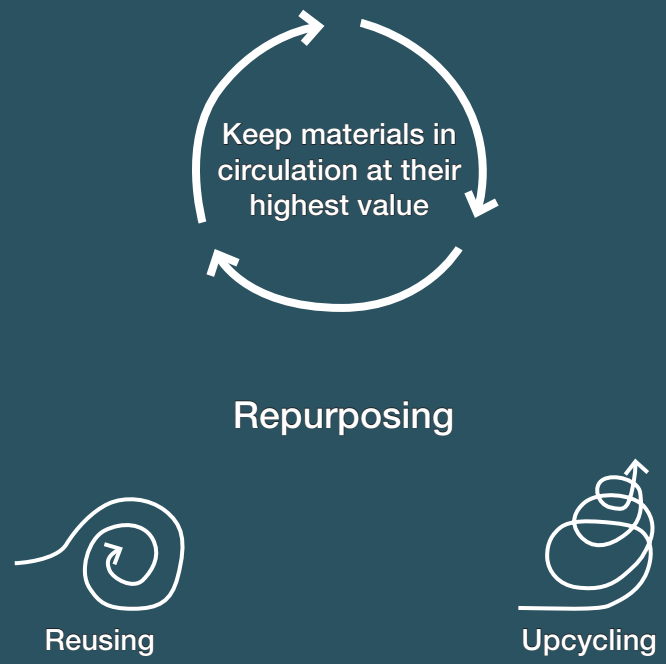
Repurposing
In this study, repurposing means the re-use or upcycle of structural timber by retaining or increasing its value.

Upcycle
In this study, upcycle refers to the manufacture of new structural products using reclaimed timber materials to create products with higher value, i.e. enhanced structural properties, with the potential of replacing concrete or steel members.

Re-use
In this study, re-use refers to re-using components in the same way (or largely retaining its original form) as they were originally designed for by retaining its value, e.g. re-using a timber beam as a timber beam after re-conditioning, etc.

Recycle
In this study, recycle refers to significantly modifying the properties (in other materials usually by separating them into its individual components) of a structural timber element to create another product, usually with lower value, expending energy and carbon for the recycling process and with no use for construction, e.g. manufacturing recycled wood products such as animal bedding. In this context, we consider recycling as downcycling.

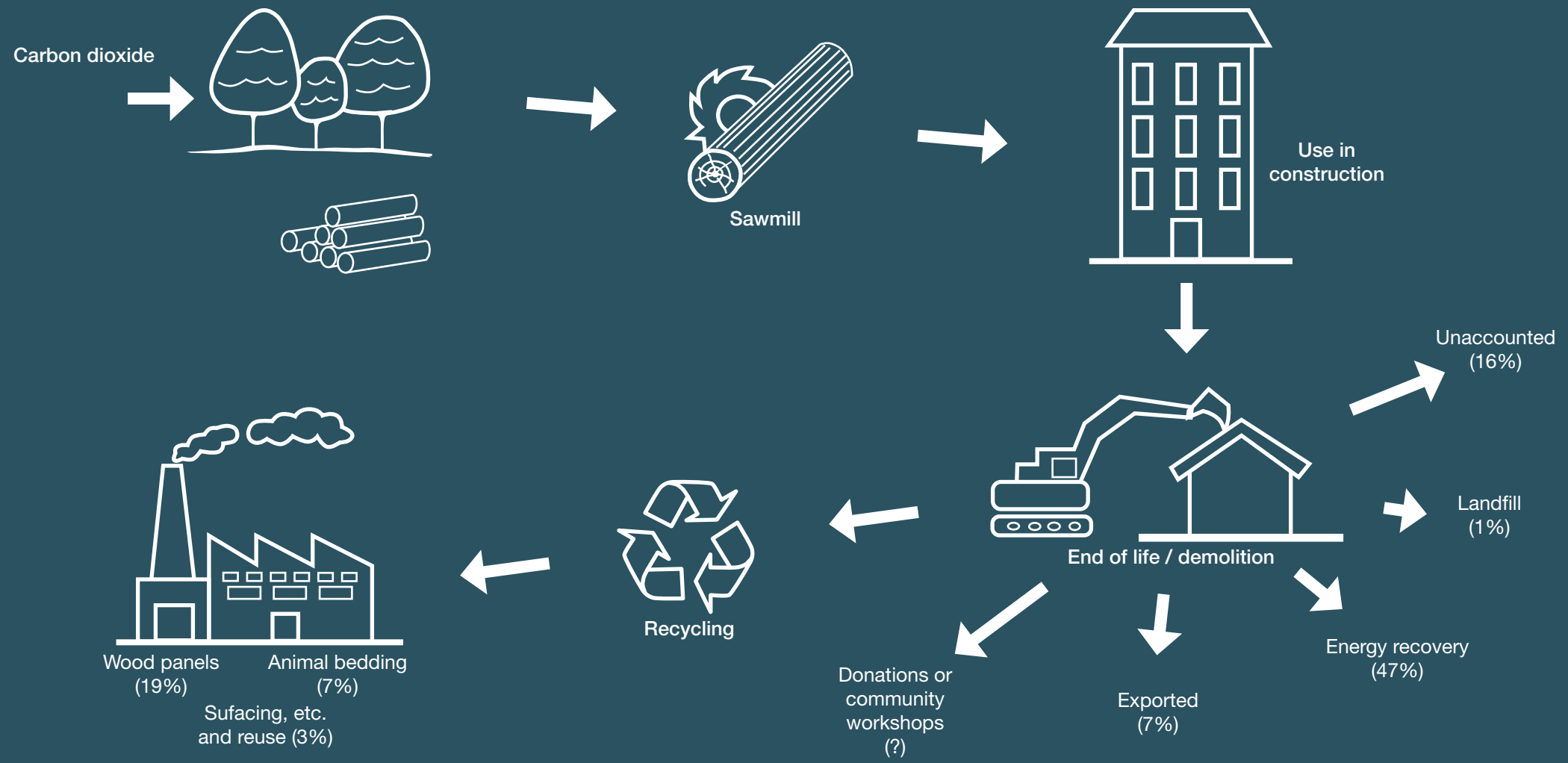
Salvage
In this study, salvaged material refers to the recovered structural timbers from demolition/ deconstruction sites for its future use either by direct re-use or upcycling. Also referred to as reclaimed timber, second-hand timber and secondary timber.



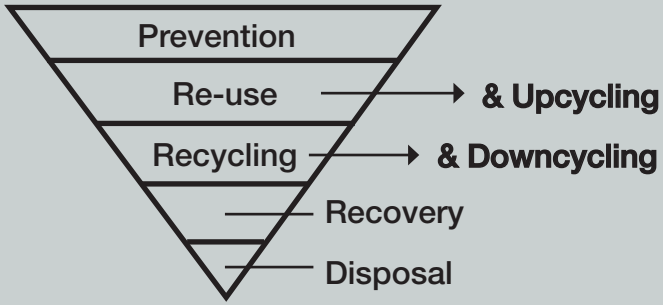
Waste wood

The figure below shows the current waste wood routes. In 2018, the total amount of waste wood available in the UK was 4.5 million tonnes, for which approximately 40% was from construction and demolition activities (Wood Recyclers Association, 2019).

From this, approximately 83% is processed, 1% ends up in landfill and the rest 16% is unaccounted (Wood Recyclers Association, 2019; TRADA 2020). Some of the timber is donated or sent to recycling facilities. However, the overall amount of reclaimed and reused material is unknown as the practice of reuse is informal. The majority of the waste wood processed is used as fuel in biomass for energy recovery - including the waste wood exported as fuel. However, this remains highly controversial as unlike other renewable energy technologies, most of the current technologies used for the combustion of biomass generates carbon emissions (Office for National Statistics, 2019). New technologies like bioenergy with carbon capture and storage (BECCS) can capture and store the carbon produced through the burning of biomass. But these technologies are not yet being deployed at large scale and they have been slowly developed (Climate Change Committee, 2019; Consoli, 2019). Furthermore, demand for biomass could impact current timber reuse or recycling options (TRADA, 2020).



Data from Wood Recyclers Association (2019), TRADA (2020) and The European Confederation of Woodworking Industries (CEI-BOIS) Tackle Climate Change (2009, quoted in Sustainable Construction Solutions, 2016)



Waste hierarchy
Adapted from the EU Waste Framework Directive (European Commission, 2019)

Waste wood assessment guidance

The Waste Wood Assessment Guidance for the Construction and Demolition sectors (Law, 2021) is an output of the Waste Wood Classification project started in 2017 due to concerns of misdescribing waste wood and confusion about the identification of hazardous waste wood. The project was led by the Wood Recyclers Association (WRA) by request of the Environmental Agency (EA) and have some implications in the way waste wood is classified and dealt with.

Waste Wood Assessment Guidance 2021

- Provides guidance for the classification of waste wood at its origin into non-hazardous, hazardous or with the potential to be hazardous.
- The potential hazardous items could be waste wood from the refurbishment or demolition of heavy industrial installations, or structures constructed or altered between 1950 and 2007.
- Once the items are classed as potential hazardous, these need to be tested in a UKAS accredited laboratory to ensure the hazardous substances are below the hazardous threshold.
- Possible treatments in hazardous wood are chromated cooper arsenate (CCA), creosote, halogenated compounds or metal pigment containing treatments.
- The guide provides a detailed description of the tests required as well as visual examples to help the identification of individual timber components, including structural timbers such as joists, trusses, rafters, purlins, upstands, etc.

Waste wood grades

The table below shows the waste wood grades (Wood Recylers's Association 2021). The waste wood grading system developed by the Wood Recyclers' Association can help to identify and segregate waste wood to appropriate routes.

Typically, construction and demolition waste is considered as Grade B. Usually, this waste wood contains some non-wood materials prior to processing such as nails, metal fixings, paint, plastic, glass, grit, coatings, binders and glues (The Wood Recycle's Association, 2021).

Grade	Description	Typical materials	Processing routes
GRADE A Pre-consumer waste wood and untreated wooden packaging	Clean and untreated	Solid softwood and hardwood Packaging waste Scrap pallets Packing cases Cable drums Process of off-cuts from the manufacture of virgin/sawn timber and untreated board products	Feedstock for products such as animal bedding, equine and landscaping surfacing May be used as a fuel in domestic and non-IED Chapter IV biomass installation Manufacture of pellets and briquettes
GRADE B Industrial waste wood	Treated and non-hazardous	Grade A Building and demolition materials Domestic furniture made from solid wood	Manufacture of panel board products Biomass
GRADE C Municipal wood waste	Treated and non-hazardous	Grade A & B Flat pack furniture made from board products DIY materials	Use in IED Chapter IV biomass installations Panel board in controlled volumes
GRADE D Hazardous waste wood	Hazardous waste wood	Grade A, B & C Agricultural fencing Transmission poles Railway sleepers Cooling towers	Requires disposal at facilities licensed to accept hazardous waste

Reclamation and repurpose barriers for structural timber

The current reclamation and reuse barriers of structural timber in the UK demolition and construction industry were identified from the interviews. These barriers were presented together as it was found that when focusing on the reclamation barriers with the demolition contractors, the reuse challenges were one of the main factors. Similarly, when focusing on the reuse barriers, the challenges with deconstruction came up. Therefore, highlighting the fact that the barriers of reclamation and reuse are inherently related. The barriers were grouped into three:

- Deconstruction activities
- Future re-use
- Market

Deconstruction activities

Time
Time was one of the aspects mentioned by all the interviewees. If reclamation is sought, the speed of removal decreases – and in turn the cost increases. Time limitations are usually driven by client's aspirations. Usually, there is not enough time for proper timber waste segregation, de-nailing or de-screwing as currently this is a manual and slow process. At most nails are bent over or buried and the timbers throwed into the wood skip. There is also no sufficient time to plan accordingly and find potential buyers, as demolition contractors are usually involved at later stages.

Cost
Careful deconstruction is much more labour-intensive in comparison to demolition. Deconstruction requires more operatives and it's usually done by hand, whilst demolition is usually done using machines which are faster. All these increase the time and number of operators required which impacts the general cost. In addition, finding temporary storage for the reclaimed timbers generates extra costs.

Logistics
Logistics for reclamation projects increases. Activities such as carefully moving timber materials around, segregation of timber waste, the bundling up of timber members and storing materials need to be considered. For example, in small sites it is difficult to have a crane to move materials around. Therefore, contractors need to plan how to move the timber elements from floor to floor. Storage on site is also challenging for small sites and thus a place to store the materials needs to be found at a convenient location.

Demolition methods / skillset
The majority of the demolition is carried out using demolition machines (i.e mechanical demolition) rather than hand demolition which is currently quite rare. Therefore, there is inherent damage to the salvaged timber that has been recovered after mechanical demolition. In addition, the skillset required for deconstruction/dismantling is different from that of demolition. For example, skilled carpenters may be required to make clean cuts through the timber members.

Safety
Particularly in tight sites, there is no space to move around with materials and work safely.

Uncertainties
Before demolition/deconstruction, contractors usually do not know whether the material is rotten, infested, contaminated, etc. unless it is very evident.

- Time
- Cost
- Logistics
- Demolition methods / skillset
- Safety
- Uncertainties

Future re-use

Lack of supply chain
The lack of an integrated supply chain that can support the activities between reclamation and re-use is one of the main reasons why timber is not reclaimed in the first place. This lack of supply chain involves extra tasks for the demolition contractor that create difficulties. For example, finding a location to store the materials after reclamation, finding potential buyers, negotiating costs and changes to contracts to indicate who will own the salvaged material. In addition, reclaimed material could end up stored in their yards for years until they find a suitable buyer.

Certifications
Unlike new timber that is graded, and CE marked, reclaimed timber lack certification and therefore results difficult to guarantee that the material is fit for purpose. In addition, the interviewees indicated that the re-certification route, re-grading methods, and the type of tests required is unknown. Without certifications, there is the risk of using a material with uncertainties.

Specifications
Designers usually specify new graded timber. Reclaimed timber is generally of unknown specification and does not comply with the NBS specifications required.

Insurance
Buildings with reclaimed timber may find it difficult to obtain insurance, especially in the commercial sector as opposed to the residential sector. This is a big cultural barrier that needs to be fully understood to determine if this is a real or an assumed barrier.

Lack of supply chain

Certifications

Specifications

Insurance

Market

Lack of demand
There is currently no demand for reclaimed timber for structural purposes. Due to this lack of demand - and supply chain as described above - contractors don't know where to look for second-hand timber. If they are required to source reclaimed timber, they will need to invest time finding the right place and material until the market reaches a critical mass. Clients and designers play a key role as they could be advocating for the increase of use of second-hand timber.

Uneconomic
Due to the high labour costs in the UK, reclaiming timber is uneconomic in comparison with new timber. Furthermore, it is likely that testing and re-certification of reclaimed wood will increase the cost.

One of the challenges highlighted was the fact that deconstruction is being measured against demolition. However, the cost and value of these two should be considered together with the value of the material after deconstruction/demolition and where it sits within the waste hierarchy.

Overall, we need a better understanding of the costs of reclaiming and repurposing structural timber.

Security of supply
One of the main challenges is to have a reclaimed timber market that guarantees security of supply to ensure that the material will be available in the required quantities and in time.

Limited market
Some of the participants consider the residential sector to be suitable for the reuse of second-hand timber, but they presume it would be very difficult to reuse second-hand timber in the commercial sector.

Amount of timber in building structures
The perception is that there is very little structural timber to reclaim to create a market due to the building types, in particular in the commercial sector. Large developments have very few timber elements, most of which could be non-structural. New developments use modern methods of constructions with composite materials, which are difficult to reclaimed.

Clients
There were various responses with respect to what clients are currently asking. Some of the participants have stated that clients are more frequently asking about reclamation of building materials (not necessarily wood) whereas others have said that they haven't had conversations with their clients regarding material re-use or the circular economy. If salvaging material is not considered from the outset, it is difficult for the demolition contractors to include reclamation in their programme as this will take them more time and therefore the cost will rise making them less competitive.

- Lack of demand
- Uneconomic
- Security of supply
- Limited market
- Amount of timber in building structures
- Clients

Salvaging opportunities

Salvaging timber for reuse was more common a few decades ago (Construction Resources and Waste Plataform, 2007). However, all the participants have had at least one reclamation experience with timber in the past. Based on their experience, determining whether timber members were going to be salvaged or not, was generally left to the contractor's discretion.

According to the participants, the careful disassemble of old traditional timber structures that were not designed for deconstruction is straightforward. However, it was recognised that the skillset required for a careful deconstruction is different from that of demolition. There are certain aspects that need to be considered, like logistics, safety, understanding the site space, disassembly plan, the competence of the driver operator and on-site segregation of timber members.

The Building Deconstruction Institute (2021) have 29 years of experience deconstructing buildings and saving materials. They have completed about 5000 projects, having experience with many types of buildings including construction, agricultural, commercial, residential and industrial. Their experience enabled them to become faster and more efficient and now offered hybrid deconstruction and reclamation of components and assemblies - these are described below.

The principal drivers that made reclamation happened were many, but clients were identified as the biggest drivers. Other drivers include the financial incentive of selling the reclaimed timber, the easy identification of timber members in good condition, the nature of the structural demolition/deconstruction method, individuals approaching demolition contractors to buy structural timber to be demolished from a site and period pieces (from historical buildings) with bulk sections not normally found in the market today.

Previous research has found that early involvement of demolition contractors during the design stage can significantly improve the end-of life phase of a design by encouraging the application of design for deconstruction (Osaily et al., 2019). However, it is less clear what the role is and what the advantages are of the early involvement of demolition contractors for salvaging timber from existing building structures. Some of the early involvement benefits identified from the interviewees' experiences are: the real time information about the costs and the programme as opposed to potential estimates, the identification of opportunities for the project (time to find buyers for the material) and advice on the deconstruction method.

Pre-demo audits

Pre-demolition audit / reclamation audit

Pre-demolition audits (or reclamation audits) are useful to identify material that could be salvaged. There are a few pre-demolition audit guidelines or tools developed or under development by different bodies (e.g. BREEAM, BRE, SmartWaste, Resource protocol NFDC, EU Construction and Demolition Waste Management) that could be used, and the contractors could plan in accordance to these. However, pre-demolition audits are not business as usual. From the interviews, we know that clients are starting to ask for these, especially in the past two years, albeit these are procured very late during the design process.

For pre-demolition audits to have a higher impact, they need to be very robust and done professionally so that the audit has value and can be referred to. In addition, instead of having several guidelines, a single audit with one set of standards would be ideal; however, standardisation of guidance and policies is required.

Furthermore, surveys to obtain information about the structure (e.g. condition of joints), the condition (e.g. decay), the type of load the elements are being subjected to and the environment to which they have been exposed are crucial to understand the value of the material to be reclaimed at the outset. In addition, these would enable to create a list of itemised elements and materials identified as salvageable, providing a better understanding of the potential for repurposing. For example, large sections for reuse and small sections for upcycling (Llana et al., 2020), to make effective use of the different sizes.

These audits and surveys can inform the feasibility study for reclaiming and repurposing timber. Therefore, the early involment of demolition contractors and other specialists is crucial to gather sufficient information and enabling clients to make informed decisions.

Reclamation specialist

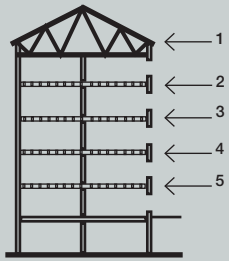
Having reclamation specialists on-site could be useful to identify the elements to be salvaged. Alternatively, if there's enough time in the programme, individual slots could be arranged to allow for the reclamation specialists to remove and take the materials away.

Waste Wood Assessment Guidance for the Construction and Demolition sector

Waste coming from demolition is the responsibility of the demolition contractors. All the participants indicated that there are no specific methods in place for demolition contractors to determine which materials are deemed waste and which could be potentially recycled or reused. They usually determine whether the materials are waste or not by inspection. However, none of the participants have undertaken tests to determine whether timber members have hazardous materials.

Common practice for dealing with timber materials is to put them on a skip and sending them to a material recovery facility centre (i.e. transfer station or license carrier) – where it is guarantee that the material will be recycled. When sufficient quantities of timber elements in good condition are identified, these are salvaged for selling or donations. However, once the timbers are smashed and put in a skip, it is not possible to reused them as load bearing elements.

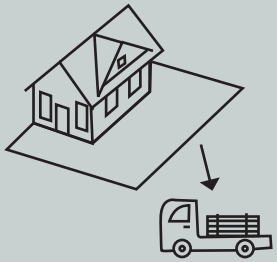
The Waste Wood Assessment guidance could help to identify non-hazardous timber members with the potential to be repurposed. It is especially relevant for structures constructed or altered between the 1950 and 2007. This guidance requests contractors to classify waste wood at its origin depending on the expected level of hazardous substances. This will require segregation of waste wood on site, otherwise it will all be considered as hazardous waste and subsequently requiring specialist hazardous waste disposal. Therefore, adopting this guidance could assist the segregation of waste wood from the site. It will be beneficial to make the initial assessment at an appropriate stage to identify whether there is any potentially hazardous waste wood. This will enable to plan accordingly for time and costing due to segregation, testing (samples collection, testing and getting the results) or disposal.



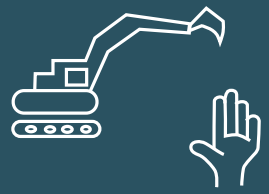
Demolition method and logistics

If deconstruction occurs following the top-down approach, the timber elements can be salvaged floor by floor by cutting, stacking, wrapping, storing and sending them for reclamation.

If demolition machines (or ground bearing machines) are used, the only point where it is possible to salvage material is once the building has been pulled down. Individual timbers can be picked from the ground and sorted.



If there is sufficient volume of timber in a project and the site have enough space for a crane, the timbers can be bundled up and send for reclamation.



Hybrid approach

Hybrid deconstruction using machines and labour to maximise the resources. Machines can be used for removing non-recyclable or reusable materials, cleaning, sorting and moving materials around, whilst the careful dismantling and handling of valuable materials can be done by workers.

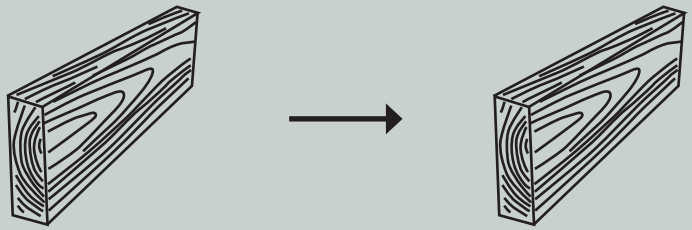
Assemblies

Salvaging assemblies (e.g. a timber wall, truss, etc.) rather than individual components can save time during deconstruction as well as in the future construction where the assemblies are going to be re-used.

Jobs

Activities such as cleaning, sorting, de-nailing, etc. could provide new job opportunities.

Repurposing opportunities - reusing

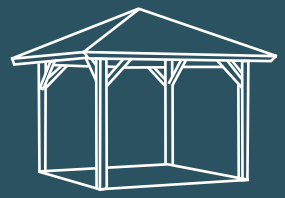


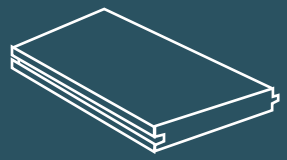
First service life:
a timber joist

Second service life:
a timber joist

The opportunities identified for the reuse of structural timber were mainly for private builders working in the residential sector (e.g. homes, extensions, or sheds), temporary works and historical buildings with timber structures. This is because the retail market to build these types of structures is probably not going to be very worried about recertification which is assumed to be expensive due to the testing required. The consensus with respect the opportunities to reuse reclaimed timber as a structural material for building types other than residential, such as commercial and industrial, was that it was very unlikely.

Some of the reuse opportunities identified were for floorboards, feature timber, cladding, temporary elements used in construction (e.g. shutters), garden furniture and furniture like benches.





Other opportunities identified for timber reuse were:

- Clients' aspirations: progressive customers and projects aiming to achieve net zero carbon. Currently, tenders are asking for setting targets around embodied carbon (A1-A5 lifecycle)
- Business opportunity to the younger generation to create a supply chain
- Properties of reclaimed timber: some properties such as the dimensional stability of mature timber or the weathering of old timber could be used as a selling point as they are sometimes regarded as superior from that of new timbers. For example, an old timber is more dimensionally stable as the seasoning has occurred over hundreds of years
- Design could be adapted to other section sizes to fit the available material in terms of dimensions and properties
- Off-site manufacturing for reclaimed timber members and modular construction
- PassivHaus
- Data of available stock for designers to use

Supply chain

One of the opportunities highlighted was to have a blended approach to source second-hand timber. For example, from reclamation yards as well as from established markets currently selling new timber. Ideally, the government could incentivise retailers to sell reclaimed timber – e.g. by making these items exempt from VAT because they are reclaimed.

In addition, opportunities for timber manufacturers were identified. Having timber manufacturers collecting the timber for free and guaranteeing they will make them good to be reused.

Repurposing opportunities - upcycling

The views on the uptake of EWPs made with secondary timber were positive as long as the product was reliable (and comparable to EWPs made with new timber) and provided that there is an established market where they can supply the material. Unlike for the direct reuse of reclaimed timber, products made by upcycling reclaimed timber were not perceived as constrained to the residential sector only.

The value of using upcycled timber is arguably greater than simply reusing it as these have superior properties and therefore the potential to replace a concrete or steel element, saving significant amount of embodied carbon. Modular construction, prefabrication and methods for the design of demountable timber products were also identified as opportunities that could be harnessed in upcycled secondary timber. Large Cross-laminated timber (CLT) panels could be deconstructed and cut to desired lengths to be repurposed. There would be a small amount of wastage during this process that needs to be considered. It will be essential to provide advice on how the material could be reused once it reaches its end of life, along with the disassembly method. Also, the opportunity for the manufacturers (or main suppliers) to take the products at their end of life to put them back into the market and enable their future reclamation.

Some of the challenges related to the certification of upcycled secondary timber were the surface qualities in comparison with CLT made with new timber (visual quality) and the fact that it is a flammable material.

A crucial barrier for the adoption of these products is the lack of manufacturing companies to fabricate CLT and Glulam in the UK at large scale.

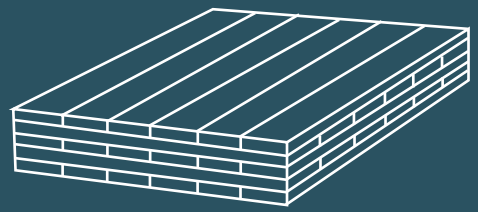
CLT manufactured using reclaimed timber

Reclaimed timber can be used to fabricate CLT panels. Usually, strength graded C16 and C24 can be used with a minimum cross-section of approximately 20x70mm.

A research team at University College London (UCL) (Rose, 2019) have been investigating the environmental implications and technical feasibility of using secondary timber as feedstock for the manufacturing of Cross-laminated secondary timber (CLST). Initial tests to compare the mechanical properties of CLST against CLT made with new timber were carried out. No significant differences for the compressive strength and stiffness were found between CLST and CLT. However, there were differences in the bending strength and stiffness – bending strength of CLST lower than that of CLT and bending stiffness higher than that of CLT. These were associated with the tensile failure at the finger joints and attributed to the large number of finger joints with respect the length of the specimens, and in particular to the quality of the finger joints as these were not fabricated in a manufactory company for CLT panels.

The effect of the age of the secondary timber was also mentioned as a possible factor that requires further investigation. One of the key aspects that needs particular attention for the commercial implementation of CLST is the need of regrading systems for secondary timber to have a better understanding of its properties. They also suggest the use of appropriate combinations of new and secondary timber to manufacture CLT for specific structural applications.

The research (Rose, 2019) also investigates the end-of-use of building components and how information on existing buildings is currently collected. In 2020, Colin Rose received the Flemming Bligaard Award to continue his work on CLST and together with his research team is aiming to “progress research into timber as a secondary resource, develop new links between the academic world and the construction industry, and add to the critical mass in applying circular economy thinking” (Ramboll, 2020).



Glulam manufactured using reclaimed timber

One of the manufacturers of glulam beams in the UK is Buckland Timber (2021). They design, manufacture and install glulam timber made by order. The manufacturing process is outlined in the diagram below and some of the specifications for sourcing reclaimed timber are summarised here:

Size
It is possible to source reclaimed timber with different cross-section sizes, as these can be planed to create planks of the same size. The preferable lengths are >1.5m, but it is possible to have shorter lengths with finger joints.

Moisture content
Ideally timber should be dried to 12%. When possible, waste wood should be covered and not left outside unprotected.

Properties
Usually C24, but C16 can also be used.

Metal-free
Reclaimed timber should be nail and screw free.

The biggest barrier for the manufacture of glulam products made from reclaimed timber is the identification and removal of screws and nails. If reclamation is sought, instructions to demolition contractors should be given to prevent buried screws and nails. Metal detectors do not always identify buried fasteners, and if identified it could take a considerable time to remove them. If these are not identified, nails and screws can interrupt the manufacturing process and damage the blades of the timber cutting tools.

The research project “Feasibility study exploring turning reclaimed timber into structural glulam” (Bergsagel, Isaac and Koeck, 2021) commissioned by the Circular Construction in Regenerative Cities (CIRCuIT) showcases the possibility of using reclaimed timber as feedstock for the manufacturing of glulam.

They have published the results from the first stage of the research project (Bergsagel, Isaac and Koeck, 2021) describing the processes and challenges encountered at different stages, including sourcing waste timber (from the internal soft-strip of the building), the processing of reclaimed timber, the characterisation of timber from non-destructive measurements, the preparation as feedstock for glulam manufacture and the manufacturing process of glulam beams.

The main challenges identified from the project were in three areas: logistics, material properties and manufacturing process. The timing of sourcing waste timber from demolition contractors was one of the first challenges. In this case, the short length of the reclaimed timbers facilitated the logistics and transportation of timber to the delivery site. The second challenge was in the characterisation methods for secondary timber. They developed a secondary timber characterisation flowchart including fastening and damage recording, mechanical characterisation, and visual characterisation. Their measurement procedures were mainly based in British and European standards, but they adapted them to consider secondary timber features, as currently there are no specific methods for dealing with aspects such as damage, cracks, aspect ratio of the samples, non-rectangular sections, fastening holes, etc. The last challenge was related to the manufacturing process and is similar to the main challenge described above of identifying and removing metallic fasteners.

They fabricated a total of 6 glulam beams from 177 pieces of average length between 1.3 and 1.4m. The second stage of the project will report on the results from the testing of these beams.

Strategies to reclaim and repurpose structural timber

The flowchart below outlines the overall reclamation and repurposing processes suggested.

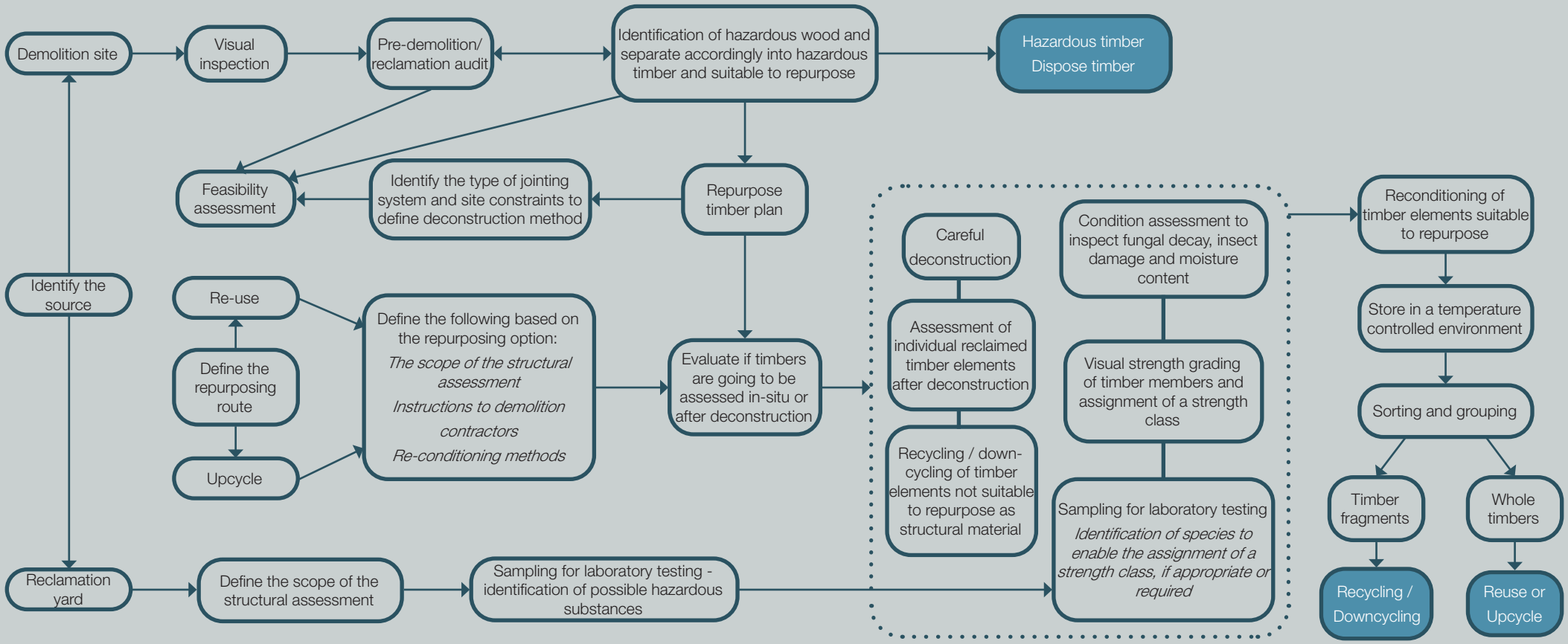
Identify the source
Second-hand timber could be obtained from the same site, another demolition site or a reclamation yard. This research focused on the reclamation of timber from a demolition site after dismantling. Reclaimed timber can also be obtained from suppliers such as Ashwells Timber Ltd (2019), Community Wood Recycling (2021), and those advertised at Salvoweb (Salvo Ltd., 2021).

Overall, when sourcing secondary timber, the relevant aspects contractors will look for are: re-certification (performance), warranties, previous treatment the timber was subjected to, aesthetics (the client's perception will influence the acceptance of reclaimed timber) and availability of material.

In addition to the sourcing requirements described above, one of the specifications typically looked by contractors for new structural timber are sustainably source certification schemes such as the Forest Stewardship Council (FSC), or the Programme of Endorsement of Forest Certification (PEFC).

For reclaimed timber, two potential options were found to verify that the material is reclaimed. The FSC certification system for reclaimed timber products (FSC, 2011) – Ashwells Timber supplies FSC reclaimed timber – and the new Truly Reclaimed label (Salvo, 2021b, 2021a).

Visual inspection
Once a building with structural timber is to be demolished, a visual inspection is carried out to identify the timber members (e.g. timber floorboards, walls, beams, rafters, columns, etc.). Refer to the guidance provided by Elliott Wood (2021) on the initial studies to undertake (desk study, site walk round, surveys and structural investigations) to create an inventory and structural sketches of the material with potential to be reused.



Audits and assessments
Undertake a pre-demolition or reclamation audit and the assessment to identify hazardous waste wood according to the Waste Wood Assessment Guidance for the Construction and Demolition Sectors (Law, 2021). The pre-demolition/reclamation audits need to be focused on the potential reuse of materials rather than only in recycling/downcycling. Early involvement of demolition contractors and circular economy aspirations from the outset are crucial for this step. In addition, following the assessment guidance for identification of hazardous waste could help with the segregation of waste wood from the site.

Feasibility assessment
A feasibility study to evaluate the impact of reclamation and repurposing on the programme and cost of deconstruction and future re-use.

Repurposing route
Defining the repurposing route (reuse or upcycle) will help to define the scope of the demolition works, structural evaluation (testing programme) and the reconditioning works.

Careful deconstruction and testing programme
The deconstruction and testing steps could be interchanged depending on whether it is considered suitable to carry out the assessment in-situ or after deconstruction. Strength grading in-situ is only possible if the strength grader has access to inspect the 4 faces of the timber and there is no paint or coating. There are NDTs however, these are usually carried out in timber members of the same size and therefore consistency could be difficult to obtain with reclaimed timber. Also, any fixings (e.g. nails or screws) could hamper this process.

The tests should be carried out by UKAS accredited laboratories providing different services, such as, visual strength grading and UKCA marking (Timber Trade Federation, 2021) and ideally these should be contacted well in advance to understand the type of services they can provide. TRADA (Bmtrada, 2021) provides a list of certified companies offering different services.

It is important to understand that the process outlined above is only a possibility that could enable us to evaluate the properties of the reclaimed timber now, but it is based on standards developed for the assessment of new timber rather than reclaimed timber. Therefore, issues such as creep, age, etc. are not considered. An explanation of strength grades and strength classes is provided by Ridley-Ellis, Stapel and Baño (2016). They argued that it is possible to make a more productive use of the methods for grading in order to optimise our designs and exploit the properties of timber. Similar principles could be applied to reclaimed timber to make the most of the reclaimed material. The project Innovative Design for the Future – Use and Reuse of Wood (Building) Components InFutUReWood (2020) provides a series of webinars that gives insight in this area.

Re-conditioning and sorting
Once deconstruction and testing are completed, the timbers are cleaned, de-nailed and re-sized, then stored in appropriate conditions and sorted and grouped to then define which timbers are going to be either re-use or upcycle.

Recommendations

- Carry out pre-demolition or reclamation audits early in the design process
- Follow the Waste Wood Assessment Guidance to help to identify non-hazardous timber members with the potential to be repurposed
- Collaboration with timber deconstruction specialists, manufacturers of timber products, designers, etc.
- Endeavour to incorporate reuse/upcycle into your projects. If it is not possible to reuse or upcycle all the elements for a new structure, start with a small number of elements to learn from the process and share the information
- Push for incentives to repurpose timber, > 95% landfill diversion rate or high recycling rates is not enough to address the climate and biodiversity emergencies. We need to push for incentives and legislation to facilitate and prioritise dismantling over demolition through the recovery of materials and its future use according to the waste hierarchy
- Have early conversations with stakeholders about the circular economy, the concepts of repurposing, reuse and upcycle, the importance of prioritising repurposing over recycling and set out circular economy aspirations from the outset

Future work

- Interviews with reclamation yards and timber merchants
- Interviews with contractors working in the residential sector
- Pilot study to undertake reclamation, reuse and upcycle of timber
- Investigate the possible re-certification methods for timber to gain a better understanding of strength grading for reclaimed timber and their implications
- Life-cycle assessment to better understand the carbon impact of re-using and upcycling timber at their second, third etc. service life

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The successful reuse or upcycle of reclaimed structural timber can help to: a) minimise the carbon emissions associated with demolition waste; b) prevent the need to source new material and their associated carbon footprint; and c) keep timber elements in circulation for as long as possible at their highest value.

Currently, very few load-bearing building components are re-used, and whilst the diversion rates from landfill are high, most of the building components are recycled or downcycled. To make a significant impact, we need to make re-using existing buildings and the materials held within them the norm for the construction.

Increasing material re-use and design for deconstruction are aligned with the goals of the circular economy in the construction sector. The London Plan 2021 (Mayor of London, 2021) states that the circular economy principles should be taken into consideration in all referrable applications.

Timber is one of the most promising sustainable construction materials that can help mitigate climate change. Unlike conventional building materials such as concrete or steel, timber is a renewable material, and during its growth the trees sequester carbon from the atmosphere. However, the use of structural timber in construction is mostly restricted to a single service life. Therefore, limiting its potential to fully exploit the sequestered carbon for as long as possible and maximise its use as an asset.

There is no specific guidance or route within the current business as usual model to enable the circularity of structural timber (i.e. recovery and repurposing) and assessment to guarantee that the material is fit for purpose.