Recovered Wood as Raw Material for Structural Timber Products. Characteristics, Situation and Study Cases: Ireland and Spain

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Abstract

The circular economy is an efficient system to reuse materials reducing the amount of waste generated. In order to implement it in the timber sector, the InFutUReWood (Innovative Design for the Future – Use and Reuse of Wood (Building) Components) is a European project studying the possibilities for reuse and recycling of timber from demolition for structural applications. Nowadays in Ireland and Spain, most of the wood waste is reduced to chips. In Ireland, chips are mainly used for energy production, pallet blocks, and composting, while in Spain are used for energy production and particleboard manufacture.

Possible structural applications depend on the amount, dimensions, and condition of recovered timber. Most of the recovered timber in Ireland has medium size cross-sections, while in Spain it is mainly large cross-section. Cross laminated timber (CLT) is a good option for reuse and experimental tests are ongoing in Ireland on CLT manufactured from old timber trusses. However, for large cross-sections, direct reuse for rehabilitation works will be a more efficient use of the material.

Key words: Circular economy, classification system, construction and demolition waste, mass timber products, timber recycling, reclaimed wood, wood waste management

Introduction

The circular economy is a sustainable system to reduce the amount of waste by reusing it as a new resource with the consequent environmental and value-added benefits. Ever increasing timber demand for construction purposes in Europe will lead to a deficiency of new timber resources in the future. Therefore, the implementation of a circular economy system in the timber sector is strongly recommended. InFutUReWood (Innovative Design for the Future – Use and Reuse of Wood (Building) Components) is a 3-year European project that focuses on the reuse and recycling of current reclaimed wood in the circular economy as structural material (InFutUReWood 2020).The National University of Ireland Galway (NUIG) from Ireland and the Universidad Politécnica de Madrid (UPM) from Spain are two of the eight European institutional partners of the project.

The Construction and Demolition (C&D) sector creates a large amount of wood waste, generally now used for energy recovery and wood panel production (Irle et al. 2015). Much of that wood could be salvaged to be reused or recycled for structural purposes. Potential end-use structural applications include high quality Engineered Wood Products (EWP) such as Glue-laminated (Glulam) timber, solid wood panels and Cross Laminated Timber (CLT) (Hafner et al. 2014). Previous tests on CLT from recovered timber showed higher stiffness capacity and lower strength than CLT from new sawn timber (Rose et al. 2018). However, this was a small scale study and it doesn´t appear to taken into account the natural variability of timber quality. The CaReWood project studied the possibilities to recycle recovered wood in laminated products (Irle et al. 2019).

In the present work, the term "recovered timber" includes structural and sawn timber from demolition, while "recovered wood" includes recovered timber, plus doors, windows, door and window frames, furniture, pallets, and packaging. Finally, "wood" also includes carpentry waste, forest pruning and thinning.

The main objective of this paper is to show the particularities of the current situation of recovered wood in Ireland and Spain and to explore structural applications for recovered timber.

Current situation of recovered wood in Ireland and Spain

The information presented from Ireland and Spain was mainly obtained by surveys, interviews and technical visits to demolition companies and wood waste management facilities.

Most recovered timber in Ireland comprises medium size cross-section timber (Fig. 1a) including joists and roof rafters from buildings from the 1960s-70s. The timber is usually sourced from the roof structure. Building typologies at that time were mainly composed of concrete structures with roof timber trusses.

Figure 1. Recovered timber a) from Ireland, b) from Spain

Irish demolition companies remove timber in the easiest and cheapest way as there is not an established market in Ireland for long and good quality recovered timber pieces. Some companies segregate the timber in-situ in order to reduce skip cost, but most of the recovered timber arrives in the waste management facilities mixed with other materials. A very small amount of wood waste goes to landfill.

Recovered wood is managed in wood waste facilities where it is segregated and reduced to chips, 60 mm size or smaller. This includes timber from demolition, furniture, broken pallets, and packaging. The end-uses for the chips include energy production (exported to the UK), the manufacture of pallet blocks, composting, animal bedding, garden mulch, and playground surfacing. A preliminary study estimates slightly more than 100,000 t per year of wood waste is processed into chips. Furthermore, some companies use wood waste as boiler fuel.

The classification system for wood waste used in Ireland is dependent on whether it is to be exported or used locally. If the wood waste is to be exported to the UK, a classification system developed by Wood Recyclers' Association in 2009 and published as an informative annex in PAS 111 (2012) is used (Table 1). However, if the final use is in Ireland, the European classification system (OJEU 2018), implemented by the Irish Environmental Protection Agency (EPA 2018), is used (Table 2).

Table 1: UK wood waste classification system according to annex A of PAS 111 (2012)

Grade	Materials
A	Solid wood, pallets, packing cases and cable drums Untreated
B	Grade A plus building and demolition materials and furniture made from solid wood Limits on treated and coated materials
C	Grades A and B plus panel products (chipboard, MDF, plywood, OSB and fiberboard) Mix wood including painted timber and glues. Coated and treated timber
D*	Hazardous material (fencing, transmission poles, railway sleepers, cooling towers) Treated with Copper/Chrome/Arsenic (CCA) and creosote
*The European Commission is concerned about the UK classification system because the amount of wood waste classified as "D" hazardous is around 0.5% of the total wood waste, while in other European countries like Germany is around 15% (Perchard 2017)	

Table 2: European waste classification system according to OJEU (2018)

Most common used codes	Materials
170201	Wood non-hazardous (when wood waste is segregated in-situ, skips containing only wood)
170903	C&D wastes containing hazardous substances (mixed or segregated wood waste in the skips)
170904	Mixed C&D wastes non-hazardous (when wood waste is mixed in the skips with other materials)
191206	Wood containing hazardous substances
191207	Wood other than that mentioned in 191206 (this code is assigned to 170201 skips arriving at waste management facilities or is assigned to wood from 170904 skips after it is segregated from other materials in the facilities)
Codes starting with 17 are assigned by C&D companies when skips are filled in-situ Codes starting with 19 are assigned by waste management facilities for wood waste processing	

In the case of Spain, most of the recovered timber from demolition comprises large cross-sections (Fig. 1b) from buildings over 100 years old. This is due to a scarcity of timber construction after the Spanish Civil War (1936-1939).

In general, big C&D companies do not care about recovering timber from demolition, because there is not a consolidated recovered timber market. However, there are small C&D companies deconstructing small buildings and also purchasing timber from big demolitions sites. These small companies reuse it for their own refurnishing works or sell it for restoration purposes. Typical markets include refurbishment of heritage buildings, carpentries for vintage furniture, and private domestic construction. The market price of large cross-section 5-meter length recovered timber from pine is approximately double the equivalent new sawn timber, because of the great amount of labour needed during deconstruction, removing nails and cleaning pieces, and the perception that old timber is of better quality than new timber due to different forest management.

A significant amount of wood is reduced to chips in wood waste management facilities for two final end-uses: energy production and particleboards. Not all processed wood is recovered wood. In the case of energy production, most of it is from pruning, thinning, or undermanaged forest. For particleboards, recovered timber, furniture from demolition, broken pallets, and carpentry waste are processed together. A small amount of demolition timber processed in the north of Spain comes from France, while the final uses are always in Spain. Furthermore, there is a well-established network to collect furniture from individual owners and packaging and this recovered wood is used in the manufacture of particleboards.

There is no national classification system for wood waste or recovered timber in Spain. Wood waste management facilities usually classify it according to the European List of Waste (OJEU 2018) (Table 2).

Possible structural applications for recovered timber

The main issue for reuse or recycling of recovered timber is its separation from other materials during demolition or in the wood waste management facility. The newer the demolished building the more difficult it is to segregate different materials. Buildings that are more than 100-year old have mainly large cross-section timber (heavy beams, joist, rafters…), which is easy to segregate. Modern buildings (from the 1950s) have a lot of nails and glue in the timber members.

Important also is the quantity of recovered timber, its dimensions and condition. As a preliminary estimation from a 5-storey building in an Irish urban area from the 1960s (timber mainly in the roof), around 30 t of wood were recovered (including furniture and doors). In the case of Spain, a 5-storey building in an urban area from the 1890s (large cross-section timber) around 120t of timber were recovered (only sawn timber).

The end-uses of reclaimed structural timber are determined by the timber length and the cross-section of the recovered timber together with the structural capacity.

Medium size cross-section timber is suitable for EWP manufacturing. Timber trusses (commonly available in Ireland) provide similar cross-sections to boards used for CLT panels and the amount of waste generated during manufacturing will be minimum. In this case, medium length pieces (circa 2 m) are suitable as finger joints can be used. A testing program of CLT panels from recovered timber is currently ongoing in the NUIG laboratories (Fig. 2).

Large cross-section timber (commonly available in Spain) can be also used for CLT panels, however, a reduction of the section to CLT board dimensions implies a significant amount of wood waste and energy consumption and restricts a possible further life of the timber following the cascading principle of sequential reuse (Sirkin and Houten 1994). Therefore, it is deemed better to reuse it in restoration works on heritage buildings where long recovered timber pieces are available (more than 5 m length).

Furthermore, in renovation works, mainly due to energy efficiency regulations, roof decking boards are usually removed. Sometimes, floor boards are also removed. The common thickness of these planks is 25 mm, so, this recovered timber could be suitable for EWP.

Demolition techniques should be adapted in order to maximize the yield of good condition and length of recovered timber for the potential uses described above. Furthermore, the development of a classification system that combines non-destructive testing and visual grading for recovered wood is necessary.

Figure 2. CLT panels from recovered timber in the NUIG laboratory

Summary and Conclusions

Circular economy implementation in the timber sector is necessary. InFutUReWood, including institutional partners from Ireland and Spain, is a European project that focuses on the reuse and recycling of current reclaimed wood as structural material.

In Ireland, most of the recovered timber has medium size cross-section from buildings from the 1960s-70s. At present, all timber is reduced to chips mainly for use in energy production, pallet blocks manufacturing, and composting.

In Spain, most of the recovered timber has large cross-sections from structural elements salvaged from buildings more than 100 years old. Currently, a small amount is reused in construction while most of it is reduced to chips for energy production and particleboards.

The potential use of recovered timber is influenced by several factors: the segregation of timber from other materials, the amount of timber recovered, its condition and dimensions. Medium size cross-sections are suitable for CLT manufacturing, while large cross-sections are better suited for reuse in restoration and renovation works. CLT panels manufactured from recovered and new timber have been manufactured in Ireland and are soon to be tested in the NUIG laboratories.

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Biography

Llana, Daniel

Expertise: Non-destructive testing for grading new timber and evaluation of existing structures, Reuse and recycling of recovered wood, Standardization

Biography - Daniel F. Llana

Dr. Daniel F. Llana

2007. Bachelor of Engineering (Agronomy) by Universidad de León, Spain.

2010. M.Sc.Eng. (Rural Construction) by Universidad Politécnica de Madrid, Spain.

2016. Ph.D. by Universidad Politécnica de Madrid, Spain. Topic: Non-destructive techniques applied to structural grading of timber in new and rehabilitation works.

2016-2017. Post-doc at the Universidad Politécnica de Madrid, Spain. Topic: Assessment of existing timber structures by NDT techniques.

2017-2020. Post-doc in the Timber Engineering Research Group of the National University of Ireland Galway, Ireland. Main topics: Engineered Wood Products, Recycling of timber from demolition and Hardwood forest.

2020-present. Post-doc in the Timber Construction Research Group of the Universidad Politécnica de Madrid, Spain. Topic: Reuse and recycle of timber from demolition in structural products and design for the deconstruction in the future (InFutUReWood European project).

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Assessment of existing timber structures

Reuse and recycle of timber from demolition in mass timber products

Standardization

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