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RE[4] Project

REuse and REcycling of CDW materials and structures in energy efficient pREfabricated elements for building REfurbishment and construction

D5.4 Prefabricated elements on other materials
Public summary of deliverable

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Abstract:	D5.4 reports on the development of non-load bearing, prefabricated wall elements based on CDW timber for the application as external façade element and internal partition wall. Both systems incorporate a high ratio of recycled CDW waste wood as well as CDW silt and clay. The development of this exercise integrates results obtained from previous tasks, where materials and components have been developed.
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[1] Just mention the partner(s) responsible for the Deliverable
[2] PU: Public, RE: restricted to a group specified by the consortium, CO: Confidential, only for members of the consortium; Commission services always included.
[3] Draft, Revised, Final

Introduction

Deliverable 5.4 summarises the results obtained by the RE^4 team involved in *Task 5.4 – Development of prefabricated elements based on other materials,* (ZRS) of *WP5 – Development of precast components and elements from CDW*. The work focused on the development of non-load bearing, prefabricated wall elements based on other materials, namely CWD timber.

At first, design concepts for both elements have been developed and briefly been presented that illustrate the ideas for a prefabricated fully reversible non-load bearing façade element and a partly prefabricated, fully reversible, internal partition wall developed under WP3. Pre-studies carried out for the development and optimisation of the production of different components required for the production of both elements are illustrated in greater detail. In addition, a general approach how to maximise the implementation of CDW timber in both prefabricated wall elements was outlined. To maximise the potential for future reuse, recycling or the cascading use of timber components, concepts for reversible connections and the cascading use of timber have been studied and tested. In addition, a strategy for the omission of wood preservatives especially for the façade element is introduced to avoid thermal recovery as only means for future exploitation.

Furthermore, the reprocessing procedure of waste wood necessary for the manufacturing of solid timber components that are part of both elements have been optimised. The potential for implementation of CDW timber into other timber-based components that were not developed within the framework of the project, but were required for the production of both prefab elements, have been briefly highlighted. As a last step the assembly process of both prefabricated wall elements has been illustrated, highlighting the single steps necessary for a speedy installation.

Design Concept Prefab Façade Element

The prefabricated façade element from CDW timber is conceptualised as non-load bearing, rear ventilated system, which can be fixed as hanging façade to the loadbearing structure of the building. The anchor points are to be defined on a project by project basis and can vary from beam, to ceiling and column. Determining factors for the size for the panel have been defined.

The width of the element follows the standard grid established in timber construction, which is defined by the dimensions of the stiffening boards. Deviations, due to site constraints or design aspirations can easily be accommodated by modification of the edge section through either addition of another stud or reduction of the axial dimension.

The structural system of the element is designed as a stiffened frame and composed of a threshold (bottom), studs and a plate (top). All bearing components consist of either structural solid wood (KVH) or glued laminated timber (BS timber).
The overall thickness of the panel is mainly determined by the hygrothermal requirements set out in the national regulations of the respective country of construction. The RE4 project addresses both, the design of façade elements suitable for the Northern European climate as well as for the Southern European climate.

The CDW timber façade element has been designed as a vapour permeable wall build-up, that consists of multiple layers. The order of the single layers follows a compulsory vapour pressure gradient to enable vapour diffusion

through the panel. In such way moisture is not trapped at any point within the element.

Figure 1 shows the design concept for the prefabricated timber façade element in plan, section and elevation, developed for the Southern European scenario provides an overview about the final dimensions.

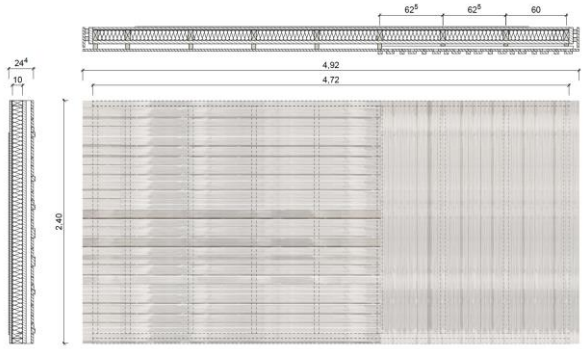

Figure 1 - **Dimensions of the produced timber facade panel, wood chip insulation, U-value= 0.29 W/(m²*k)**

The build-up of the prefabricated façade element is shown in Figure 2 and consists of the following layers:

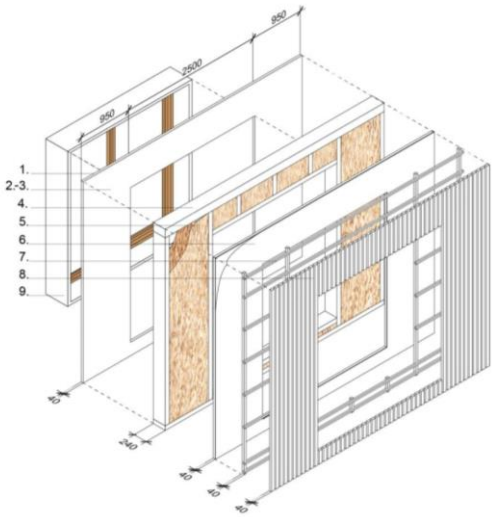

Figure 2 - **Layers of the RE⁴ CDW prefabricated timber facade element**

1 RE⁴ earth plaster

2 Wood fibre board

3 Wood fibre hardboard

4 RE⁴ timber studs & RE⁴ timber threshold (bottom) and plate (top)

5 RE⁴ Wood fibre insulation

6 RE⁴ DWD – Wood fibre board

7 RE⁴ Batten and counter batten

8 RE⁴ Weather boards

9 Windows and openings (not part of D5.4)

Design Concept Internal Partition Wall

An innovative internal partition wall system which fosters the idea of prefabrication to enable easy installation and dismantling was developed. Prefabrication for internal wall systems is not common, as such walls often require adaptation to on-site situations. Furthermore, such systems are normally not designed for disassembly. In consequence a significant amount of waste is generated, when elements are dismantled, as single components are often demolished.

The innovative RE⁴ solution aims to address such challenges and developed a system based on the standard grid for timber construction (62.5 cm) that can easily be installed on site and joined together. Single elements are mounted against timber rails, which again are fixed to floor and ceiling. The size of the element creates a high level of flexibility, however, corner or end sections might require customised sizes in order to match dimensions on site. The weight of single elements enables easy transport to and on-site as necessary.

Figure 3 - 5 show the development of the system in detail.

Figure 3 – **Standardised elements with reversible connections at the head**

Figure 4 – **Standardised elements with reversible connections at the foot**

Figure 5 – **Standardised elements with reversible connections between elements**

Reversible connections

Reversible connections are key for the success of both developments. Carpenter or screwed connections have been considered and tested for all connections within the panels, whereas steel connections have been proposed for the connection between façade panel and building. For the internal partition wall, a proposal of an timber infill in combination with screws enables reversible and easy accessible connections between element and building structure.

Production

As the fabrication of both panels is still executed at workshop scale and not on industrial level, most work steps are carried out with common carpenter tools.

The different steps of production and assembly are, apart from the cleaning of the different CDW timber sections very similar to the production of façade elements or internal partition walls from virgin timber. Figure 6 shows the final elements.

Figure 6 – **RE^4 CDW prefabricated timber facade element**

Results

The fabrication of both elements could be carried out with common carpenter tools. Industrial production would however be beneficial and improve the process regarding production time and therefore cost.

The CDW timber used for the fabrication of both elements was obtained from a former roof structure of a building located in Berlin. Single timber planks demonstrated a high level

of metal impurities such as smaller and larger nail plates, that were used as means of connections in the former building.

The final outcome of usable material, which is produced by processing one board of CDW wood has been monitored. Such figures always vary in relation to the harvested CDW material, but in this specific case 54 % of the processed wood could be reused and brought back into the building cycle to be used for manufacturing of construction materials. The process showed, that the number of usable products can be increased significantly when several different cross sections are processed out of one source material. As the retrieved CDW wood was treated with chemical wood protection, the accumulated wood chips could not be recycled and were disposed as harmful substances. Figure 7 shows the source material and the final outcome of usable material (UW1-3).

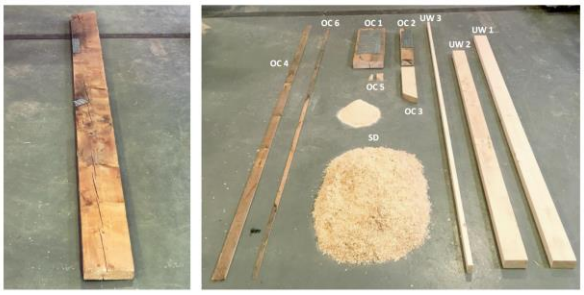

Figure 7 – **CDW source material and outcome of usable materials**

Conclusions

Integration of CDW timber

For both elements, all solid wood components e.g. studs, thresholds, plates and battens were manufactured from 100% CDW timber. The material demonstrated the same quality as fresh wood. Wood fibre insulation for the internal partition wall was also manufactured from 100 % CDW timber. The application as insulation material for façade elements seems promising, needs however additional investigations to improve the thermal conductivity first of all for application in Northern Europe. However, it is assumed that additional research will deliver promising results. Furthermore, it is assumed that all other wood fibre or wood dust-based products can be manufactured from recycled timber. Commercial are mostly manufactured from secondary raw materials and not necessarily from fresh wood. However, incentives for manufacturers are needed in order to stipulate such a process.

Material efficient production

The concept of material efficient production was also very successful. The cutting of incoming sections according to required dimensions for final production demonstrated that significantly more timber can be obtained and reprocessed for production of solid components. In addition, incoming CDW timber demonstrated more cracks than fresh wood, so that this strategy would be beneficial to cut off major cracks. Additional research would be required to establish whether this approach might be too time consuming or if modern CNC machinery could overcome such constraints.

Solid timber components

Glued connections are common in modern timber construction to join pre-cut lamellas to the required dimensions. Initial tests to make use of dowel connections, which are viable for ceiling elements, showed promising results, would however require additional research and testing to be able to compete with glued solutions.

Reversible connections

Reversible connection could be established on all levels. Connections within the element but also between elements (façade element and support structure) are 100 % reversible, so that

a complete reuse of all developed components is anticipated. In addition, reversible connections within the element enable a cascading use of timber, increasing the material use of CDW timber significantly. As timber is a dry and very light material it is very well suited for reversible joints that promote and facilitate successfully circular construction.

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