WOODCUBE

Hamburg, Germany [Architekturagentur]

2013	**Year**
DeepGreen Development	**Client**
Isenmann Ingenieure	**Structural Engineer**
Thoma Holz 100 GmbH	**Engineered Wood Fabricator**
Residential	**Program**

This project explores the many environmentally beneficial attributes of wood, offering a new vision for urban living that goes beyond energy efficiency to embrace life cycle impacts and occupant health.

The CLT panels extend the full length of the balconies to provide structural support.

From 2006 to 2013, the city of Hamburg was host to the International Building Exhibition (IBA), a unique initiative that devised and implemented 70 innovative planning and building projects, exploring environmentally responsible and socially balanced forms of urban redevelopment. These projects, conceived in part around ideas of decentralized renewable energy strategies and the efficient use of local resources, now form the nucleus of urban renewal efforts on the mostly industrial island of Wilhelmsburg in the River Elbe. The IBA's legacy includes the Woodcube, a 1,370 square metre, five-storey apartment building constructed almost entirely from wood. The in-depth research that underpins the innovative design has confirmed the versatility of wood, its potential contribution to sustainable development and its effectiveness in addressing many aspects of building performance.

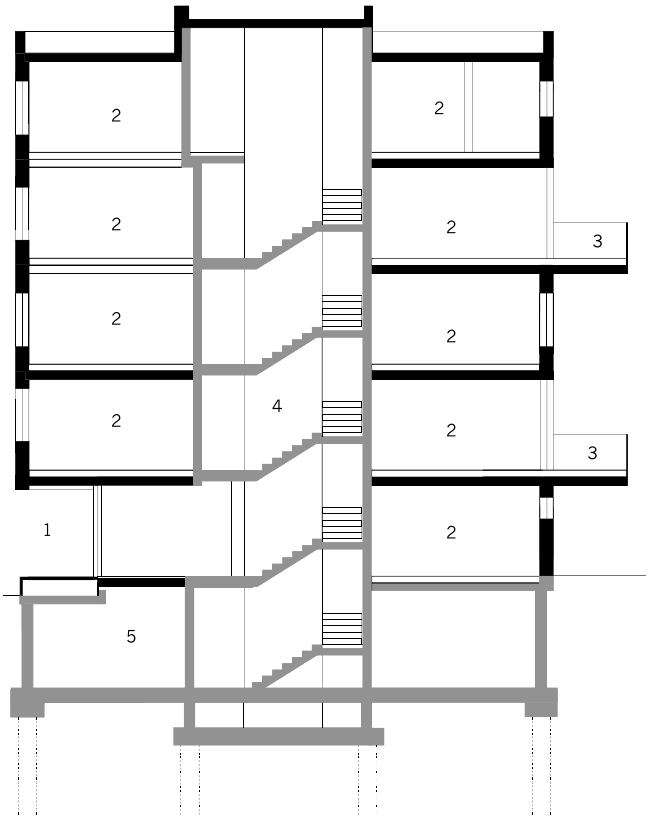
CONCEPT

From an urban design perspective, the Woodcube was conceived as a prototype for a systematized yet flexible approach to the design and construction of multi-family residential buildings. At the same time, the design team wanted to broaden the discussion of sustainability from one focused largely on the operating energy of buildings, to one that embraces carbon neutralconstruction and a healthy indoor environment.

CONSTRUCTION

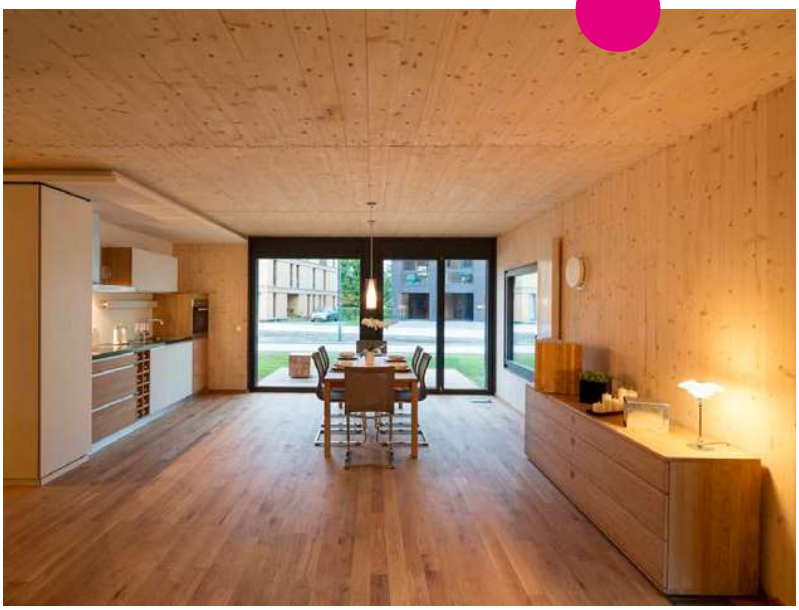
Low energy buildings, such as those constructed to the Passive House standard, typically rely on a tightly sealed and highly insulated envelope to control heat gain and loss. Often the materials used for vapour checks and insulation are manufactured using harmful chemicals that can release toxins into the air long

The building is part of the Wilhelmsburg Central Integrated Energy Network which provides heat from renewable sources.



1 Entrance
2 Residence
3 Balcony
4 Concrete stair core
5 Concrete basement

Section AA



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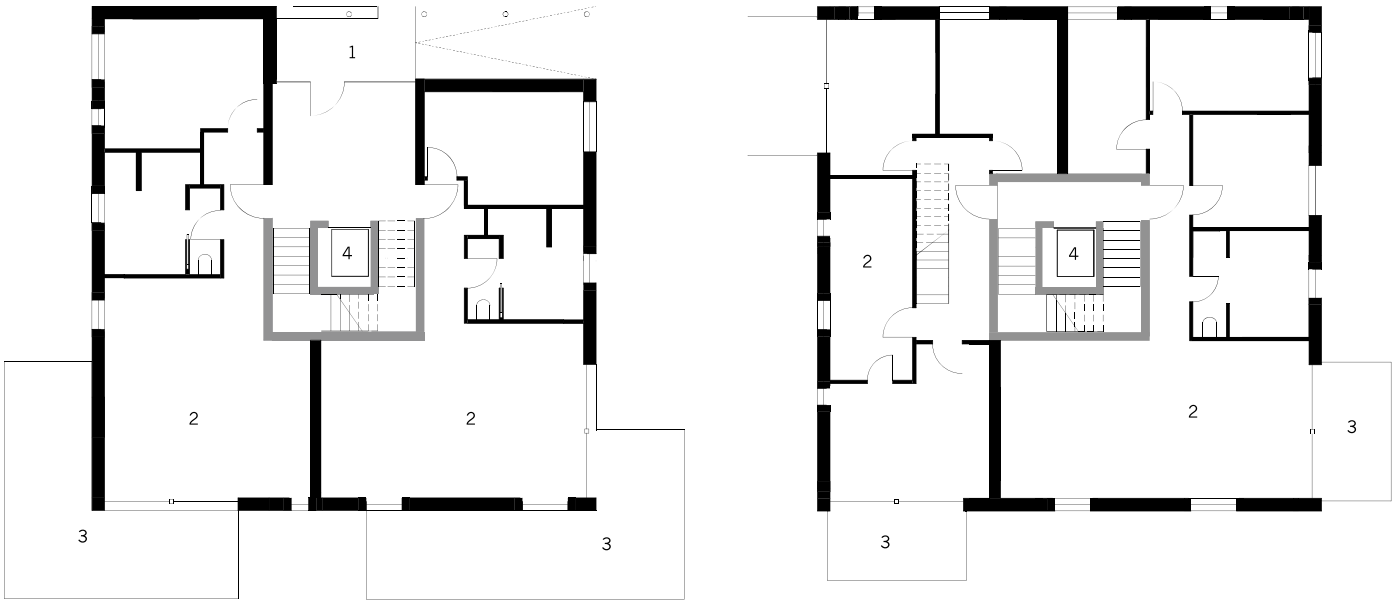
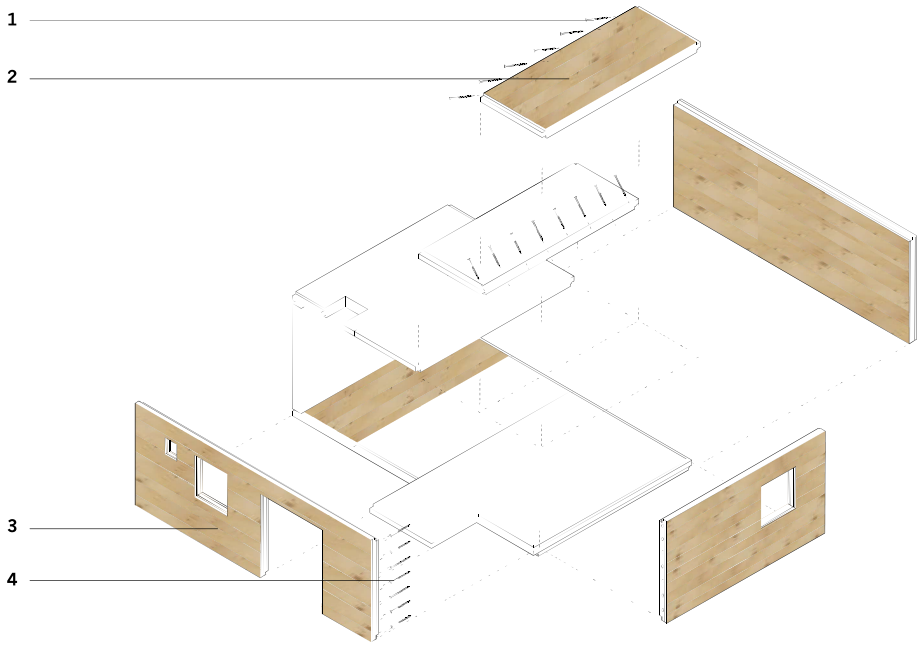


Ground floor plan and typical floor plan

Wall and floor assembly

The Woodcube uses no glue or adhesives, instead the CLT dry fit system is combined with high-strength ASSY screws to form the connection points. **1** ASSY screws inserted at a diagonal into both roof and wall CLT **2** CLT roof panel with edge groves for form fitting of assemblies **3** CLT dry fit wall panel **4** ASSY screws connect the walls, the ends of the walls have groves to connect the corners



The Woodcube was built using prefabricated wall and floor/ceiling panels. During construction and until the roof was in place, the assemblies where kept dry using tarps and scaffolding.

after installation. Similarly, some materials used to encapsulate or sheathe a structure to achieve the fire resistance required in a multi-storey building also emit harmful vapours or give off dust.

Furthermore, most low energy building standards focus exclusively on the reduction of operating energy, and do not concern themselves with the source of that energy. Nor do these standards consider the embodied energy present in the materials used to construct the building, or the carbon footprint, life cycle implications or other environmental impacts of those materials. Hence the design team chose to start with locally sourced, sustainably managed wood, a 'smart'[1] multifunctional material that in principle met all these criteria; and, through research and testing, develop solutions that would meet their own performance requirements, as well as those of the applicable building codes.

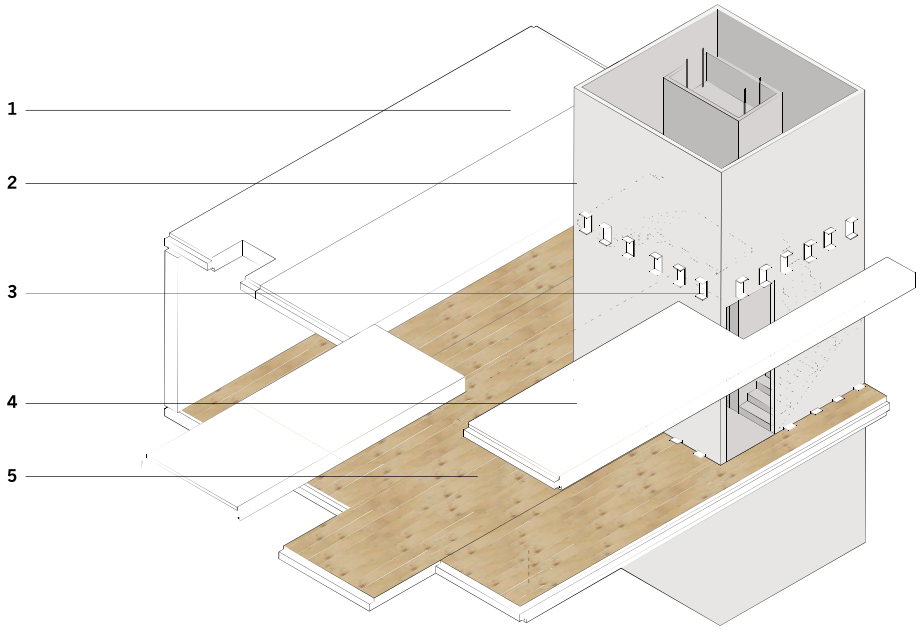
The Woodcube is a 15.10 metre square in plan, with exterior load-bearing walls and a central concrete stair and elevator core that rises from a concrete basement structure. There are no intermediate supports and apartments are subdivided with non-load-bearing wood frame partitions to facilitate future reconfiguration. Flexibility is further enhanced by clustering service risers against the exterior walls. Woodcube comprises eight apartments of different types, including both single level and maisonette units.

The walls, floors and roof are made from prefabricated solid wood panels that are cross laminated in

Connection to central core

A central concrete core houses the stairs and acts as a lateral brace for the structure

1 Roof panels connect to one another **2** Concrete core with stairs **3** Metal C-brackets connect the CLT panels to the concrete core. **4** Roof panels are cut to fit around the concrete core **5** After installation the floor receives insulating boards, sound insulation and a wooden floor system.



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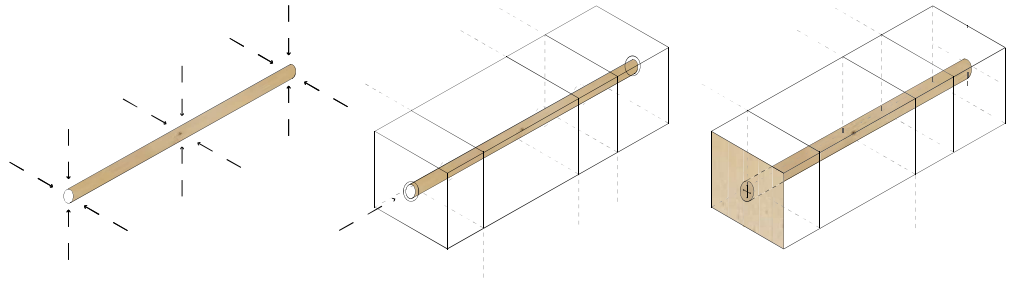

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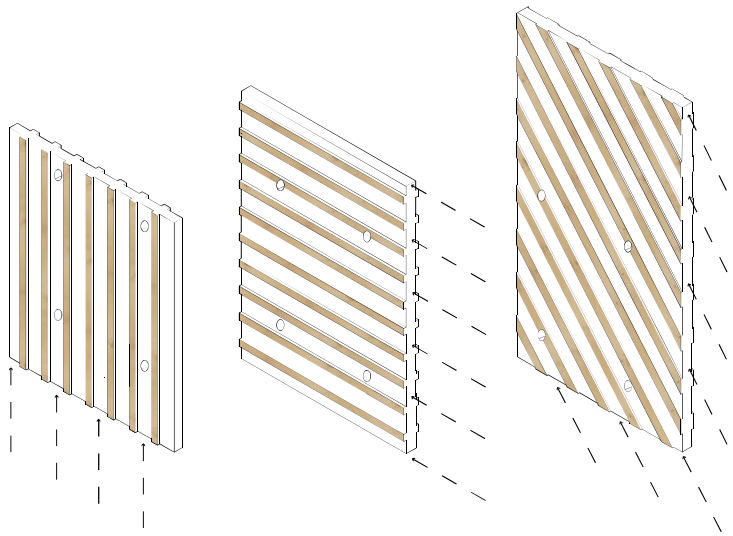

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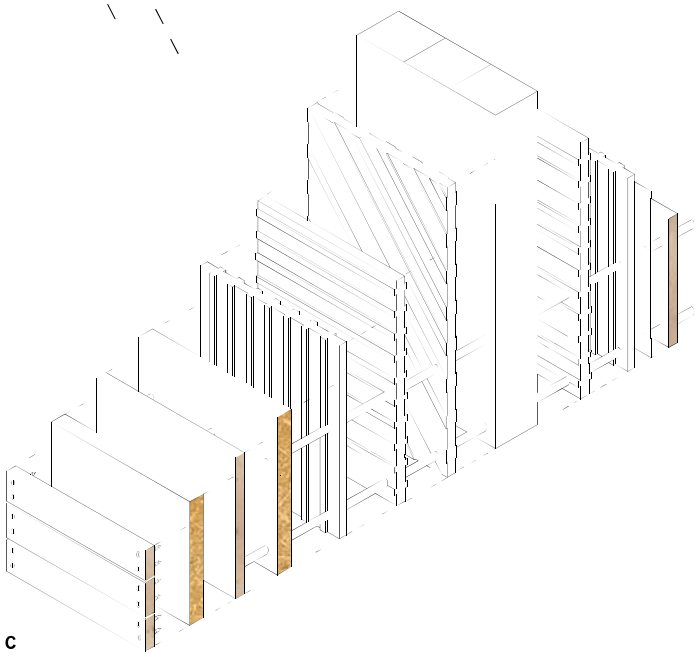
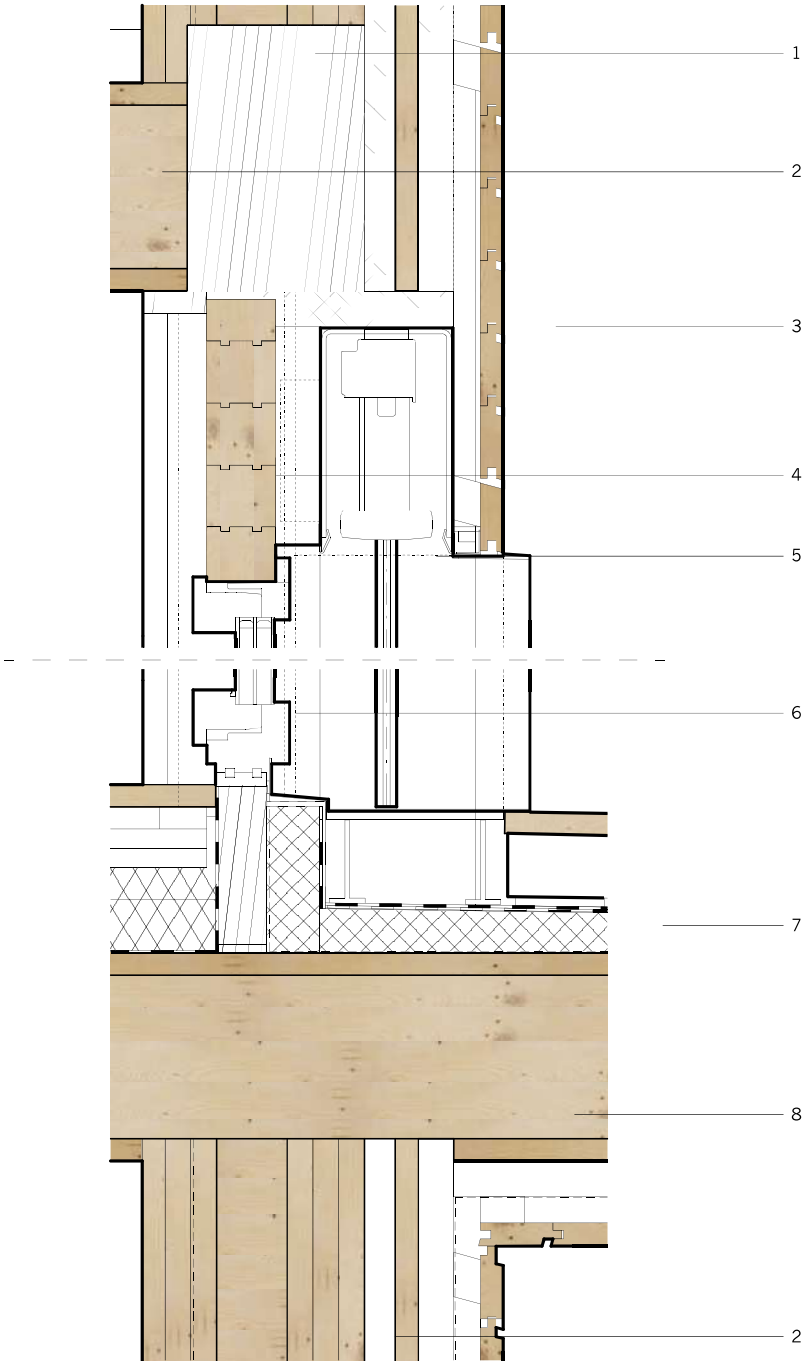


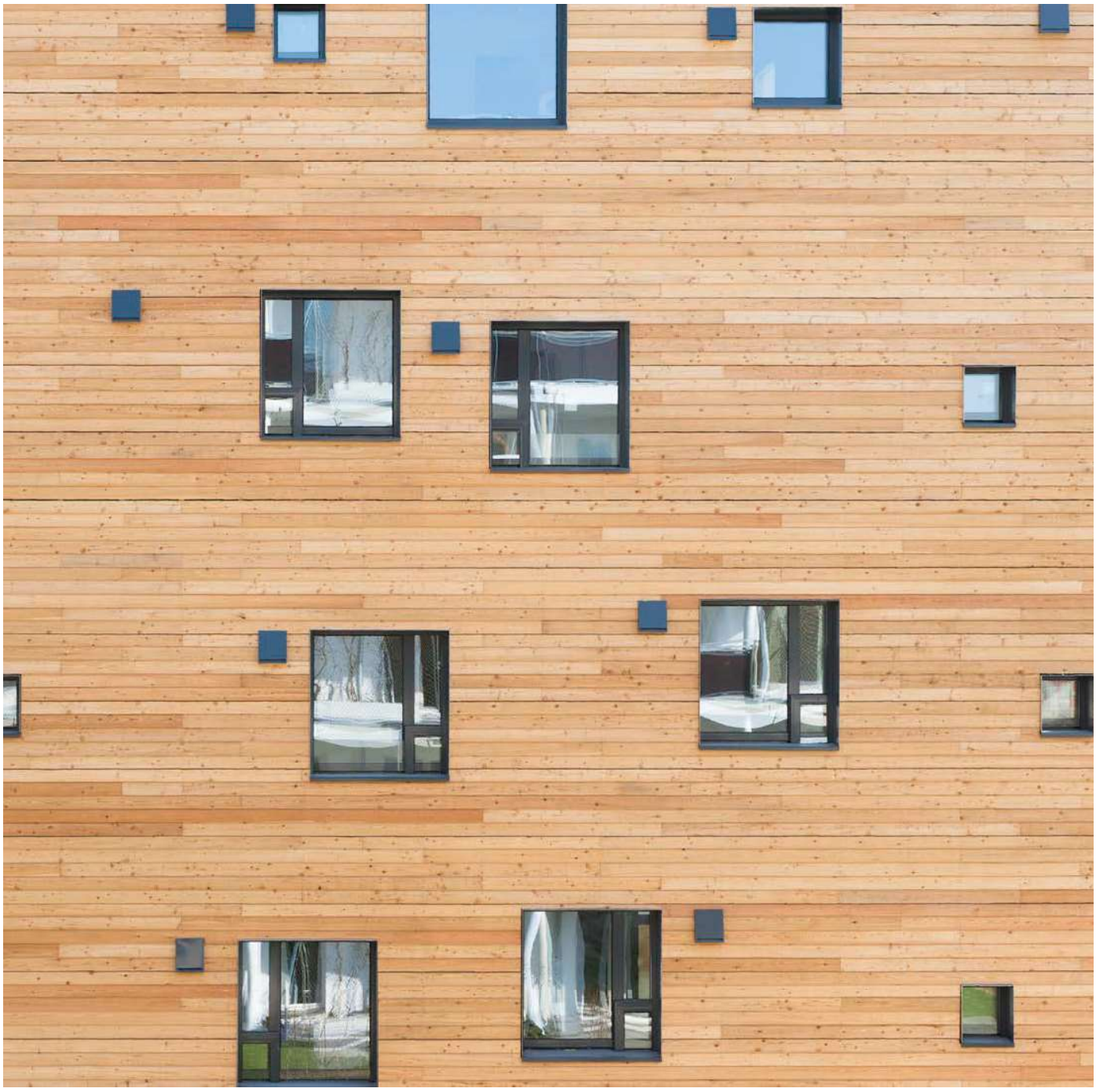
C

A The CLT panels employ no adhesives. Instead the wall was designed with beech wood dowels inserted through the layers of the wall. The dowel is kiln dried below the moisture content of the other components which results in its expansion and secure fit once brought to the moisture levels of other components **B** The wood components adjacent to the main structural posts have channels milled in diagonal, horizontal and vertical directions. These channels trap air for greater thermal resistance. **C** The pre-made wall panels are composed of 12 layers of wood and mineral wool. These layers are dry fit together and act as the main structure while providing a high degree of thermal resistance



Detail section

1 Wood beam
2 CLT wall section
3 Internal wall cladding
4 Exterior wall cladding
5 Sliding door system
6 Triple pane glazing
7 Wooden flooring
8 Cross section of CLT floor



The exterior is clad in unfinished, horizontal larch siding; note the exhaust vents and metal lines indicating the fi re compartments.

layers of horizontal, vertical and diagonal boards. The layers are mechanically fastened using beech dowels inserted into holes drilled perpendicular to the face of the panels on a 240mm x 300mm grid. The bond between layers is achieved by kiln drying the dowels, inserting them into tight fit holes, then allowing them to expand until they reach their equilibrium moisture content. This creates a friction fit, and a panel with comparable strength to conventional CLT without the need for adhesives. The dry, single material construction makes it possible for these panels to be dismantled and individual components reclaimed simply by 'reverse programming' the same CNC machines used to fabricate them.

The wall panels are 320mm thick, comprising (from inside to outside) a 251mm thick panel of dowelled and cross laminated fir boards (within which is an 80mm solid wood core) a 44mm layer of softwood fibreboard insulation and a 29mm layer of fir boards. Structural loads are carried by the solid wood cores, which line up vertically from floor to floor. The remainder of the 250mm wood thickness serves as a sacrificial layer for fire resistance.

The CLT floor panels span 6 metres between the exterior walls and the central service core. Only where the panels extend beyond the building to form balconies is a steel and wood composite beam required to increase panel stiffness. These beams are the same depth as the panels themselves, maintaining a flush ceiling surface to permit flexibility in the placement of interior walls.

The exterior finish for the Woodcube is untreated larch panels, detailed to create mini compartments (500mm in height) behind the cladding, rather than a continuous rainscreen cavity. This is to prevent the spread of flame upwards in the event of fire. A cellulose-based sealing foil within the wall assembly prevents smoke infiltration into the building, and also acts as a wind barrier. The assembly was tested for compliance with local fire codes, and is the first non-encapsulated system to meet the requirements of Germany's Category 4 (two-hour fire resistance) classification without the need for sprinklers or a standpipe.

The wall assembly has a thermal transmittance of 0.19W/m^2/°C (R53 equivalent). Baseline thermal performance was enhanced by milling grooves into the individual board layers, providing macroscopic non-circulating air cushions that further reduce the thermal conductivity of the walls. With the roof assembly having a thermal transmittance of 0.105W/m^2/°C (R95 equivalent), the Woodcube achieves an annual operating energy consumption of 18KWh/m^2 – very close to Passive House standard. This energy is supplied from renewable sources including a rooftop photovoltaic array. The vapour open wall assembly means that the risk of condensation and mould growth is virtually eliminated, and the panels carry a 50-year manufacturer's warranty in this regard. The carbon stored in the wood panels more than offsets the carbon footprint of the concrete and steel components, making the Woodcube carbon neutral or even carbon positive over its anticipated 50-year service life.

CONCLUSION

The Woodcube capitalizes on the multiple environmental attributes of wood, including its application as a bio-fuel, its low embodied energy, its ability to sequester and store carbon, its thermal characteristics, its performance in fire and its contribution to healthy indoor environments. While the building is not cost competitive with current market equivalents, it establishes important precedents that are potentially transformative. It also repositions wood as an inherently 'smart' material which plays an active role in in many aspects of building physics.

REFERENCES

1 'Smart Materials', i.e.materials that change with time to mitigate the environmental forces acting on a building, was one of the themes of IBA 2013.