University of Belgrade
Faculty of Forestry

University of Ljubljana
Biotechnical Faculty
Department of Wood Science and Technology

PURDUE UNIVERSITY
FORESTRY AND NATURAL RESOURCES
130 YEARS OF EXCELLENCE

Increasing the Use of Wood in the Global Bio-economy

September, 28 2018

Development of multy storey buildings in Europe and US

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Forestry and Natural Resources

Trends that will drive the timber industry most

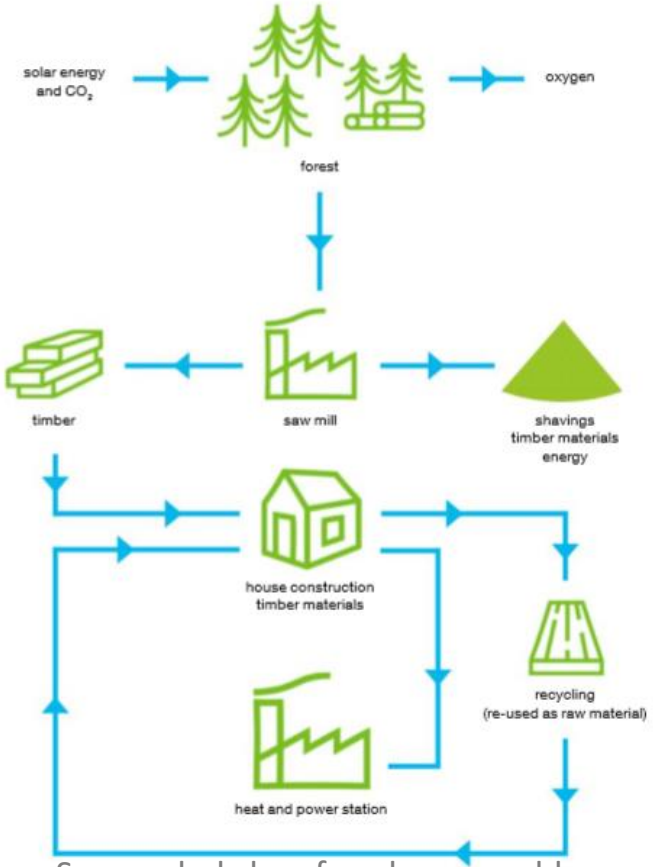
Timber construction tomorow

- Ecology
- Short construction times
- Flexibility

Energy efficiency will be the critical factor

What social aspects will influence buildings in the future?

Natural cycle:
Wood can be used again and again



Source: holz.bau forschungs gmbh

Strategy – example Sweden

The building industry – cost efficient and affordable buildings

More building with wood ⇒ more living with wood

i.e. more wooden houses will also result in other products of wood

Building with wood

- Industrial manufacture of single-family timber houses
- Multi-storey buildings in wood

To increasing the:

- added value, and in the end the profit for industry
- use of sawn timber
- job opportunities in Sweden

Wood is a trendy material

Because timber is natural, calculable, timeless, modern, flexible and fascinatingly versatile.

Building in wood is super fast, super accurate, and also makes the most amazingly beautiful spaces.
Andrew Waugh, British Architect

Innovation of wood products | Building with wood

- Engineered Wood Products (e.g. CLT) and design are revolutionising the architectural possibilities.
- Lower carbon footprint than concrete and steel
- Computational design, robotics for assembly, 3D printing

Naturalness
Comfort
Ecology

Future orientated architecture

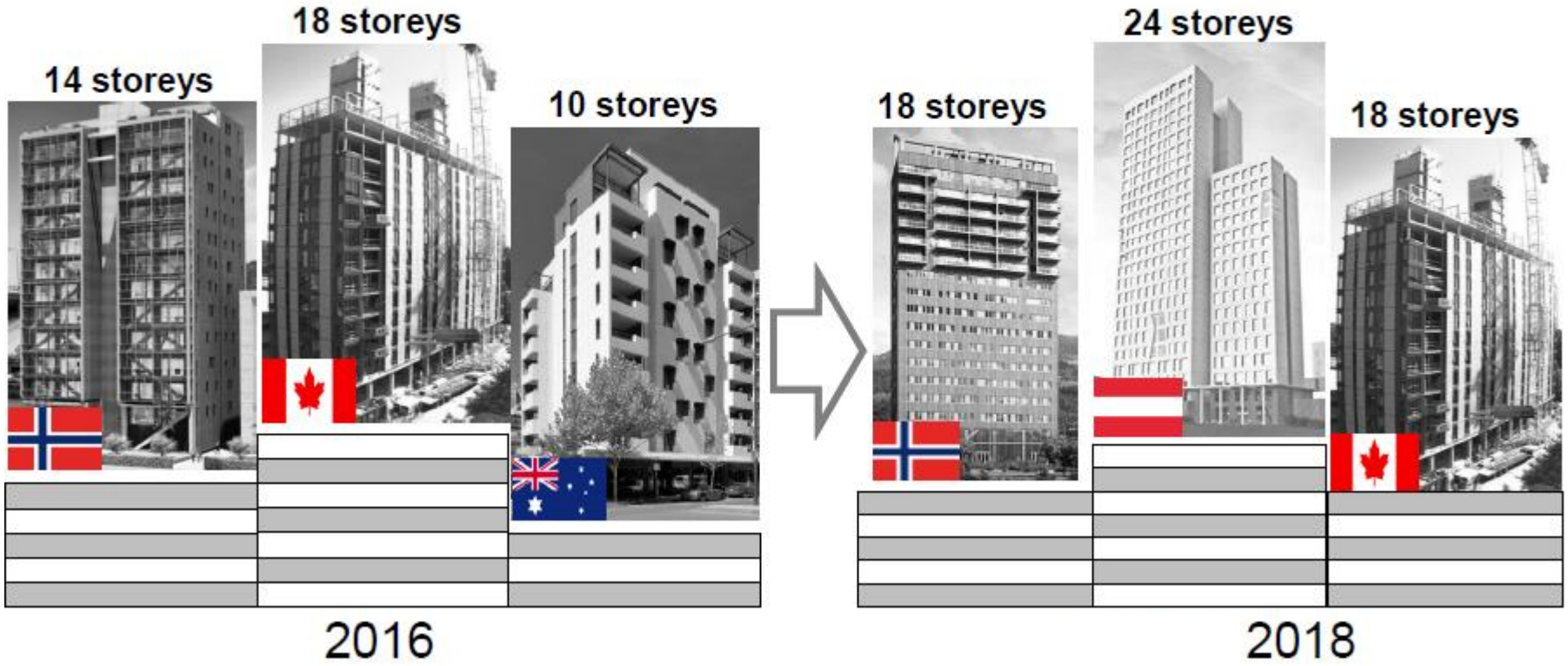
Modern, unpretentious, elegant and yet cosily inviting: Timber simply creates a pleasant atmosphere
The Kindergarten of Bizau is a case in point.

Development of multi-storey buildings of CLT

Focus is CLT in high rise

M. Green: "The race is on!"*

Extensive research has shown that material-neutral building regulations are preferable and, for over a decade, function-based regulations have been common in many countries.

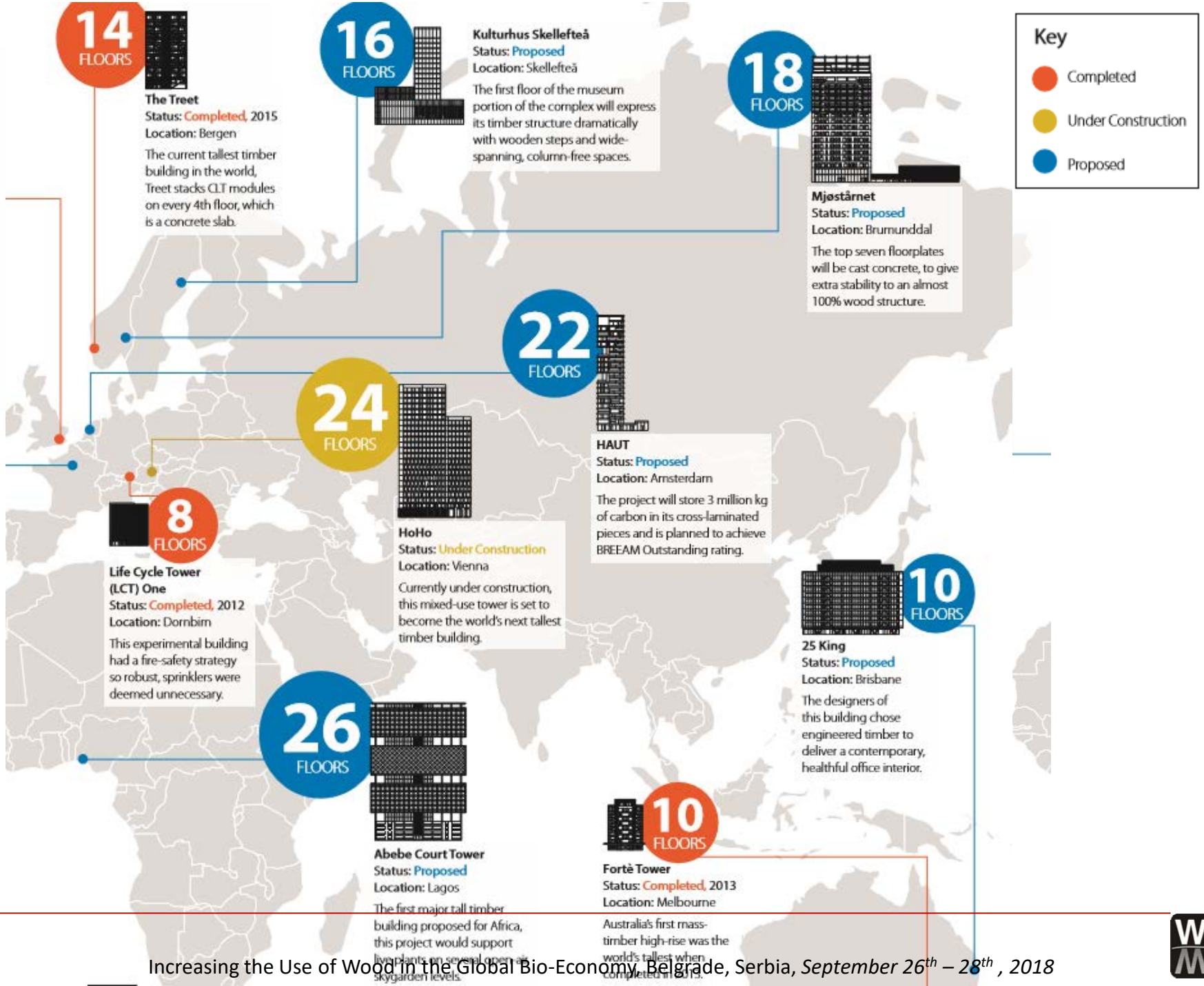


The Case for Tall Wood Buildings *encourages architects, engineers and designers to push the envelope of conventional thinking by demonstrating that wood is a viable material for tall and large buildings and exposing its environmental and economic benefits.*

Present stage and future suggestions for multi-storey buildings

Wooden Skyscrapers

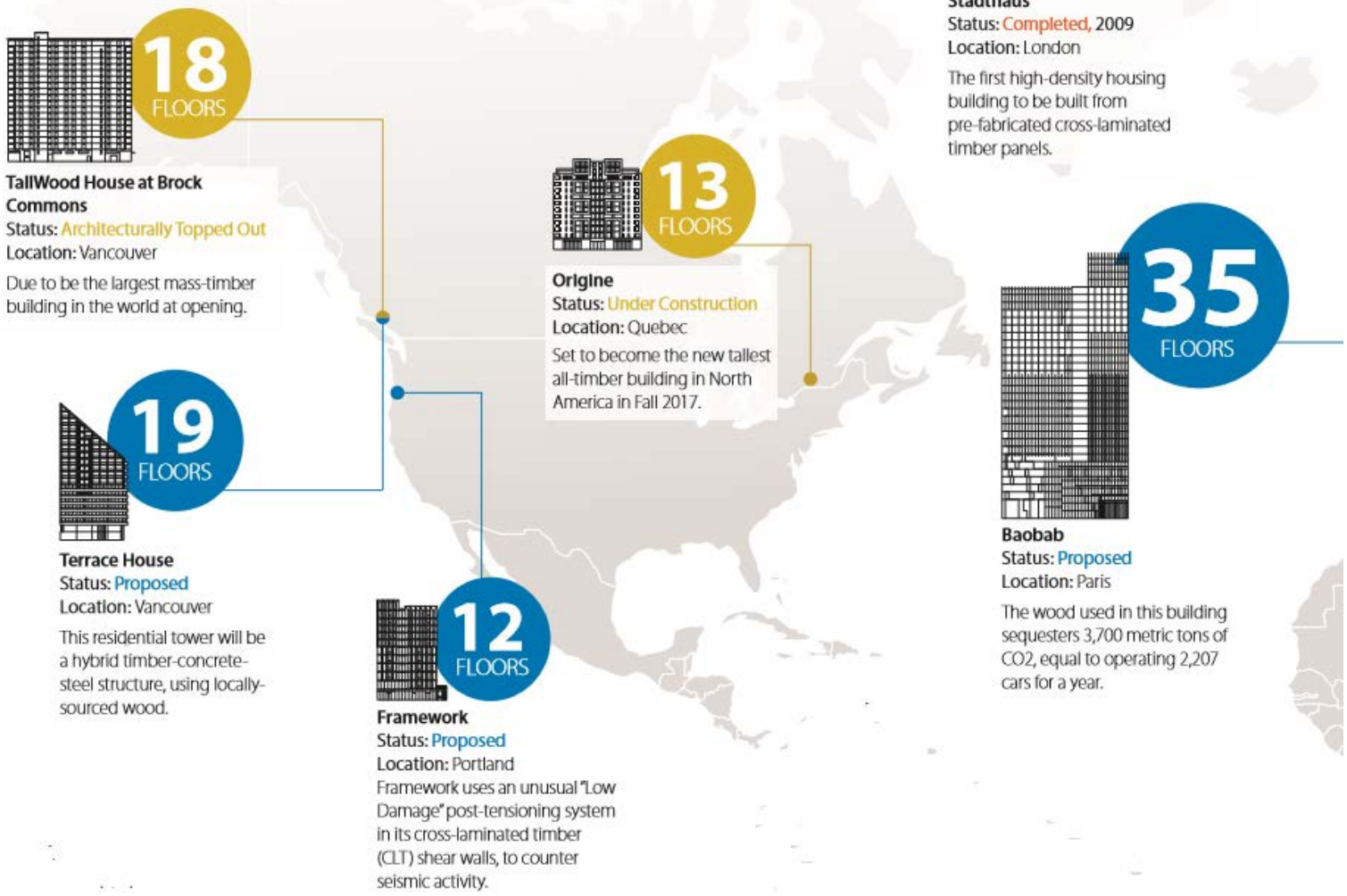
1995	5-storey building, Wälludden, Växjö, Sweden
1995-2005	3-5 storey buildings in several European countries
2008	8-storey tenant-owned apartments, Växjö, Sweden
2009	9-storey tenant-owned apartments, London, UK
2011	7-storey multi-family house, Berlin, Germany
2012	8-storey tenant-owned apartments, Bad Aibing, Germany
2013	9-storey apartment building, Milan, Italy
2013	10-storey building in Melbourne, Australia
2014	14-storey apartment building, Bergen, Norway
2018 2020?	24-storey building HoHo, Vienna, Austria 30-storey building, Canada
2025?	34-storey building, Stockholm, Sweden
?	80-storey building, London, UK



Research: Tall Buildings in Numbers, Council on Tall Buildings and Urban Habitat, 2017

Tall Timber: A Global Audit

This map highlights several examples of tall timber buildings currently built, under construction, or proposed around the world (see page 47 for table).

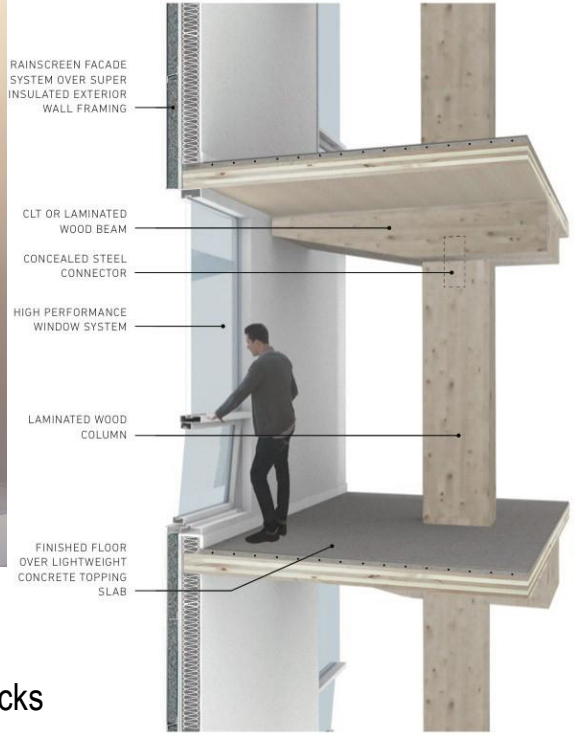


Research: Tall Buildings in Numbers, Council on Tall Buildings and Urban Habitat, 2017

Framework the first timber high-rise in the US

Portland, Oregon – Framework consists of 12-storey high residential buildings

https://leverarchitecture.com/projects/framework



Residential building

Location | Portland, Oregon
Construction type | residential blocks
Building year | Under construction
Architect | LEVER Artchitecture
Energy performance: energy class | low-energy
Number of floors | 12-story buildings
Type of ownership| Residential and office

Framework will be tallest wooden-framed building in U.S. Made of CLT and beam gluelam.

Framework is supported by a 1.5 million dollar award from the US Tall Wood Building Prize Competition to offset the costs of testing and peer review necessary to pursue a performance-based project beyond what is permitted in current building codes.

Wood reflects character of Skellefteå

Wooden Sky Scrapers- cultural centre and hotel CO_2 ····▸ ····▸

White Arkitekter selected to build timber-framed high-rise in Sweden

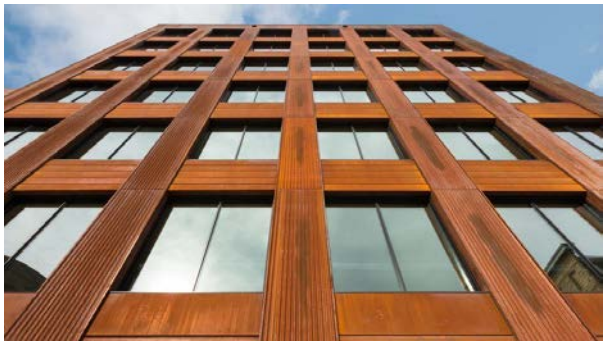
*Named **Kulturhus i Skellefteå**, the 19-storey structure will contain a series of cultural facilities at its base and 16 hotel floors above, reaching a height of 76 metres.*

https://www.archdaily.com/2016/06/07/kulturhus-i-skellefteå-white-arkitekter-cultural-centre-hotel-sweden-wooden-tower-crane/

T3 Minneapolis

Minneapolis, Minnesota – T3 consists of 7-story buildings

http://mg-architecture.ca/work/t3-minneapolis/



Office building

Location | Minneapolis
Construction type | residential
Building year | 2016
Architect | Michael Green
Total area | 20,810 m^2
Total building time| 2.5 months
One storey erection time | 9 days
Construction | Magnusson Klemencic Associates
Energy performance: energy class | low-energy
Number of floors | 7-story buildings
Type of ownership| Retail and office spaces

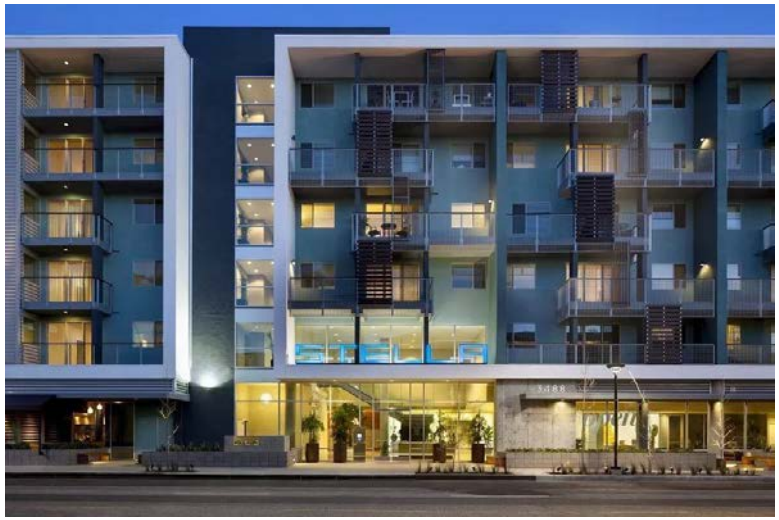
The building has a structure built entirely from wooden slaps, columns and beams. Glue and nail laminated timber were used.

Approximately 3600 m^3 of wood are used in the structure

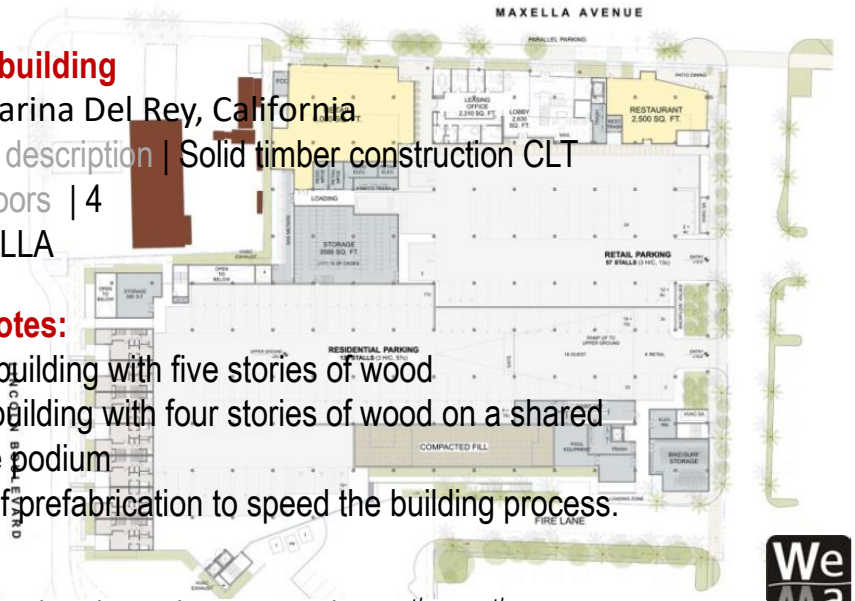
Stella Apartments

Marina Del Rey, California

Prefabricated wooden buildings



https://www.thinkwood.com/our-ceus/designing-sustainable-prefabricated-wood-buildings



Residential building

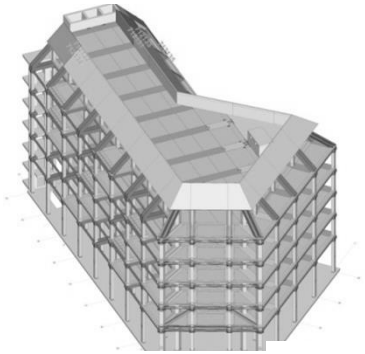
Location | Marina Del Rey, California
Construction description | Solid timber construction CLT
Number of floors | 4
Owner | STELLA

Technical Notes:

- Type III building with five stories of wood
- Type V building with four stories of wood on a shared concrete podium
- To use of prefabrication to speed the building process.

Tamedia office building

5-storey building in Zürich, Switzerland



Office building

Location | Zurich, Switzerland
Year of construction | 2014
Architect | Shigeru Bahn Architects
Construction description | structural system made entirely of timber, with no metal connectors
Energy performance | energy class: low-energy
Number of floors | 6
Area | 10.120 m^2

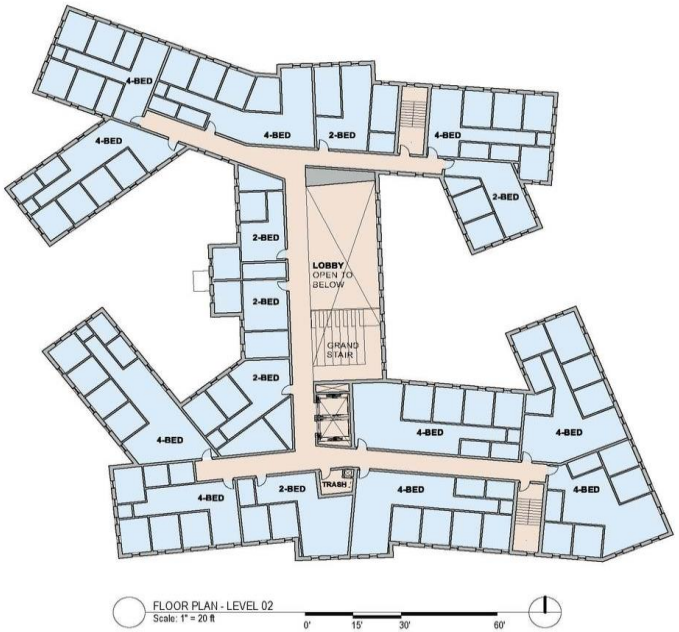
www.archdaily.com/498686/molle-by-the-sea-elding-oscarson

Olympia Place

Holst Architecture + DiMella Shaffer

The future of innovative student living

Study area, collaborative areas, wall of glass, brakout rooms, ….



Privately-developed student housing project

Location | Amherst, MA, US
Year of construction | 2016
Architect | DiMella Shaffer, Holst Architecture
Architect in Charge | Michael Green, Candice Nichol
Photographs | Christian Phillips
Manufacturers| Trane, Belden
Area | 100000.0 ft2
Development | Archipelago Investments LLC
General Constractor | Cutler Assiciates Inc.

https://olympiaplace.com/

West Campus Union / Grimshaw

renovation and expansion

Durham, North Carolina

https://www.archdaily.com/801457/west-campus-union-grimshaw

Student housing project

Location | Duke University's West Campus Union, Durham, NC, US
Year of construction | 2016
Architect | Grimshaw
Area | 10200.0 m2
Manufacturers | Roschmann
Elevated Walkway | James Carpenter Design Associates Inc. and Architecture Operations D.P.C
Landscape Architects | Reed Hilderbrand
•Facade Consulting | Front Inc.
Civil Engineers | Stewart Consulting Engineers
Acoustics/AV/IT | Jaffee Holden
Signage and Wayfinding | Two Twelve
General Constractor | Skanska USA

The new design focuses on the introduction of lightness and porosity to the structure, inviting students in from all directions and activating sightlines across the university precinct.

The 14-storey residential building Treet

Bergen, Norway. Currently the tallest timber-framed building in the world

Timber high-rise is a good answer to sustainable building in urban areas

⌂3D-view from the south

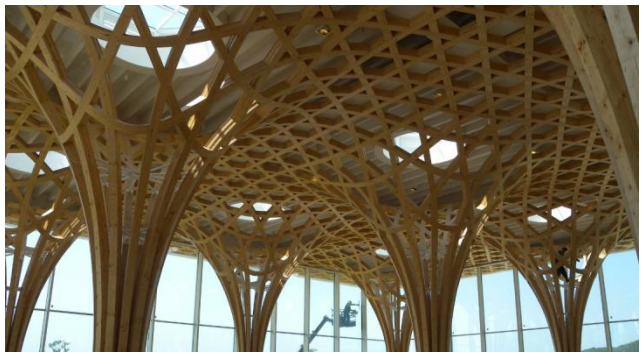
Residential building

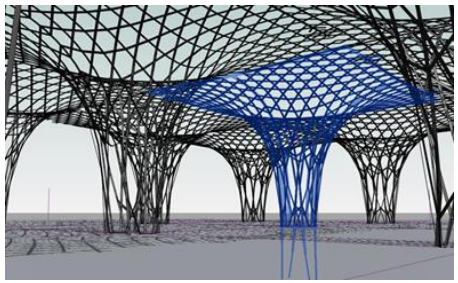
Location | Bergen, Norway
Type of building| residential building,
62 apartments
Total height | 52.8 m
Year of construction | 2015
Architect | Artec. SWECO Norway
Construction | Glulam and CLT - Moelven Limtre, subcontractor Stora Enso, Prefabricated building modules - Kodumaja
Construction description | gluelam and CLT
Area | 5830 m^2
Energy performance: energy class: passive house standard
Number of floors | 14 floors

The Yeoju golf clubhouse

Sport building, Korea

www.archdaily.com/498686/molle-by-the-sea-elding-oscarson





The roof over the main building measures 36 x 72 m

Sport, leisure building

Location| Yeoju, Korea

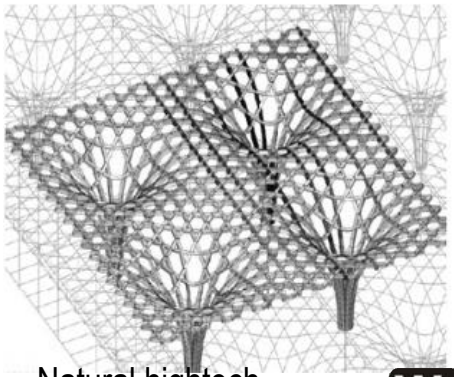
Year of construction | 2010

Architect | Shigeru Ban Architects

Area | 16,000 m^2 facility

Number of floors | 3 floors

Prize | 2014 Pritzker Prize



Natural hightech

Multi-residence building, Älvsbacka Strand

Skellefteå - 6-storey high residential buildings

Factors of increase:

-a lower cost of wood-building
-advantages of using wood in industrial building,
-growing environmental awareness,
-a renewable material,
-reduces CO_2 emissions,
-timber is harvested in forests where sustainable forestry, with replanting and management plans, is practiced.

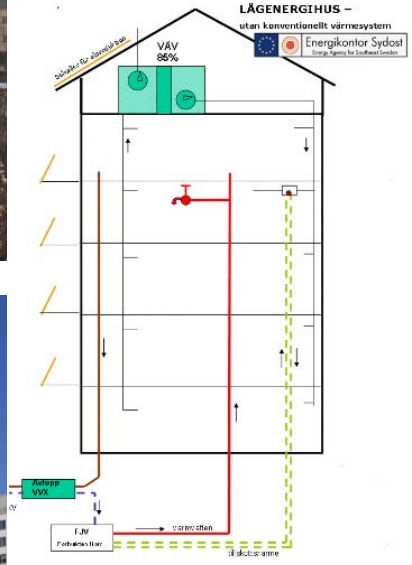
Residential building

Location | Skellefteå
Construction type | residential, 3 houses
Year of construction | 2008, 2009, 2010
Architect | White arkitekte
Construction company | Martinsons
www.martinsons.se
Construction description | solid timber construction CLT
Energy performance | energy class: low-energy
Number of floors | 6
Fasad | timber panel facades
Owner | Brf Älvsbacka Strand

Portvakten residential building

Växjö - two 8-storey houses with wooden framework and passive house technology

⌂ Weather protection. All assembly work takes place under protection against weather.



⌂ Passive house installations. Draft of installation system.

Residential building

Location | Växjö
Year of construction | 2009
Architect | BSV Arkitekter
Construction company | Martinsons, www.martinsons.se
Construction description | CLT, solid wood frame
Project | project »Energy efficient Växjö«
Area | 64 apartments in 2 buildings
Energy performance: energy class: passive house, 15 kWh/(m^{2}a)
Number of floors | 8 floors
www.martinsons.se

CLT Offers a Host of Convincing Advantages

Challenges for architects

Industrial robots can easily manufacture cross-laminated timber into practically any desired configuration – even curved CLT elements.

Curved CLT panels, Hamsphire

Production hall of Unterrainer Holzbau company Austria

Alison Brooks Architects, Arup, American Hardwood Export Council, and the London Design Festival

www.tugraz.at/en/tu-graz/services/news-stories/talking-about/singleview/article/zukunftsbaustoff-holz/

CLT Offers a Host of Convincing Advantages

Challenges for architects

- Buildings made of CLT are extremely earthquake-resistant.
- Buildings made of CLT are erected very quickly; it is also **possible to manufacture module-like room cells in a simple process.**

Solid timber walls are equally suitable for ***temporary buildings*** to provide **flexible living possibilities for limited periods of use.**

Spatial cells Residential appartments Skagersvägen

Stockholm

To achieve the unbroken vertical lines that run up the facade, the architect designed the cladding piece by piece.

Type of building | residential, 33 appartments

Location | Skagersvägen 22-26, Årsta, Stockholm

Advantages:

-Total cost is up to 20-25% lower than building to site,

-Time saving up to 80%,

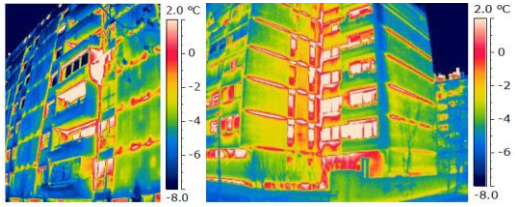
-Prefabricated cells are light,

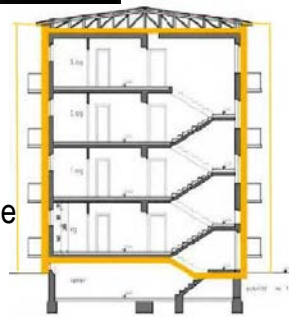
-Requires early commitment in the projects with little scope makeing changes later.

Fabricated large-scale façade wooden moduls

***Reconstruction**, Thermal modernisation of old buildings*

Residential area Dieselweg 4 – Graz, Austria





Key technologies

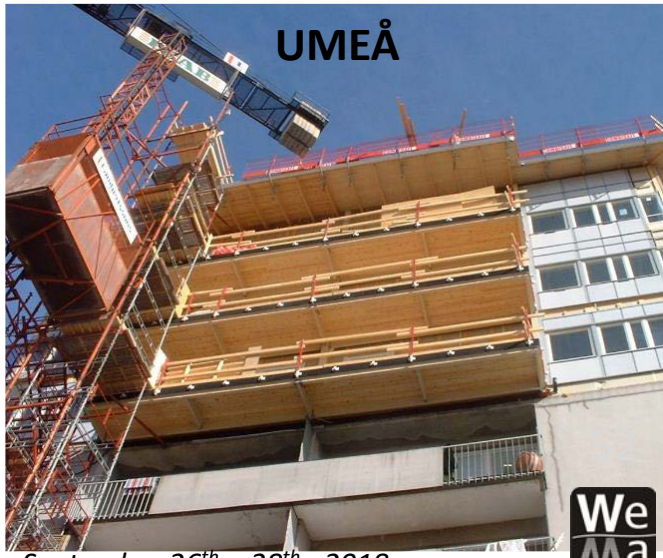
- Solar façade
- Pre-fabrication of facade modules
- Energy concept based onrenewable energy sources
- New heating- and DHW supply system installed between the façade and existing wall
- Decentralized ventilation systems with heat recovery
- Control and remote maintenance via internet

Additional stories or extensions to roof

Timber - great potential for modernizing older buildings

Effective additional floors of CLT

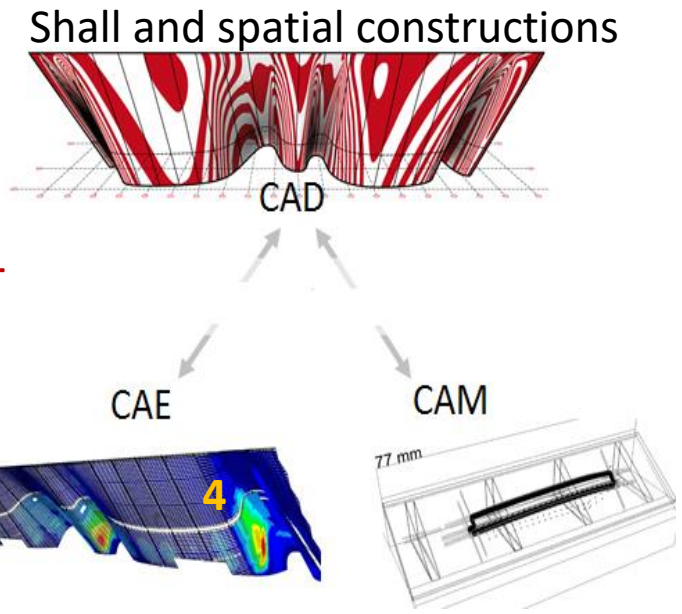
Martinsons' construction system in glulam and CLT offers unique possibilities for additional floors to existing buildings. Thanks to the construction parts' strength compared to their low weight, additional floors can be made without expensive and time-consuming frame reinforcements which are often required with the use of other materials.



Future opportunities & trends for CLT: Free form structures

Production with minimum tolerances and maximum flexibility

The development potential and obstacles in multi-storey building



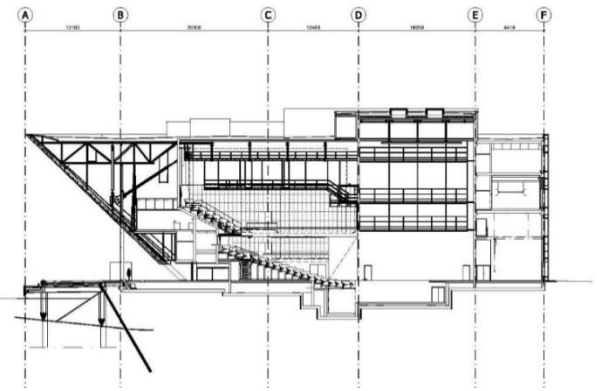
Digital design and production using CAE (computer-aided engineering), CAD (computer-aided design) and CAM (computer-aided manufacturing) have allowed timber construction to forge ahead into new dimensions of design. Innovative connections, modern wood-based materials and cutting-edge CNC milling offer entirely new possibilities and shape wood into almost any conceivable form.

Le Curbusier: The chapel of Notre Dame du Haut in Ronchamp

……He quickly became fascinated, however, with the remarkable adaptability of concrete, and with its sculptural and structural potential. **Concrete's ability to** take any shape and to be enhanced by the surfaces of various molding forms entranced Le Corbusier.....

Kilden Performing Arts Centre

Kristiansand, Norway



Architectural expression for the edifice represents the functionality and sustainability of the local area while also serving as a landmark piece for the entire city.

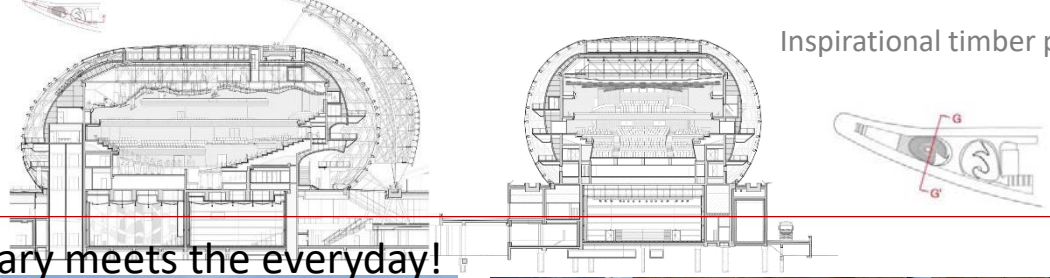
Performing Art Centre

Location | Kristiansand, Norway
Year of construction | 2012
Architect | ALA Architects
Owner | Teater- og Konserthus for Sørlandet
Area | 24,600 m^2

www.archdaily.com/498686/molle-by-the-sea-elding-oscarson

La Seine Musicale

Boulogne-Billancourt, France

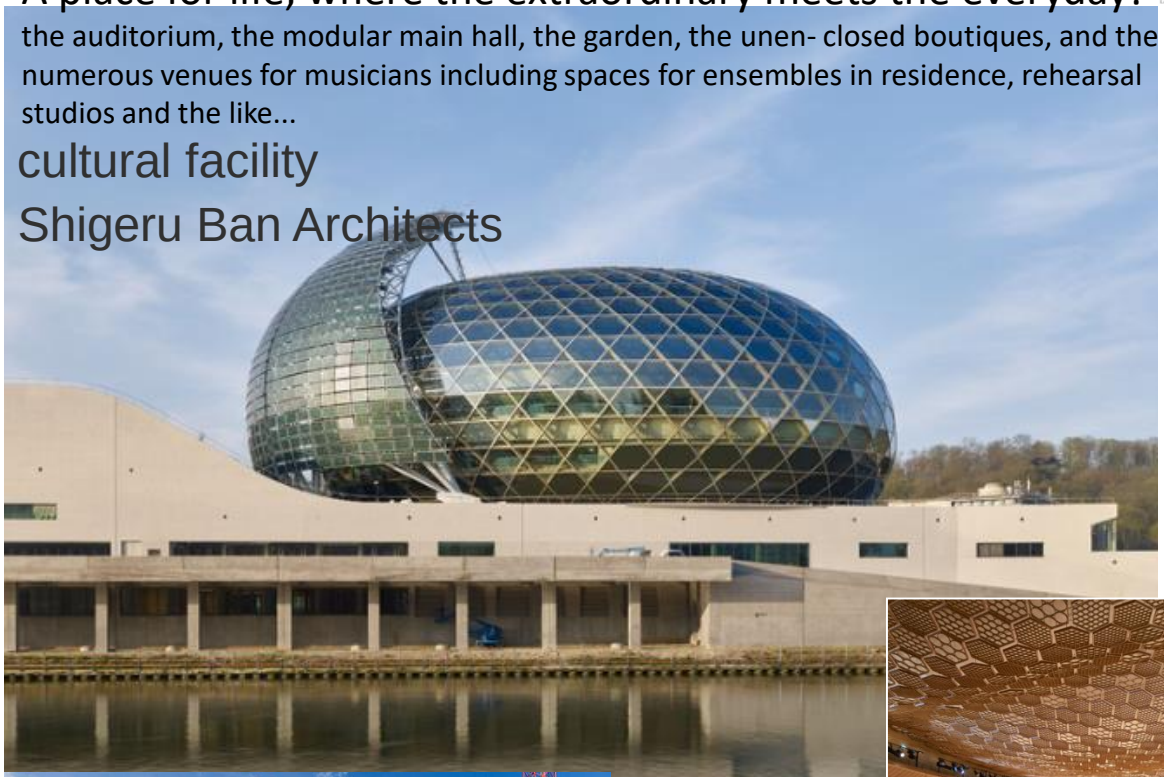


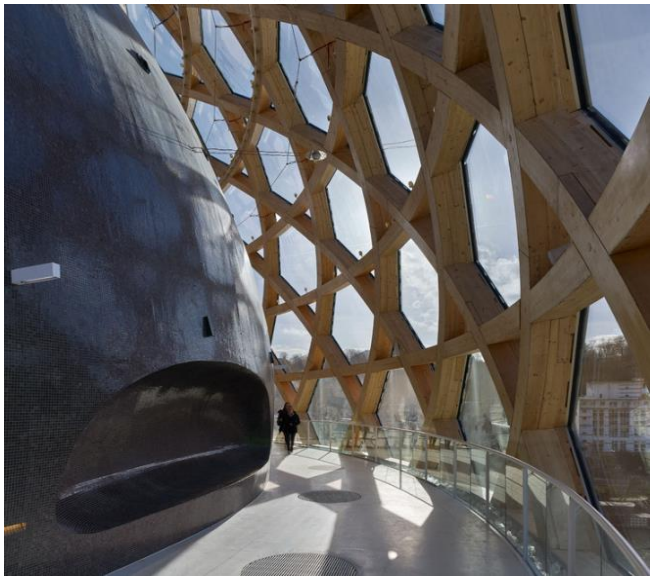
A place for life, where the extraordinary meets the everyday!

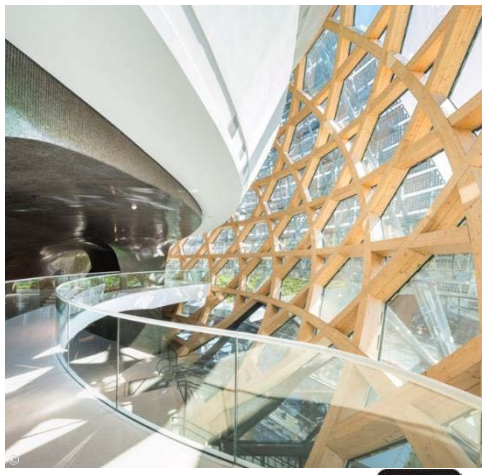
the auditorium, the modular main hall, the garden, the unen- closed boutiques, and the numerous venues for musicians including spaces for ensembles in residence, rehearsal studios and the like...

cultural facility

Shigeru Ban Architects







http://www.archdaily.com/

Use of advanced Engineered Wood Products (EWPs)

Opportunities for architects

Different composite materials or engineer materials *from Hardwood*

IR-temperature image of a human hand having touched thermally modified aspen board for 10 seconds at 23°C room temperature. Holzforschung Austria.

- Ceiling – sawn-timber components of Norway spruce
- Play area – Norway spruce cross-laminated timber
- Play area – Norway spruce edge-glued panels
- Interior fitting – laminated MDF
- Doors – high-pressure laminated veneer
- Interior of high-pressure laminated veneer
- Furniture – beech sawn-timber components
- Flooring – three layered beech panels


• Ceiling – length-wise joined ash components
• Panelling – ash edge-glued panels
• EGP – Edge-glued panels
• Shelves – ash edge-glued panels
• Flooring – sawn-timber components of oak
Propstei St. Gerold, Vorarlberg


Bark EWPs

Three layered interior panels of oak with one visible surface of aged wood material
Aged wood


Flexible wood of Norway spruce (DUKTA, type JANUS)
Flexible


A core of cork and surface layers of birch plywood
Charred wood


A core of cork and surface layers of birch plywood
A core of cork and surface layers of poplar
Wood sandwich panels


We Ma

Survey: Architects perception of selected EWPs

The Perception of Innovative Engineer Wood Products (EWPs) by architects

Objectives of the study

- To evaluate the perceived experience and regional trends of EWPs by archit
- to identify the use of EWPs in loa and non-loadbearing systems;
- to characterize information sourc their perceived value used by arc
- to identify EWPs information nee architects;

With Andreja and Rich

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Architect perceptions of engineered wood products: An exploratory study of selected countries in Central and Southeast Europe

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HIGHLIGHTS

- Architect perceptions of engineered wood products in Europe countries were studied.
- A positive perception regarding the use of wood in general in all countries.
- A lack of knowledge of principles of design options with EWPs.
- The internet is the leading source of information used by architects.
- There is a need for more technical information to understand the potential of EWPs.

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Central and Southeast Europe

ABSTRACT

The wood industries in Slovenia, Croatia, Bosnia and Hercegovina (BiH) and Macedonia have a long tradition of producing a wide range of products. BiH and Macedonia have similar forest sectors and both countries have experienced similar problems in the manufacturing, sale and use of wood-based products in recent years due to the global financial crisis and resulting national economic challenges. Despite having a long and prosperous history, over the past two decades, the wood products sectors in these four countries have faced a steady decline in profitability, the ability to add value through downstream manufacturing, and overall competitiveness.

Engineered wood products (EWPs) are structural building materials that have been used since the early 1980s as replacements for, or in conjunction with, concrete and steel. In this study, we compare architect attitudes, awareness and preferences regarding the use of EWPs between these four countries. The study is based on a sample of 373 architects using on-line surveys. Results suggest that there is a positive perception regarding the use of wood in general in all countries, with the majority of respondents believing that wood use will increase in the future. However, specific to EWPs, differences were found in familiarity and knowledge of potential applications in timber-based construction. Results provide indicators of knowledge gaps between respondents and, conversely, where awareness and willingness to use EWPs exist. These findings can have implications for market opportunities, identifying barriers to EWPs adoption, and content for workshops, seminars, and other outreach mechanisms for architects.

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1. Introduction

Growing environmental awareness presents one of the most important advantages of wood as a construction material, where the choice is motivated by the fact that wood is a renewable material and that its use reduces CO_2 emissions – provided that the raw material is harvested in forests where sustainable forestry is

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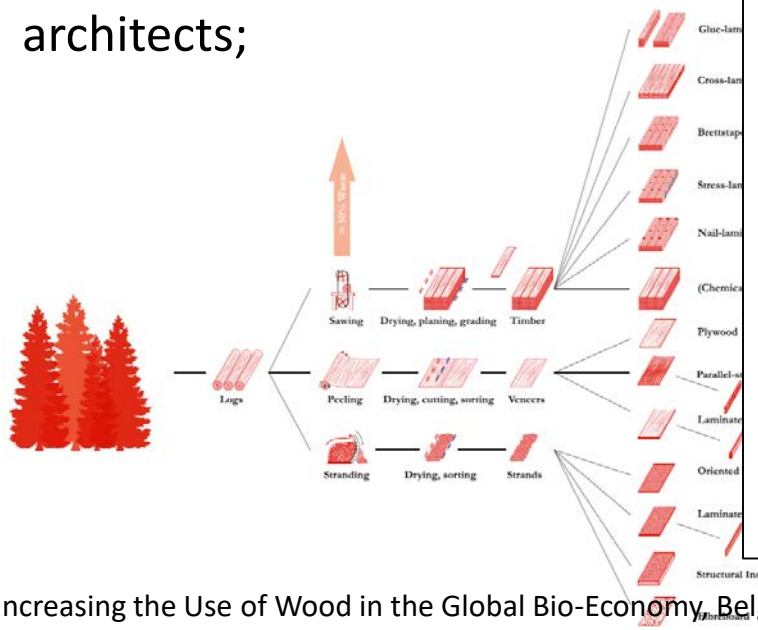
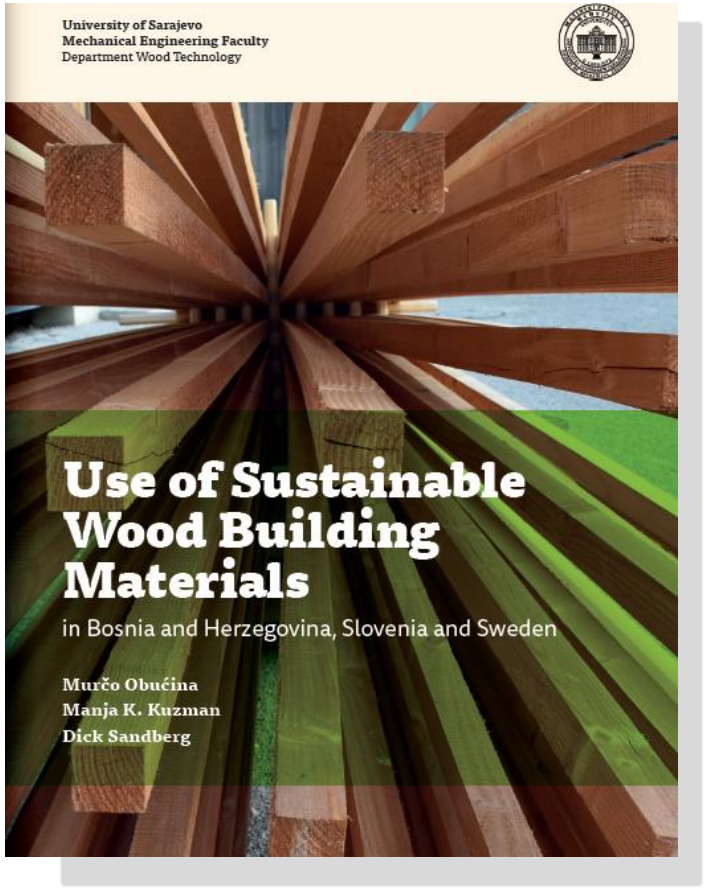


Result of STSM COST FP1407

Book: Use of Sustainable Wood Building Materials BiH, Slovenia and Sweden



Three forest countries, but also three different cultures, identities, mentalities, languages, religions, people, and collaboration between architecture, engineering and timber craftsmanship.

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Biotechnical Faculty
Department of Wood Science and Technology

LULEÅ UNIVERSITY OF TECHNOLOGY

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For French and English speaking

Engineered Wood Products in Contemporary Architectural use

EWPs based on Sawn Timber

- Components of sawn timber
- Edge-glued panels- EGP
- Glued-laminated timber – GLT
- Cross-laminated timber – CLT
- Lightweight materials
- Fibre-reinforced timber

EWPs based on Veneers

- Plywood – PW
- Mass plywood panels – MPP
- Laminated veneer lumber – LVL
- Laminated veneer products – LVP
- High-pressure laminated veneer – HPLV

EWPs based on Strands, Strips, Chips or Particles

- Parallel strand lumber – PSL
- Waferboard – WB and oriented strand boards - OSB
- Laminated strand lumber - LSL
- Particleboard - PB
- Inorganic bonded composites - IBC
- Wood-plastic composites - WPC

EWPs based on Fibre

- Low-density fibreboard – LDF
- Medium-density fibreboard – MDF
- High-density fibreboard – HDF

Hybrid EWPs | EWPs hybrides and Decorative check

- I-joists and box-beams
- Wood sandwich panels
- Bark EWPs, Flexible EWPs,
- Aged wood EWPs, Charred wood

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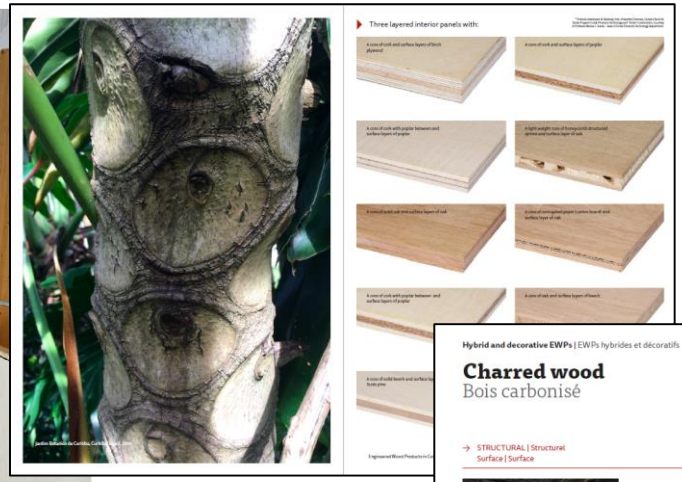
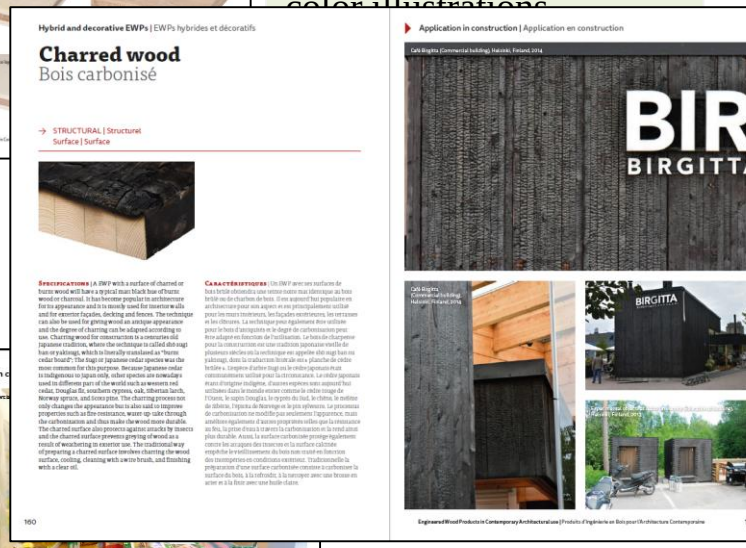
University of Ljubljana

eBook
harcover, 175pages,
color illustrations

For Czech speaking countries

Engineered Wood Products





ISBN 978-80-213-2869-3
Publisher:
Czech University of Life Sciences Pragus
2018
harcover, 185 pages,
color illustrations

Development and implentation of timber construction

in multi-storey buildings is on different levels in different European countries

+ renewable and available locally
+ beautiful, sensuous and has superb technical characteristic,
+ timber construction leads the way in terms of energy-efficient building,
+ timber construction because of its efficient use of both resources and money.
+ Use of Hardwods
+ EWPs

→ High prefabrication as a basic princip
→ Modular building
→ Partnership and increased responsibilities for planning and construction
→ Improved and systematic feedback of experiences
→ Demonstation projects are vital
→ Team coopertion

Attitudes towar

The next generation of wood

The specific issues of c
! fire requirements
! sound proofing
! the cost of facade maintenance
! installations
! weather protection.

Ass. Prof. Dr. Manja K.Kuzman, architect
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University of Ljubljana, Slovenia
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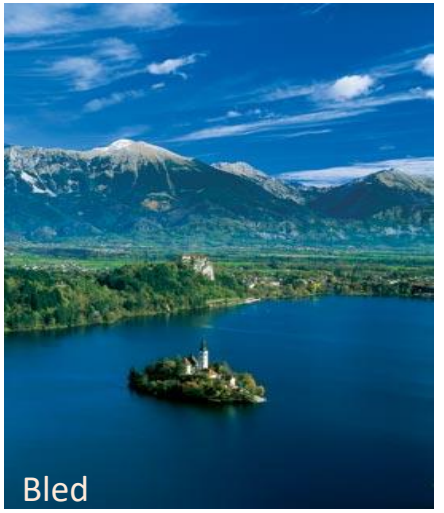
University of Ljubljana
Biotechnical Faculty
Department of Wood Science and Technology

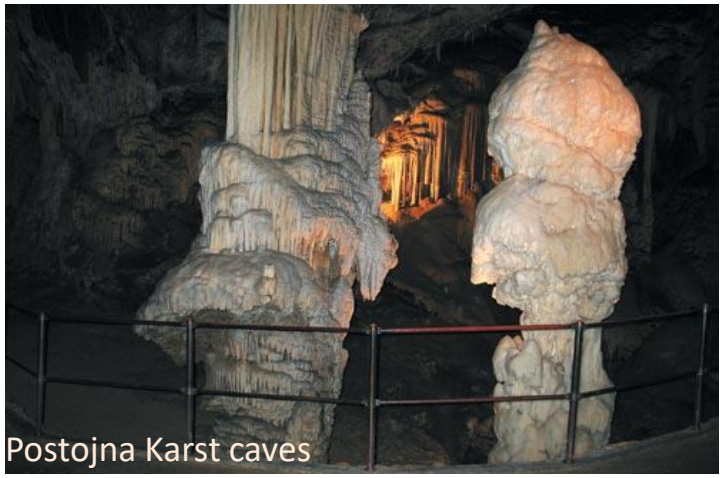
Thank you!

Welcome in Slovenia

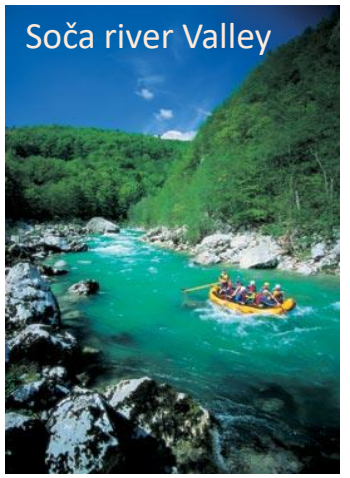

Julian Alps Triglav National park


Ljubljana


Bled


Postojna Karst caves


Adriatic sea – Slovene riviera


Soča river Valley