A Status Report from the CLT Hot Spot in Europe | Austria


* Institute of Timber Engineering and Wood Technology, Graz University of Technology
** Centre of Competence holz.bau.forschung gmbh, Graz

CLT Seminar
sola city Conference Center, Tokyo
March 21st 2017

INTRODUCTION

- TIMBER at Graz University of Technology – Teaching and R&D
- Data & Facts about CLT

SELECTED SUB- AND PROJECTS

- “CLT+GLT_ribbed plates” for large spans
- “PREFAB_modules” for densification
- “CLT_follows_form” | house of bread

SUMMARY AND FUTURE PROSPECTS
INTRODUCTION

Graz University of Technology
7 faculties | 13,800 students | 3,270 staff (2016/17)
budget: € 236 Mil. (1/3 is 3rd party budget)

Faculty of Civil Engineering Sciences
15 institutes | about 1,500 students (2016/17)
Institute of Timber Engineering
and Wood Technology
1991: Chair for Timber Engineering
10/2004: Institute of Timber Engineering and Wood Technology
Scientific staff: 8.0 FTE | 3rd party budget: € 270,000 (2016)

Competence Centre
holz.bau forschungs gmbh
12/2002: Competence Centre holz.bau forschungs gmbh
2013-2016: 4-year funded programme:
COMET-Project “focus sts” [budget: € 3 millions]
Scientific staff: 8.3 FTE | budget: € 810,000 (2016)

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R&D topics regarding Timber Engineering and Wood Technology at TU Graz

- Shell and Spatial Timber Constructions (SSTC)
- Innovative and Intelligent Connection Systems (IICS)
- Lightweight and Hybrid Hardwood Applications (LHHA)
- Evaluation and Maintenance of Historic Structures (EMHS)

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CLT plants

Europe 2016 2017 2018
- 29 ~ 32 ~ 37
NA, JP, AUS/NZ 2016 2017 2018
- 15 ~ 16 ~ 17
Total 2016 2017 2018
- 44 ~ 48 ~ 54

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**CLT production**

*Phase 1: niche product*
- Idea | Patent | Prototype
- Market entry

*Phase 2: pilot projects*
- Regional | National competition
- Market entry
- SET | BBS | MM

*Phase 3: mass production (?)*
- Global | International competition
- Market entry
- SET | BBS | MM

**CLT production 2016**
- ~ 89 % in Europe
- ~ 65 % in Austria

**important future markets in Europe**
- Scandinavia (SE, FI, NO)
- United Kingdom
- France

**Hot Spot - Austria**
- CLT production 2016
  - ~ 65 % of total production in Austria
  - ~ 500,000 m³/year

- reasons for the success in Austria
  - “fast forward” sawmill industry
  - Efficient forestry and timber industry
  - Innovation-friendly environment
  - Strong tradition in solid constructions (concrete, bricks)
  - Fast integration of new topics in teaching and research
  - Application-oriented R&D at universities
  - Tireless and constant cooperation between architects and civil engineers

**www.cltdesigner.at**
- Software tool for the design of CLT
- 5 modules
- ~ 7,800 users from 66 nations

**requests in total**
- 120,000
- 600 / week

**users**
- Engineers 3108 (40%)
- R&D 2094 (27%)
- Carpenters 1418 (18%)
- Architects 545 (7%)
- N.A. 602 (8%)
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CLT+GLT_ribbed plates | large spans

Austrian pavilion in Venice
completed backyard of the pavilion, 1934

- first intention to build the “Austria pavilion” in 1910
- the initiative was interrupted by the outbreak of the first world war
- Austria continued to exhibit in the central pavilion in 1920
- plans were drafted by architects Josef Hoffmann and Robert Kramreiter in 1933
- officially inaugurated in 1934

source: www.austrianpavilion.at

figure: adaption based on "JOSEF HOFFMANN – 50 Jahre österreichischer Pavillon"

requirements of the architect
- flawless surface (no visible cracks or joints)
- inherently stable at unfavorable weather conditions
- easy transport of the elements
- simply to assemble and disassemble
- no connection to the existing building
- barrier-free entrance

span = 10 [m]
CLT+GLT_ribbed plates | large spans

**assembly steps**

- step 1: column base and bearing plates
- step 2: CLT floor elements
- step 3: ribbed wall elements and temporary securing
- step 4: disassembling of securing
- step 5: lift-in ribbed ceiling elements
- step 6: entrance and ramp

**structure | layers:**
- 1st sealing layer
- CLT (20|20|20|20|20)
- GLT-rib
- 2nd sealing layer
- soffit (matt white colour)
- planking (matt white colour)
- CLT (30|20|30)
- GLT-rib
- paint finish (matt white colour)

**values in [cm]**
- ceiling element
- wall element

**middle floor element**

- variation of rib-design
  - GLT
  - TRIO
  - CLT
  - double TRIO

**edge floor element**

- combined GLT

**cross-section**

- clear height = 450
- total height = 525

**benefits of CLT + GLT-RBP**

- enables large span elements
- adjustable bending stiffness due to geometry
- further improvement with high strength lamellas at lower edge possible
- combined GLT | LVL
- CLT+CLT_ribbed plate for ribs with openings (inherent reinforcement)
**SELECTED SUB- AND PROJECTS**

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<table>
<thead>
<tr>
<th>CLT+GLT_ribbed plates</th>
<th>large spans</th>
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**benefits**
- ordinary support conditions
- no cutouts for ribs
- ordinary building physics
- space for indoor installation
- less height of the floor construction

source: SHERPA

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**mechanical model for the interface**
- perpendicular stresses, caused by the notch die away within a short distance \( l_0 \) to the notch
- sum of tensile stress perpendicular to the grain must be secured with reinforcement
- position of reinforcement as close as possible to end grain (within first 10 cm)

\[
F_{t,90,d} \leq F_{ax,Rd}
\]

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**verification of mechanical model**
- 3- and 4-point-bending-tests:
  - different spans
  - small and large scale specimens
  - variation of distance between support and notch
  - different types of reinforcement

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**verification of mechanical model**
- measurements at notch:
  - vertical and horizontal displacement between GLT-rib and CLT-plate
  - force within the reinforcement at the level of the glue joint

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**SELECTED SUB- AND PROJECTS**

### CLT+GLT_ribbed plates | large spans

**verification of mechanical model**

- **comparison of test results with analytic solution and FEM-calculation:**
  - **mean deviation** (four samples of small specimens)
    
    | Function | Measurement | Reference | +5% | +28% |
    |-----------|-------------|-----------|-----|------|
    | $F_{L90,measurement}$ | $F_{L90,model}$ | $F_{L90,FEM}$ |
    | mean deviation | 0% | 10% | 20% | 30% | 40% | 50% |

- analytic solution in **good accordance** with measurements and FEM-calculation
- **conservative** overestimation of $F_{L90}$
- verification with large scale specimen in progress

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### PREFAB_modules

**basic module and construction systems**

- **basic size** for geometric classification system
- **unit of measurement:**
  - $1 [M] \equiv $ e.g. $100, 900 [mm]$ or $62.5, 12.5 [cm]$
- all component measures must be an integer multiple of the basic module $n \times [M]$
- **basis for planning, production and assembly**

**source:** G. Staib, Elemente und Systeme, 2008

<table>
<thead>
<tr>
<th>position:</th>
<th>axis grid</th>
<th>strip grid</th>
<th>combined</th>
</tr>
</thead>
<tbody>
<tr>
<td>size:</td>
<td>✔</td>
<td>✔</td>
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**inflexible** system
- no exchange with different systems

**flexible** system
- exchange with different subsystems

**types of modules**

- **standardised width, length and height**
- **but possible steps in length**
  - small = "s"
  - medium = "m"
  - large = "l"

**types according to their position**

- edge module (e)
- middle module (m)

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**SUMMARY AND FUTURE PROSPECTS**

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**REFERENCES**

*H. Landsberg, Holzsysteme für den Hochbau, 1999*

*G. Staib, Elemente und Systeme, 2008*

*W. Neufert, Entwurfslehre 2015*
### Types of Modules

- **Structure**
  - closed on all sides (A)
  - open on one side (B)
  - open on two sides (C)
  - open on three sides (D)
  - open on all sides (E)

### Prefab Modules for Retirement Homes

**Retirement home “Hallein”**

- 140 modules (completely equipped)
- Dimension: 4 x 8 [m] (w/l)
- Only vertically routed pipelines
- Every single module has its own shaft for building services

**Source:** Kaufmann Bausysteme | architect: sps-architekten zf gmbh, 2013
**SELECTED SUB- AND PROJECTS**

### PREFAB_modules for day-care centers and schools

**European School Frankfurt**

- Classroom
- 3 modules

**Source:** Kaufmann Bausysteme | architect: nikbak Nicole K. Berganski & A. Krawczyk, 2015

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### PREFAB_modules for temporary events

**Modules for the Olympic Village of the Winter Olympics in Turin 2006**

- Complete prefabrication at the plant
- Assembling and fixing on the construction site

**Source:** F. de Monte

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**SELECTED SUB- AND PROJECTS**

### PREFAB_modules for day-care centers and schools

- 90 modules (completely equipped)
- Dimension: 3 x 9 [m] (w/l)
- One classroom consists of three modules
- Building services are integrated in sanitary modules
- Only vertically routed pipes

**European School Frankfurt**

**Source:** Kaufmann Bausysteme | architect: nkbak Nicole K. Berganski & A. Krawczyk, 2015

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### PREFAB_modules for temporary events

- Assembling: module by module and storey by storey
- Benefits: clean construction site, rapid and dry construction method and easy to disassemble for possible changes of use

**Modules for the Olympic Village of the Winter Olympics in Turin 2006**

**Source:** F. de Monte

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SELECTED SUB- AND PROJECTS

PREFAB_modules
for smart city densification

4 methods of urban densification
- horizontal extension to the existing buildings
- closing gaps and vacant lots between buildings
- dismantling existing and reconstructing new buildings
- adding stories on the rooftops of the existing buildings (“roof stacking”)

source: G. Schickhofer, Tokyo 2016

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closing gaps and vacant lots between buildings

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SELECTED SUB- AND PROJECTS

PREFAB_modules
for smart city densification

building with modules implies sustainable buildings as well as clean construction sites

closing gaps and vacant lots between buildings

source: G. Schickhofer, Tokyo 2016

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**PREFAB_modules for smart city densification**

Adding stories on the rooftops of the existing buildings

- Roof stacking can be a very efficient and attractive method for redensification

Source: G. Schickhofer, Graz

Architect: Arch. D. Koch, 2009

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“CLT_follows_form” | house of bread

- composition in layers of CLT
- joining single layers with screw-press gluing
- reinforcement with self-tapping screws

Source: coop-himmelblau.at

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house of bread II

- CLT raw material: 600 m³
  - 3-, 5-, 7-layered CLT elements

- CLT final structure: 400 m³
  - 80 “rings” → total height 10.56 m

- m = 0.40 m

- applying adhesive
- applying CLT element(s)
- introduce secondary screws
- introduce primary (load-carrying) screws
“CLT_follows_form” | house of bread

- applying adhesive
- applying CLT element(s)
- introduce secondary screws
- introduce primary (load-carrying) screws
  → totally applied screws ~ 120,000 (!)
SELECTED SUB- AND PROJECTS

“CLT_follows_form” | house of bread

house of bread II

- customers’ request
- architects’ idea
- engineers’ plan
- statics/design
- production
- assembly
- product

Source: O. Wolf, 2017

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SUMMARY AND FUTURE PROSPECTS

CLT_systems and solutions advanced applications

application possibilities

- “CLT enables 1D- and 2D-elements as well as 3D-modules and even free-form surfaces

1D-element: beam or column
2D-element: wall or ceiling
3D-module: free-form surface

PREFAB_modules

future prospects

- prefabrication and modularization will play an important role for CLT
  - prefabricated modules for habitation, building services and development reduces assembly time and flaws during constructions on-site

SUMMARY AND FUTURE PROSPECTS

CLT storey development

M. Green: “The race is on!”*

- Green, M. „Why we should build wooden skyscrapers“ TED2013

14 storeys 18 storeys 10 storeys 18 storeys 24 storeys
18 storeys

2016 outlook 2018
CLT storey development

Statements regarding "storey race"

- sole focus on maximising the number of storeys or building heights ignores the necessity of thinking and acting interdisciplinary
- such competitions miss any foresight and follow the principle of “Johnny head-in-the-air”
- CLT is a building product and NOT a building system
- NOTE: a building system...
  - ... is more than the sum of its products!
  - ... comprises adequate combinations of building products to building structures being able to fulfil all requirements without increasing the risk of structural damage
- “superlatives” should be thought with focus on application diversity and quality instead of the number of storeys

Thank you for your attention!

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