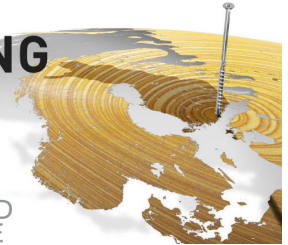




Aalto University
School of Chemical
Technology

FORUM
WOOD
BUILDING
NORDIC

ADVANCED
PROCESSES
FOR ENHANCED
PERFORMANCE



LVL – the big picture

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- Introduction
- History
- Production technology of LVL
- The Market of LVL
 - In North America
 - In Europe
- Production technology – case G5
- Conclusion



Introduction



LVL is a composite of wood veneers with wood fibres oriented in the same direction. It is pressed as a continuous billet in standard widths of 1.22, 1.83 or 2.44 m (netto) with the typical nominal veneer thickness of 3 mm. The **billet** thickness is 27–75 mm.

History of LVL as an EW-Product

First steps in the US

Research:

- 1944 First **research project** with published documentation (R.F. Luxford)
- 1967 Research reopened by Peter Koch, which led to several further projects
- 1973 main conclusion by Peter Koch: LVL and sawn timber reach the same mean value of bending strength, but the characteristic value of LVL is twice as high:

$$\frac{\text{LVL } f_k}{\text{solid wood } f_k} = 2,09$$

Industry:

- A breakthrough of the industrial facilities was achieved in the late 1960s
 - a significantly lower-cost thermosetting **phenol adhesive**
 - the **continuous hot pressing** was implemented

Kairi, M. 2005. <http://lib.tkk.fi/Diss/2005/isbn9512277069/>, see 74

History of LVL as an EW-Product

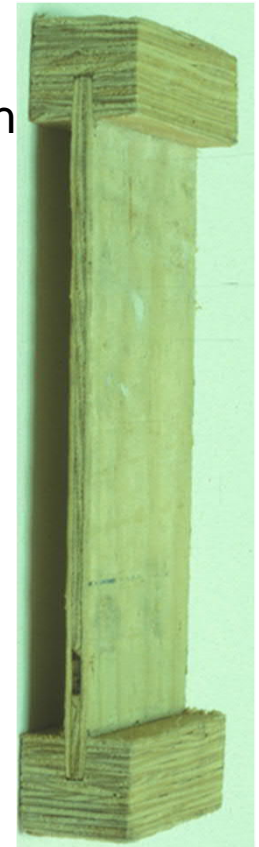
First steps in the US (continued)

Industry:

- In 1969 Trus Joist Co. (TJ) started producing new wooden I-joists with plywood webs and solid finger-jointed sawn timber flanges
- In 1972 TJ started the first 600-mm wide Micro-Lam[®] LVL production line in Eugene, Oregon, patented by Troutner
- The characteristic tensile strength of the new Micro-Lam[®] LVL was outstanding compared to finger-jointed sawn timber. Since 1977 all TJI[®] joists were replaced with Micro-Lam[®]
- It took only 5 years for Micro-Lam[®] to break through on the limited I-joist market.
- TJ considered the product (today Microllam) a **substitute** for finger-jointed sawn timber as flanges in I-joist.

MARKET PULL →

DISTRIBUTION MARKET



History of LVL as an EW-Product

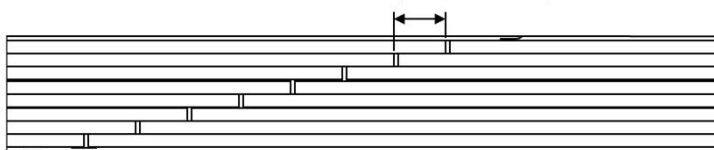
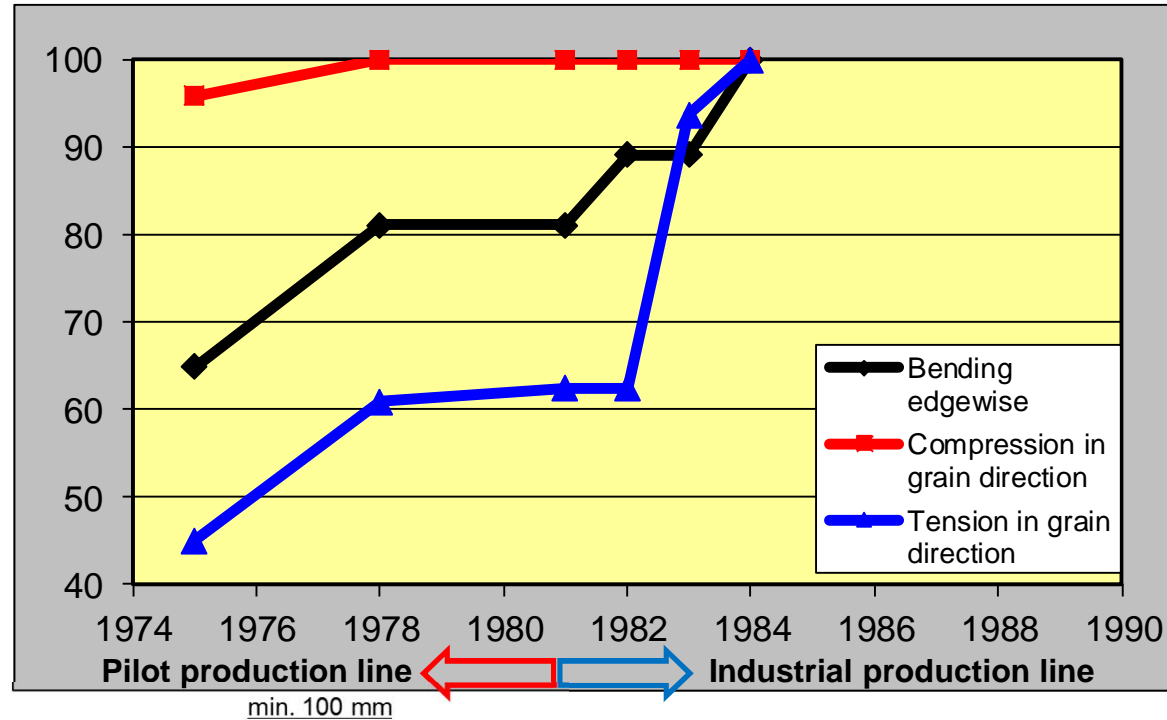
Activities in Finland

- Metsäliitto was actively searching for alternatives for oversupplied spruce sawn goods
- Invention of ANRA-line by Finnish consultant Nils Alenius to produce blockboard as a continuous billet (patented 1964)
- Discussions between Alenius and Peter Koch in the end of 1960s in the US
→ presentation of the idea of LVL to Metsäliitto
- In 1975 Metsäliitto started Kerto[®]-LVL pilot production line in Punkaharju, East-Finland, using the ANRA-line technology.

TECHNOLOGY PUSH → SOLUTION MARKET

History of LVL as an EWP

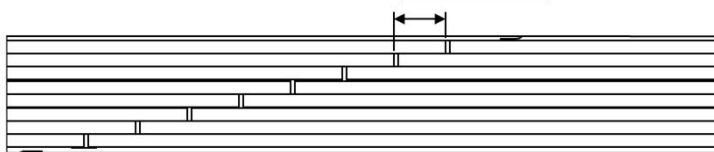
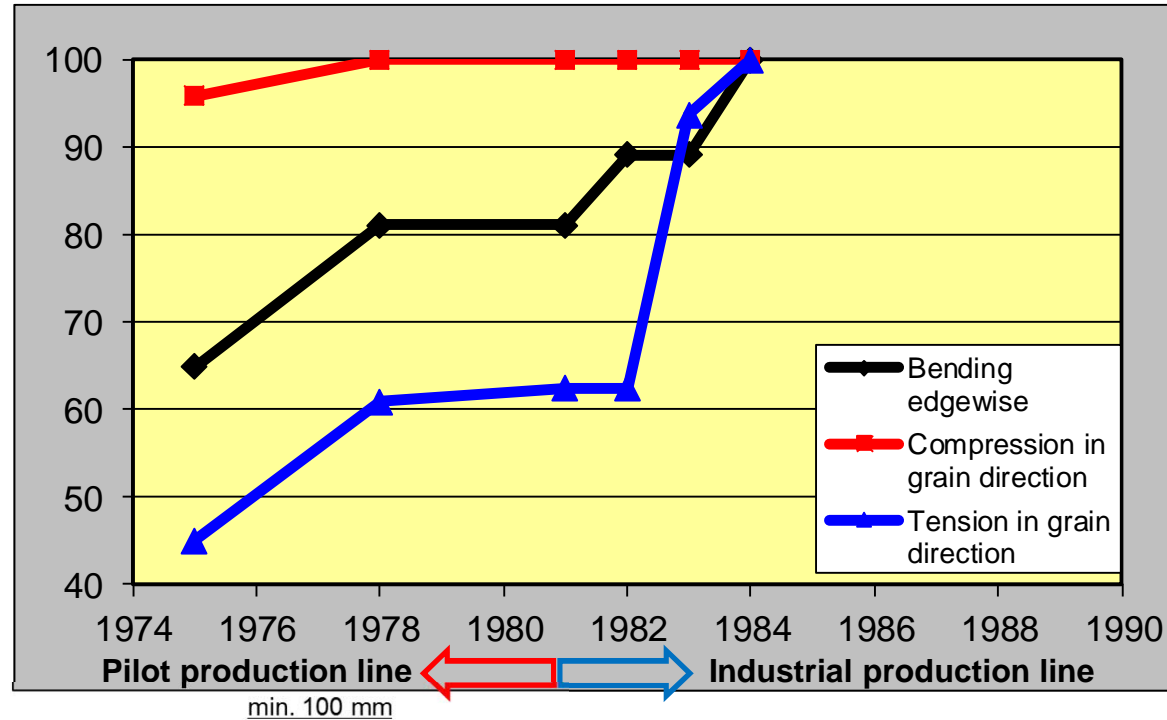
The development of the Kerto-LVL's most important strength properties



In 1975; thickness of the veneer 4,2 mm and butt-jointing

History of LVL as an EWP

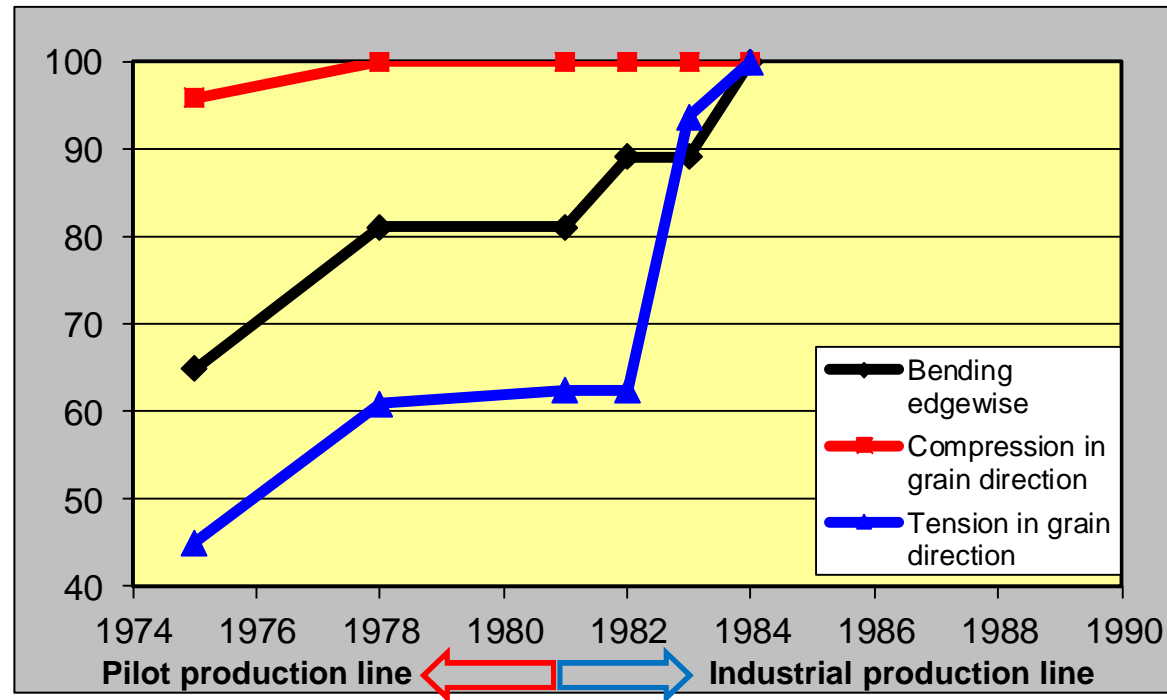
The development of the Kerto-LVL's most important strength properties



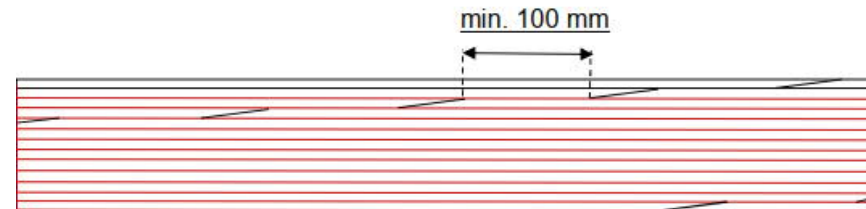
In 1978; thickness of the veneer 3,2 mm and butt-jointing

History of LVL as an EWP

The development of the Kerto-LVL's most important strength properties

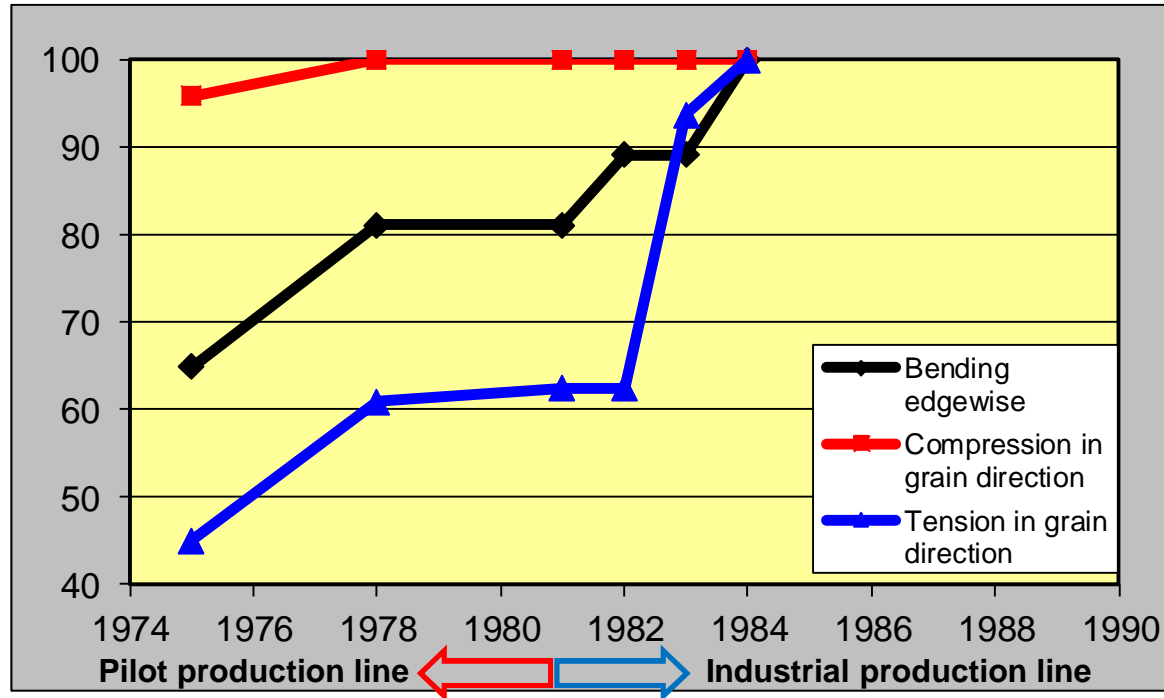


In 1981; thickness of the veneer 3,2 mm and scarf-jointing with the industrial production line



History of LVL as an EWP

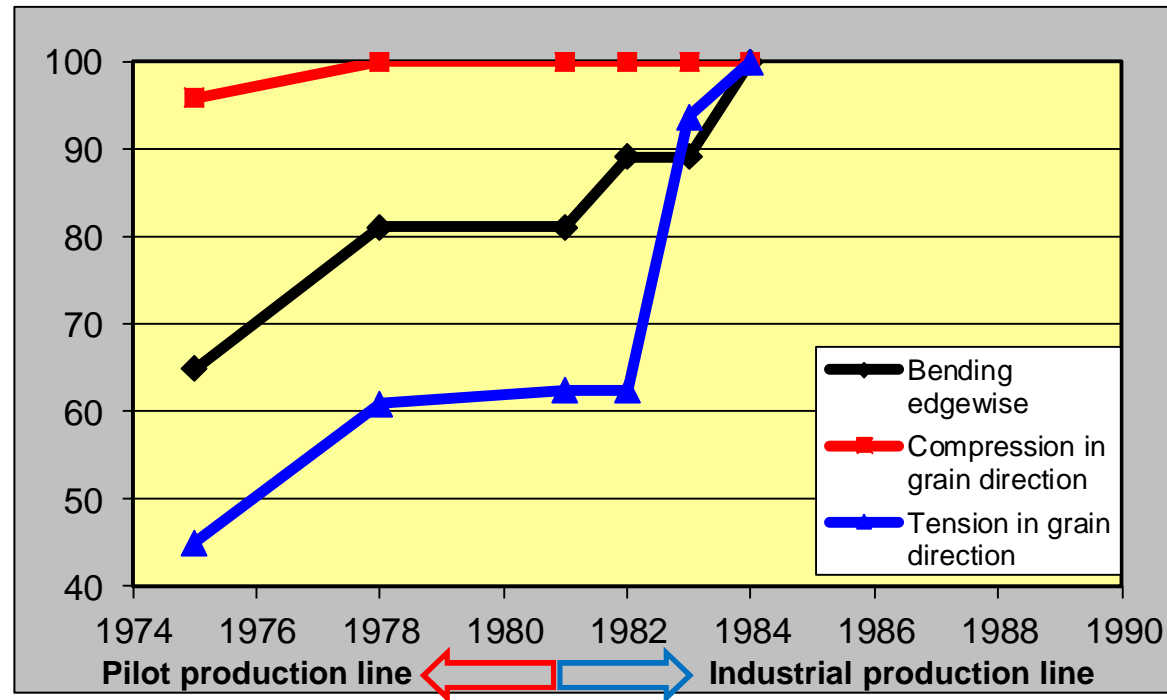
The development of the Kerto-LVL's most important strength properties



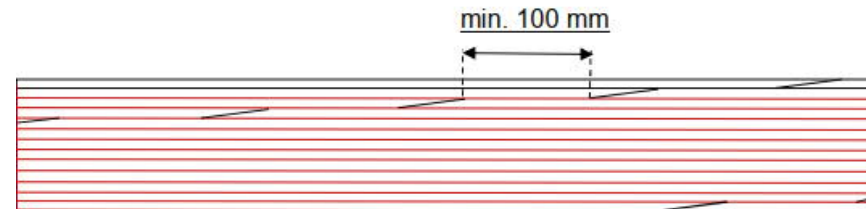
In 1982; second year of the industrial production line with 3 times more volume

History of LVL as an EWP

The development of the Kerto-LVL's most important strength properties

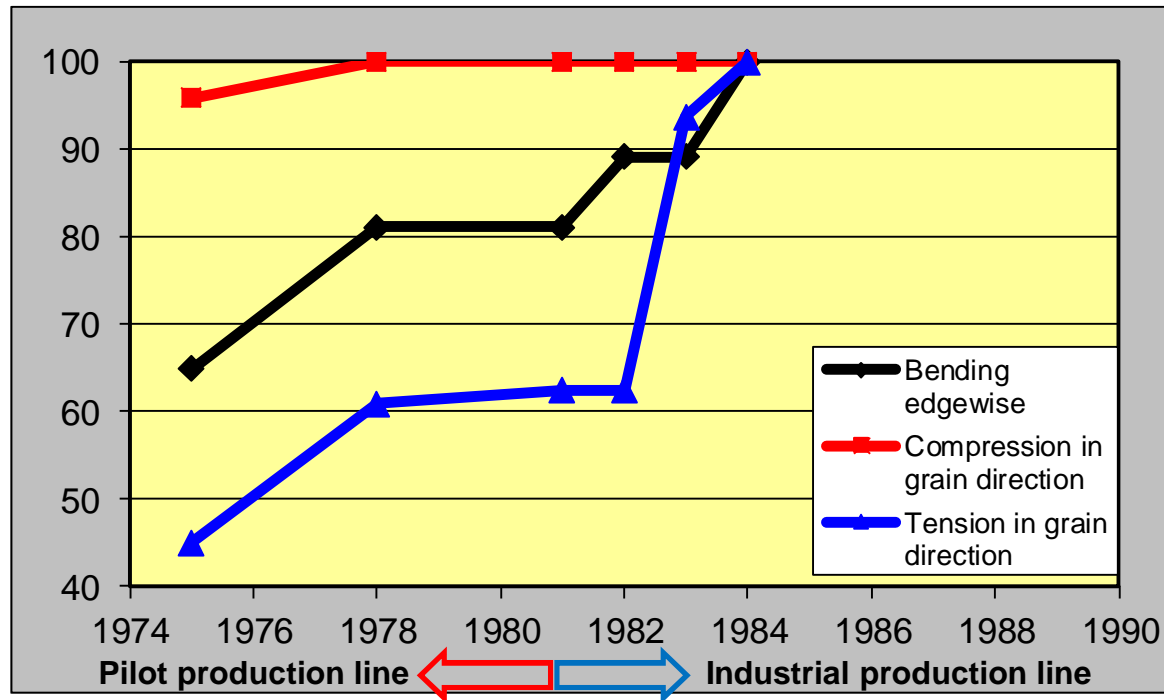


In 1983; third year of the production and better scarf-jointing



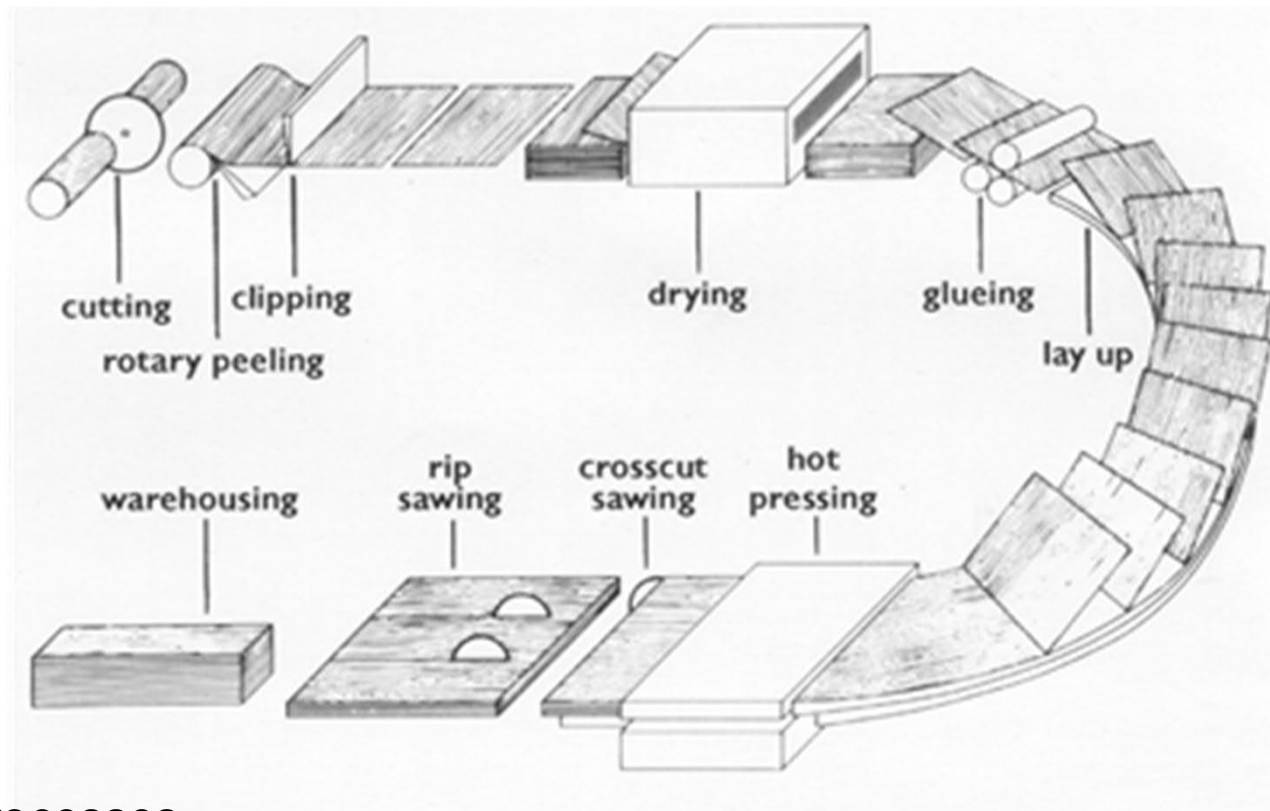
History of LVL as an EWP

The development of the Kerto-LVL's most important strength properties



In 1984; fourth year of the production and depth effect

Production Technology of LVL



Sub-processes

- Log cutting, rotary peeling and clipping
- Drying
- Gluing, lay up, hot pressing, crosscut sawing, rip sawing and warehousing

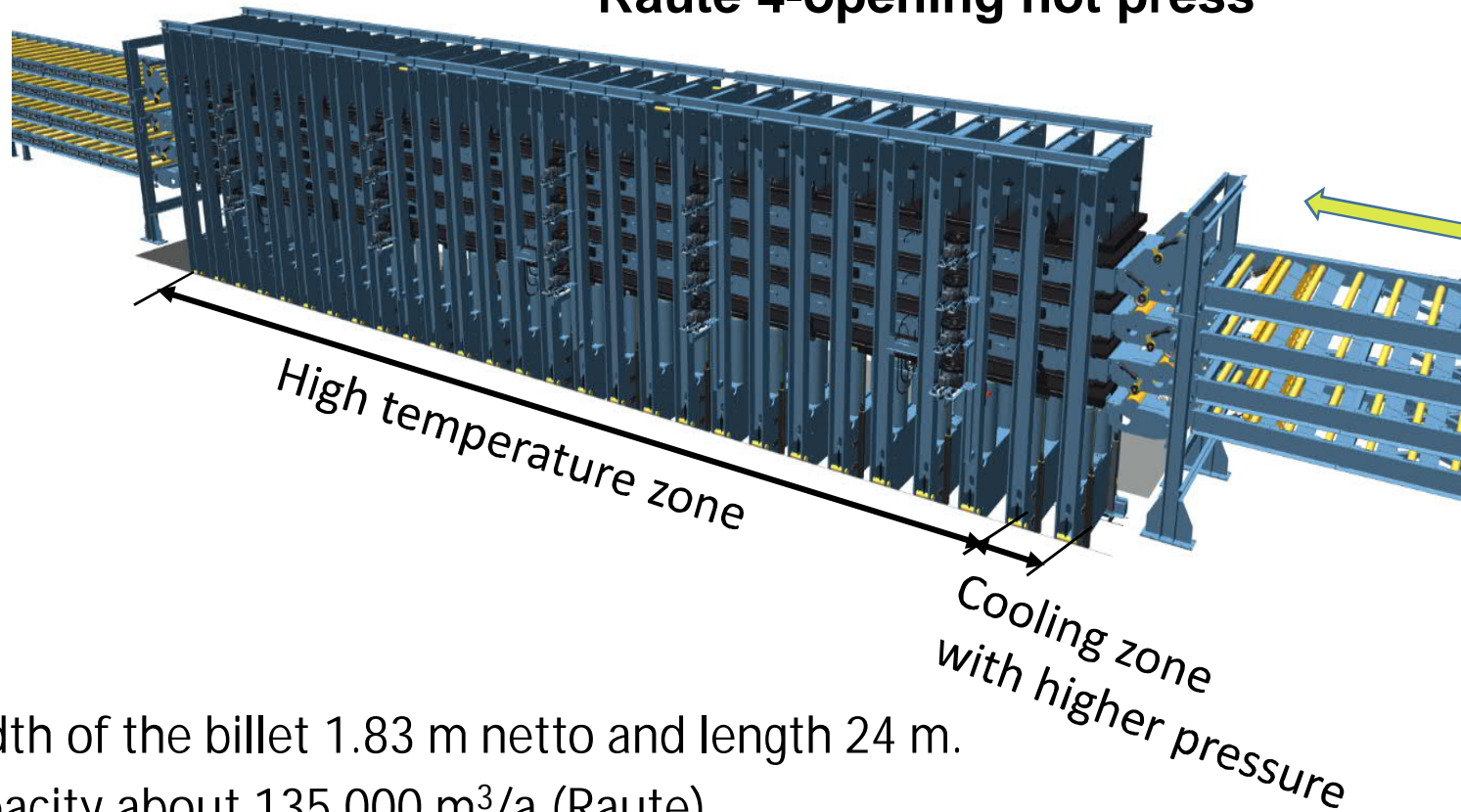
Production Technology of LVL (continued)

Two different hot pressing techniques are used:

- Cycle press originally based on the ANRA line developed by Alenius beginning of 1960s and on technology further developed by Raute Oyj.
- Continuously operated hot press developed by the German Dieffenbacher originally for the manufacture of particleboard, MDF and OSB. With LVL, the line operates without pre-press. A microwave based pre-heating system is commonly used, which shortens the hot pressing time.

Production Technology of LVL (continued)

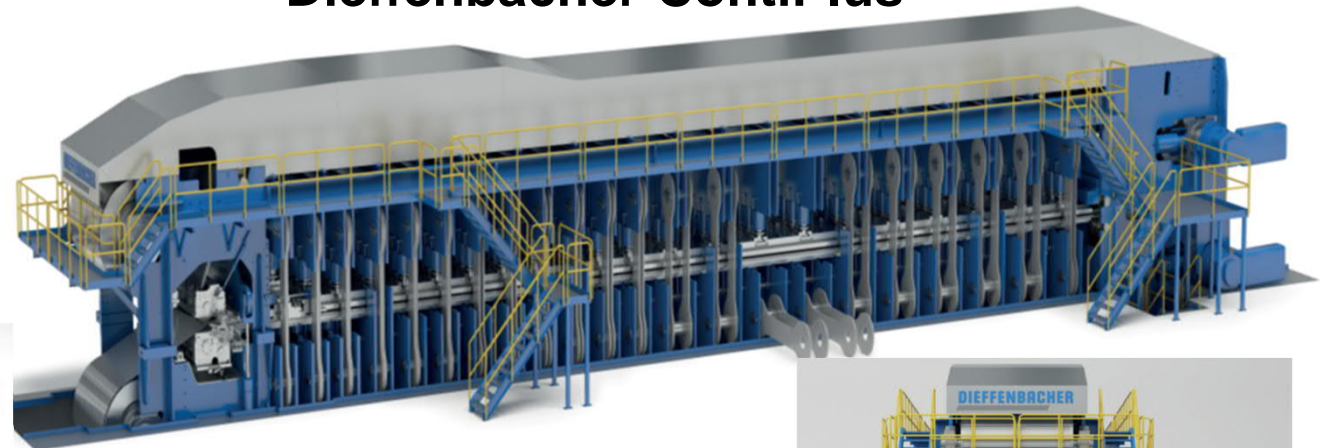
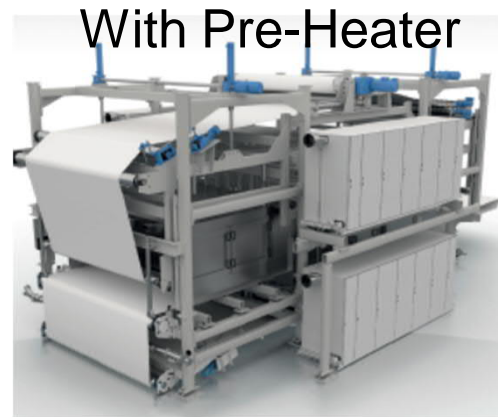
Cycle pressing Raute 4-opening hot press



Width of the billet 1.83 m netto and length 24 m.
Capacity about 135 000 m³/a (Raute).

Production Technology of LVL (continued)

Continuous pressing Dieffenbacher ContiPlus

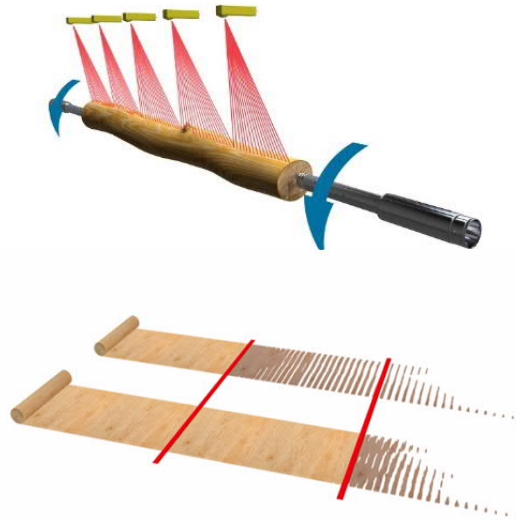


The running continuous presses for LVL are producing 1,22 or 1,83 m net width of the billet (Dieffenbacher, <https://dieffenbacher.com/en/>).

Production Technology of LVL (continued)

Technology of the rotary-veneer lathe has been developed in last 35 years. The most important improvings are

- Accurate HD laser XY centering of the bolt and
- Modern steering technique in peeling



Year	1980	2018
Yield (m ³ /m ³)	2.6	2.2
Speed (m/min)	120	300

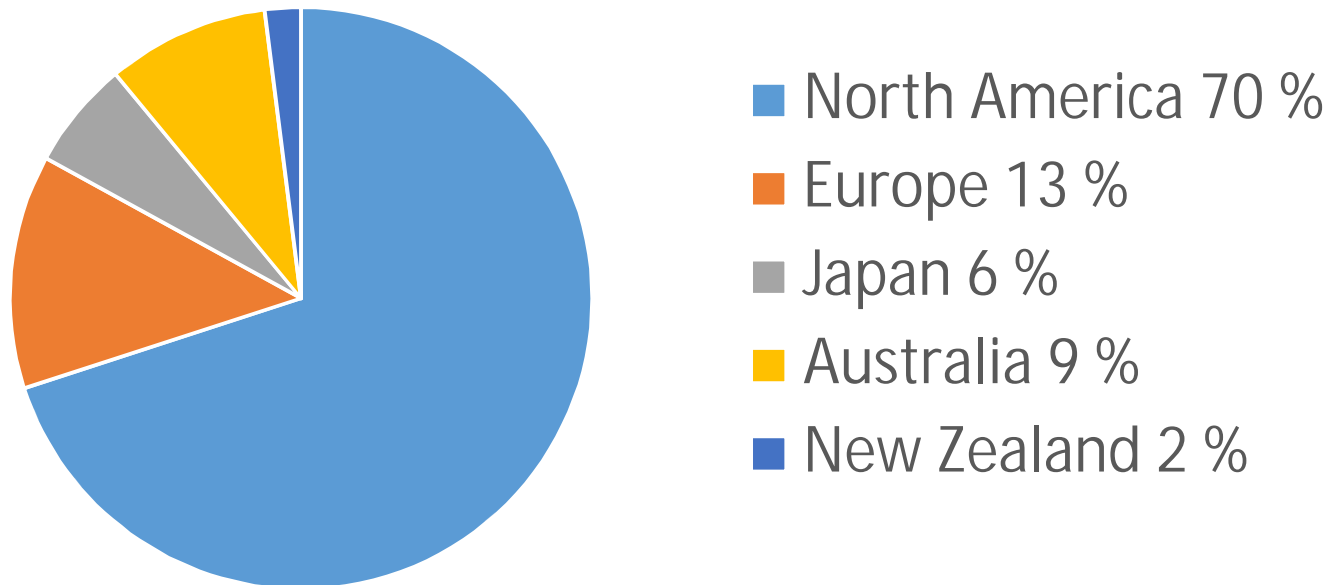
The Market of LVL

- LVL as an EW-Product has substantially increased its volume in higher-technology countries
- Because its structural use differs from the use of other veneer-based wood products, its business operations shall incorporate technical services intended for construction designers in each international market area.
- The breakthrough of LVL as a sovereign product occurred around the middle of the 1990s both in North America and in Europe. Its use on these two markets differ considerably still today.

The Market of LVL

2018 Global structural LVL consumption by market

Total: 3.18 million m³



(Source: Raute Corp.)

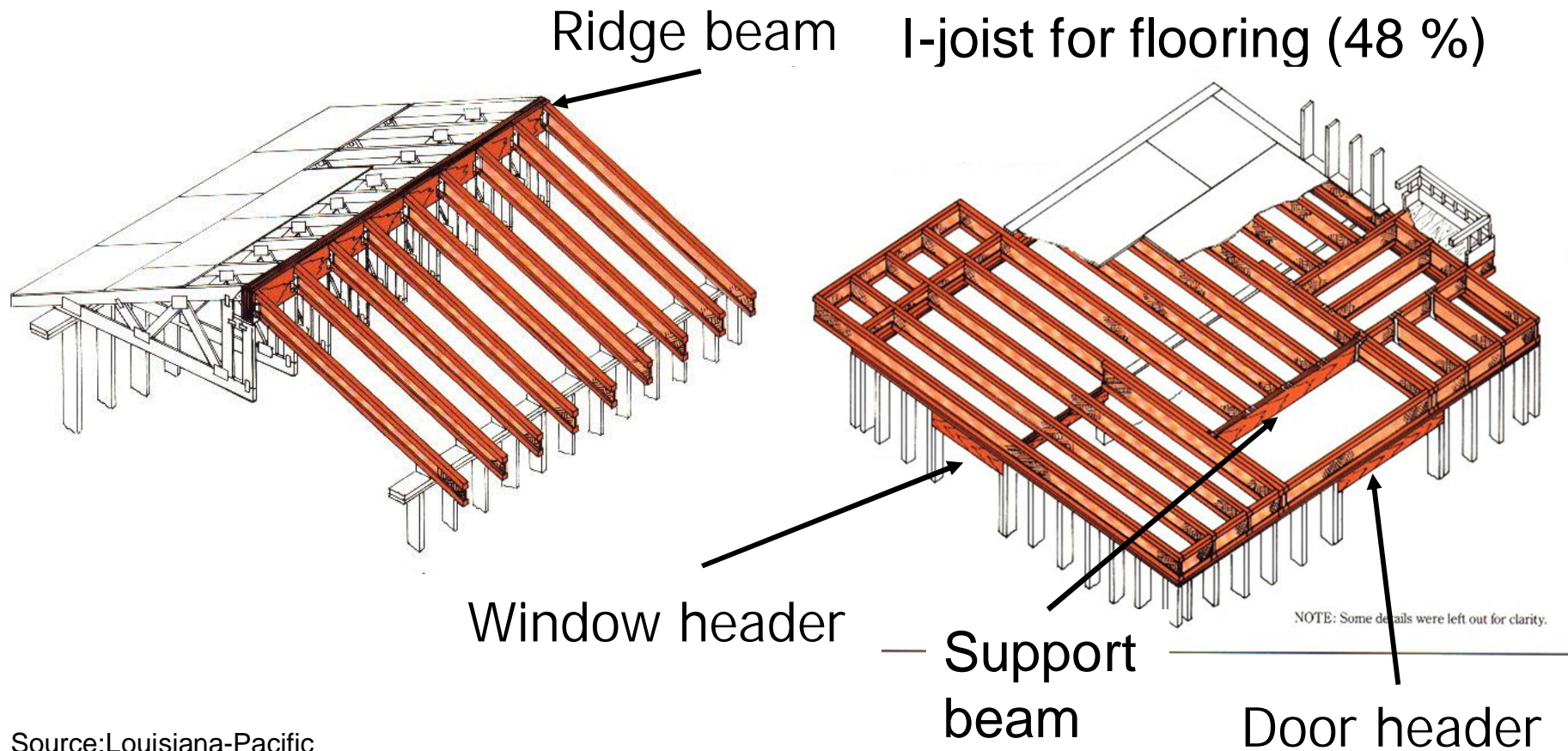
The Market of LVL

In North America

- There are more than 10 companies producing LVL
 - More than half of the companies purchase dried and graded veneers at market price from veneer mills. As these LVL mills invest only in
 - veneer handling
 - hot pressing
 - and further handling of LVL billets→the starting threshold for production is lower than in other markets
 - Roseburg Forest Product will invest in Chester, South Carolina, \$ 200 million for new production line to produce LVL about 790 m³/day, <http://www.choosechester.com/news/dieffenbacher-builds-worlds-largest-lvl-press-roseburg/>.
-

The Market of LVL

In North America (continued)



Source: Louisiana-Pacific

The Market of LVL

In North America (continued)

- The residential market utilizes almost all LVL produced for
 - I-joist flanges 27 %
 - beams and headers 68 %
 - in other end use applications, such as scaffold plank and concrete form beams 5 %
- Market share of I-joist in flooring is (in 2016)
 - 48% for Single-Family Housing sector excluding concrete slab
 - 32% in Multifamily housing sector
- Today LVL is in a commodity product in North America

(Source: Schmon, A., Forest Economic Advisors (FEA; www.getfea.com), LLC.)

The Market of LVL

In North America (continued)

Six storey timber frame construction
4133 Stolberg St, Richmond, BC V6X 1K3



The Market of LVL

In North America (continued)

Six storey timber frame construction
4133 Stolberg St, Richmond, BC V6X 1K3



The Market of LVL in Europe

- Number of producer in 2019 is 4 in EU and 2 in Russia
 - The end use applications in Europe are considerably more versatile than in North-America
 - Not only cut-to-size beams; also more and more entire pre-fabricated construction elements and modules are delivered to building sites
 - Construction work has been transferred as an off side production
 - These factories use advanced and state-of-the-art CNC and assembly lines
- In Europe LVL is a product for the **solution market**

The Market of LVL in Europe (continued)

Project case ice-hockey hall in Kuortane Finland



The Market of LVL in Europe (continued)

Project case ice-hockey hall in Kuortane Finland



Trusses; Span 36 m with c/c 6 m, Height 4,6 m

Roof elements; 24 m x 2,4 m (L x W)

The Market of LVL in Europe (continued)

Project case "Schule Nord" in Aichach, Germany



LVL Rib panels works as an integrated solution system → gives to the architect more freedom to get more light coming in

The Market of LVL in Europe (continued)

Project case "Schule Nord" in Aichach, Germany

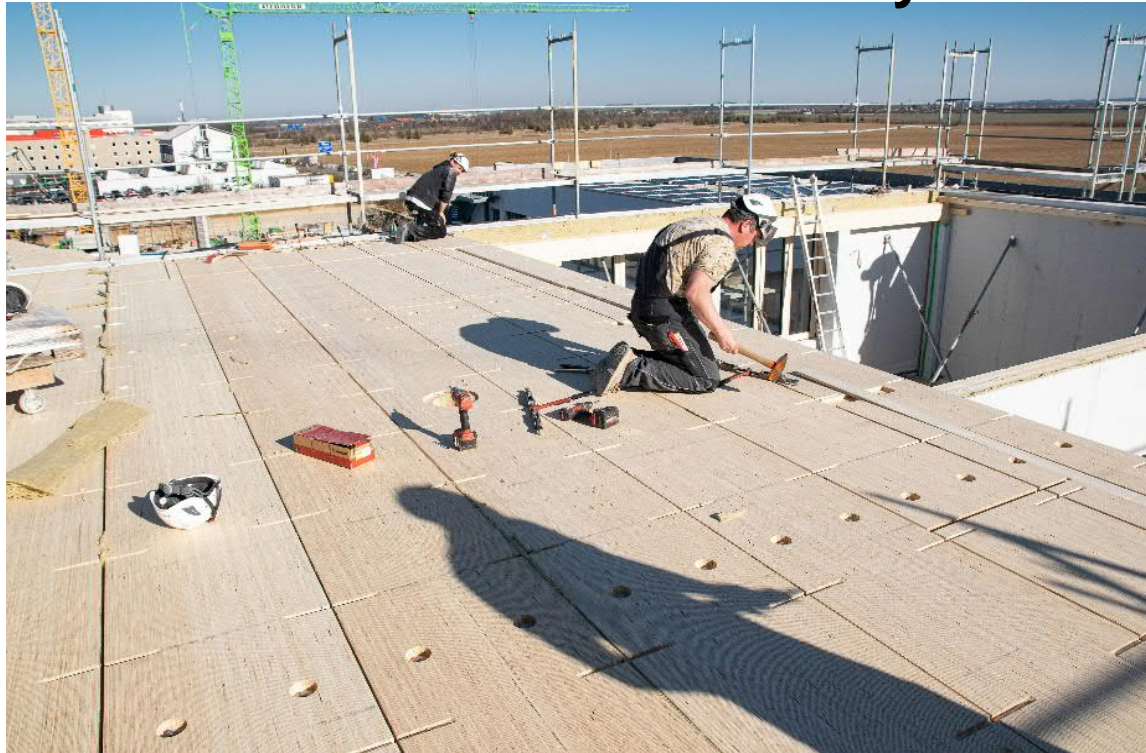


Rigid reinforced
concrete columns

- Rigid columns on the left side and rib panels together both sides of the roof are taking the stability of the whole roof
- The rib panels are fixed together as an one slab both sides of the roof

The Market of LVL in Europe (continued)

Project case STEICO Headquarters Expansion, in Feldkirchen Germany

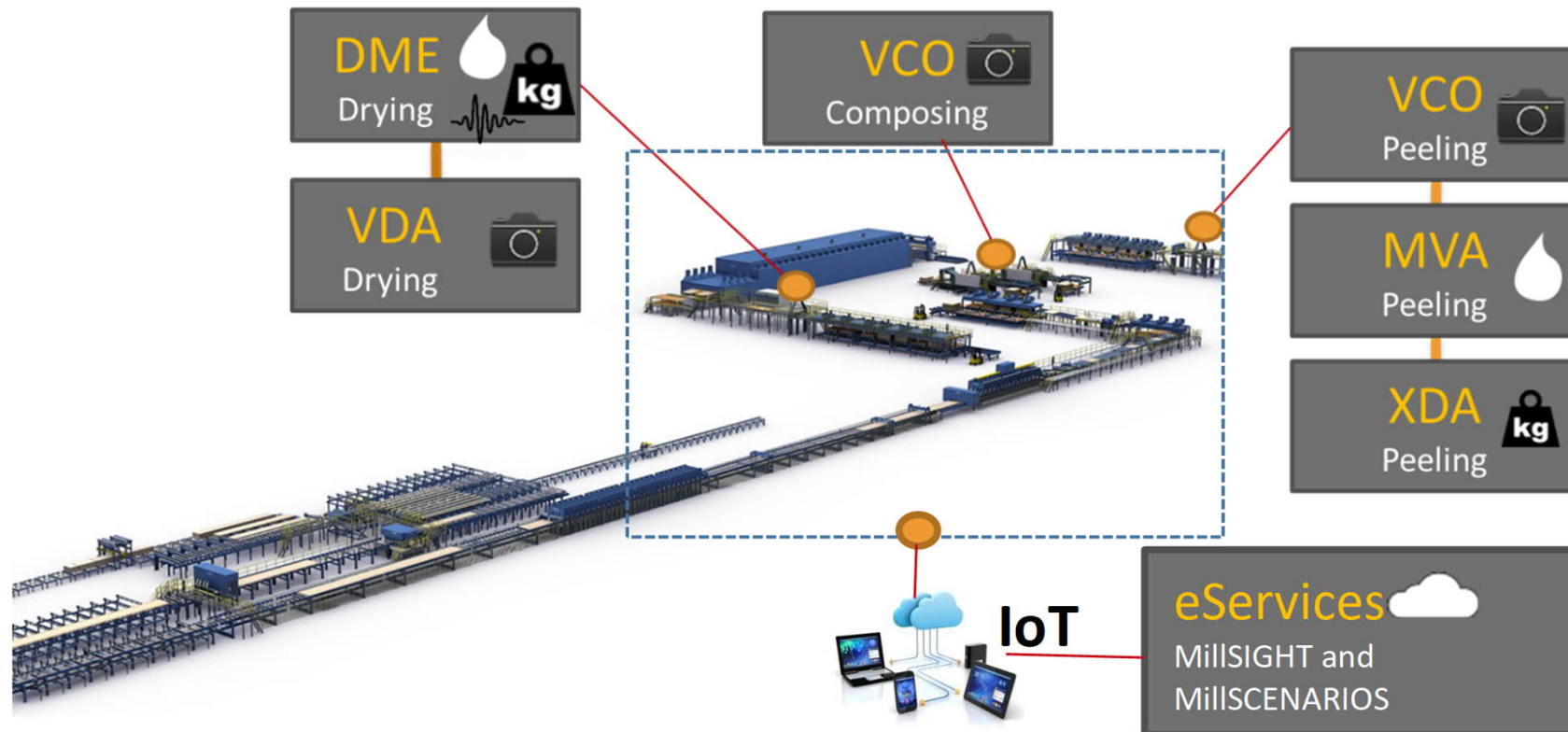


Re-glued GLVL-R beam and header system with massive re-glued floor

- Structural engineering Ingenieurbau Häussler
- Contractor company Müllerblau Stein Holzbauwerke
- Architect Rapp Architekten

Photographer: Andreas Schulze

Production Technology – case G5



Fifth generation (G5) analyzers on the LVL production line (Raute).

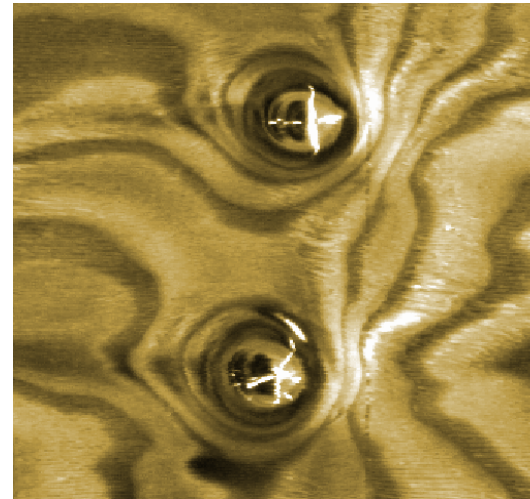
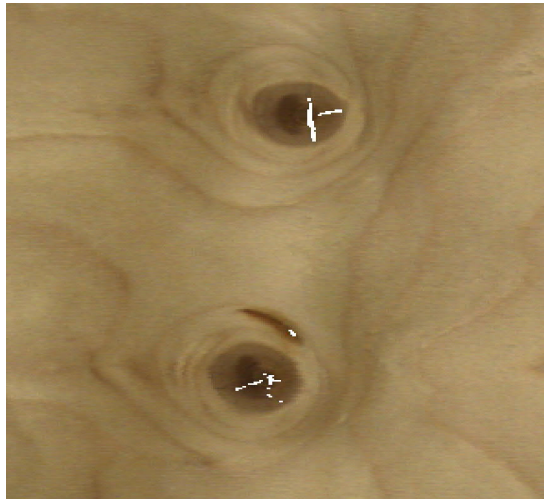
Production Technology – case G5 continued

After drying veneers are tested

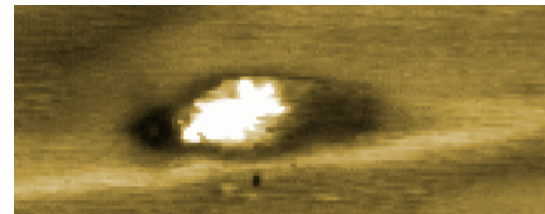


VDA Visual Defect Analyzer in the left and Veneer Tester Model 2865 **DME** in the right are integrated with G5 together. Both analyzers are up-graded high-speed equipments (Mecano and Metriguard).

Production Technology – case G5 continued

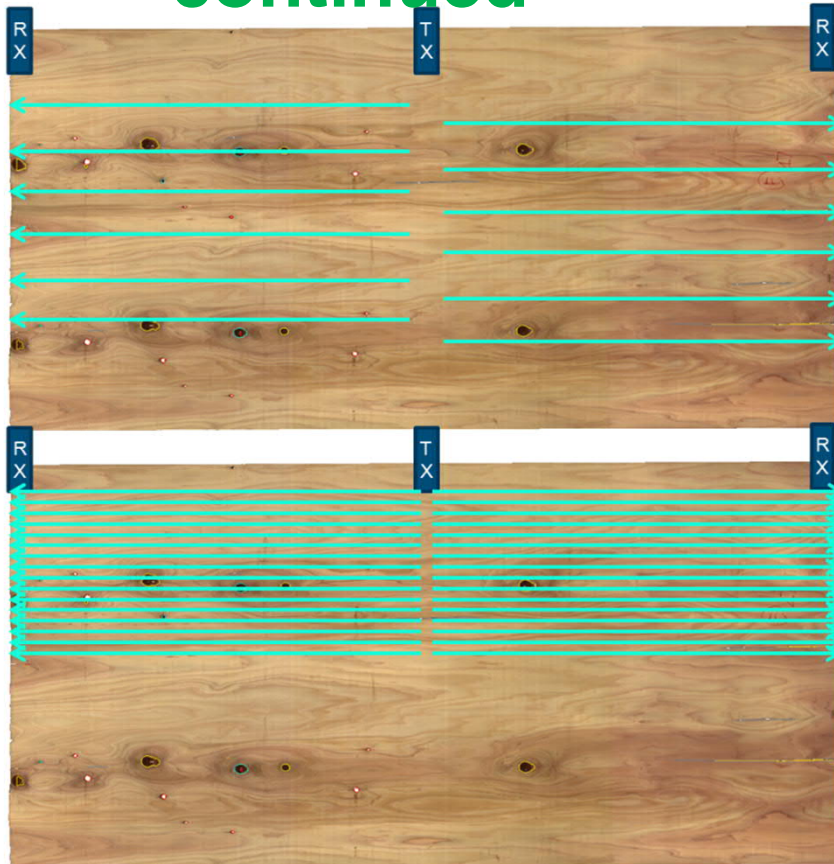


VDA is showing cross grain area or dense knot row for DME before density and sound velocity measuring



For example such thin parts of veneer that are invisible to conventional cameras (left), can be found using F-imaging (right) and use information on strength calculation properly.

Production Technology – case G5 continued

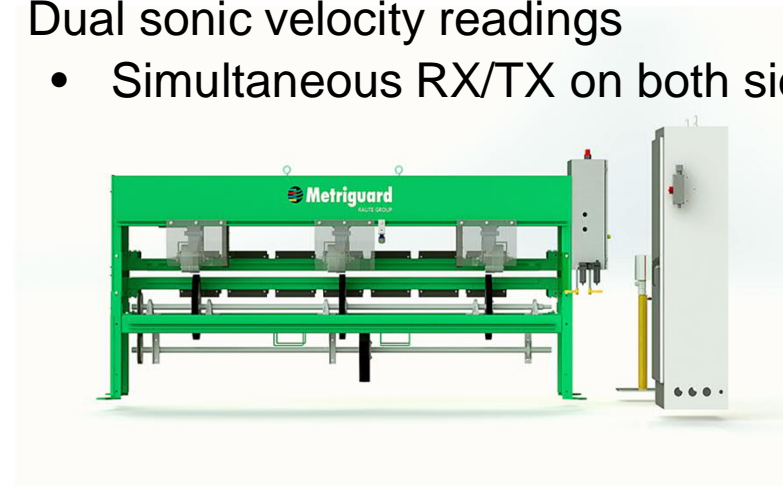


Current Veneer 2805 Grader:

- Sonic Velocity reads 121 per sheet 180 m/min
 - every fifth reading is not analyzed
- Alternate reading
 - One side at the time reading

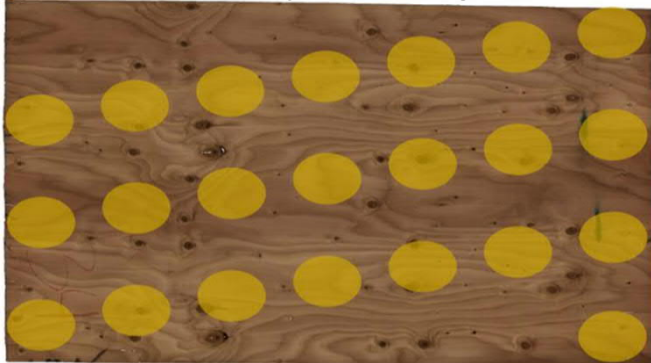
New Veneer 2865 Grader:

- Sonic velocity reads 619 per sheet
- Dual sonic velocity readings
 - Simultaneous RX/TX on both sides



Production Technology – case G5 continued

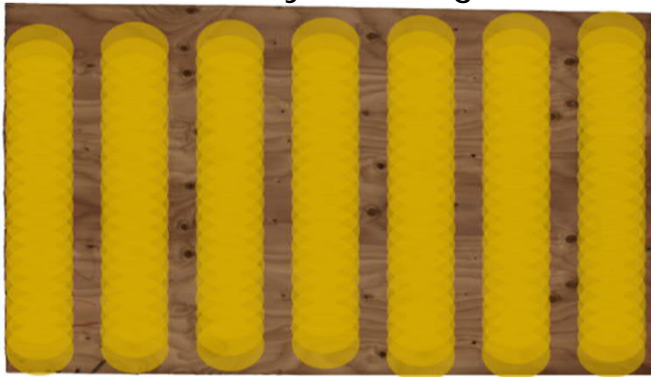
2805 RF Cavity Coverage



The current 2805 RF cavity read speed
20 ms

- At 180 m/min, that's 22 reads
- Only 3 to 4 rows per veneer
- Moisture reading limited to 12%

2865 RF Cavity Coverage



The new 2865 cavity read speed 2.5 ms

- At 180 m/min, that's 176 reads
- 8 times more measurements
- No gaps in coverage
- Moisture measurements up to 40%

Moisture and density resolution comparison with DME. The veneer runs in cross-grain direction (Metriguard).

Conclusion

Every single veneer sheet can be valuated separately and by using G5, even modeled features of each veneer sheet

it will be possible to glue LVL-products into different strength classes with very low Coefficient of Variation
→ less raw material per $m^3/area-m^2$

peeled and graded veneer is a semi-finished product offering a wide potential for professionals in using LVL in several new ways

Thank you for your attention!

For further question, please contact:

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References:

- Alenius, N. 1964. US Patent 3,133,850;
<https://patents.google.com/patent/US3133850>
- Fiset, P. 2000. The Evolution of Engineered Wood I-Joists, p. 1;
<https://bct.eco.umass.edu/publications/articles/the-evolution-of-engineered-wood-i-joists/>
- Kairi, M. 2005. <http://lib.tkk.fi/Diss/2005/isbn9512277069/>
- Koch, P. 1967. Super-strength beams laminated from rotary-cut southern pine veneer. Forest Prod. J. 17(6): 42-48.
- Luxford, R.F. 1944. Strength of glued laminated Sitka spruce made up of rotary-cut veneers. U.S. Dept.
- Nelson, S.A. 1972. Structural application of Micro-Lam lumber. Meeting Preprint 1714. ASCE National Structural Engineering Meeting April 24-28, 1972, Cleveland, Ohio.
- Troutner A.L. 1973. US Patent 3,723,230;
<https://patents.google.com/patent/US3723230>