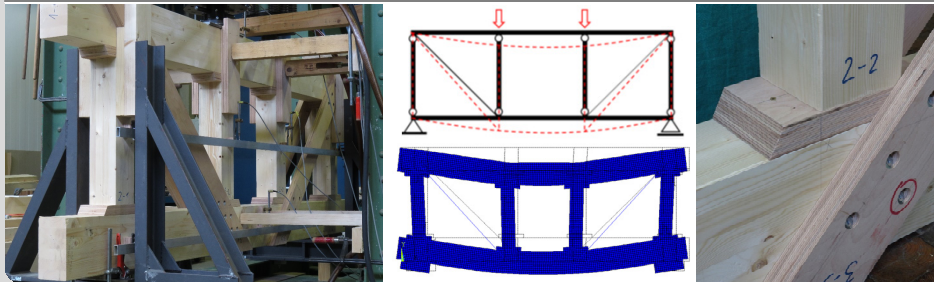


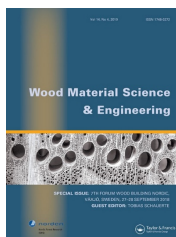
## A new truss concept for a targeted use of spruce glulam and beech LVL

Yvonne Steige & Matthias Frese

Timber Structures and Building Construction



## Reference



Study on a newly developed diagonal connection for hybrid timber trusses made of spruce glulam and beech laminated veneer lumber

Yvonne Steige & Matthias Frese

## Introduction and background

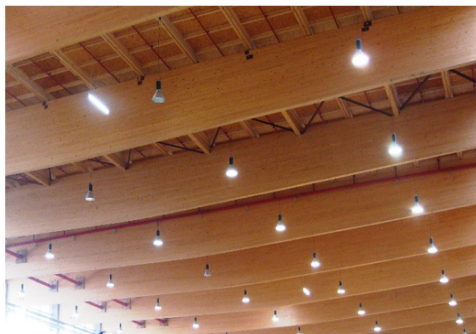


- Motivation for this study
  - Combination of soft- and hardwood in truss structures
- Truss structures are efficient
  - Material is arranged along the lines of action
  - One can benefit from the material strength to a high degree
  - Truss structures are relatively light

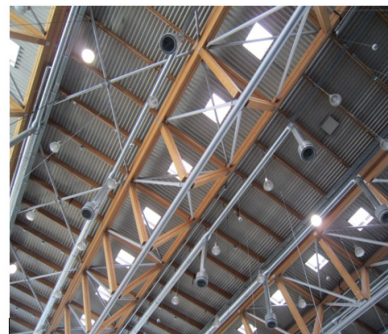
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Yvonne Steige & Matthias Frese

## Long-span glulam beams vs glulam steel truss



Production hall, Schwörer Haus, Oberstetten



Exhibition hall 7a, Messe Nürnberg

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## Introduction and background

- Forest policy promotes the use of hardwood
  - This applies particularly for beech wood
- Beech laminated veneer lumber (LVL) is available for the building industry
  - Low & medium quality of the raw material
  - High tensile strength
  - Can replace steel to a certain extent

## Contents

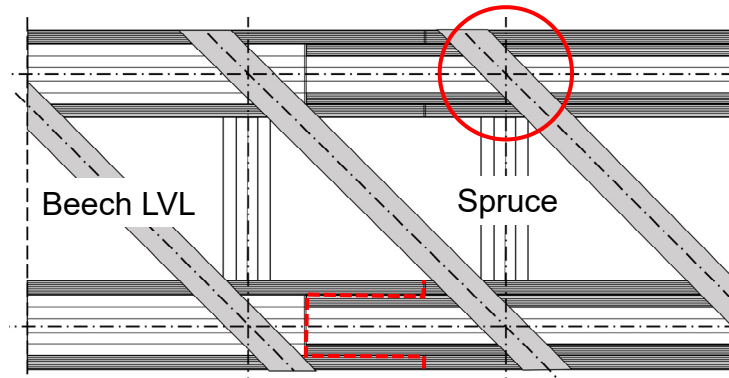
- Concept and materials
- General aspects of trusses
  - Weak points
- Truss prototype
  - Testing and results
  - Connection stiffness of diagonals
- Finite-element model
  - Key features and numerical results
- Comparison between experimental and numerical results
- Influence of the connection stiffness
- Conclusions

## Structural concept and material composition



Beech LVL/spruce

Diagonal connection

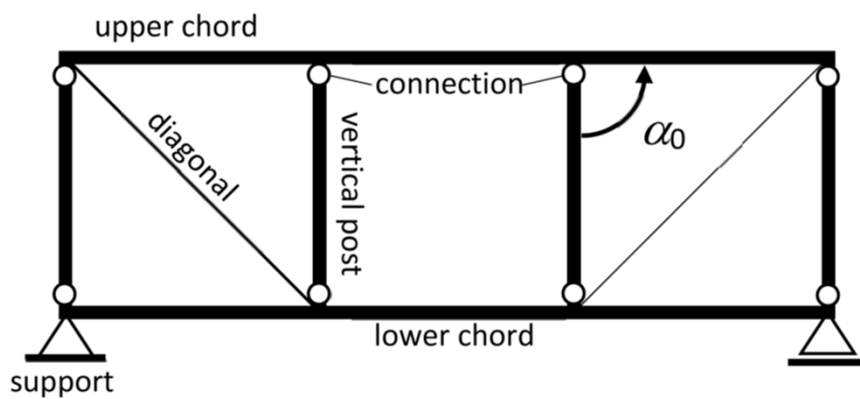


Plug-in connection

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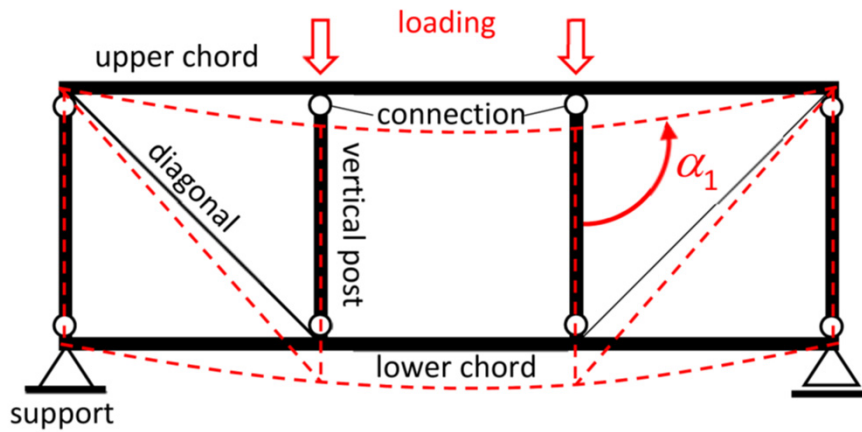
## General aspects of trusses



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## General aspects of trusses

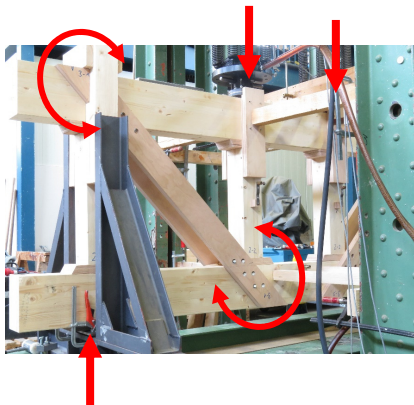


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## Weak points to be improved

- Connections are not perfect hinges
  - Secondary stresses
- Load transfer between post and chord
  - Compression perpendicular to the grain



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## Characteristics and ideas of the truss prototype

- Glulam chords and posts connected with fully threaded screws
- Diagonals screwed on the chords with inclined screws using special washers
- Reinforcements between posts and chords with beech LVL base plates

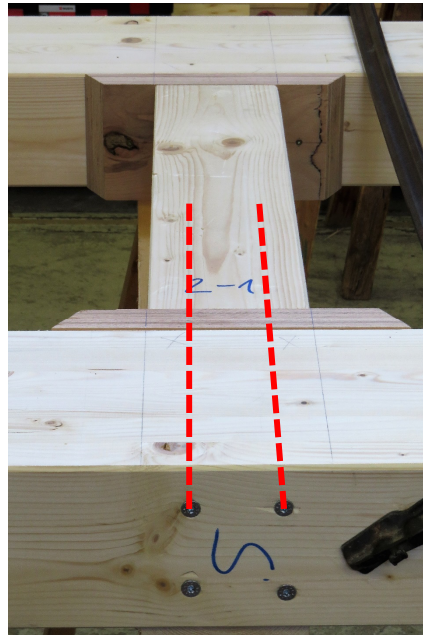


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## Base plate reinforcement

- Fully threaded screws penetrate the chord, the base plate and finally fix the posts
- Base plates enlarge the contact surface between the posts and the corresponding faces of the chords
- The high withdrawal capacity of screws in beech LVL is activated

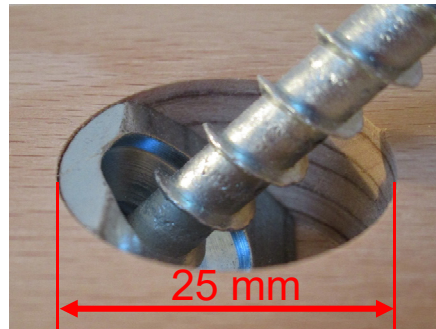


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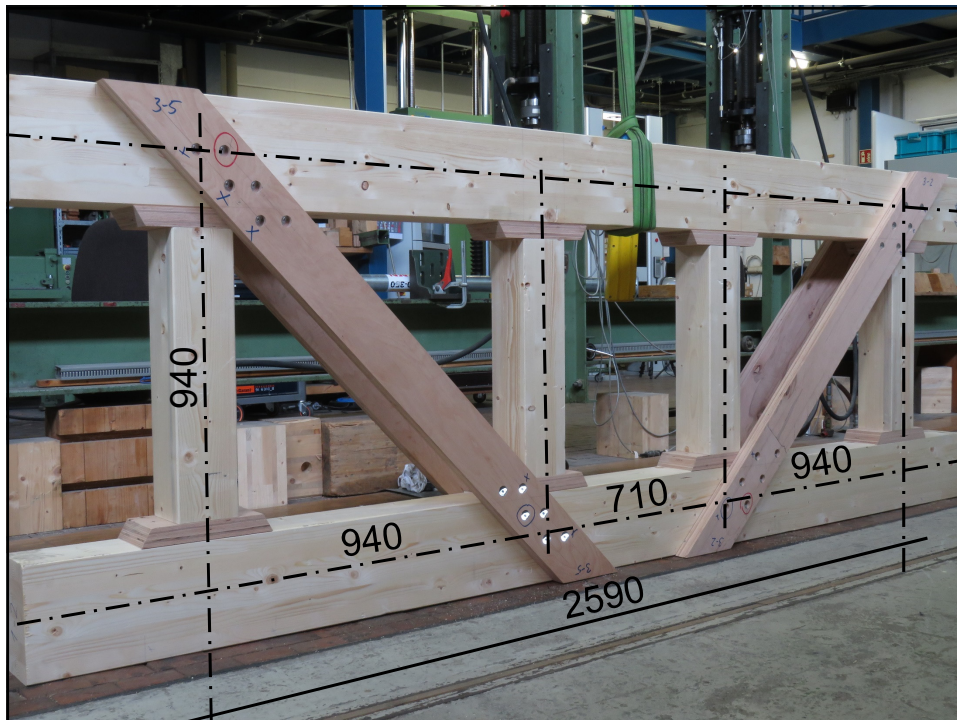
### Diagonal connection

- Special washers in blind holes
- Head pull-through is prevented
- Screws are inserted under 45°
- Favourable load transfer into the chord with inclined screws

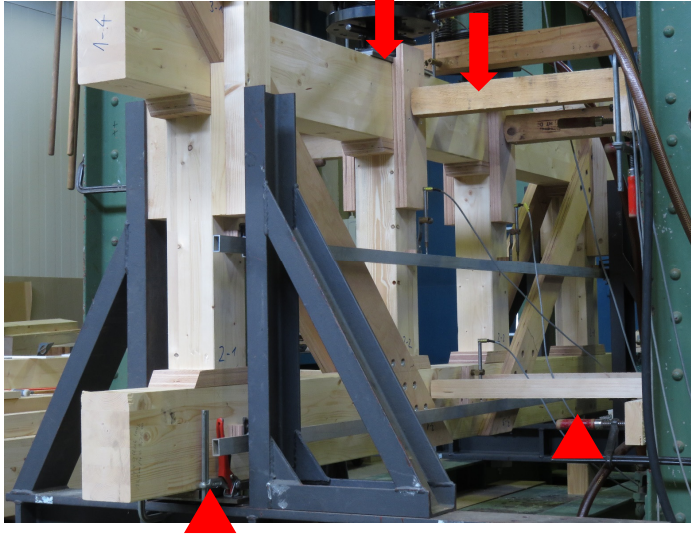


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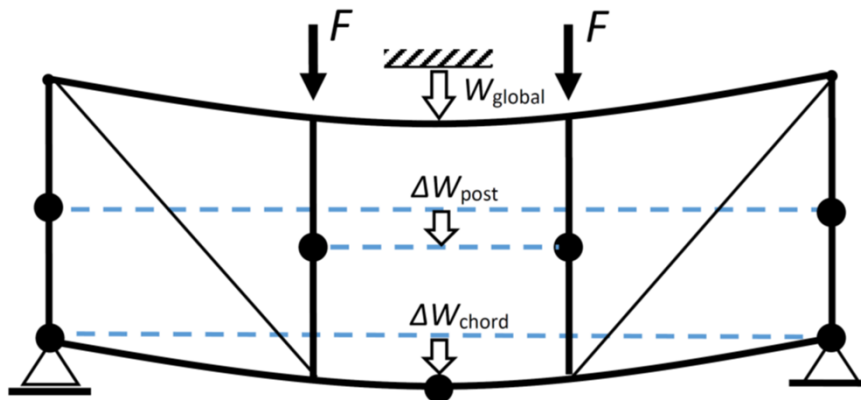
## Testing the prototype - test setup



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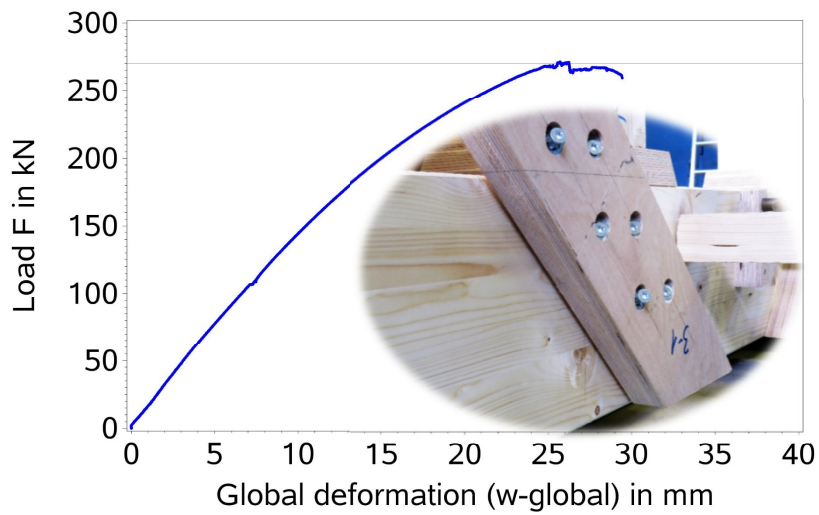
## Deformation and capacity measurements



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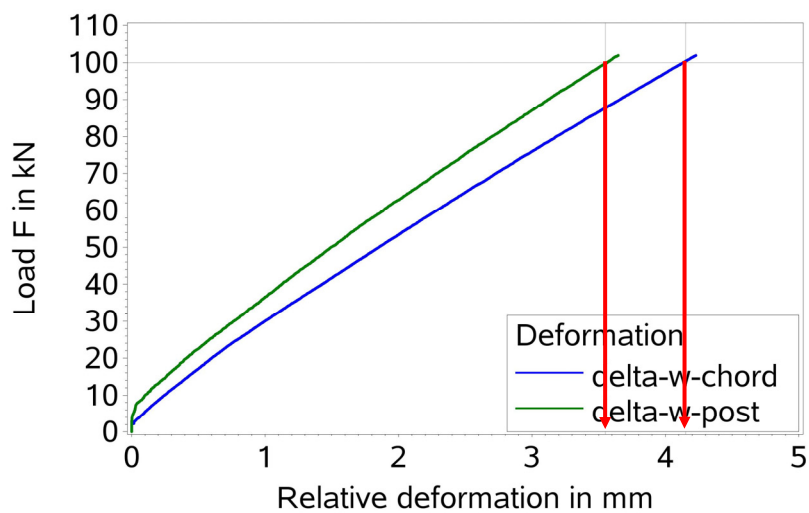
## Test results - global deformation and capacity



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## Test results – relative deformations

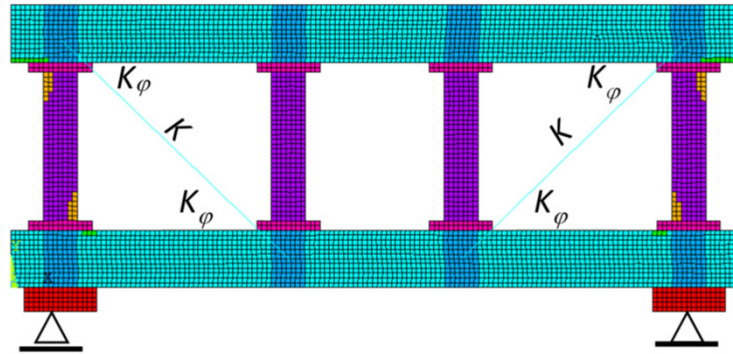


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## 2-D finite-element model

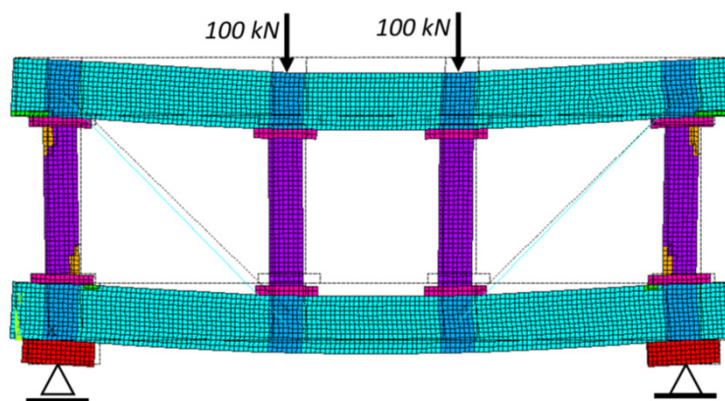


- Colours represent realistic stiffness properties
- $K$ : Function of  $K_s$  and axial rigidity of diagonals
- $K_\phi$ : set to zero because unknown

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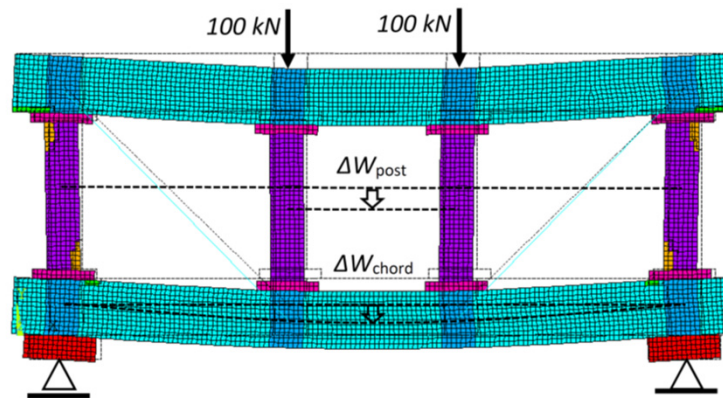
## Model under service load



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## Numerical results - relative deformations



- $\Delta W_{\text{post}} = 4.80 \text{ mm}$
- $\Delta W_{\text{chord}} = 5.20 \text{ mm}$

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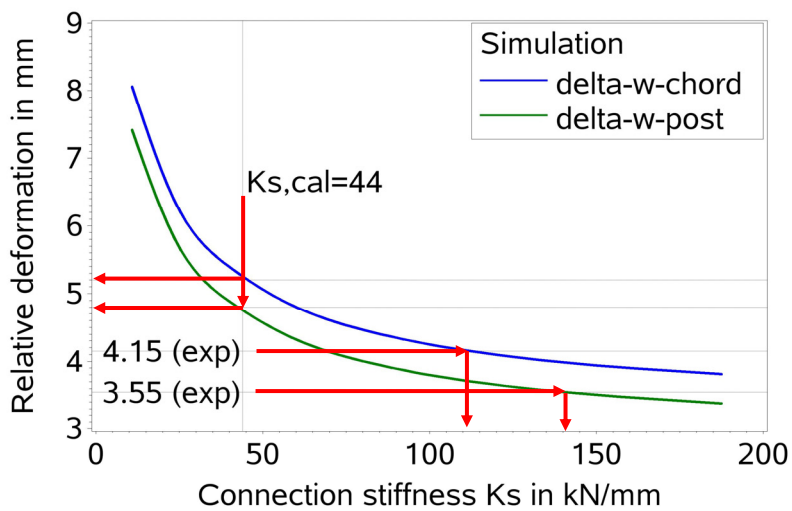
## Comparison by means of deformations

Criteria	Experimental	Numerical $K_{s,cal} = 44 \text{ kN/mm}$	Num./Exp.
$\Delta W_{\text{post}}$	3.55 mm	4.80 mm	135 %
$\Delta W_{\text{chord}}$	4.15 mm	5.20 mm	125 %

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## Sensitivity analysis



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## Conclusions

- The idea seems to promise success
  - Connection principle between diagonals and chords technically convinces and is stable
- The agreement between experimental and numerical results is only satisfying
  - There is still enough room to improve the model
- Lack of knowledge concerns the connection stiffness
  - Translational and rotational stiffness
  - Non-linear behaviour
- Ongoing research project

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## Thank you for your kind attention

### Acknowledgements

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