

COST ACTION E55 - Modeling the performance of timber structures
Short Term Scientific Mission - DTU, Lyngby, Denmark

STSM: Analyses of the bearing behaviour of dowel-type fasteners by means of non-contact full-field optical deformation measurements

Ir. Dennis Schoenmakers

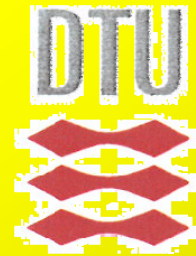
Ph.D. researcher

TU/e

technische universiteit eindhoven

Dr. Staffan Svensson

Associate professor

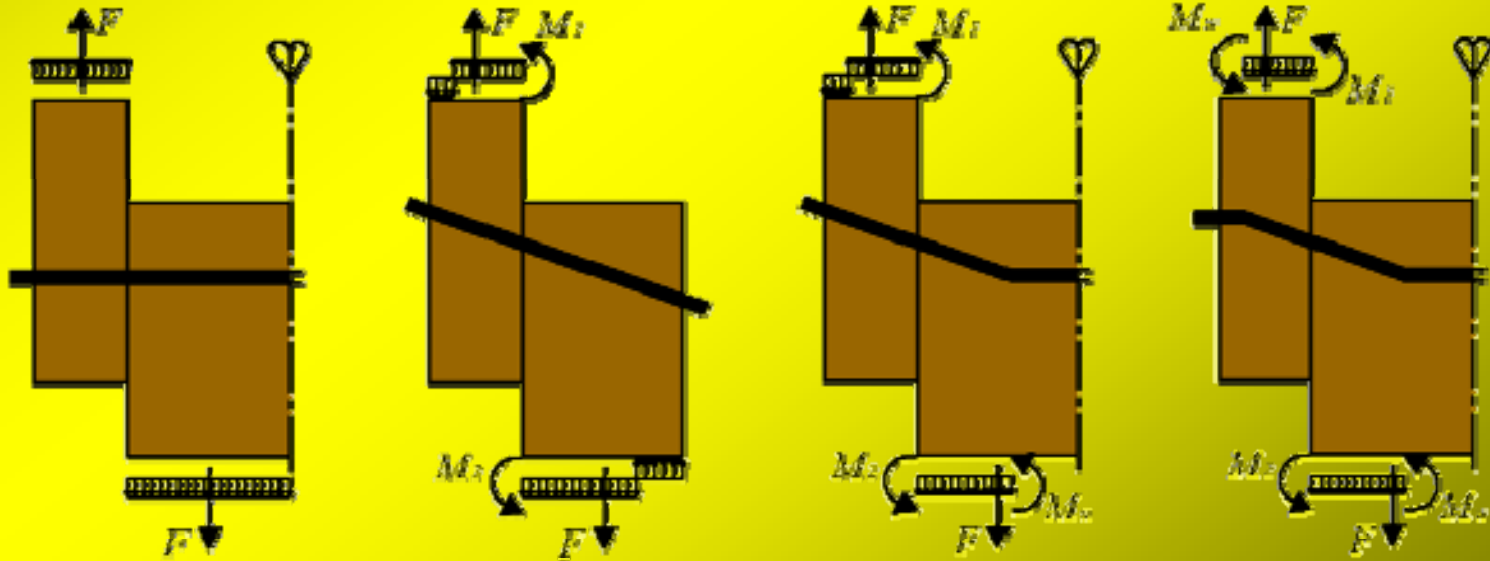


Denmark Technical University



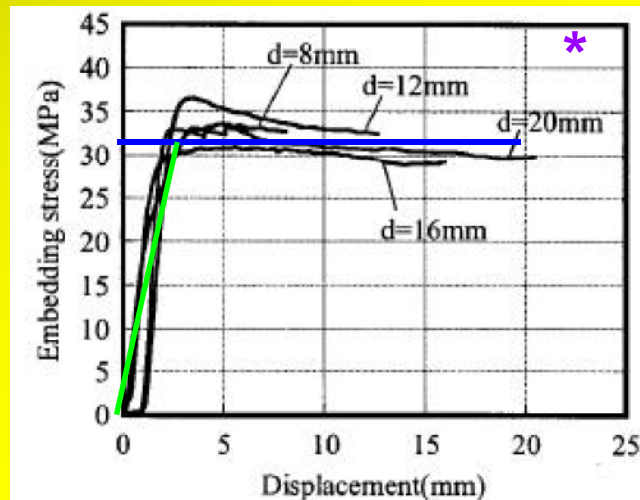
STSM: Analyses of the bearing behaviour of dowel-type fasteners by means of non-contact full-field optical deformation measurements

- Connection strength acc. Eurocode 5: 2004: EYM mechanisms

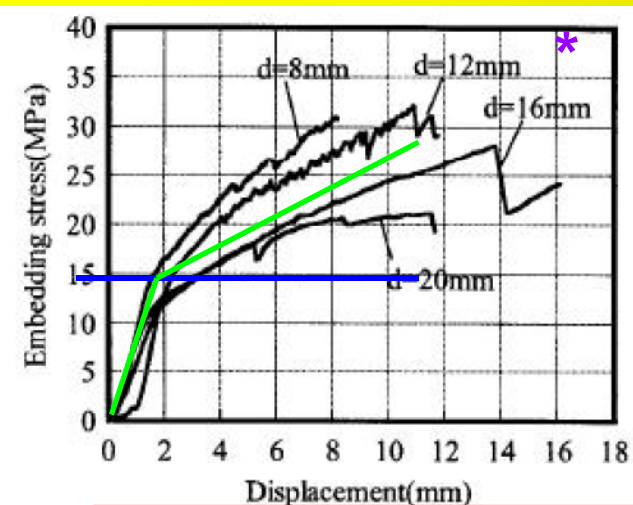


STSM: Analyses of the bearing behaviour of dowel-type fasteners by means of non-contact full-field optical deformation measurements

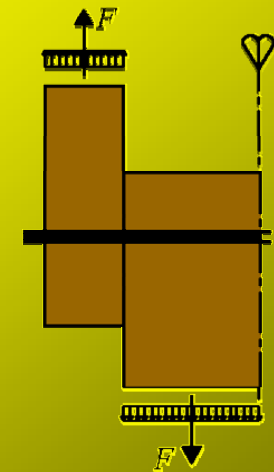
- Embedding strength definitions acc. Eurocode 5: 2004



Parallel to grain



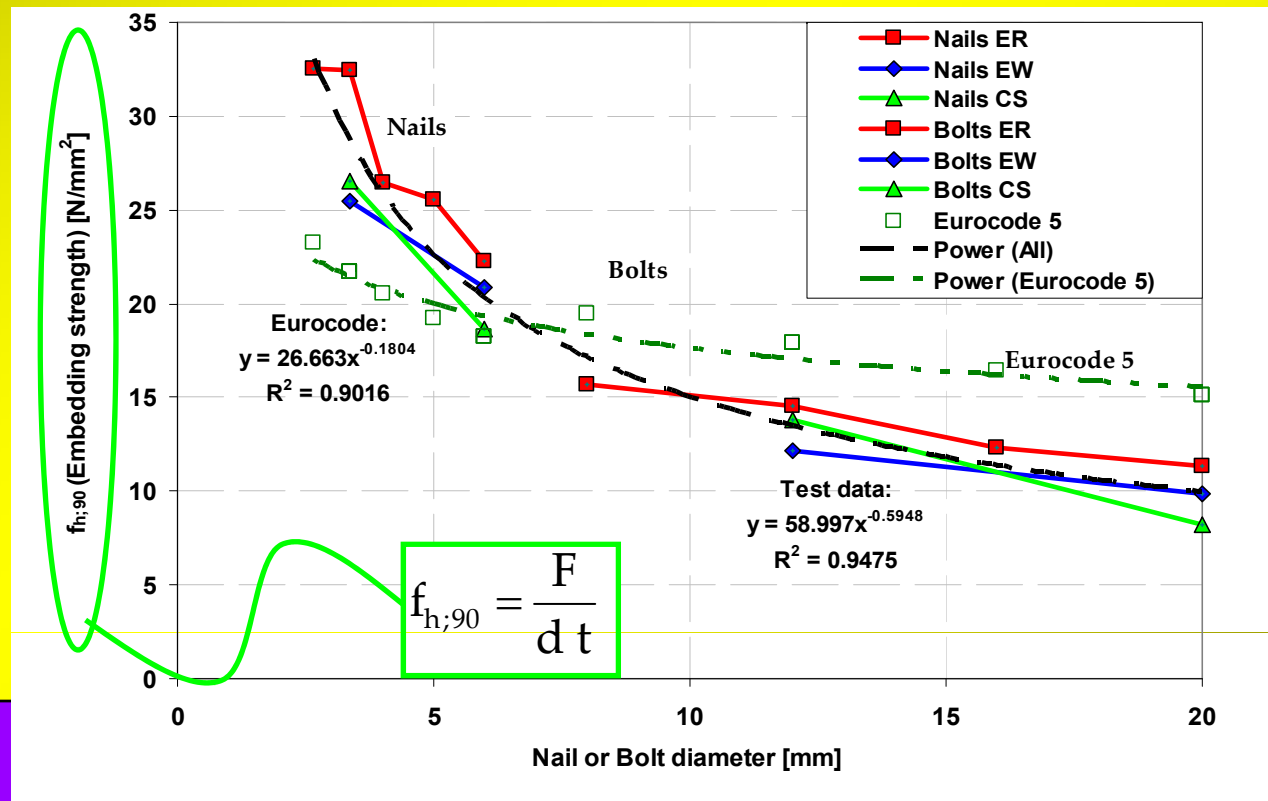
Perpendicular to grain



*: Sawata and Yasumura (2002)

STSM: Analyses of the bearing behaviour of dowel-type fasteners by means of non-contact full-field optical deformation measurements

➤ Embedding strength acc. Eurocode 5 vs experiments



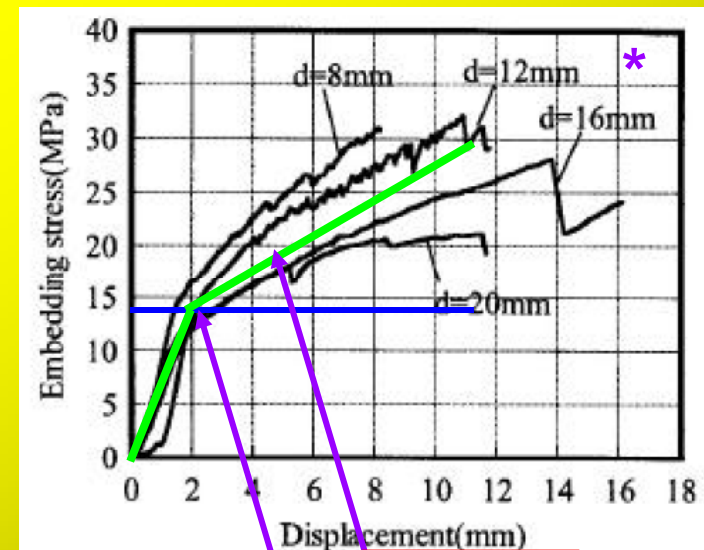
STSM: Analyses of the bearing behaviour of dowel-type fasteners by means of non-contact full-field optical deformation measurements

Contents

- Scope STSM
- Experimental results
- Discussion / remarks

Scope STSM

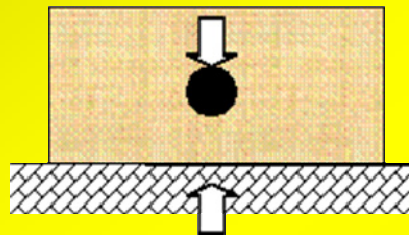
- Bearing behaviour perpendicular to grain of dowel-type fasteners
- Strength depends on deformation level underneath the fastener
- Several definitions of strength in literature



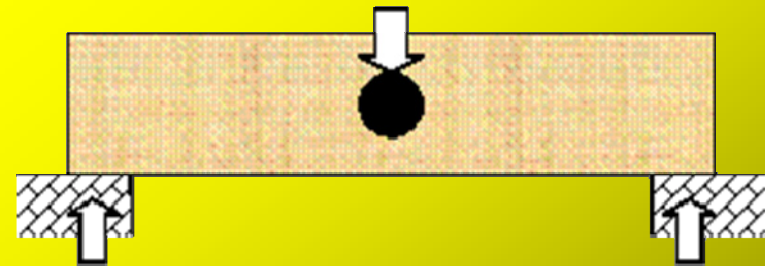
*: Sawata and Yasumura (2002)

Scope STSM

- Bearing behaviour perpendicular to grain of dowel-type fasteners
- Strength depends on deformation level underneath the fastener
 - Several definitions of strength in literature
- Test configuration (full-constrained / unconstrained)



Current EN383
Deformation 5 mm

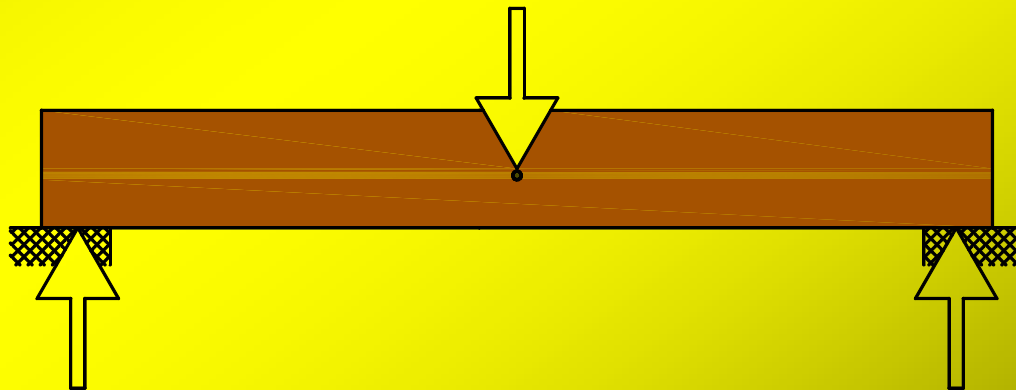


Whale and Smith (1983)
Deformation 2.1 mm

Design rules Eurocode 5

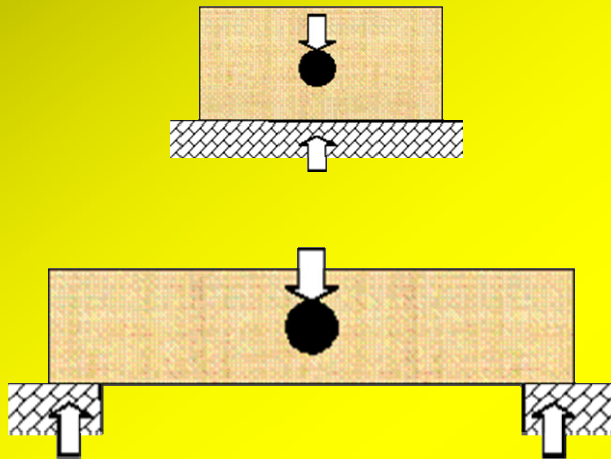
Scope STSM

- Bearing behaviour perpendicular to grain of dowel-type fasteners
- Strength depends on deformation level underneath the fastener
 - Several definitions of strength in literature
- Test configuration
- “Splitting tests” on full scale beams from literature (single fastener connections) → also bearing failure

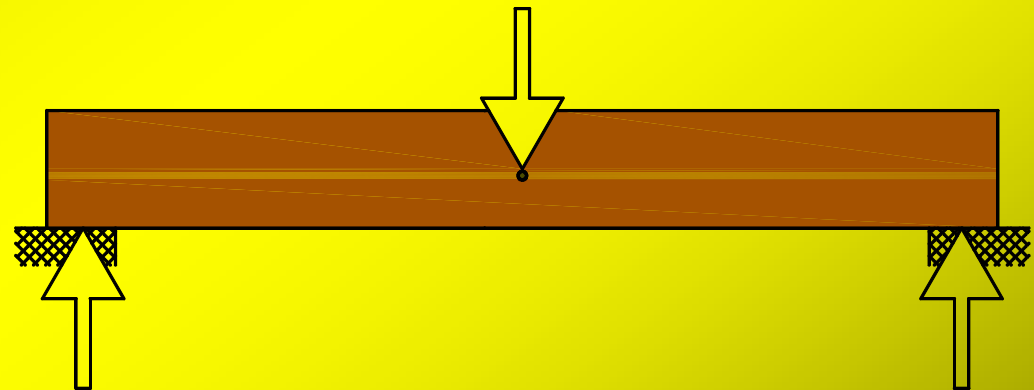


Scope STSM

- Bearing behaviour perpendicular to grain of dowel-type fasteners
- Comparison 3 test configurations



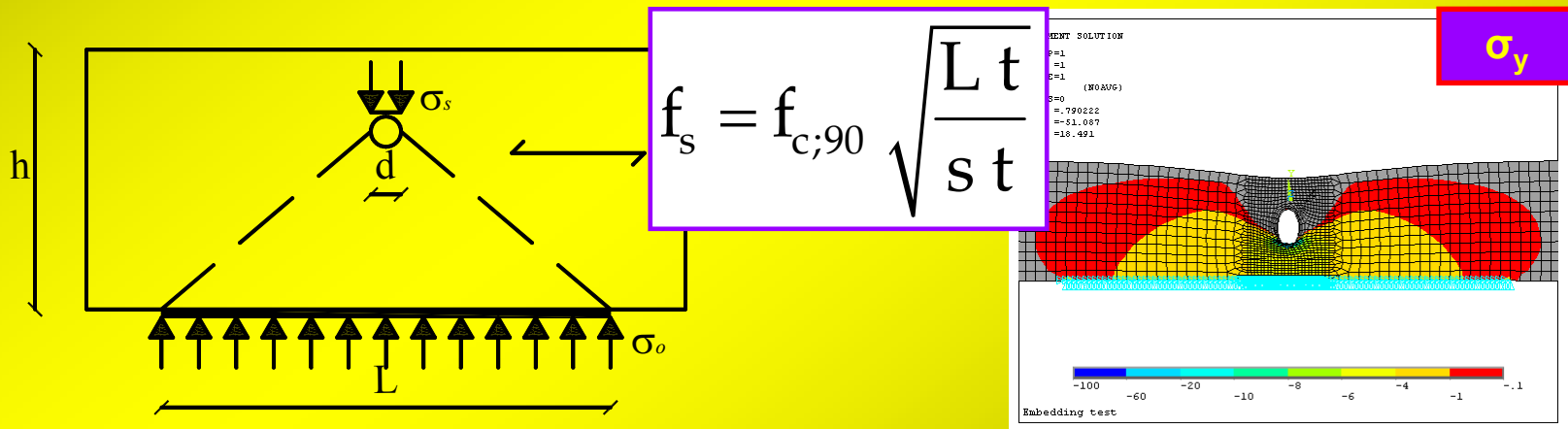
Embedment tests



“Embedment tests” on full-scale beam

Scope STSM

- Bearing behaviour perpendicular to grain of dowel-type fasteners
- Recall presentation Eindhoven meeting:
 - Forces will distribute through the specimen under an angle



- Real-time full-field deformation measurements (ARAMIS)
- Differences in behaviour can be detected

Experimental results

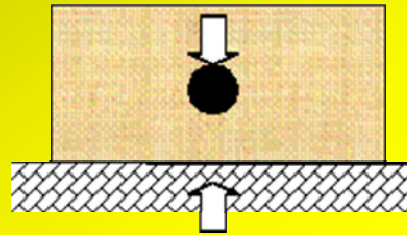
- ARAMIS optical deformation measurements
- Digital speckle photogrammetry combined with 3D correlation techniques



Experimental results

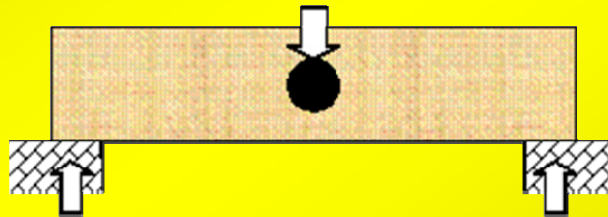
➤ Experimental program

Series A



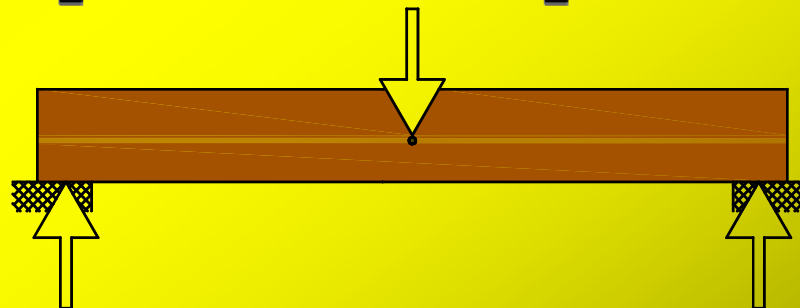
3 diameters, $d=\{6,12,24\}$ mm
3 specimen geometries

Series B



1 diameter, $d=12$ mm
1 specimen geometry

Series C

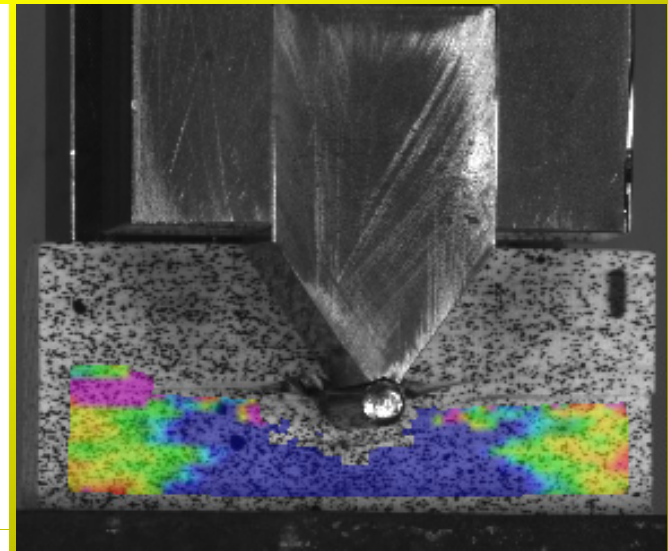
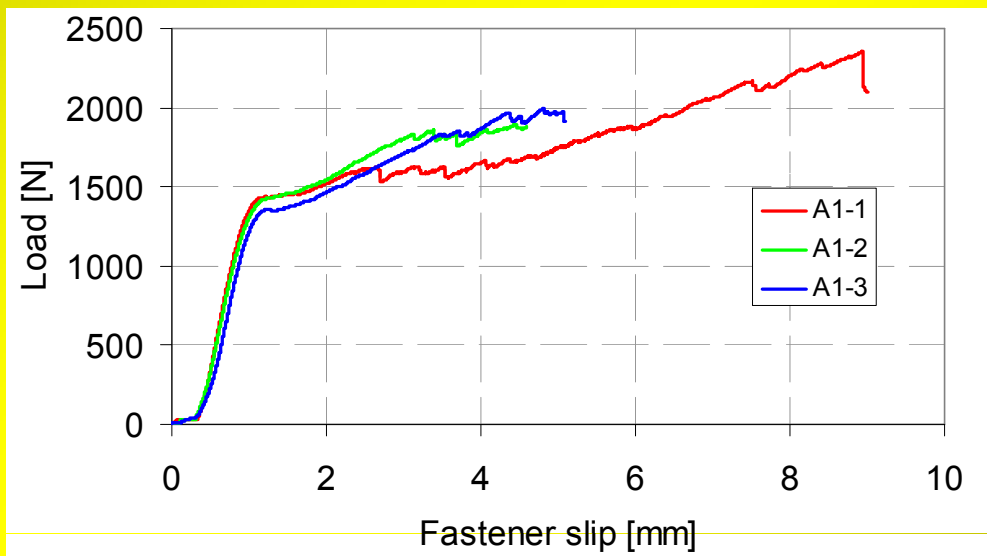
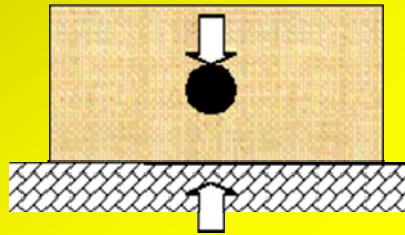


1 diameter, $d=12$ mm
1 specimen geometry
3 loaded edge distances

Experimental results

- Full-constrained embedding test, $d = 6$ mm

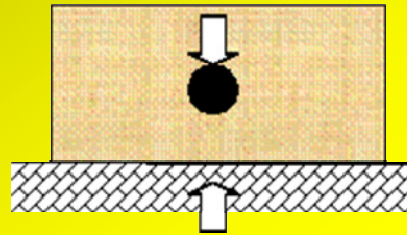
Series A



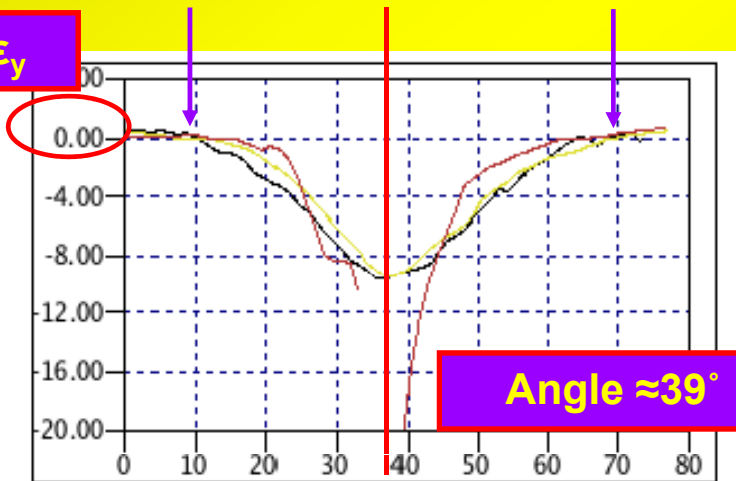
Experimental results

- Full-constrained embedding test, $d = 6$ mm

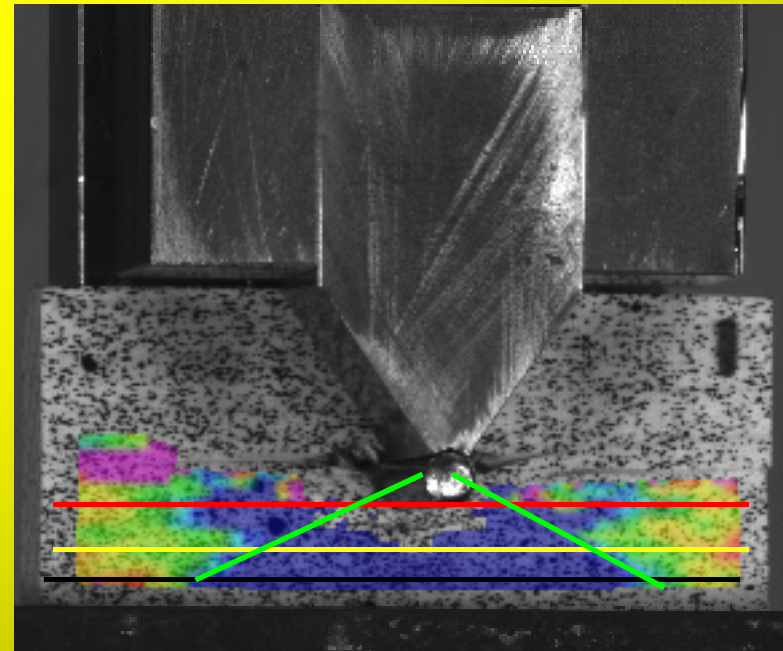
Series A



ϵ_y

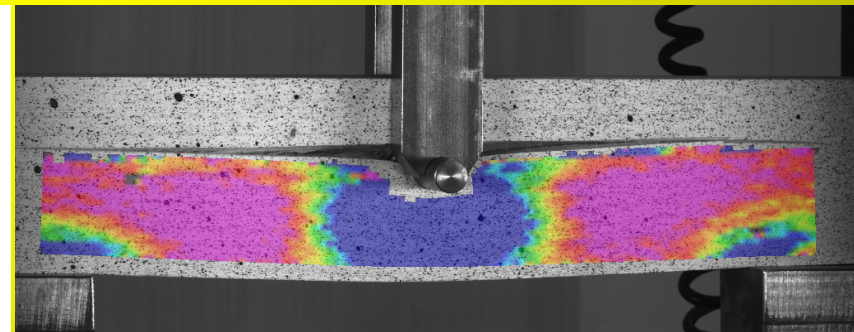
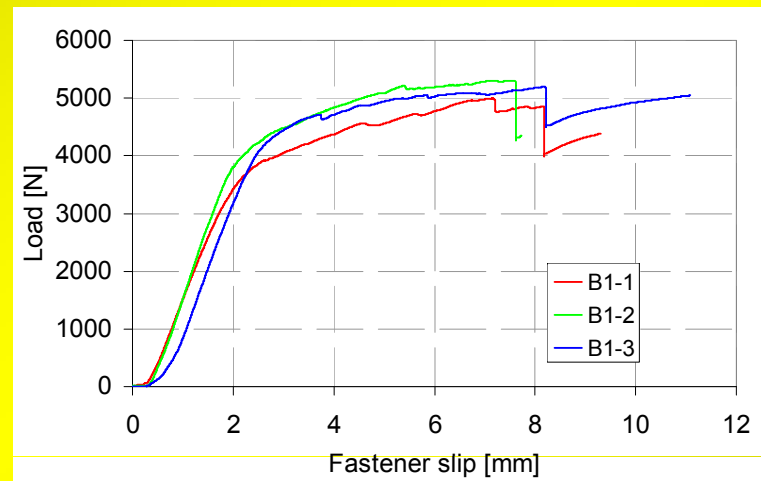
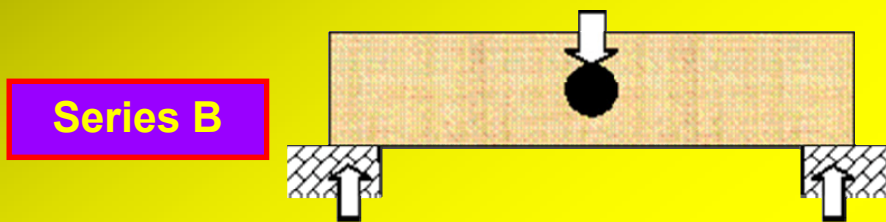


Angle $\approx 39^\circ$



Experimental results

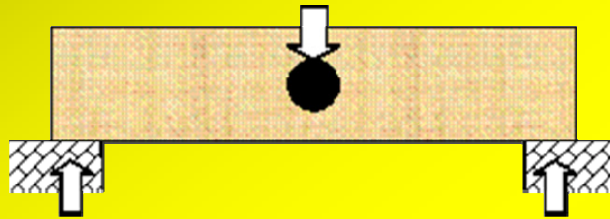
- Unconstrained embedding test, $d = 12$ mm



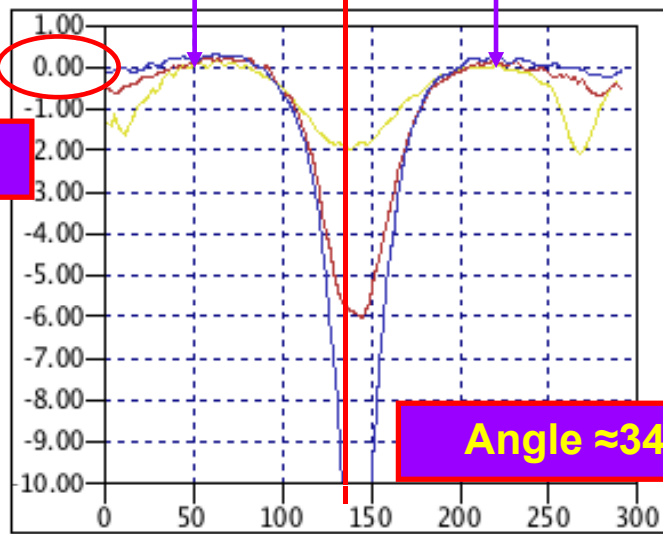
Experimental results

- Unconstrained embedding test, $d = 12$ mm

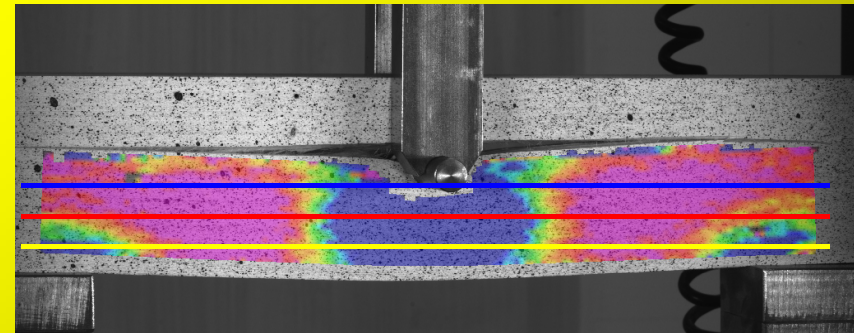
Series B



ϵ_y



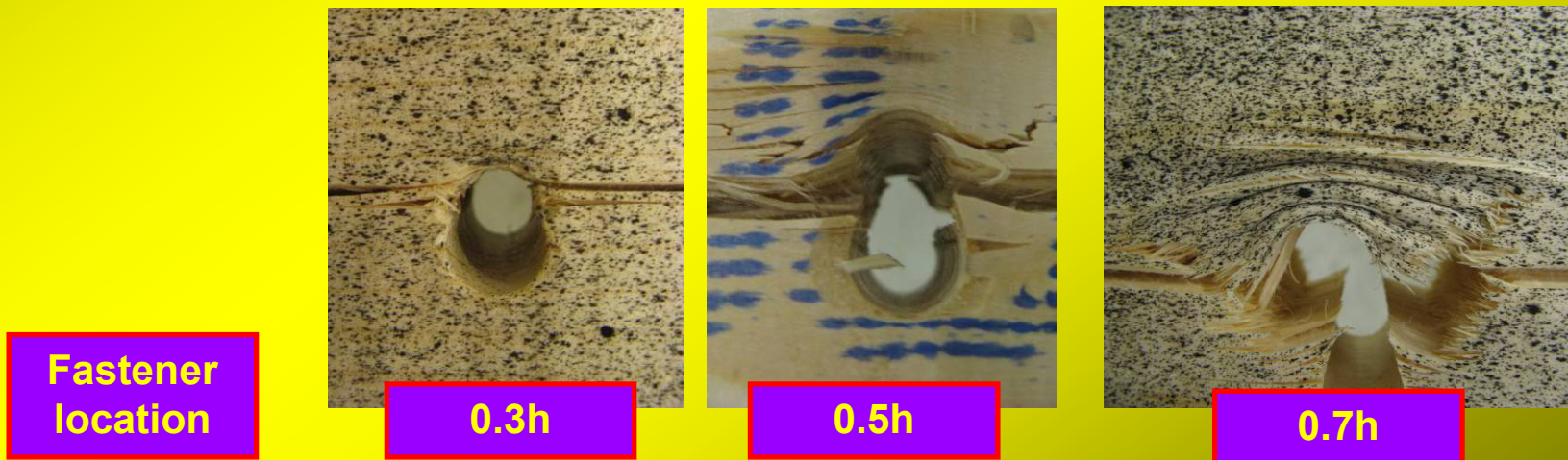
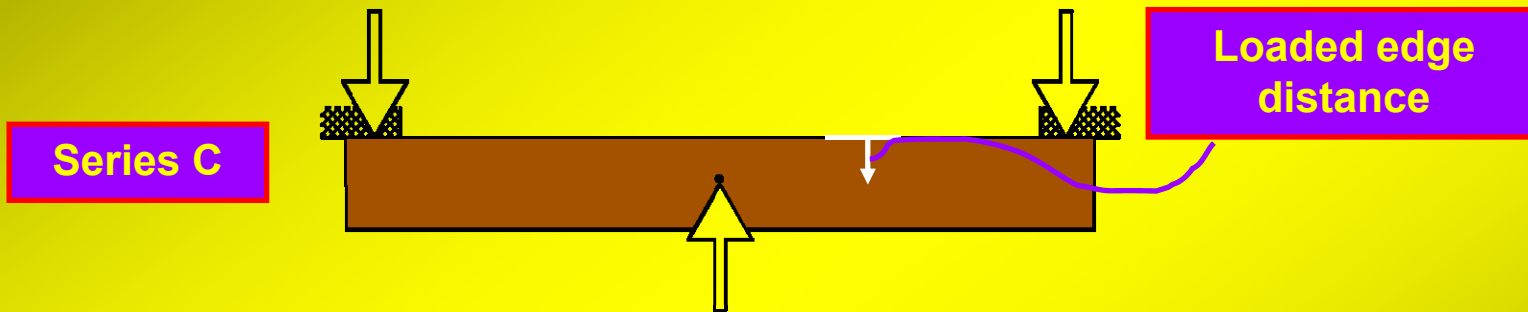
Angle $\approx 34^\circ$



Strain shape looks circular
↔ numerical values

Experimental results

- Full-scale bending embedding, $d = 12$ mm

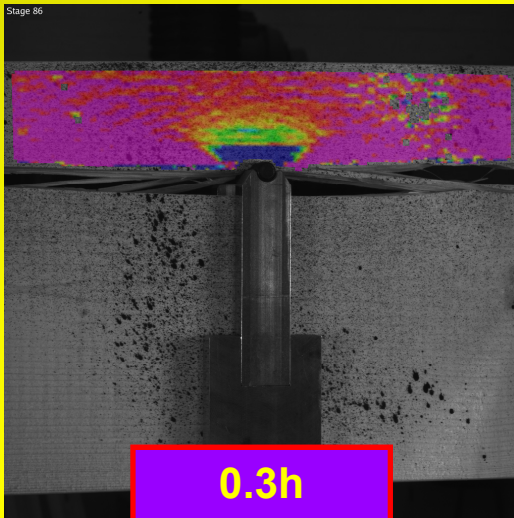
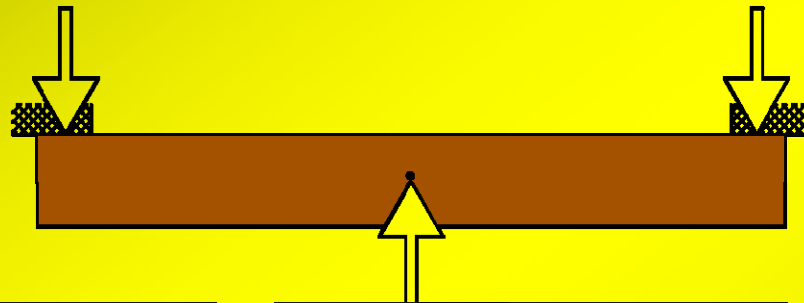


- Fastener holes after failure

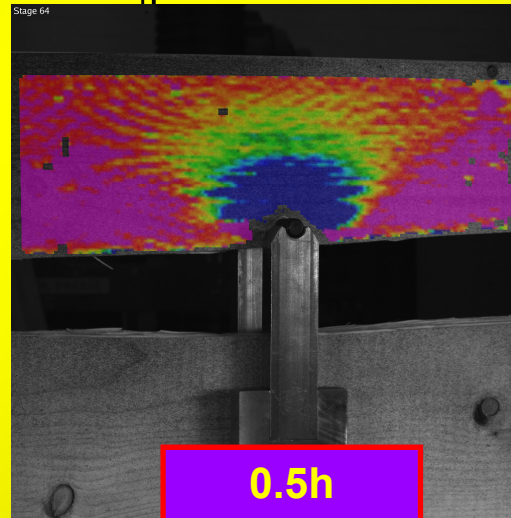
Experimental results

- Full-constrained embedding test, $d = 6 \text{ mm}$

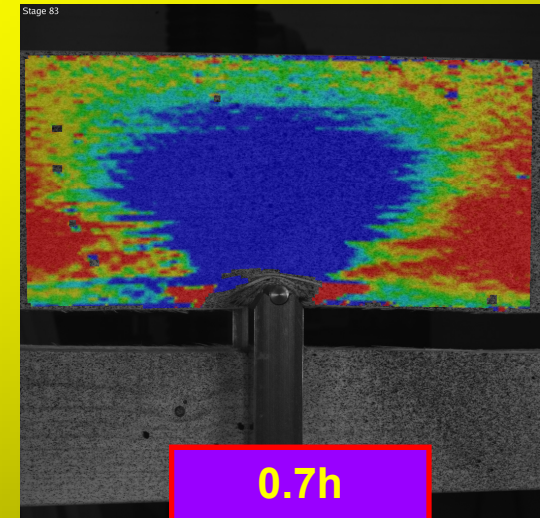
Series C



0.3h



0.5h

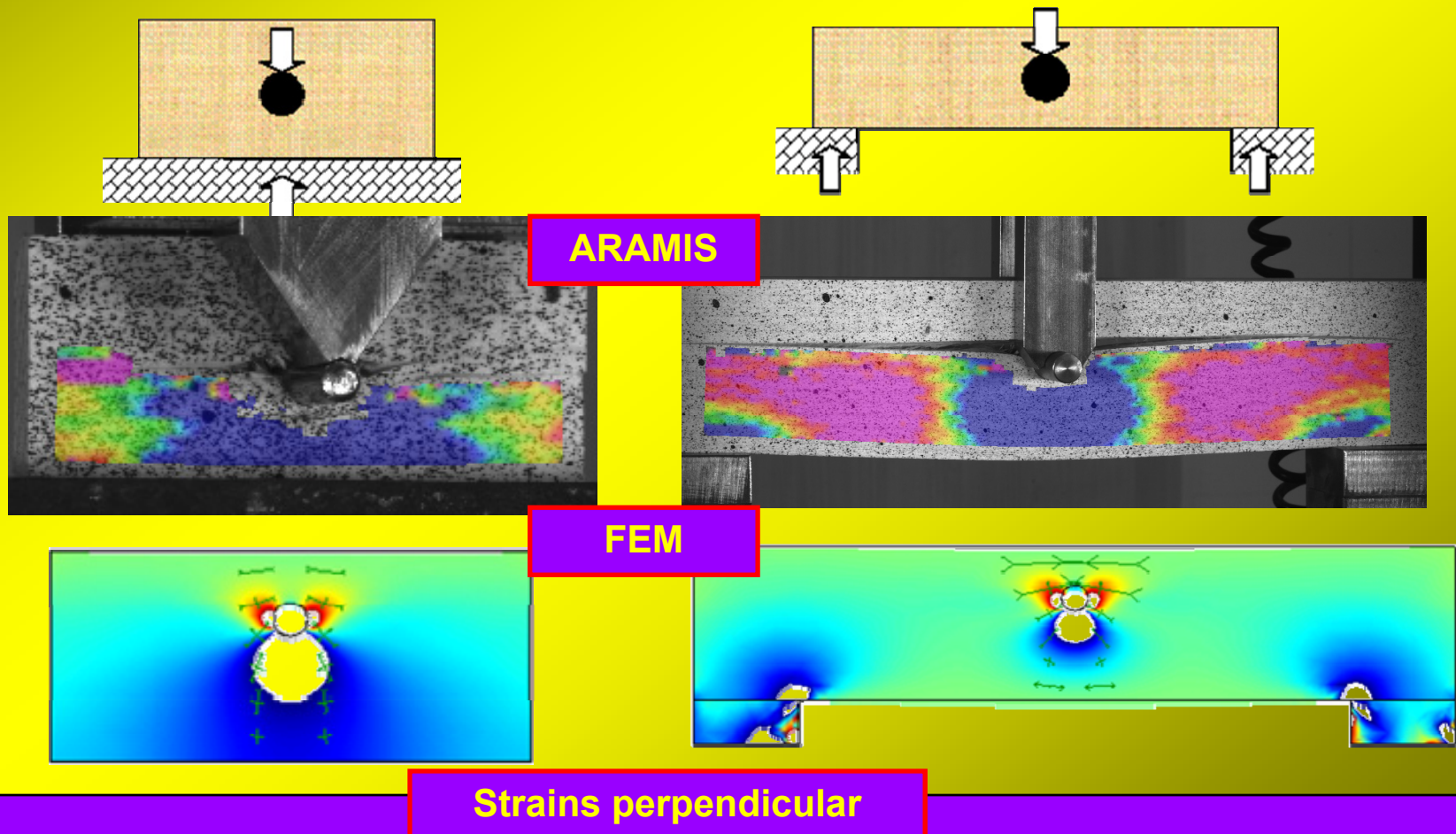


0.7h

Strain shape looks circular

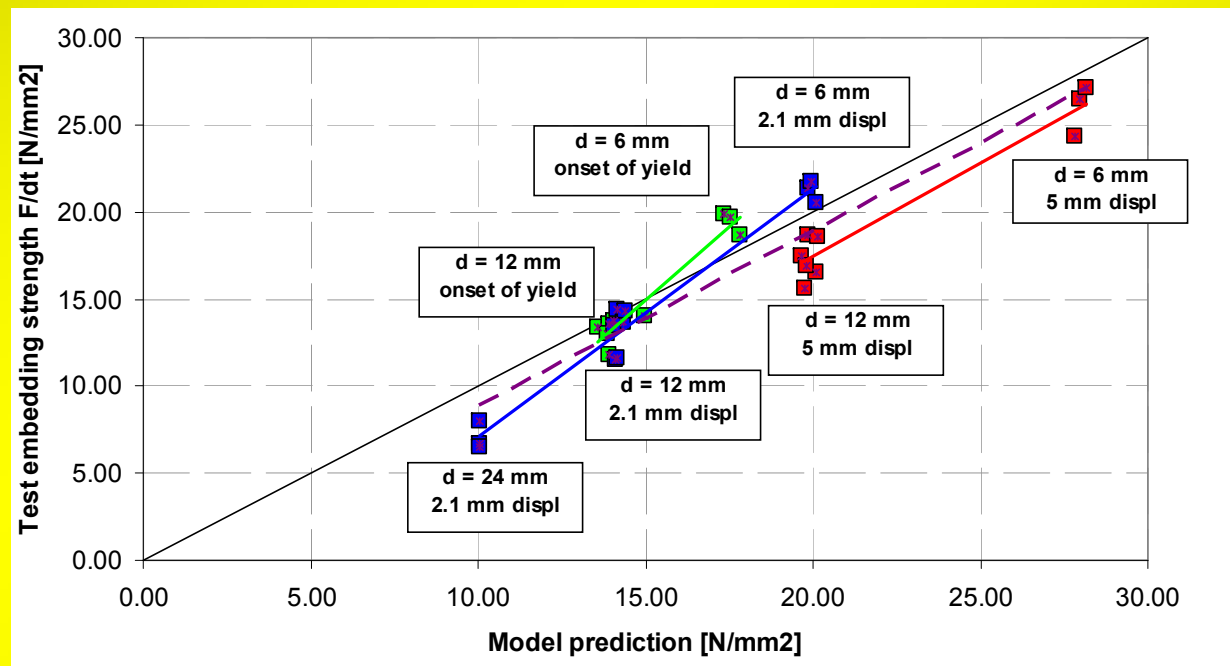
Experimental results

- Finte element modeling (COMSOL FEM-program)



Conclusions / remarks

- Strain distribution is triangular of shape (full-constrained emb. test)
- Strain shape becomes circular due to bending stresses
- Lower-order difference
- Model predictions (shown in the Eindhoven meeting) are rather accurate



End of this presentation