SHEAR TESTING OF NORWAY SPRUCE

LINEAR – NONLINEAR – PROBABILISTIC PROPERTIES

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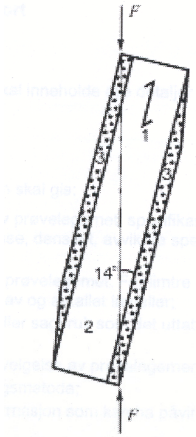
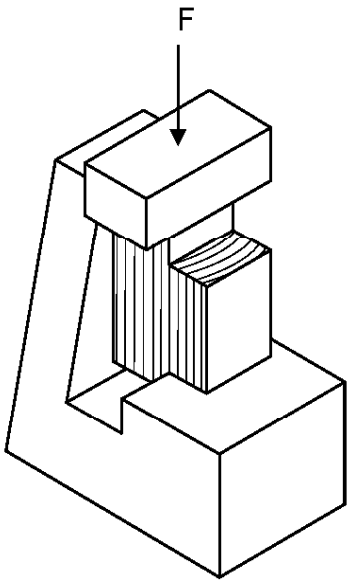
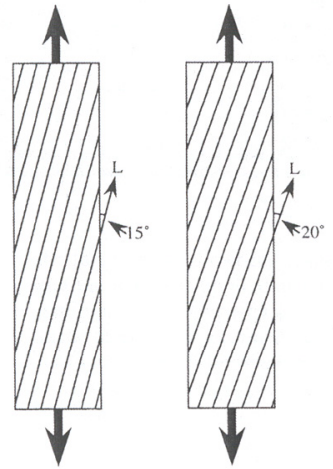
Shear tests

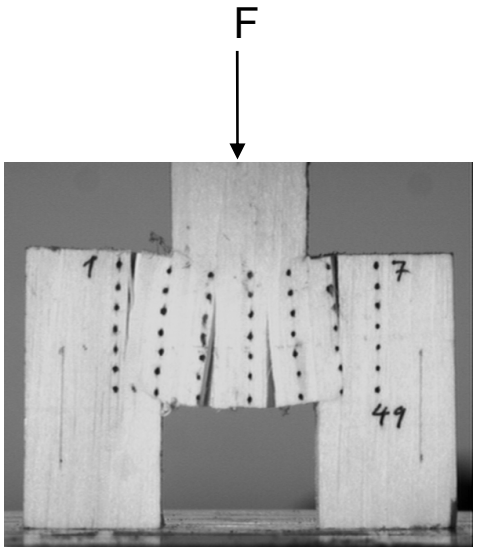
- G fraction of E
- Steel plate config.
- Notched shear block
- Plate twist test

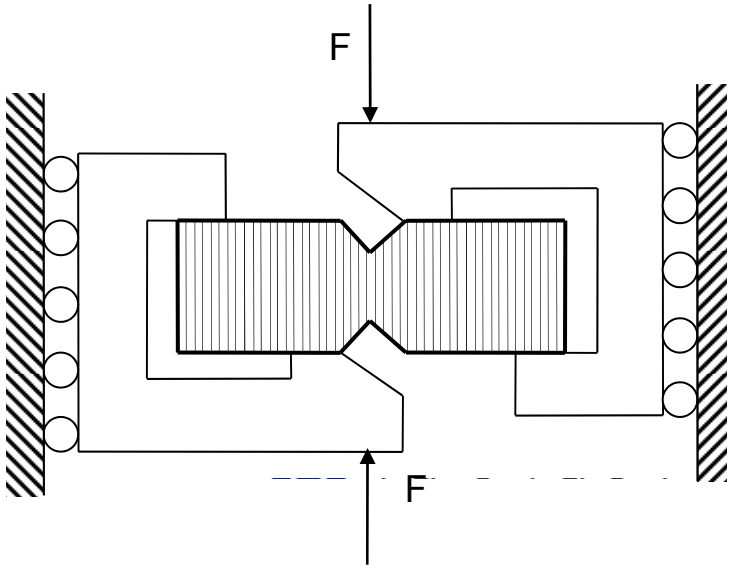




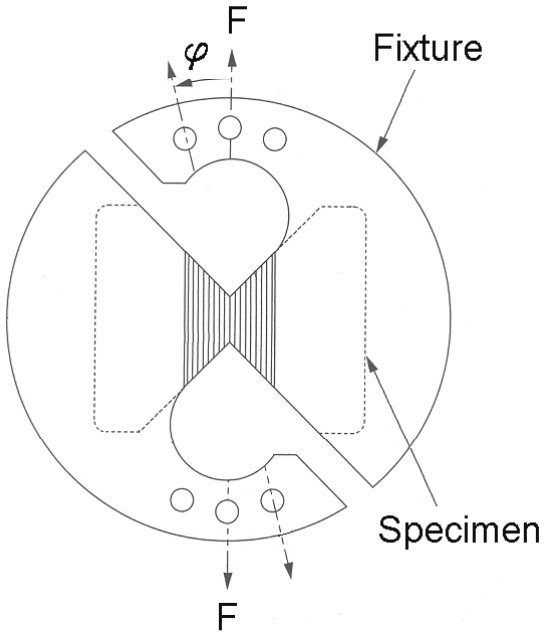


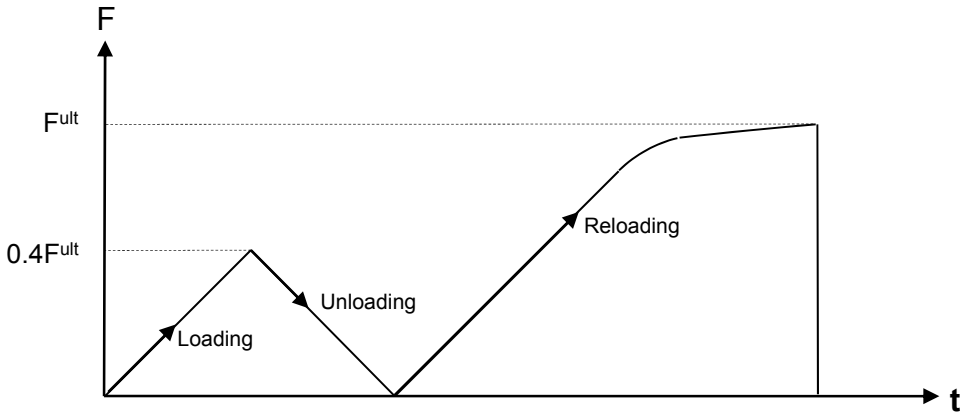
- Torsion
- Off-axis
- Iosipescu
- Short beams
- Arcan

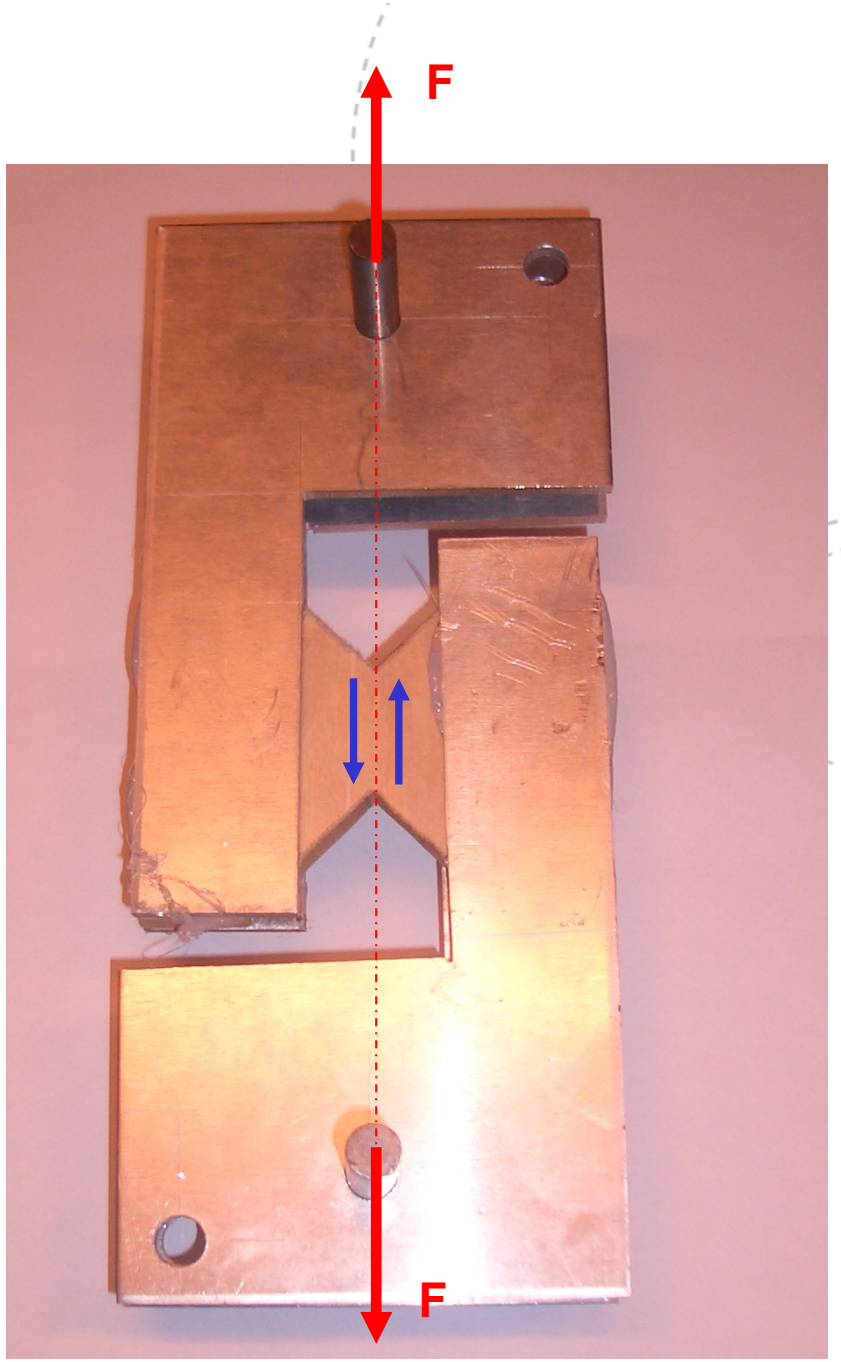




Arcan shear test

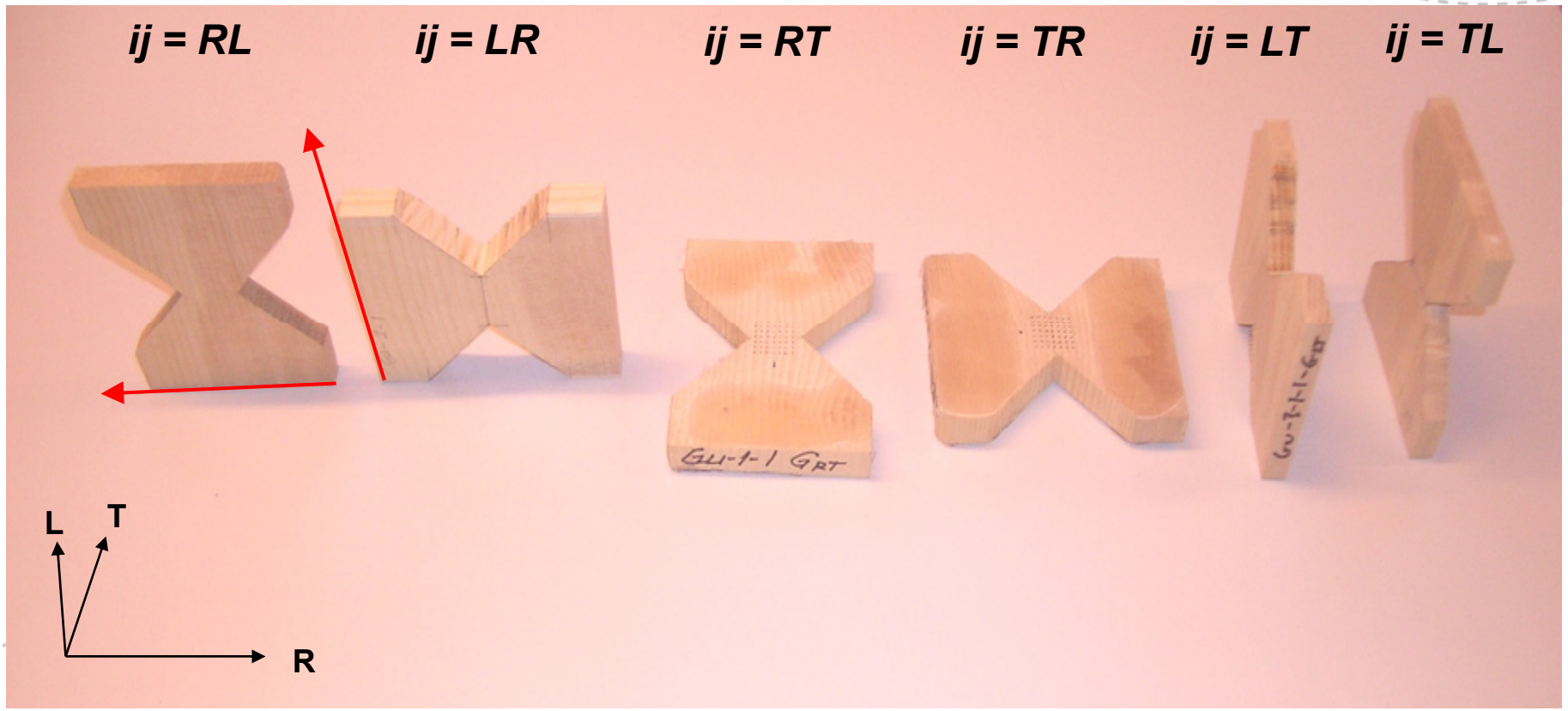




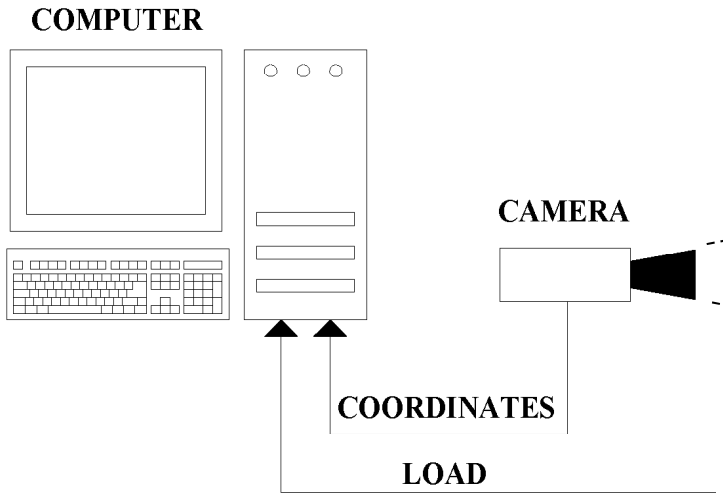


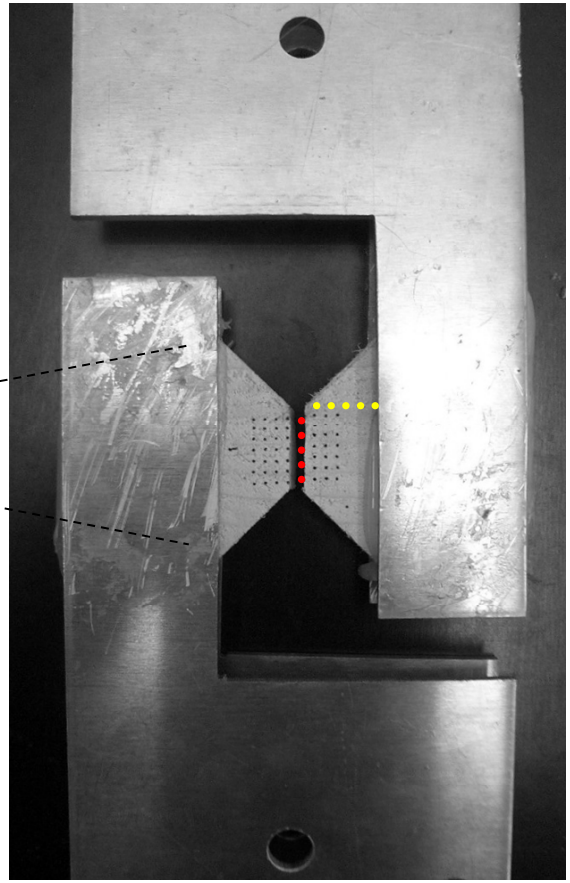
Arcan specimens

- 6 different configurations
- all material planes
- ~ 30 + 30 + 30 specimens
- on-axis



Video extensometry





$$\hat{\sigma}_{ij} = \frac{F}{A_0} \cong \frac{F}{(h \cdot t)}$$

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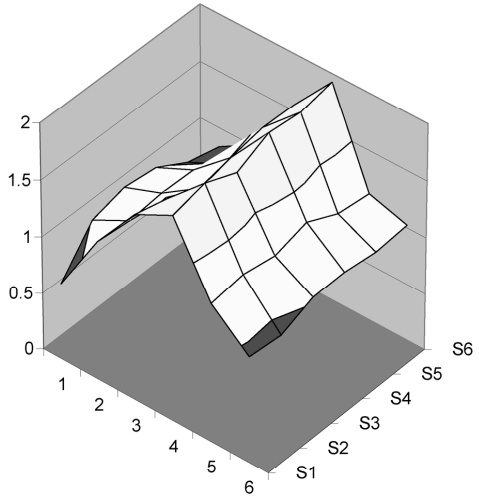
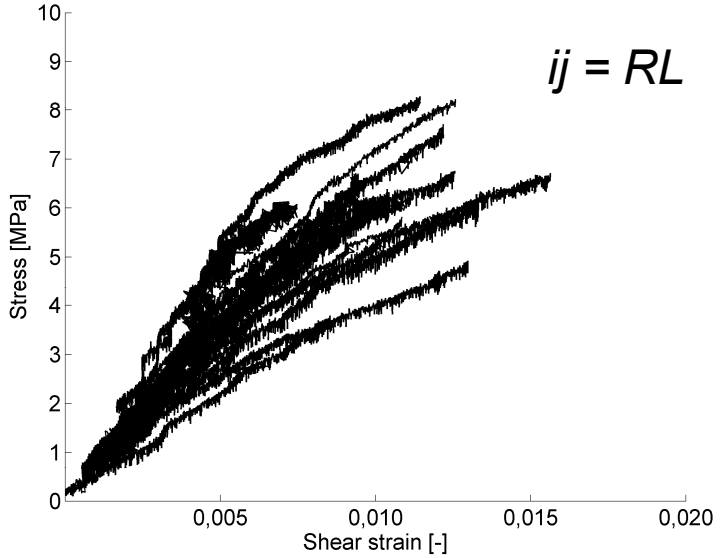
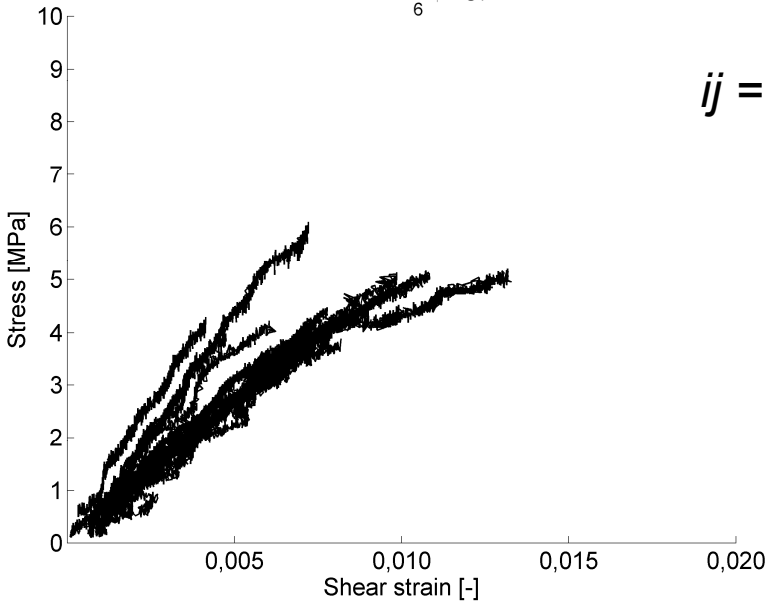
Test results



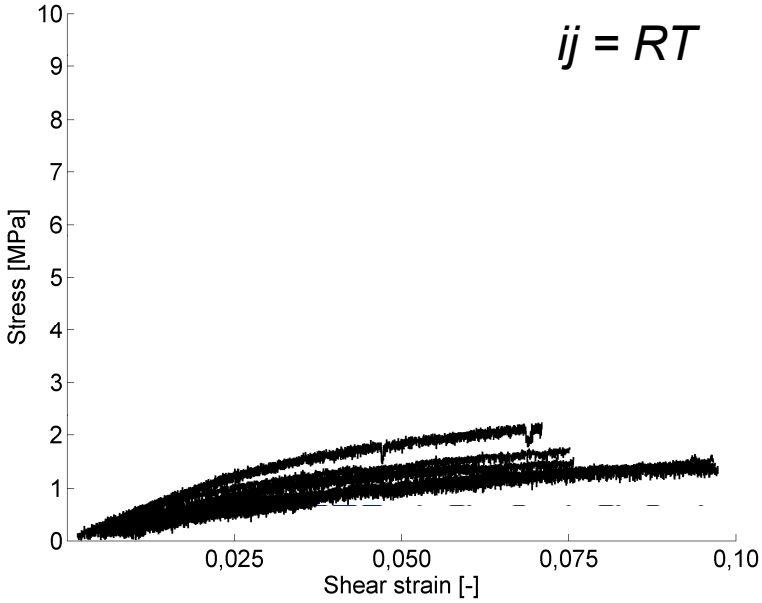
ij = RT



ij = RL

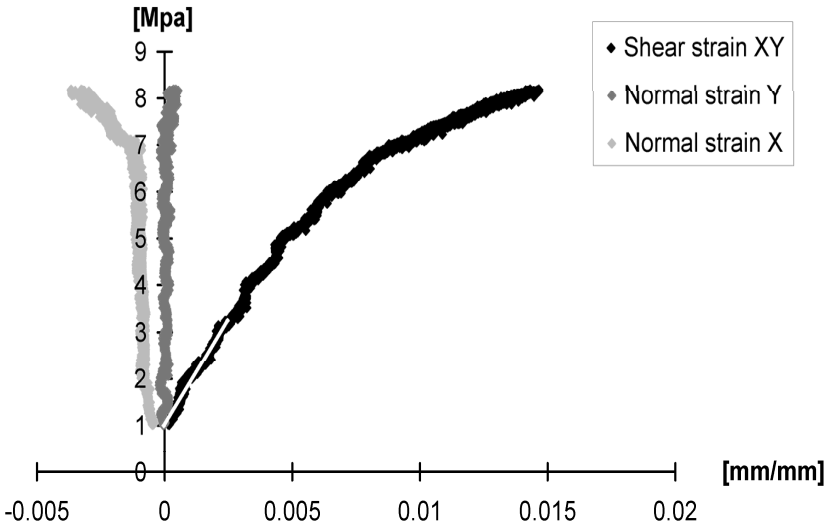


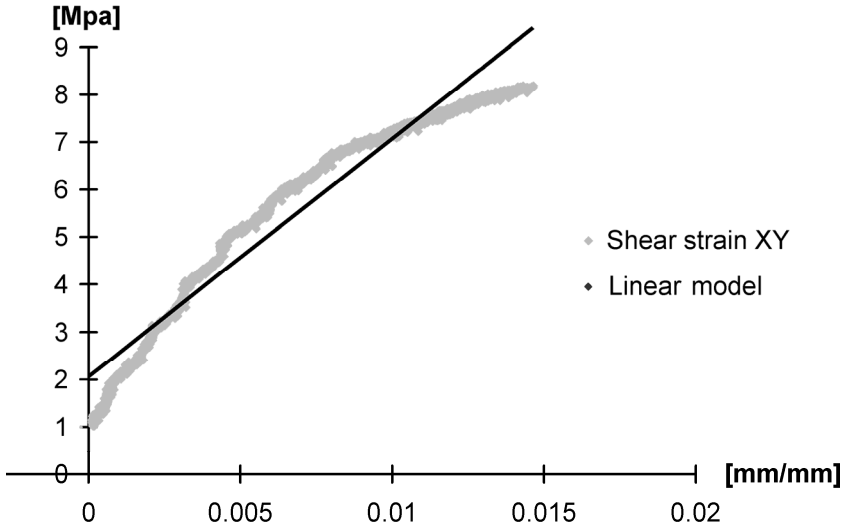
ij = TL



ij = RT

Linear properties





LR

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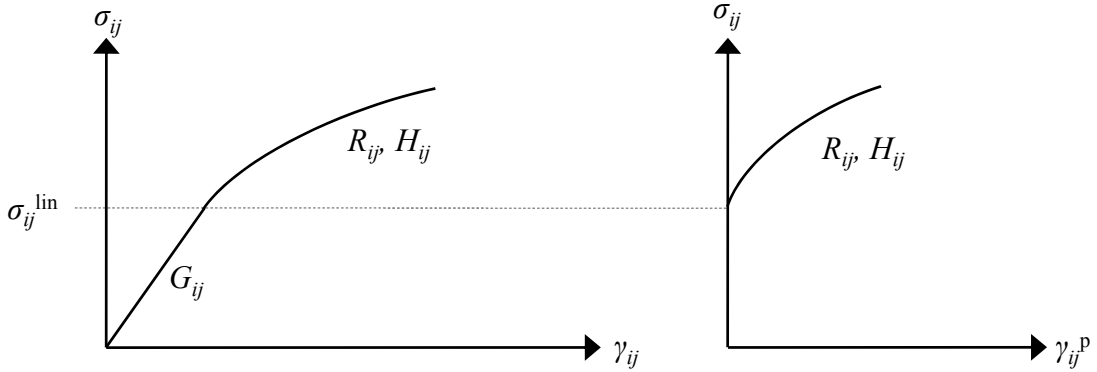
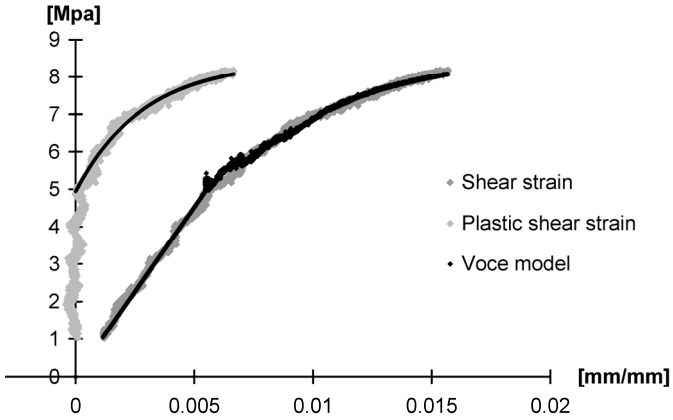
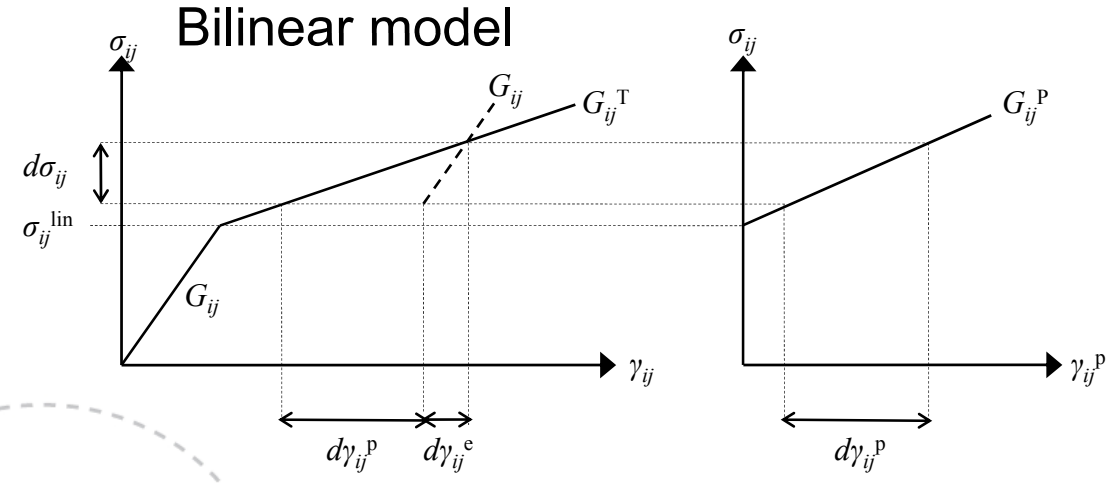
Nonlinear properties

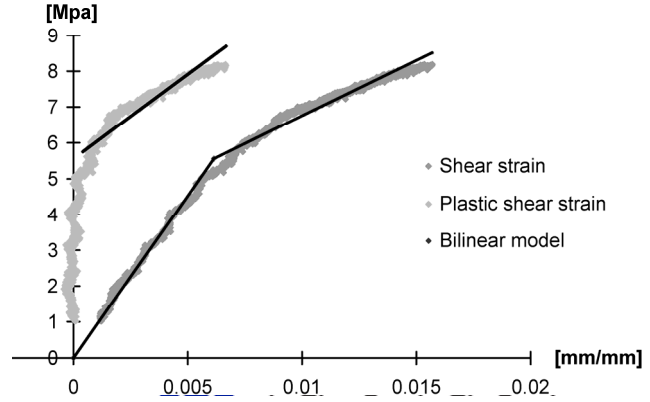
Voce model





Bilinear model

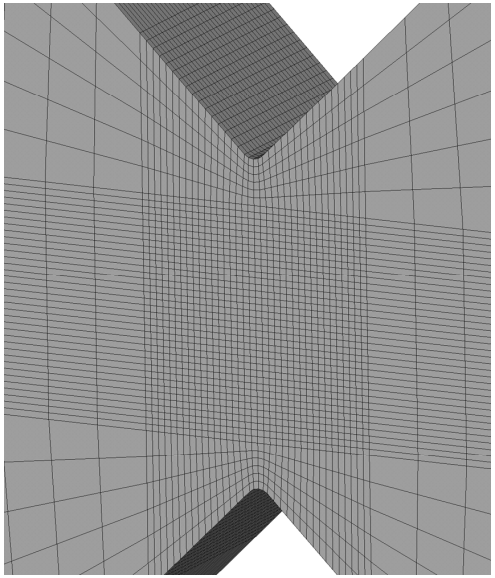


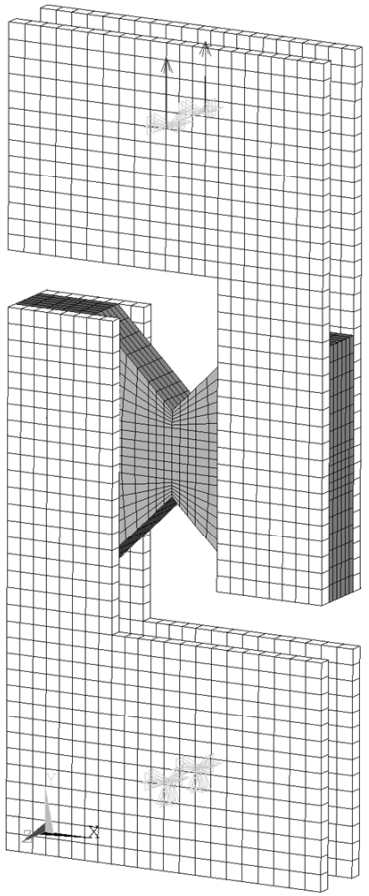


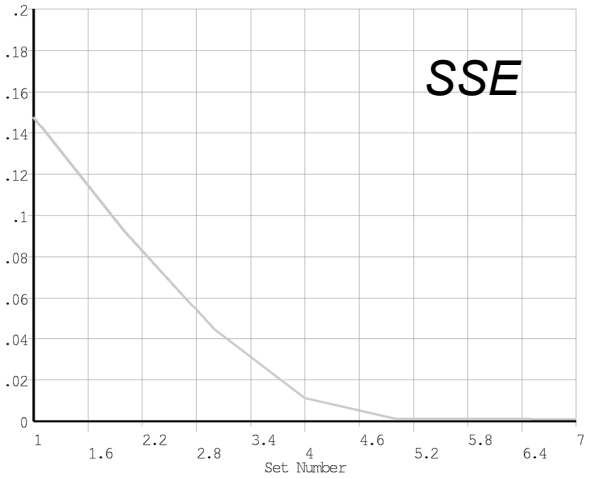
LR

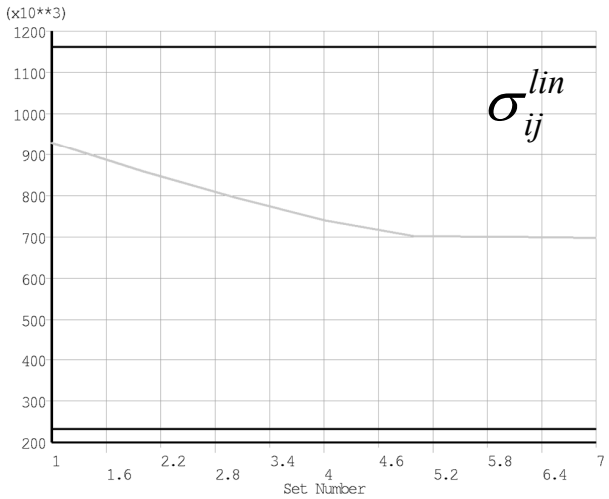
Simulations

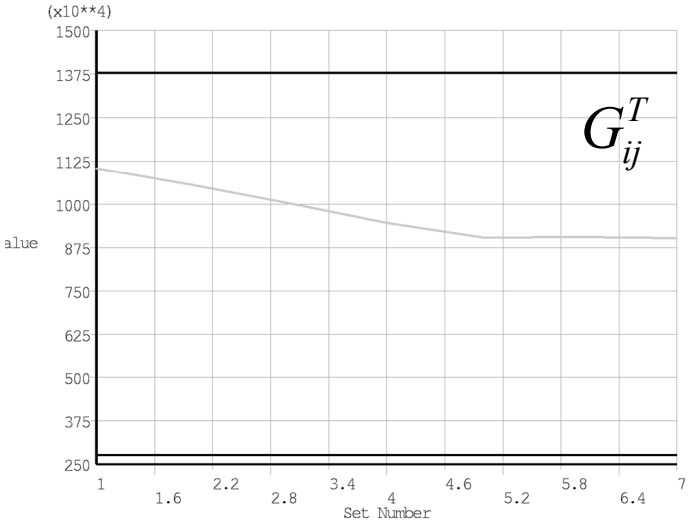
- FEM model (ANSYS 10.0)
- Solid (3D) elements
- Orthotropic
- Bilinear in shear
- Optimization analyses
  → Iterative parameter study
- Correspondence (SSE)
  - Numerical strain
  - Experimental strain
- Modified bilinear param.



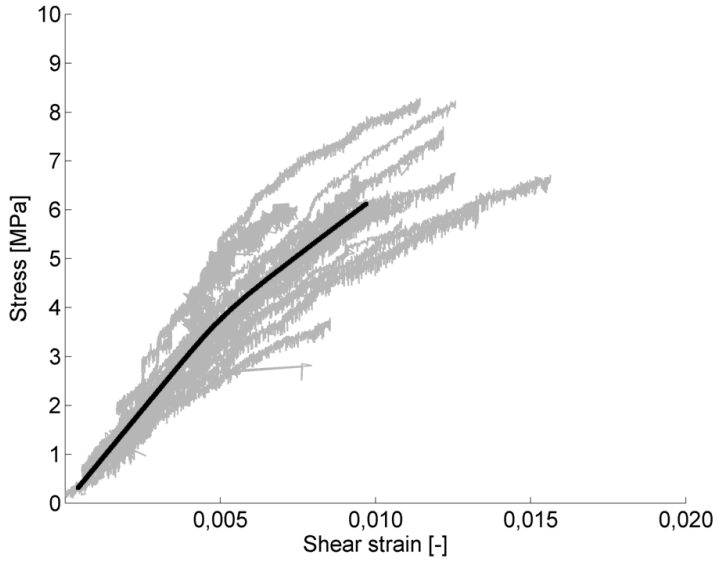




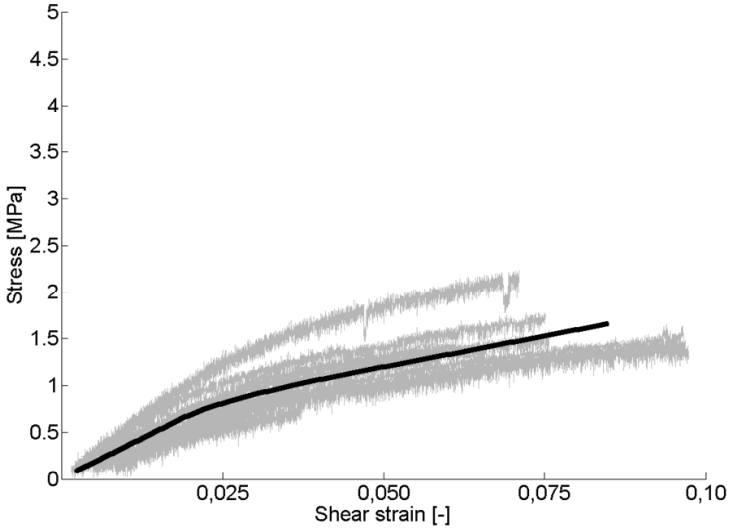




Simulations



RL



RT

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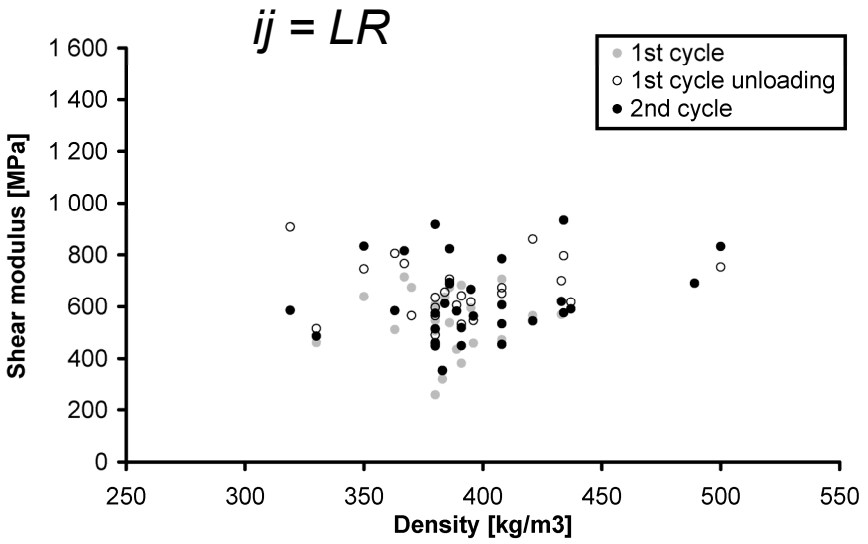
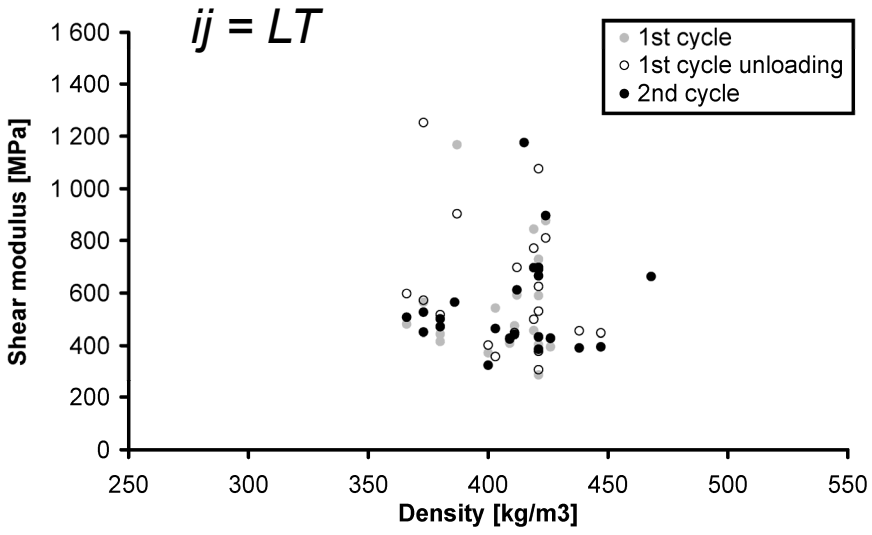
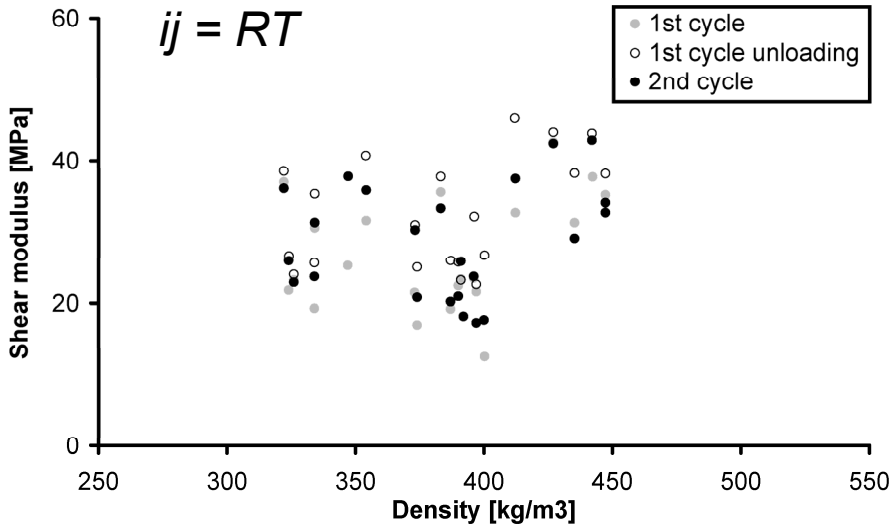
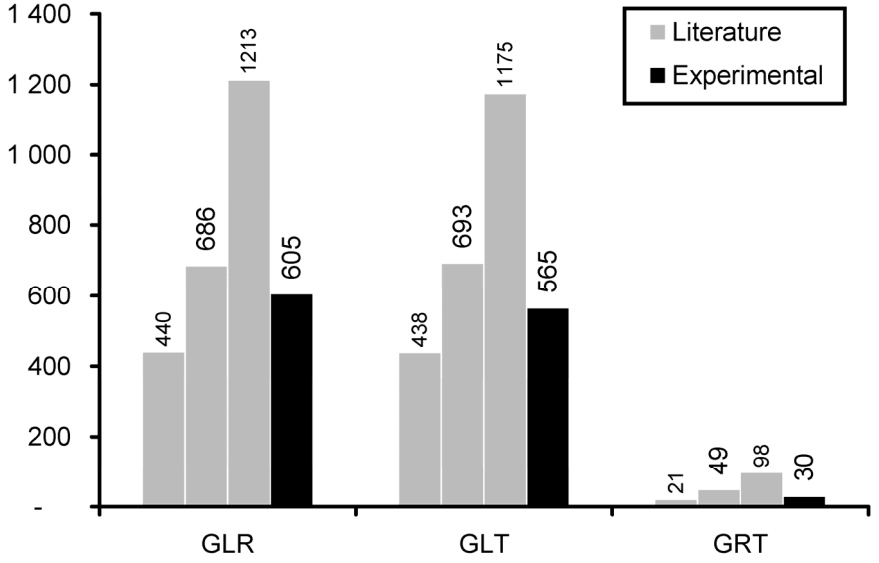
Linear shear moduli (modified)



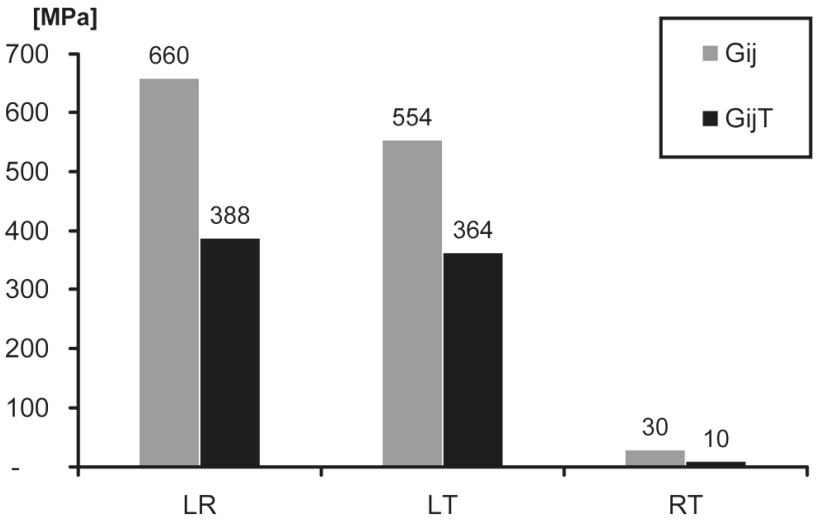




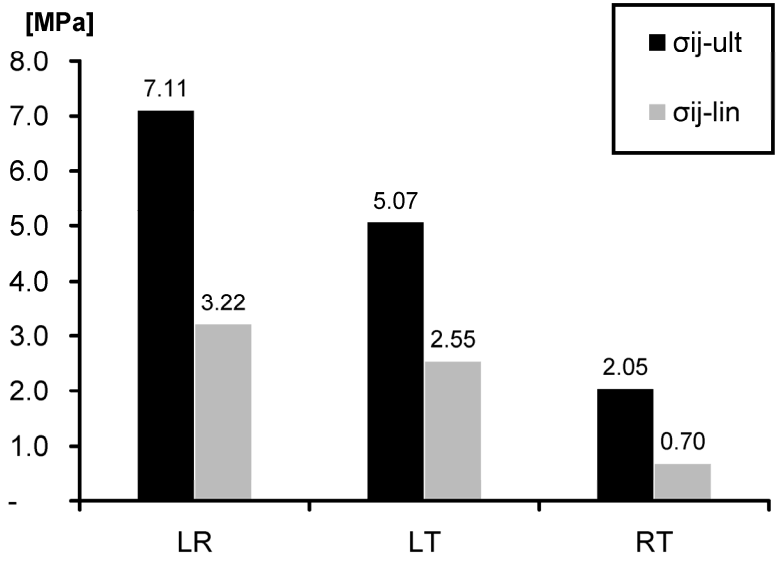


Bilinear parameters (modified)

Tangent moduli
and initial moduli



Linear limit stress
and ultimate stress (nom.)



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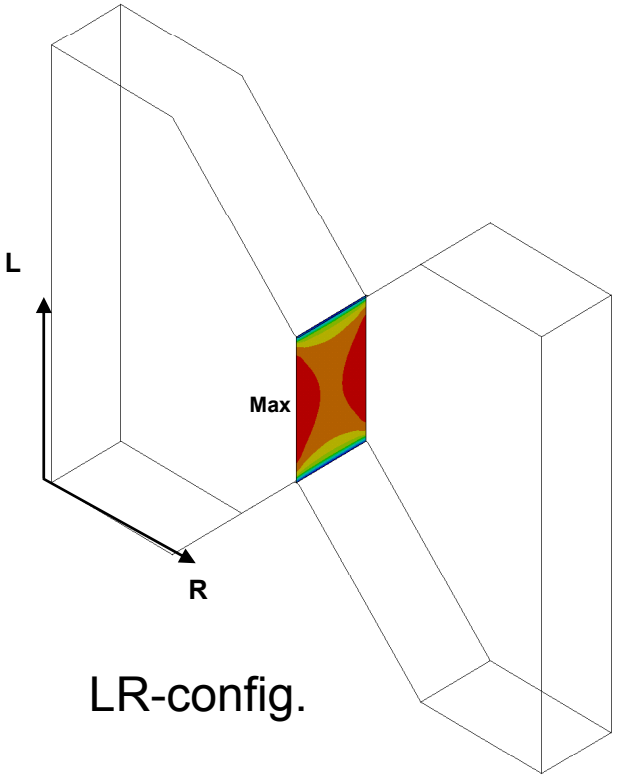
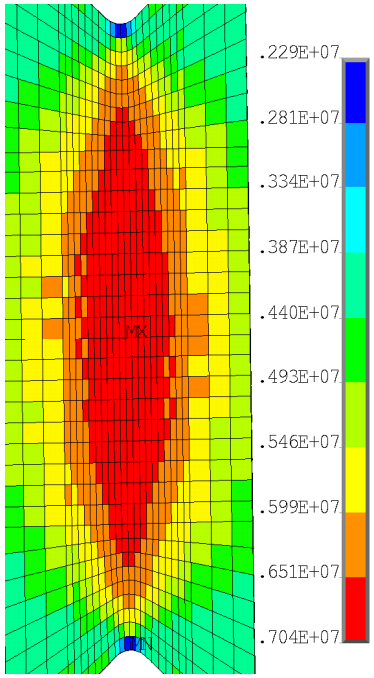
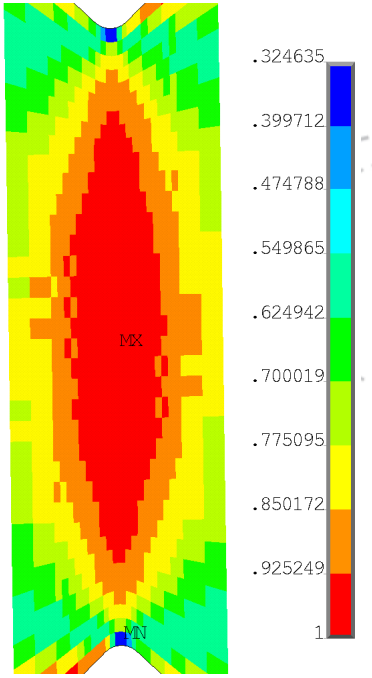
Shear strengths (modified)



LR-config.





Nominal: 6.06 MPa Max: 7.04 MPa Tsai-Wu: 7.06 MPa

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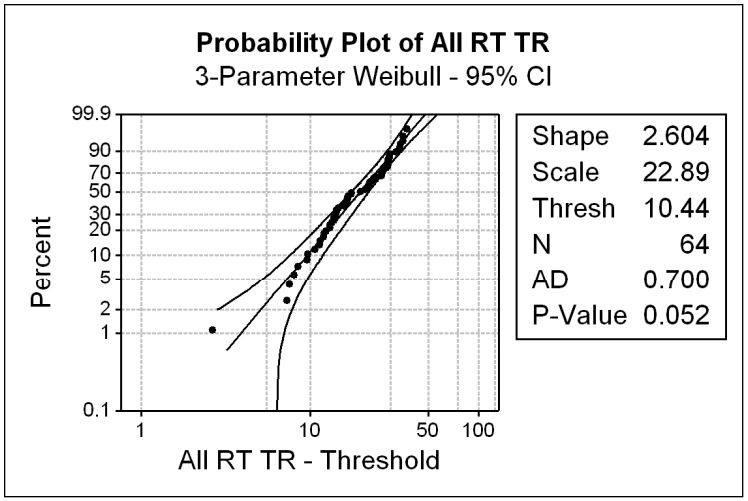
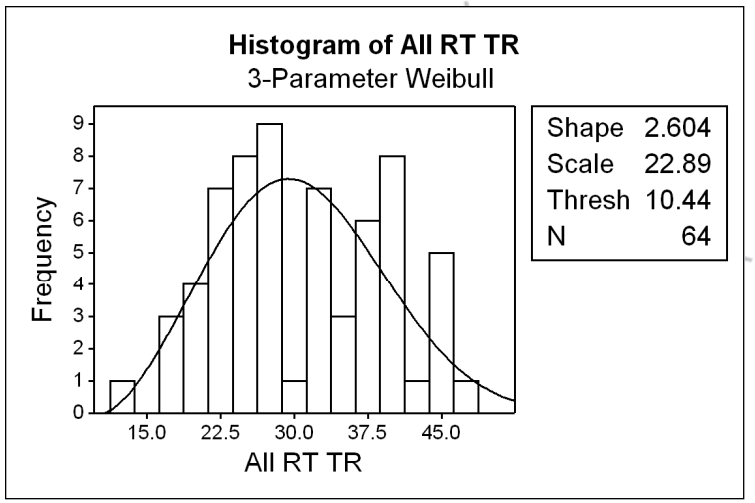
Probabilistic parameters





		Normal				*Lognormal*				*Weibull*				
	n	*Mean* μ	*StDev* σ	*AD*	*p*	*Mean* ξ	*StDev* δ	*AD*	*p*	*Shape* k	*Scale* m	*Location* x_0	*AD*	*p*
G_{LR}	83	640.6	152.4	0.487	0.22	6.434	0.244	0.49	0.21	2.856	462.0	227.5	0.62	0.08
G_{LT}	63	582.4	213.4	2.80	<0.005	6.313	0.321	1.03	0.01	1.391	306.5	303.7	0.70	0.08
G_{RT}	64	30.74	8.55	0.91	0.02	3.386	0.290	0.72	0.06	2.604	22.89	10.44	0.70	0.05

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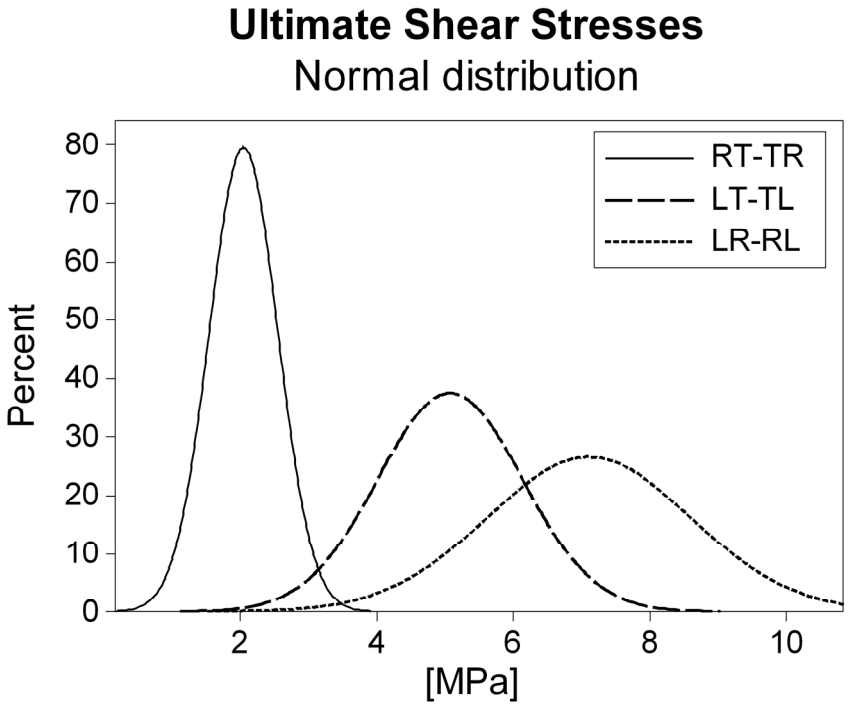
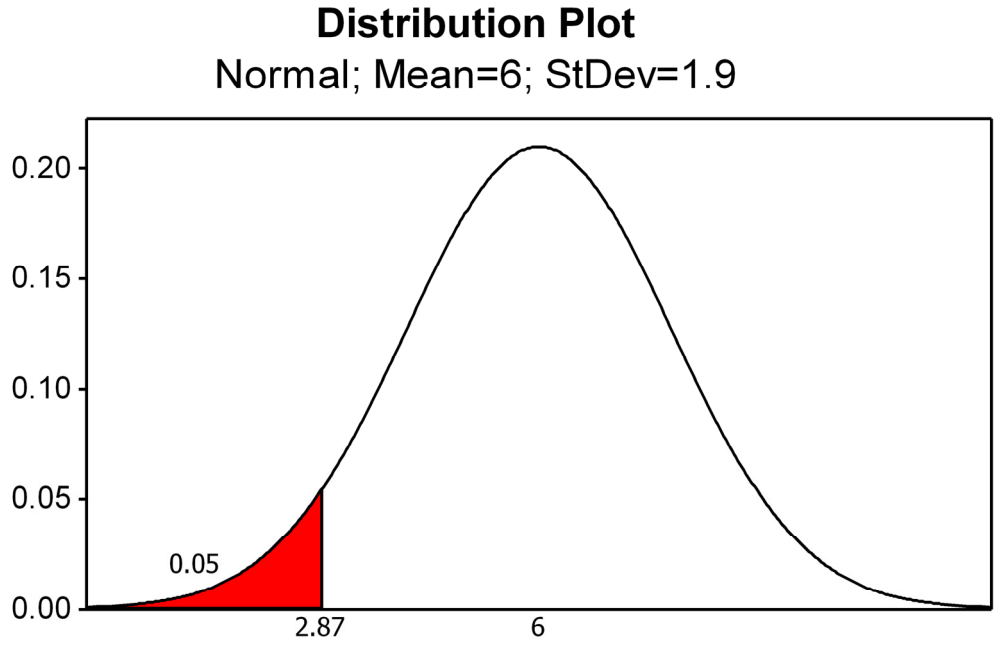
Probabilistic parameters





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Concluding remarks

- ✓ Arcan shear tests works well for testing of 3 orthotropic shear types
- ✓ LR, LT and TR Arcan configurations to be preferred
- ✓ Need of numerical modification (reduced stiffness, increased strength)
- ✓ No difference between loading and unloading except for rolling shear
- ✓ Linear shear moduli significantly different (GLR > GLT >> GRT)
- ✓ Nonlinearity:
  - ✓ Voce: Accurate
  - ✓ Bilinear: Robust
  - ✓ Linearized: Robust - inaccurate
- ✓ Study provides shear parameters for study of
  - ✓ Generalized macro level models (joints)
  - ✓ Upper stress range
  - ✓ Stiffness and strength (Ductility and capacity)
  - ✓ Probabilistic properties (Robustness)

References:

1. Dahl KB, Malo KA (2009) *Linear Shear Properties of Spruce Softwood*. Wood Science and Technology (accepted)
2. Dahl KB, Malo KA (2009) *Nonlinear Shear Properties of Spruce Softwood: Experimental findings.* Wood Science and Technology (accepted)
3. Dahl KB, Malo KA *Nonlinear Shear Properties of Spruce Softwood: Numerical Analyses of Experimental results* (submitted)
4. Dahl KB, Malo KA *Shear Strengths of Spruce Softwood: Numerical Analyses of Experimental Results* (in progress)
5. Dahl KB, Malo KA (2009) *Planar strain measurements on Wood Specimens.* Exp. Mech. (published)

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