COST E55, working group 2

Joint ductility

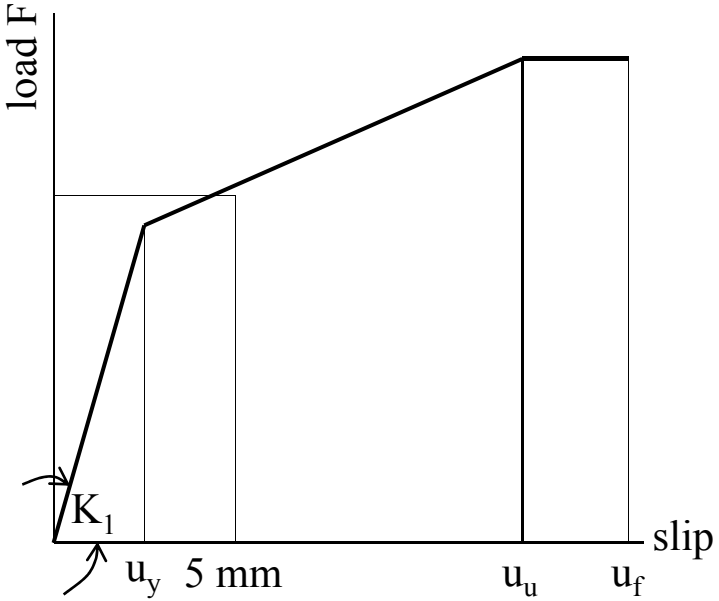
- introduction
- individual contributions
  - Ductility in connections (Thomas Bogensperger/Thomas Moosbrugger)
  - On ductility and Timber Structure Connections (Kjell A. Malo)
  - Design of timber structures consisting the plastic behavior of steel fasteners (Frank Brühl)
  - Dutility aspects of connections perpendicular to the grain (Dennis Schoenmakers/André Jorissen)
  - Shear testing of Norway spruce (Kristian Dahl)
  - Plate connectors – results (Peter Rodd)
- discussion on
  - guidelines
  - draft content of a document about timber (joint) ductility

COST E55, working group 2

Joint ductility

- introduction
  - definition
  - ductile behavior is important for
    - robust structures?
    - energy dissipation

definition



$$D_f = \frac{u_f}{u_y} \quad (1) \qquad D_u = \frac{u_u}{u_y} \quad (2)$$

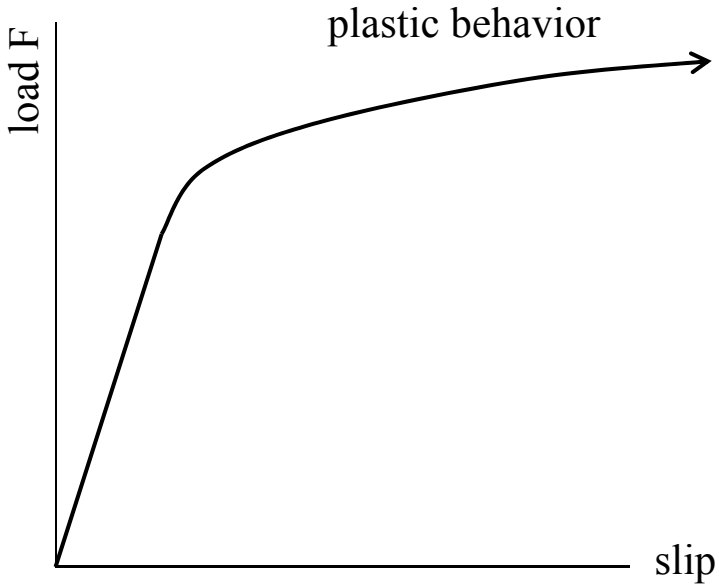
$$C_d = \frac{u_f - u_y}{u_f} \quad (3) \qquad D_{f/u} = \frac{u_f}{u_u} \quad (4)$$

$$D_{s/u} = \frac{K_1}{F_1} u_u \quad (5) \qquad D_{s/f} = \frac{K_1}{F_1} u_f \quad (6)$$

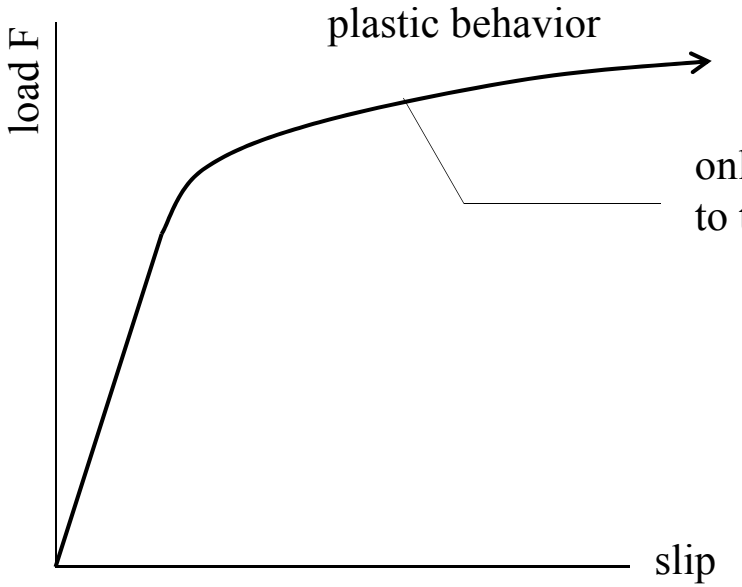
$$D_{uy} = u_u - u_y \quad (7) \qquad D_{fy} = u_f - u_y \quad (8)$$

$$D_{fu} = u_f - u_u \quad (9) \qquad E_d = \int_{u=0}^{u=u_f} f(F,u)du \quad (10)$$

definition

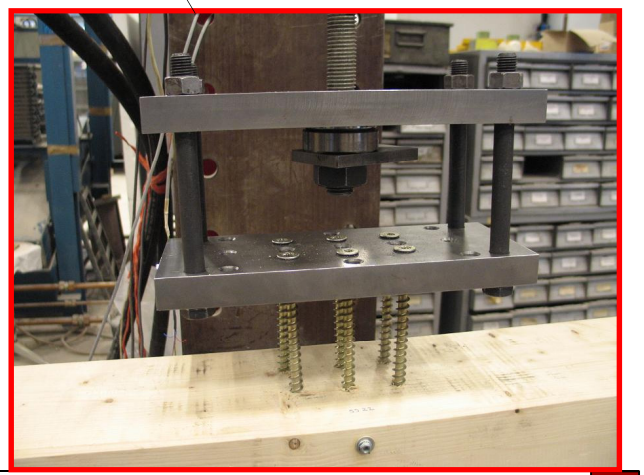


definition



only obtained when no or limited tension perpendicular to the grain is developed:

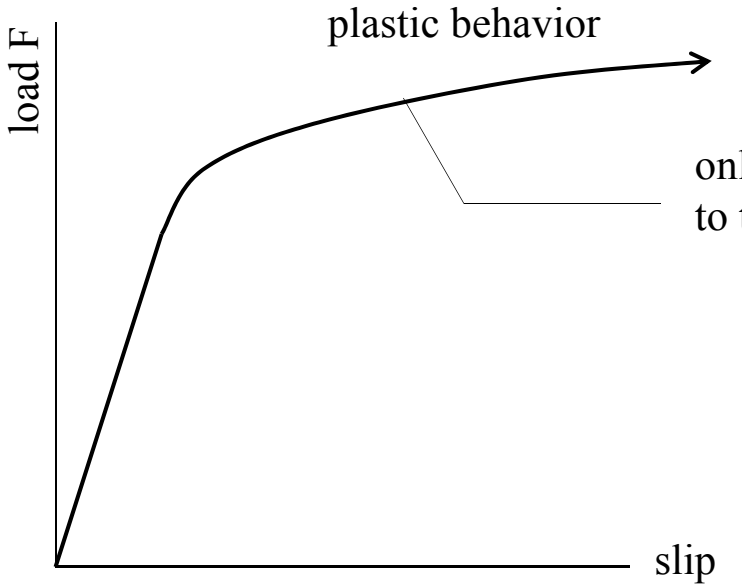
- singel dowel type fastener connections
- multiple nail or staple connections
- toothed plate connections
- axially loaded screw connections ??
- bearing
- reinforced



SHR

TU/e

definition



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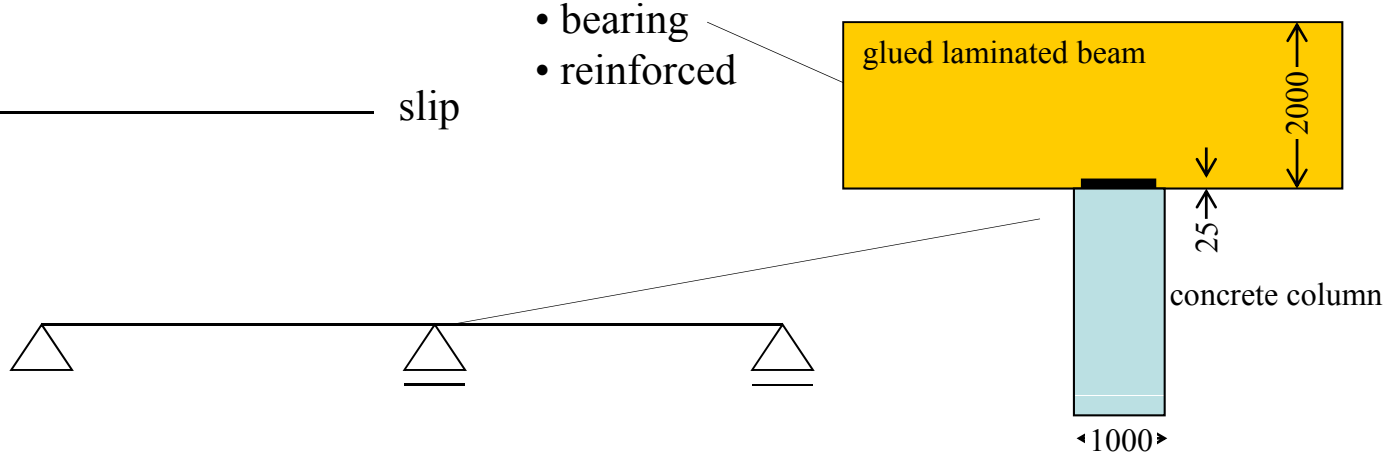
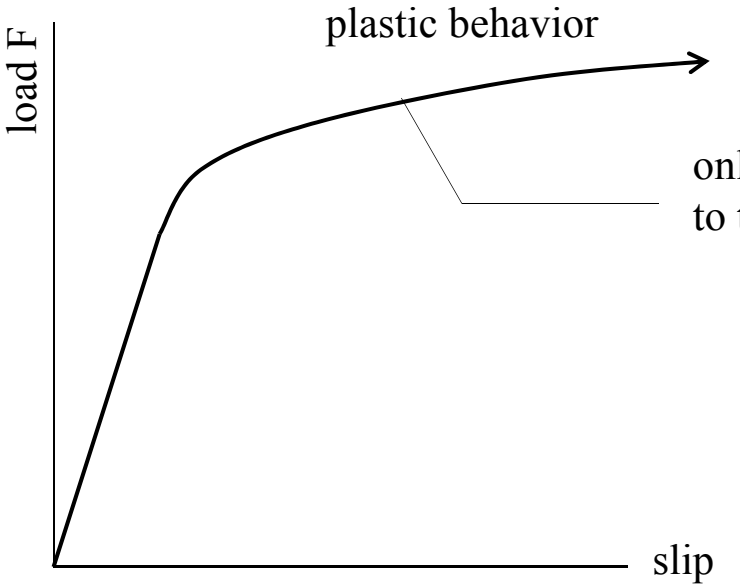
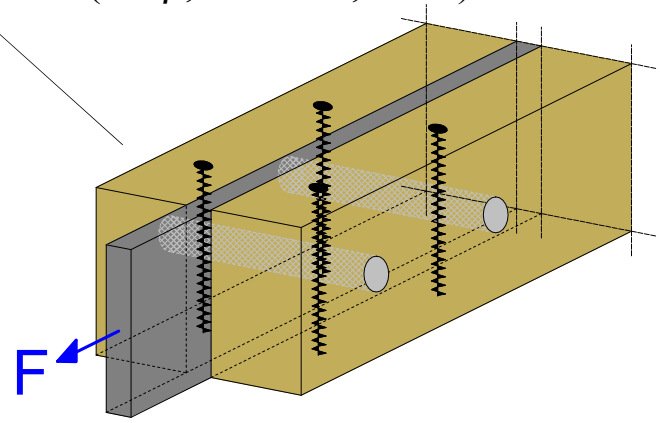


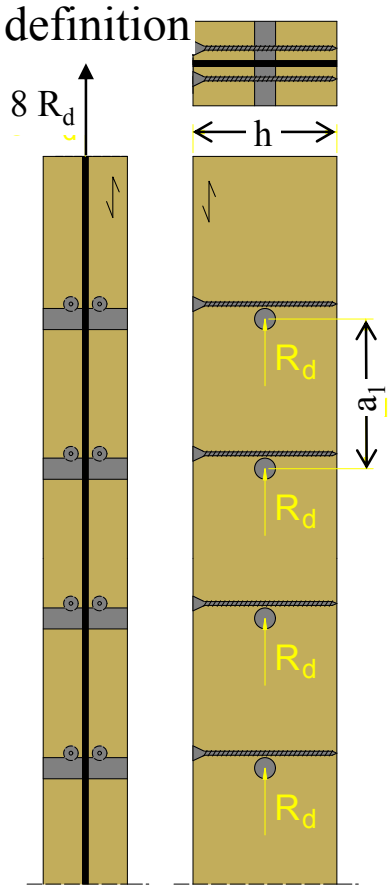
definition

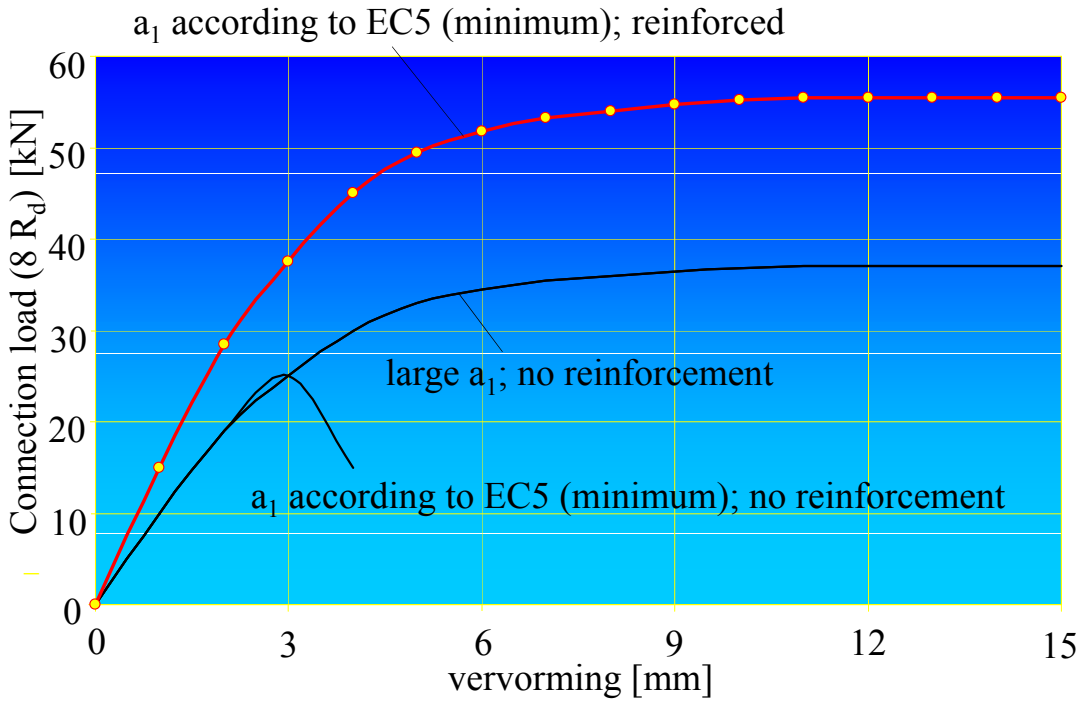


only obtained when no or limited tension perpendicular to the grain is developed:

- singel dowel type fastener connections
- multiple nail or staple connections
- toothed plate connections
- axially loaded screw connections ??
- bearing
- reinforced (Blaβ, Helsinki, 2008)







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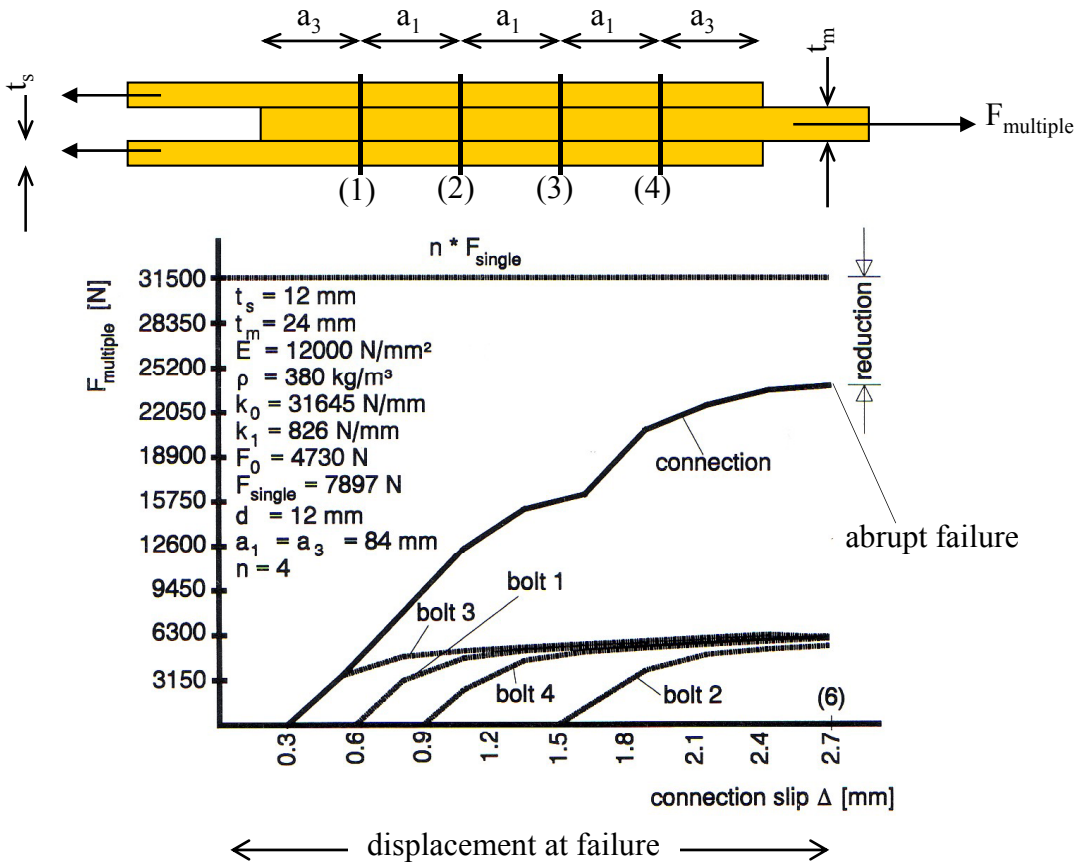
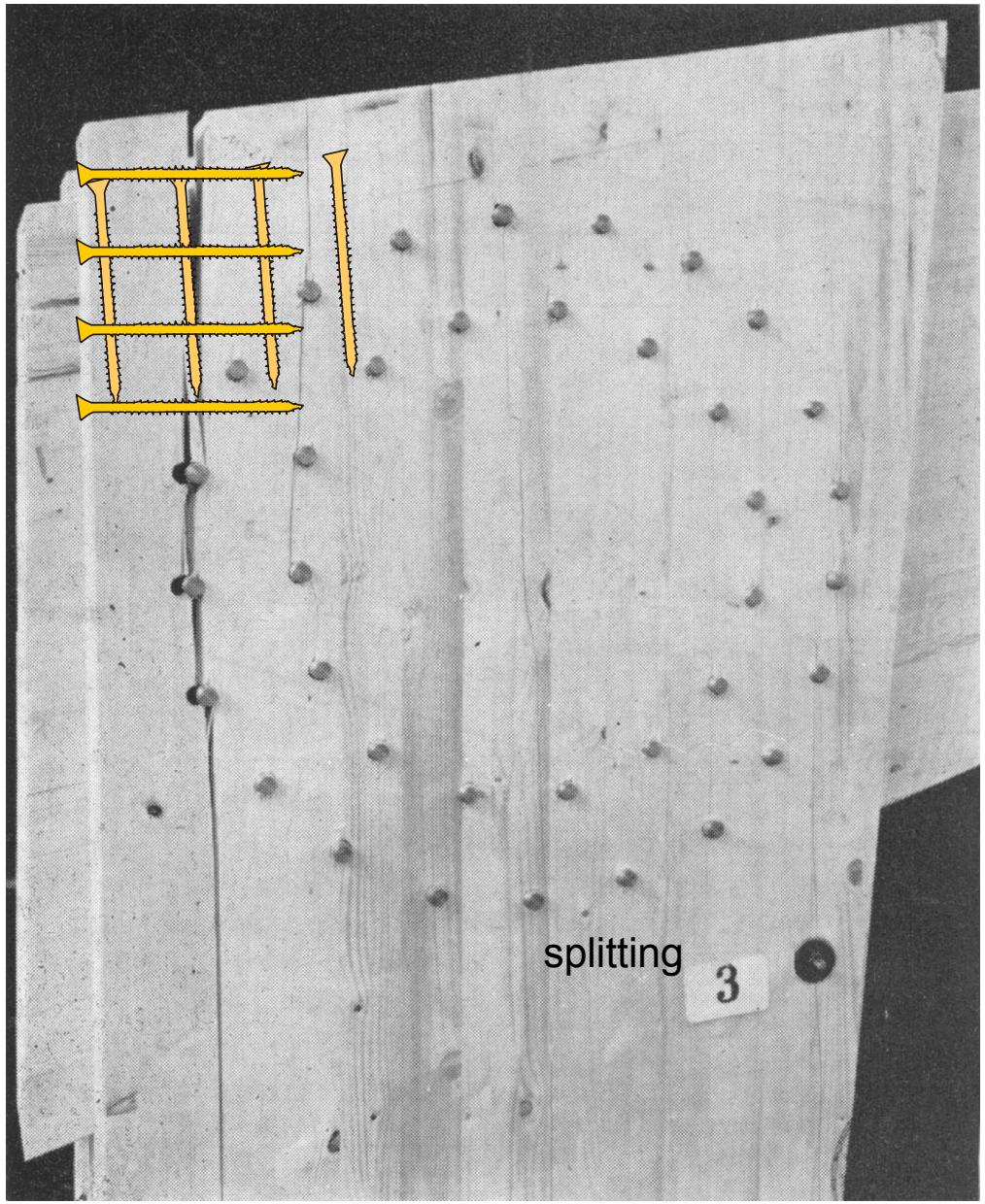
definition


a3
a1
a1
a1
a3
tm
ts
F multiple
(1)
(2)
(3)
(4)
n * F single
F multiple [N]
31500
28350
25200
22050
18900
15750
12600
9450
6300
3150
ts = 12 mm
tm = 24 mm
E = 12000 N/mm²
ρ = 380 kg/m³
k0 = 31645 N/mm
k1 = 826 N/mm
F0 = 4730 N
F single = 7897 N
d = 12 mm
a1 = a3 = 84 mm
n = 4
reduction
connection
abrupt failure
bolt 1
bolt 3
bolt 4
bolt 2
(6)
0.3
0.6
0.9
1.2
1.5
1.8
2.1
2.4
2.7
connection slip Δ [mm]
displacement at failure

definition

brittle faiure



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COST E55, working group 2

Joint ductility

- introduction
  - definition
  - ductile behavior is important for
    - robust structures?
    - energy dissipation

COST E55, working group 2

Joint ductility

- introduction
  - definition
  - ductile behavior is important for
    - robust structures?
      - progressive collapse
      - redundancy
      - ductility

} working group 3

COST E55, working group 2

Joint ductility

- introduction
  - definition
  - ductile behavior is important for
    - robust structures?
    - energy dissipation: dynamic loading (earthquake design)

COST E55, working group 2

Joint ductility

Discussion??

COST E55, working group 2

Joint ductility

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Joint ductility

Presentations

- Ductility in connections (Thomas Bogensperger/Thomas Moosbrugger)
  - Design of timber structures consisting the plastic behavior of steel fasteners (Frank Brühl)
- Ductility requirements (Ad Leijten)
- Robustness assesment of timber structures with regard to ductility (Poul Henning Kirkegaard)
  - On ductility and Timber Structure Connections (Kjell A. Malo)

  - Shear testing of Norway spruce (Kristian Dahl)
  - Dutility aspects of connections perpendicular to the grain (Dennis Schoenmakers/André Jorissen)
  - Plate connectors – results (Peter Rodd)

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Joint ductility

Discussion on:

- Guidelines: EN 1998-1 (Working group 3 document in relation to Earthquake design)
  Distinction between DCL (low ductility class), DCM (medium ductility class) and DCH (high ductility class) without defining ductility

- Draft content of a document about timber (joint) ductility

COST E55, working group 2

Joint ductility

Discussion on:

• Guidelines: EN 1998-1 (Working group 3 document in relation to Earthquake design)

structural type	DCM μ≥4	DCH μ≥6
Wall panels with glued diaphraghms connected with nails and bolts	Glued panels q = 2,0	nailed panels q = 3,0
Wall panels with nailed diaphragms connected with nails and bolts		nailed panels q = 5,0 (q = 4,0)
Trusses	doweled and bolted q = 2,0	nailed q = 3,0
Mixed structures with timber framing and non-load-bearing infills	q = 2,0	-
Hyperstatic portal frame with doweled and bolted joints	q = 2,5	q = 4,0 (q = 2,5)
slenderness (dowels / bolts / nails)	t/d > 10; d<= 12 mm	
sheeting material	t >= 4d; d <= 3,1 mm	

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Joint ductility

• Draft content of a document about timber (joint) ductility

content	drafted by
Introduction	
general	
definitions	
relationship with robustness	
ductile timber structures	
static ductility	
dynamic ductility (seismic - overstrength)	
joint ductility	
dowel type fasteners ; single / multiple	
nails	
screws	
bolts/dowels	
plate connectors	
glued connections	
reinforcements	
guidelines	
conclusions	
literature	
appendices	
examples	
ductility in codes	