

## Cracking in timber structures. What do we do?

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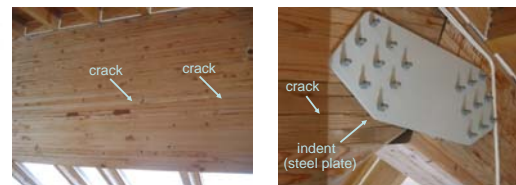
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## Timber designer's view on Cracking

- Large cross-sections most vulnerable => Glulam
- Connections most exposed:
  - Near the end
  - More 3D stress
  - Net section
  - Restrictions on dimensional change from steel parts
- Curved structures => Glulam



Frame 1



## Cracks and Shear (EC5/A1)

- Effects of cracks (due to moisture changes??)

$$k_{cr}$$

- Introduction of an effective width

$$b_{ef} = k_{cr} b$$

- Glulam (recommended national choice)

$$k_{cr} = 0.67$$

## Curved Elements; Cracks due to stresses

- Normal tensile stresses:

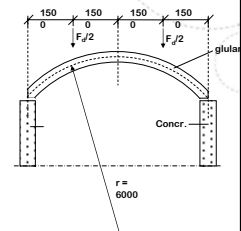
$$\frac{\sigma_{t,90,d}}{k_{dis} k_{vol} f_{t,90,d}} \leq 1$$

$$\sigma_{t,90,d} = k_{\sigma} \frac{6M_{ap,d}}{bh_{ap}^2}$$

- Glulam, "stressed volume":

$$k_{vol} = \left( \frac{V_0}{V} \right)^{0.2} \approx 0.5 ?$$

$$V_0 = 0,01 \text{ m}^3 \quad V = 2/3 \cdot V_{tot} \text{ m}^3$$



## EC5: Linear Interaction: shear & tensile stress

Linear interaction:  $\frac{1}{2} + \frac{1}{2} = 1$  !!

$$\frac{\tau_d}{f_{v,d}} + \frac{\sigma_{t,90,d}}{k_{dis} k_{vol} f_{t,90,d}} \leq 1 \quad (6.53)$$

$$b_{ef}/b = k_{cr} = 0.67$$

$$k_{vol} = \left(\frac{V_0}{V}\right)^{0.2} \approx 0.5 ?$$

## Tynset Bridge



- Norwegian Road Bridges → ?

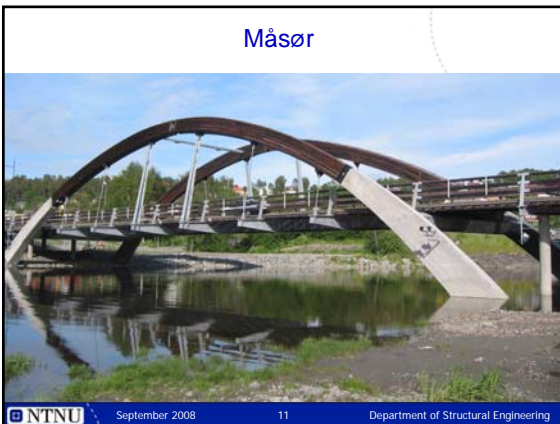
## Horne Bridge



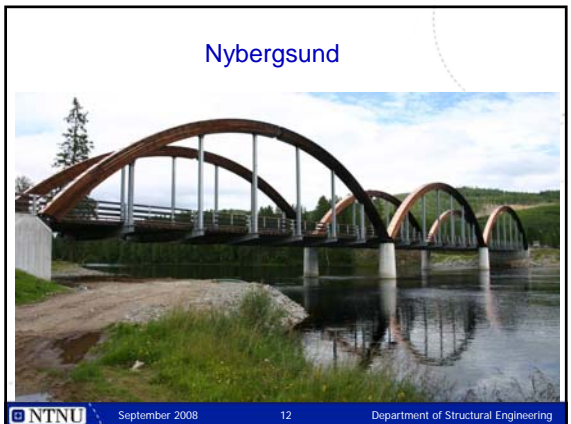
## Fretheim (Flâm)



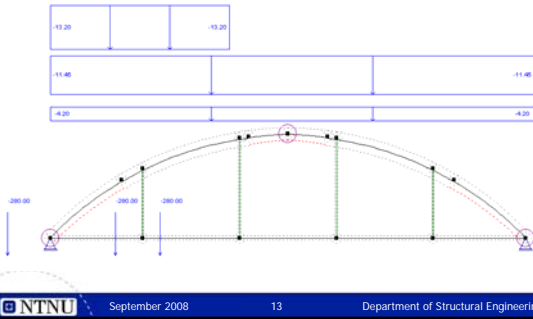
## Måsør



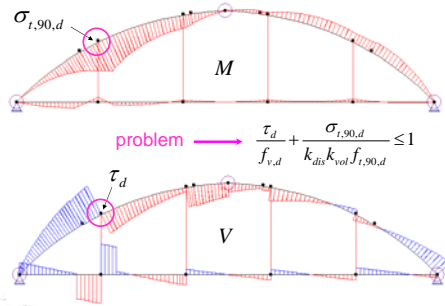
## Nybergsund



Example: Glulam arch bridge - loading



Bending moment (M) and shear force (V)  
Stressed Volume = ?



problem  $\rightarrow \frac{\tau_d}{f_{v,d}} + \frac{\sigma_{t,90,d}}{k_{dia} k_{vol} f_{t,90,d}} \leq 1$

What to do?

- Moisture as ACTION?
- Design models?
- ACTION  $\geq$  RESISTANCE ?
  - How to calculate resistance?
  - Connections?
- Crack arrestors?
  - How to calculate resistance?

Reinforcement, Repair, What to do?

Here: Reinforcement by LVL Kerto

