LBTGC: Development of new design calculations in consideration of long-term behaviour

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Abstract

The research deals with the long-term behavior of bonded timber-glass-composite shear walls under constant shear stress on the basis of theoretical and experimental investigations. Specimens in two different configurations were produced and examined under two different continuous load levels for twelve months and cycling load in question of the shear strength of the adhesive. The small specimens were assembled according to previous examinations in order to compare the results. The medium sized specimens were designed as a shear wall and they were investigated under the same experiments as the small specimens. Only the investigations under cycling load were omitted.
The creep deformation of both kinds of specimens was documented and compared. The higher load level with 0.05 N/mm² showed higher creep deformations as the lower load level with 0.04 N/mm². But under both load levels the creep deformation continued after six months of continuous stress. In previous researches the acceptable load level with no creep deformation after 90 days was defined with 0.04 N/mm². This conclusion could not be confirmed at the current observation.
A difference between the two types of specimens occurred as well. The influence of climatic conditions on the behaviour of the specimens was observed too. These results were used to derive a modification factor for calculating load-bearing timber-glass composite structures.
The shear strength tests were held after variable times of preloading to examine the loss of shear strength in order to derive the modulus of shear deformation and deformation factors. The number of ten small specimens for one test series with a load level of 0.04 N/mm² for preloading showed a continuous loss of strength. For the higher load level only five small specimens were tested each time, these showed a high variation of shear strength. The examinations with the medium sized specimens were held with four specimens per load level per test series.
Subsequently the achieved results are compared with previous studies and safety factors are derived for the calculation of timber-glass-composite structures under long-term stress according to the same theoretical considerations as used in previous researches. The known coefficients could partially be confirmed but they should be considered critically.

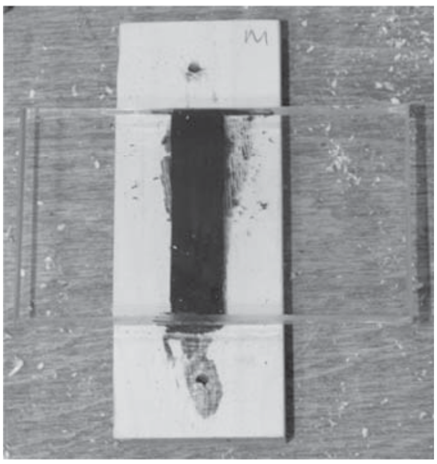

Figure 1: Small specimen

Figure 2: Medium sized specimen

LBTGC - Young Researchers Day
WoodWisdom Net ERA-NET Bioenergy
Load Bearing Timber-Glass Composites (LBTGC)

Development of design factors in consideration of long-term behaviour

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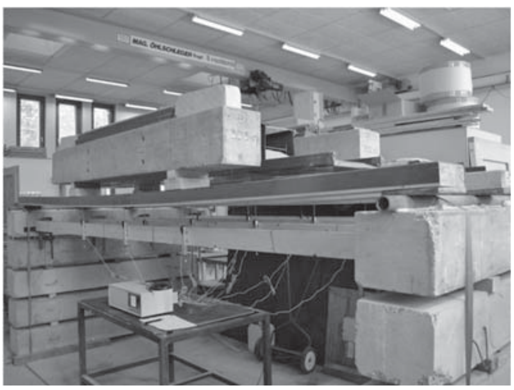
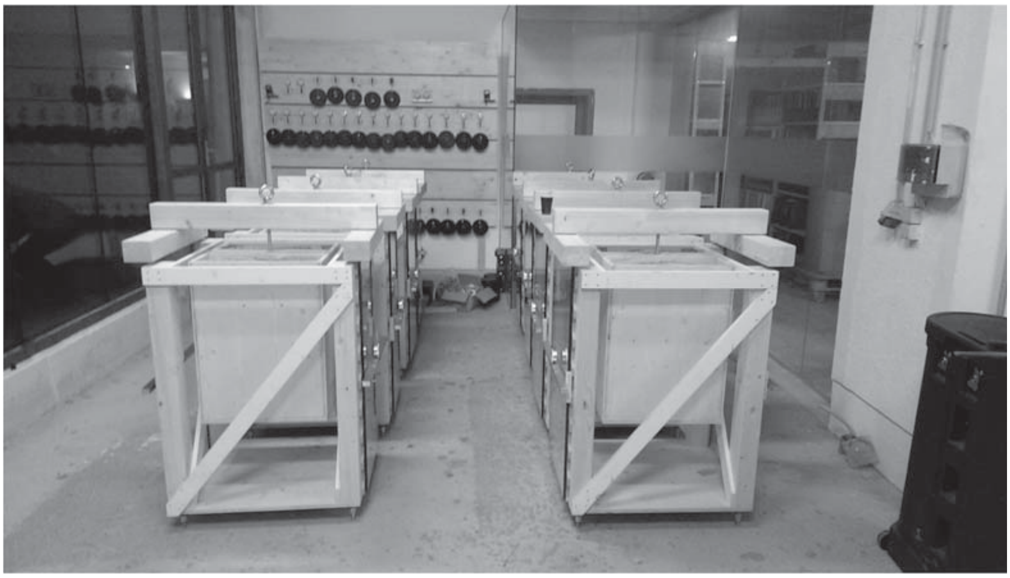
Long-term behaviour of hybrid constructions



Long-term behaviour of hybrid constructions



ETAG 002-1

- Guidline for structural sealant glazing systems
- Total safety factor for long-term behaviour $= 1/60$

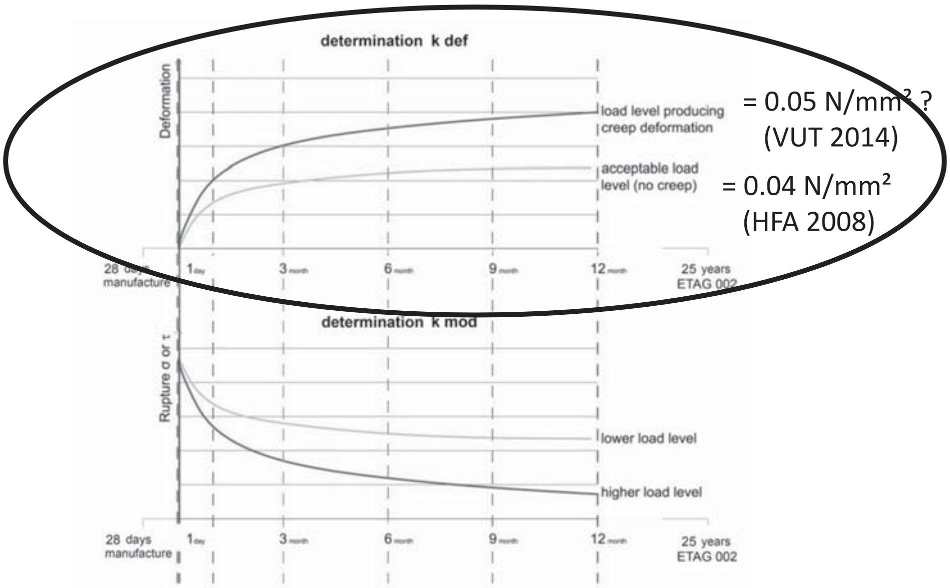
➞ Identify reserves to make LBTGC more attractive

HFA 2008

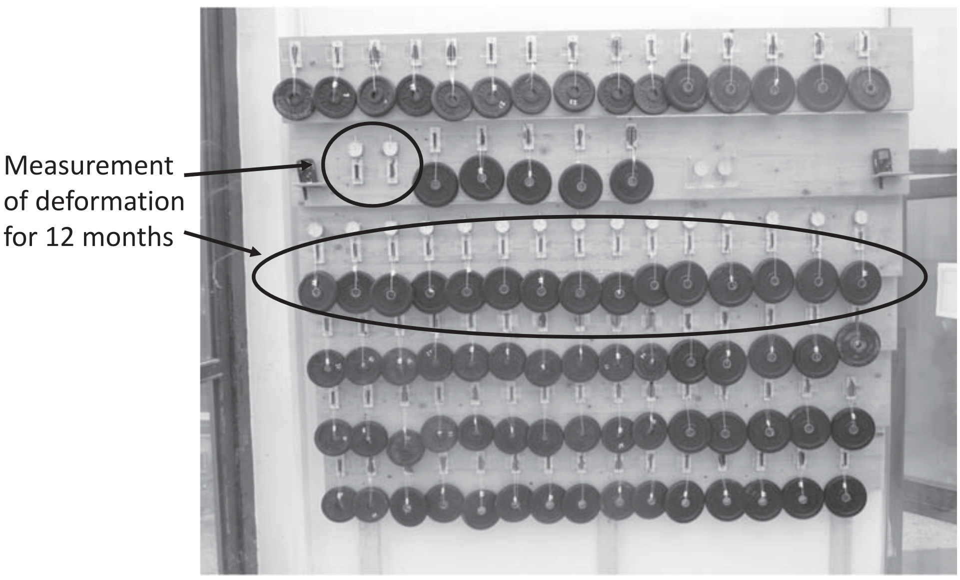
- Experiments to study long-term behaviour of LBTGC elements
- Total safety factor for long-term behaviour $= 1/15$

➞ To risky? Still reserves?

Modification and deformation factors for LBTGC - elements

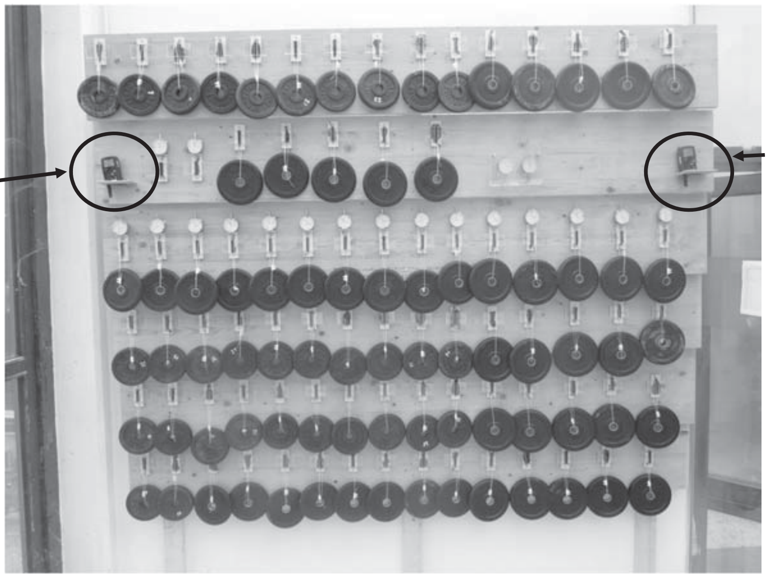


Small specimens – test setup



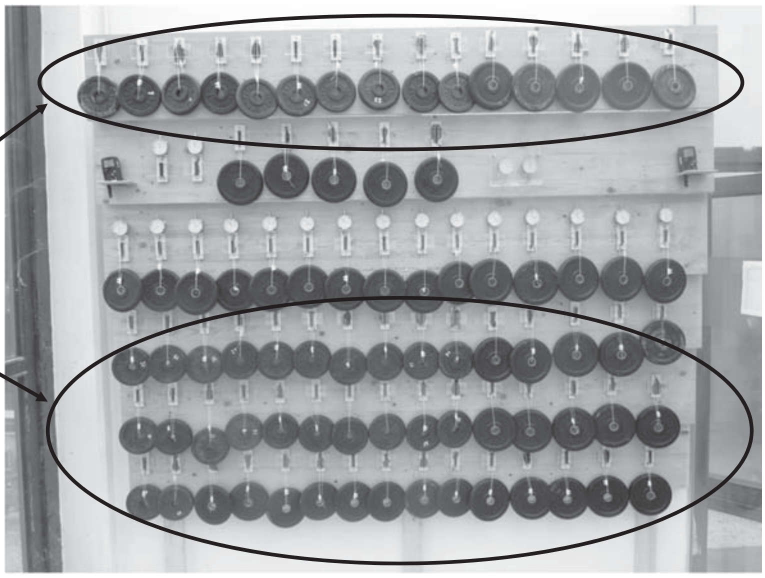
Small specimens – test setup

data logger for climate measurement



data logger for climate measurement

Small specimens – test setup



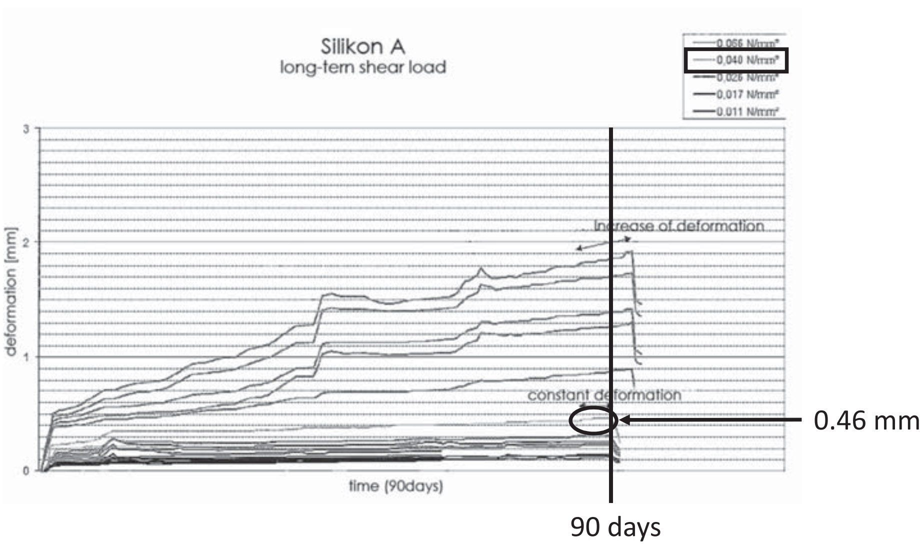
Measurement of residual shear strength at different time stages

Small specimens – test setup

Previous work from HFA 2008

Climatic conditions:

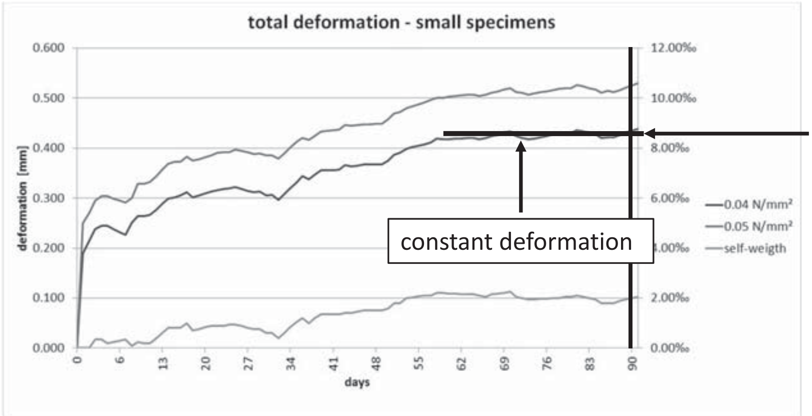
- Temperature = 20 °C
- Relative air humidity = 65 %



TU Vienna 2014 – 90 days

Climatic conditions:

- Natural indoor climate

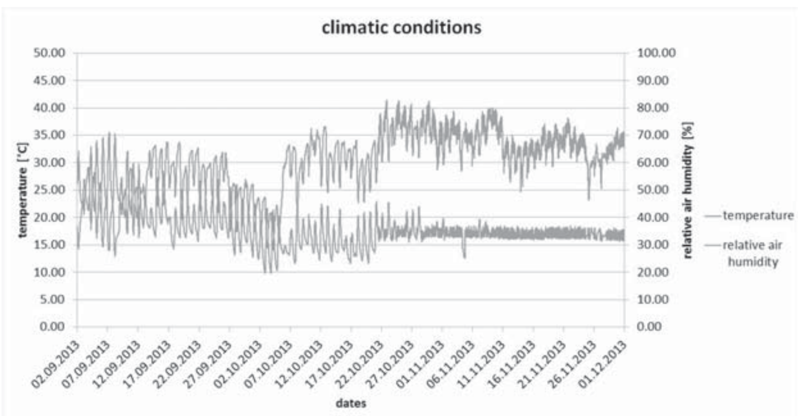


0.435 mm
(HFA: 0.46 mm)

TU Vienna 2014 – 90 days

Relative air humidity:

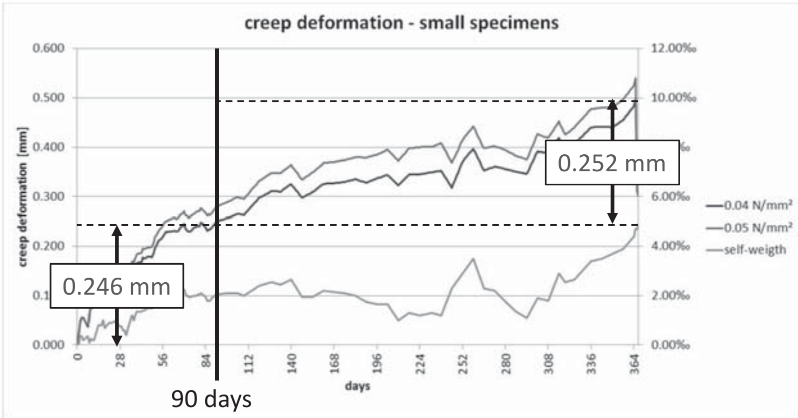
- Maximum: 83.20 %
- Minimum: 25.60 %



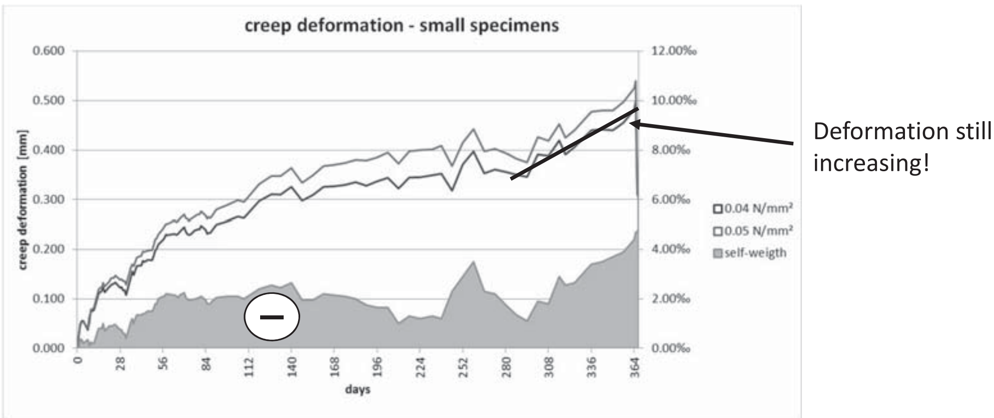
Temperature:

- Maximum: 35.60 °C
- Minimum: 9.60 °C

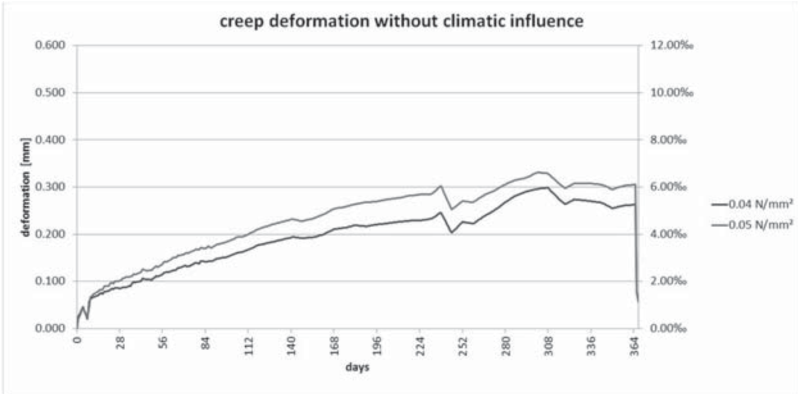
TU Vienna 2014 – 365 days



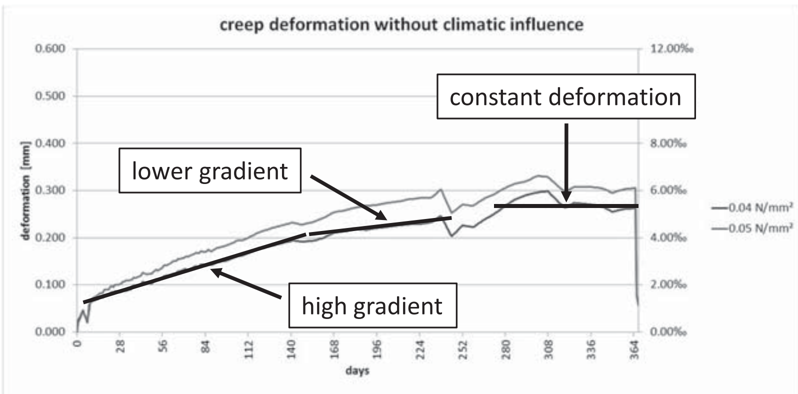
TU Vienna 2014 – 365 days



TU Vienna 2014 – 365 days



TU Vienna 2014 – 365 days



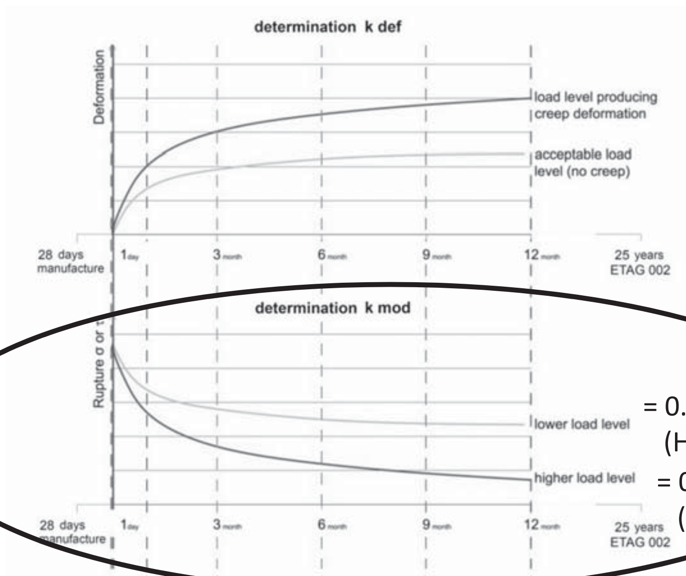
Determination of k_{def}

- $k_{def} = \frac{w_{91}}{w_0} - 1$
  - w_{91} ... deformation after 91 loaded days
  - w_0 ... deformation after initial loading

- HFA 2008:
  - $k_{def,1} = 1.0$
    (20 °C and 65 % relative air humidity)
  - $k_{def,2} = 1.6$
    (55 °C and 65 % relative air humidity)

- VUT 2014:
  - $k_{def} = \frac{0.435}{0.189} - 1 = 1.30$
    (natural indoor climate)

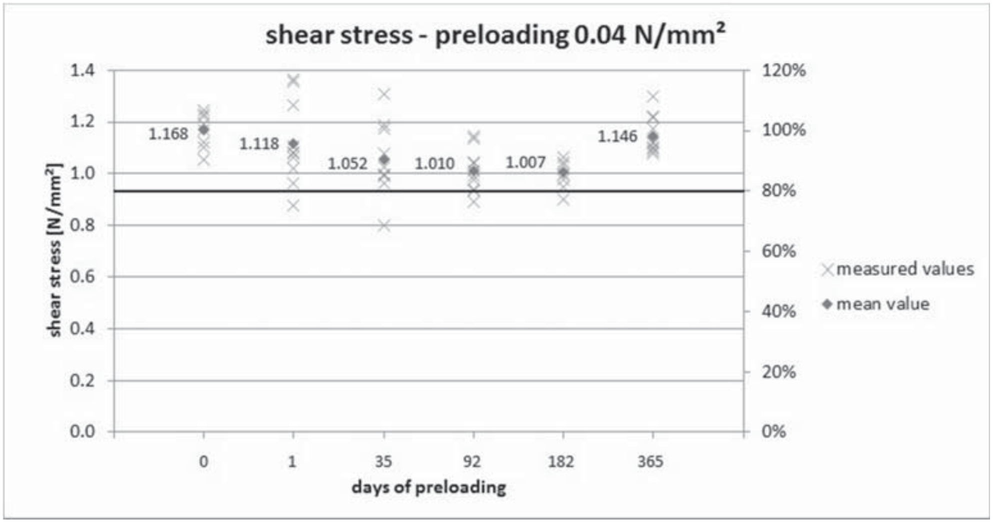
Modification and deformation factors for LBTGC - elements



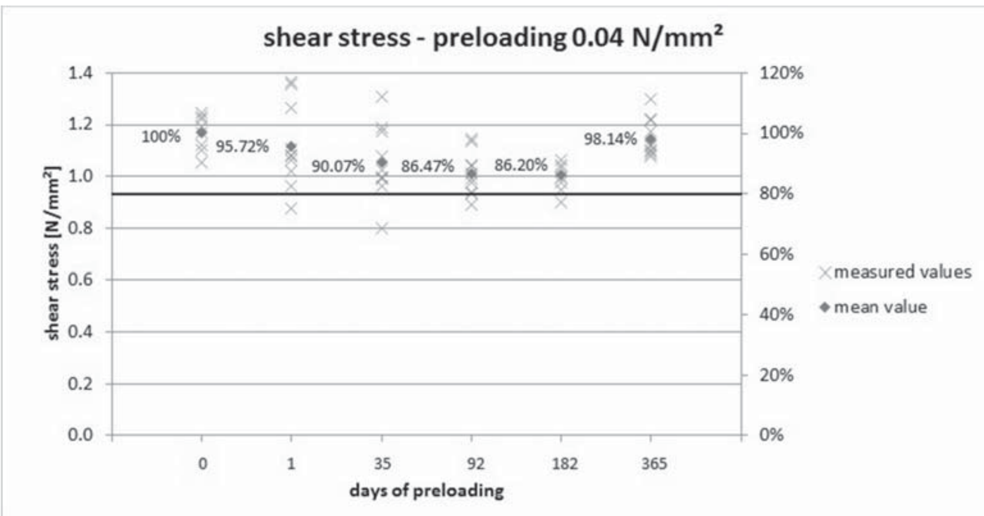
$= 0.04\ N/mm^2$ (HFA 2008)

$= 0.05\ N/mm^2$? (VUT 2014)

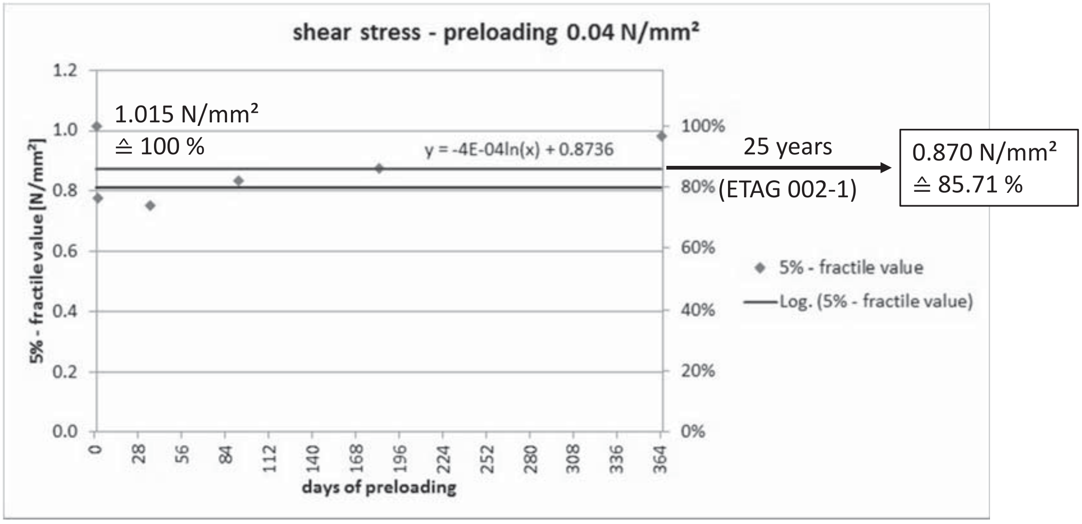
Residual shear stresses – mean values



Residual shear stresses – mean values



Residual shear stresses – 5% fractile value



Determination of k_{mod} and γ_M

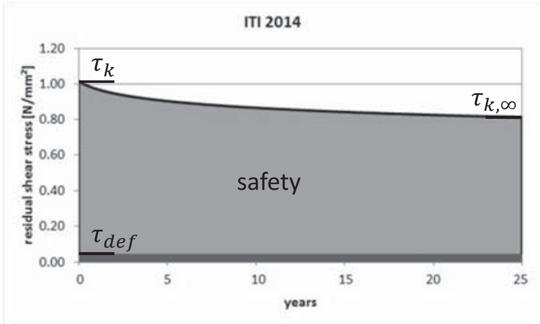
Theoretical: $k_{mod,long} = \frac{\tau_{k,\infty}}{\tau_k}$

$k_{mod,long} = \frac{0.870}{1.015} = 0.86$

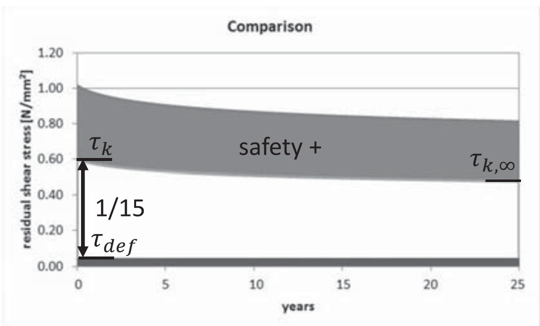
VUT 2011: $\frac{\tau_{k,91+1}}{\tau_k} > 0.8$ ✓

VUT 2014: $\frac{\tau_{k,\infty}}{\tau_k} > 0.8$ ✓

Safety factors



Safety factors



$$\frac{\tau_{def}}{\tau_k} = \frac{k_{mod}}{\gamma_M} \rightarrow \frac{0.04}{0.6} = \frac{1}{15}$$

$$\frac{\tau_{def}}{\tau_k} = \frac{k_{mod}}{\gamma_M} \rightarrow \frac{0.04}{1.015} \approx \frac{1}{25}$$

Determination of k_{mod} and γ_M

Base: $\frac{k_{mod}}{\gamma_M} = \frac{1}{25}$

1. γ_M according to VUT 2011:
- $\gamma_M = 6$ (VUT 2011)

$\rightarrow k_{mod} = 0.24$

2. k_{mod} according to VUT 2011:
- $k_{mod} = 0.2$ (VUT 2011)

$\rightarrow \gamma_M = 5$

Comparison:	HFA 2008:	$k_{mod} = 0.2$	
		$\gamma_M = 3$	$\rightarrow \frac{k_{mod}}{\gamma_M} = \frac{1}{15}$
	VUT 2011:	$k_{mod} = 0.2$	
		$\gamma_M = 6$	$\rightarrow \frac{k_{mod}}{\gamma_M} = \frac{1}{30}$
	ETAG 002-1:	$k_{mod} = 0.1$	
		$\gamma_M = 6$	$\rightarrow \frac{k_{mod}}{\gamma_M} = \frac{1}{60}$

Outlook

$$\frac{\tau_{def}}{\tau_k} = \frac{k_{mod}}{\gamma_M}$$

- Increase τ_{def}
  $\rightarrow$ 0.05 N/mm² as acceptable load-level?
- Decrease τ_k
  $\rightarrow$ why not $\tau_{k,\infty}$ instead of τ_k?
- Decrease γ_M
  $\rightarrow$ optimize bondline quality

Make LBTGC elements
more economic and more attractive
for industry and for users!