GFRP-Rebar in Construction

Introduction into design and application

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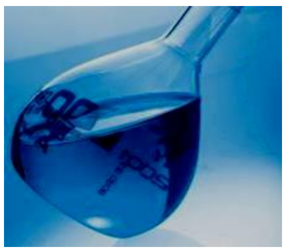
Agenda

- Production and Physical Properties of Glassfibre Rebar
- Application Fields
- Mechanical Properties and Design Basics
- Resumee

Material properties

load-bearing



corrosion resistant

machinable

not conducting, non-magnetic

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Glass Fibre Reinforcement: range of materials

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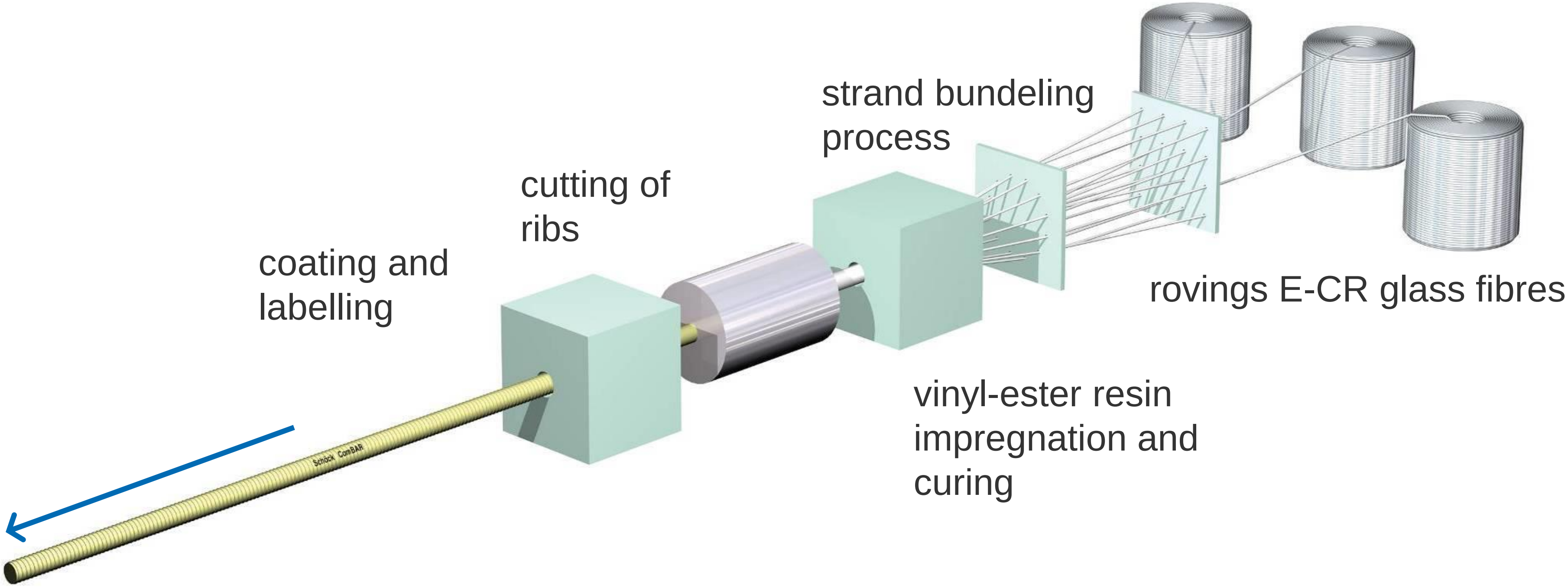
Material Properties: production process

Pultrusion



<u>Fiber content:</u>
75 % volume
88 % weight

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Tunnelling shafts – machinable reinforcement

- Paris Metro – Line 15
  (soft-eye, Station Clamart)

Coastal defence – non corrosive reinforcement

- Coastal Defence scheme, Rossall, UK

- Reinforced Earth, Hartlepool, UK

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Bridge structures – non corrosive reinforcement

- McHugh Street bridge, CA
  (bridge decks and barrier walls**)**

Research facilities – non magnetic reinforcement

- Max-Planck-Institut, Düsseldorf, DE (basic research on metal materials)

- Research facility for sub-sea cables, NL

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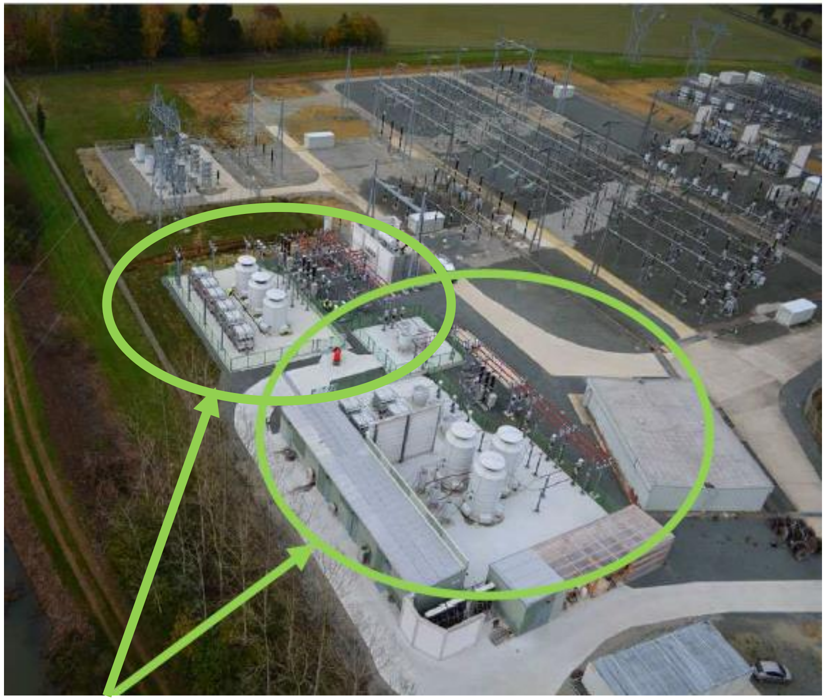
Light Rail structures - Non conductive reinforcement

- Crossrail London, UK
  (safeguard against electric shock)

- Tram Network Düsseldorf, DE
  (switch block for passage of trains)

Power transmission – non conductive reinforcement

- Domloup, FR
  (MSCDN-setup for power supply)



- Ras Al-Khair, KSA
  (Power line for aluminium smelter)

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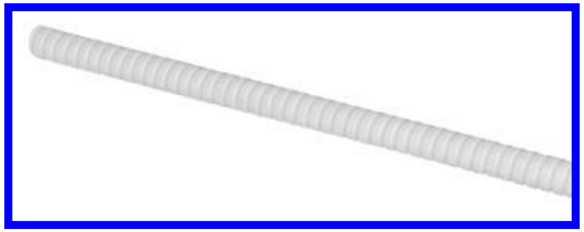
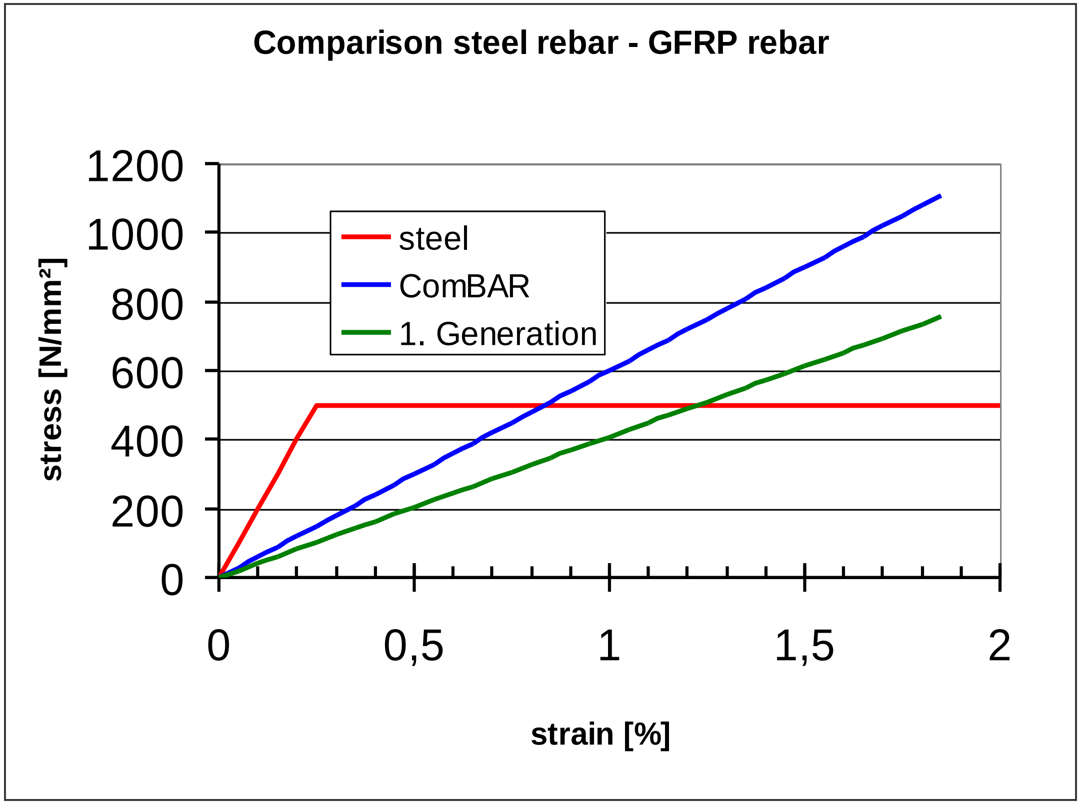
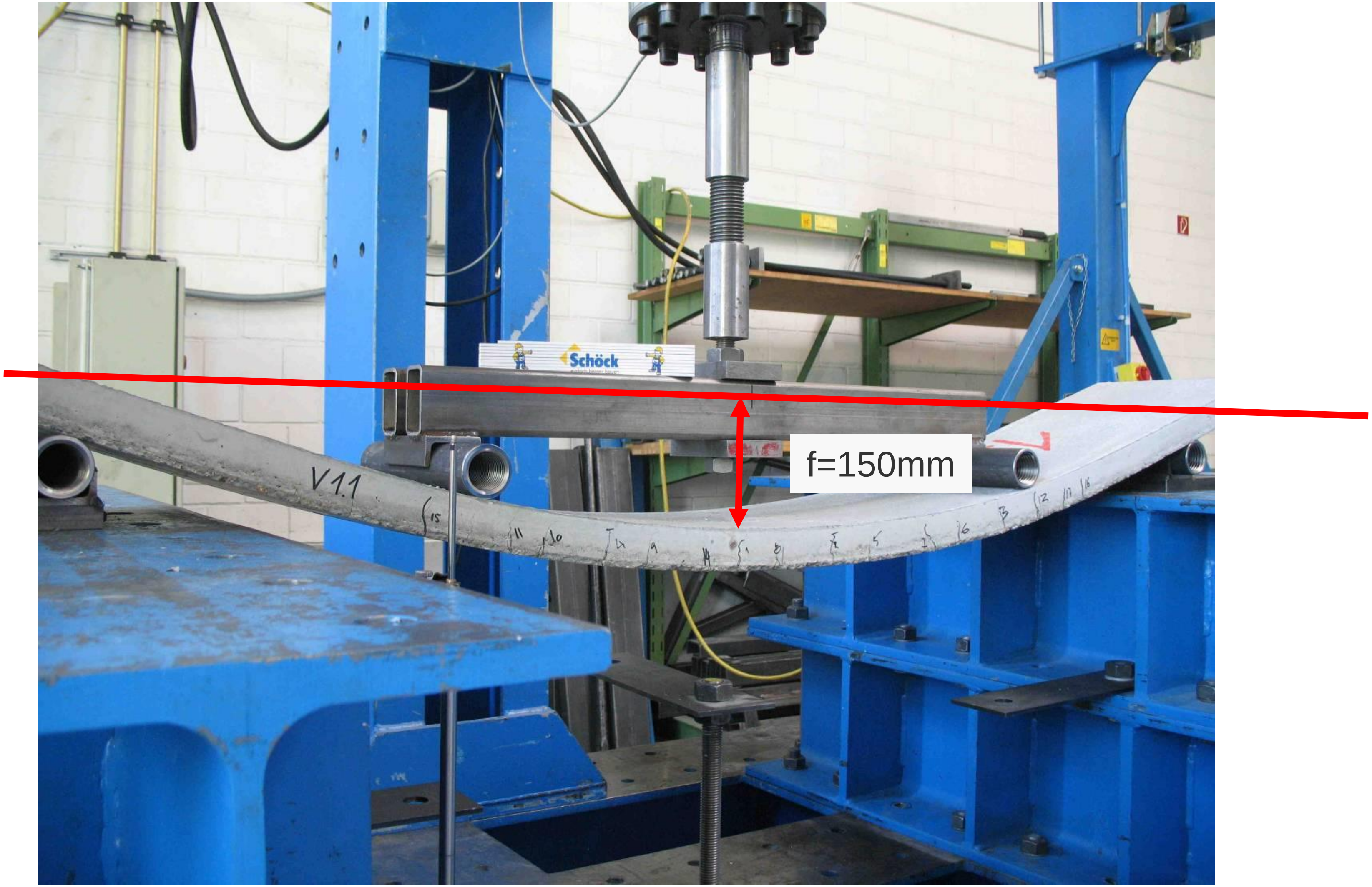
Stress-strain for generations of gfrp rebar

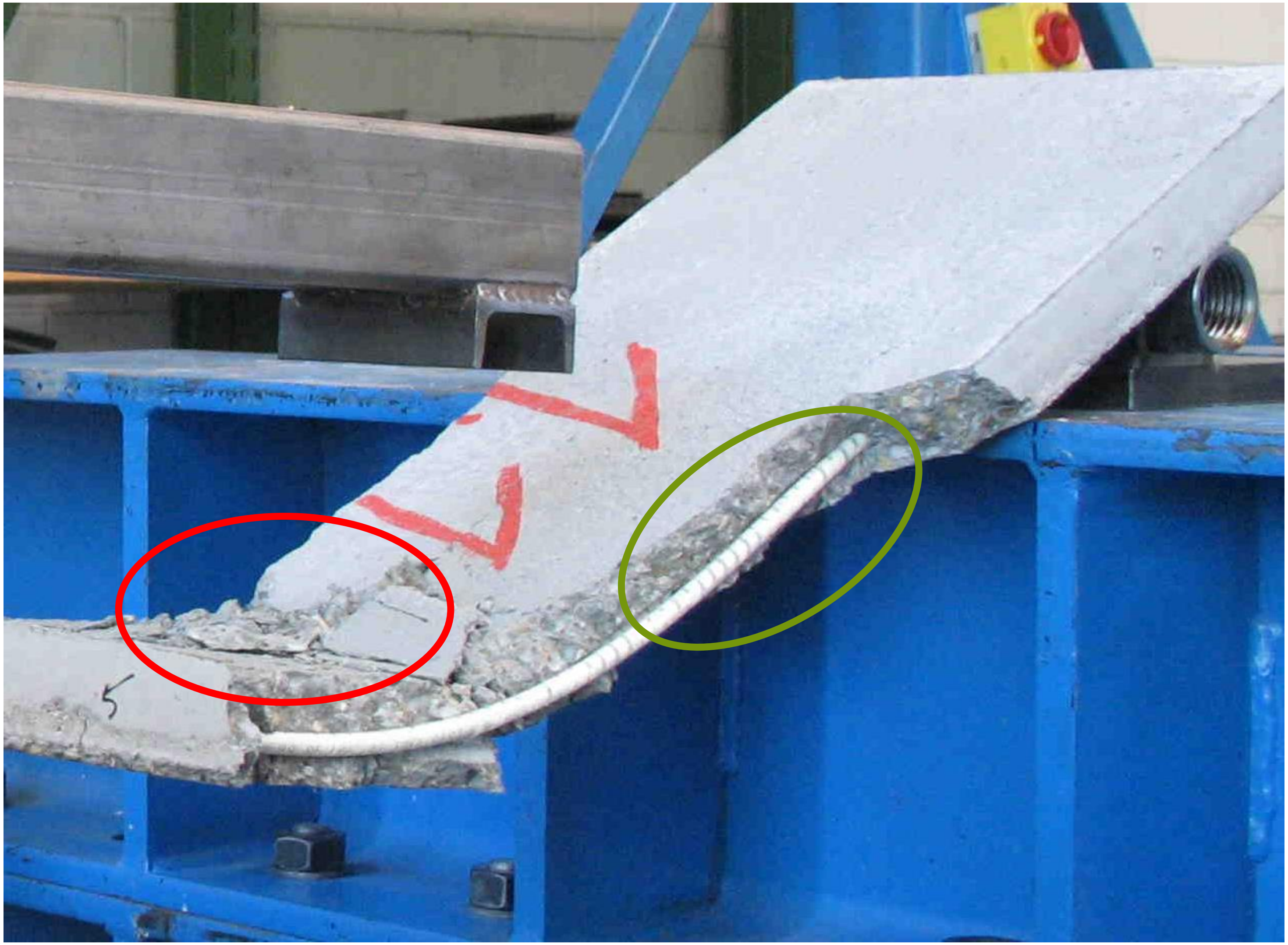




Bending test concrete slab 45mm

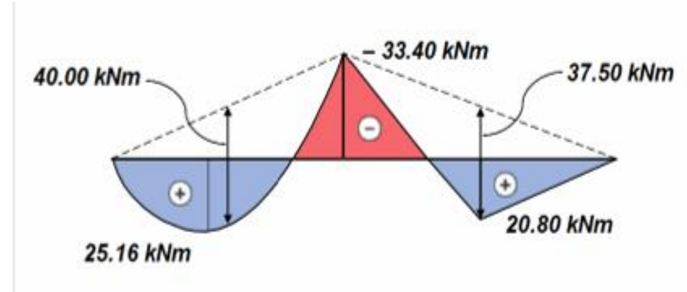


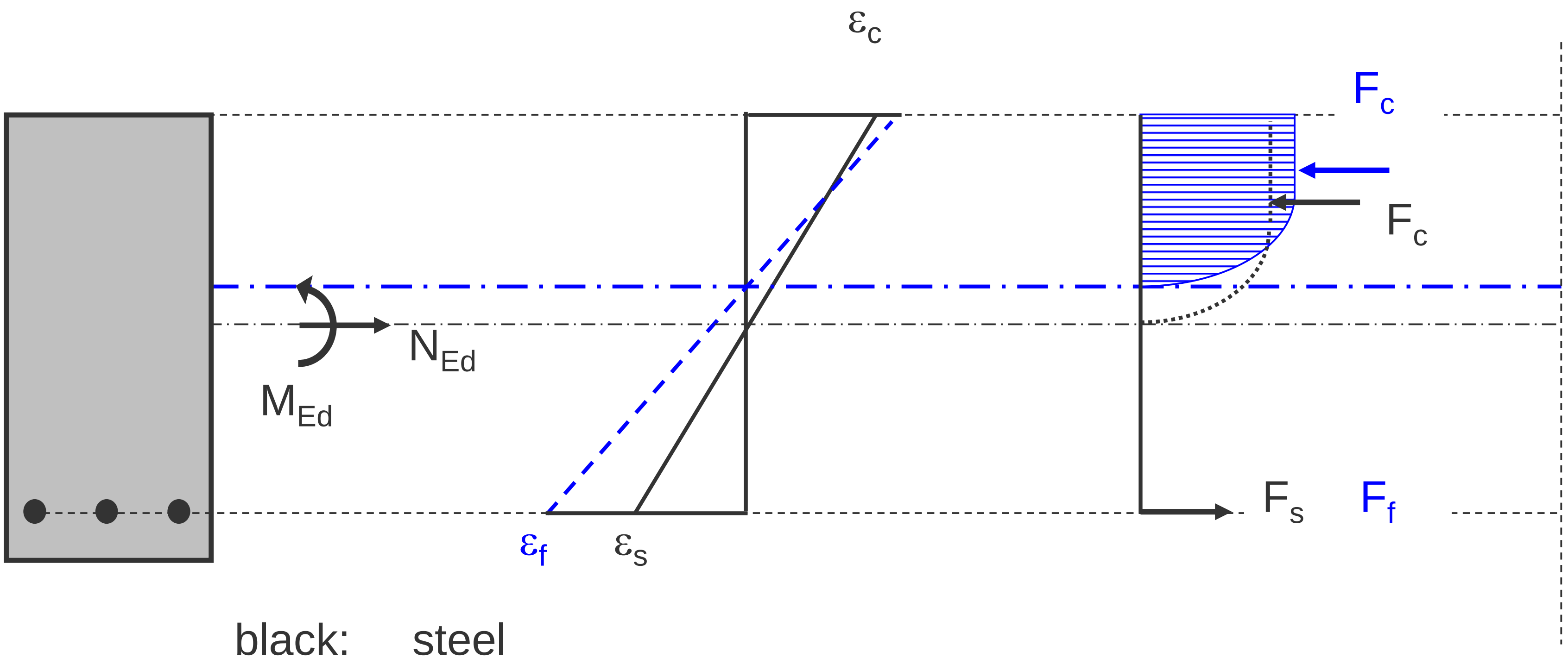
Bending test concrete slab 45mm



Design: M + N (EC-basis)

- confinement of compressive zone

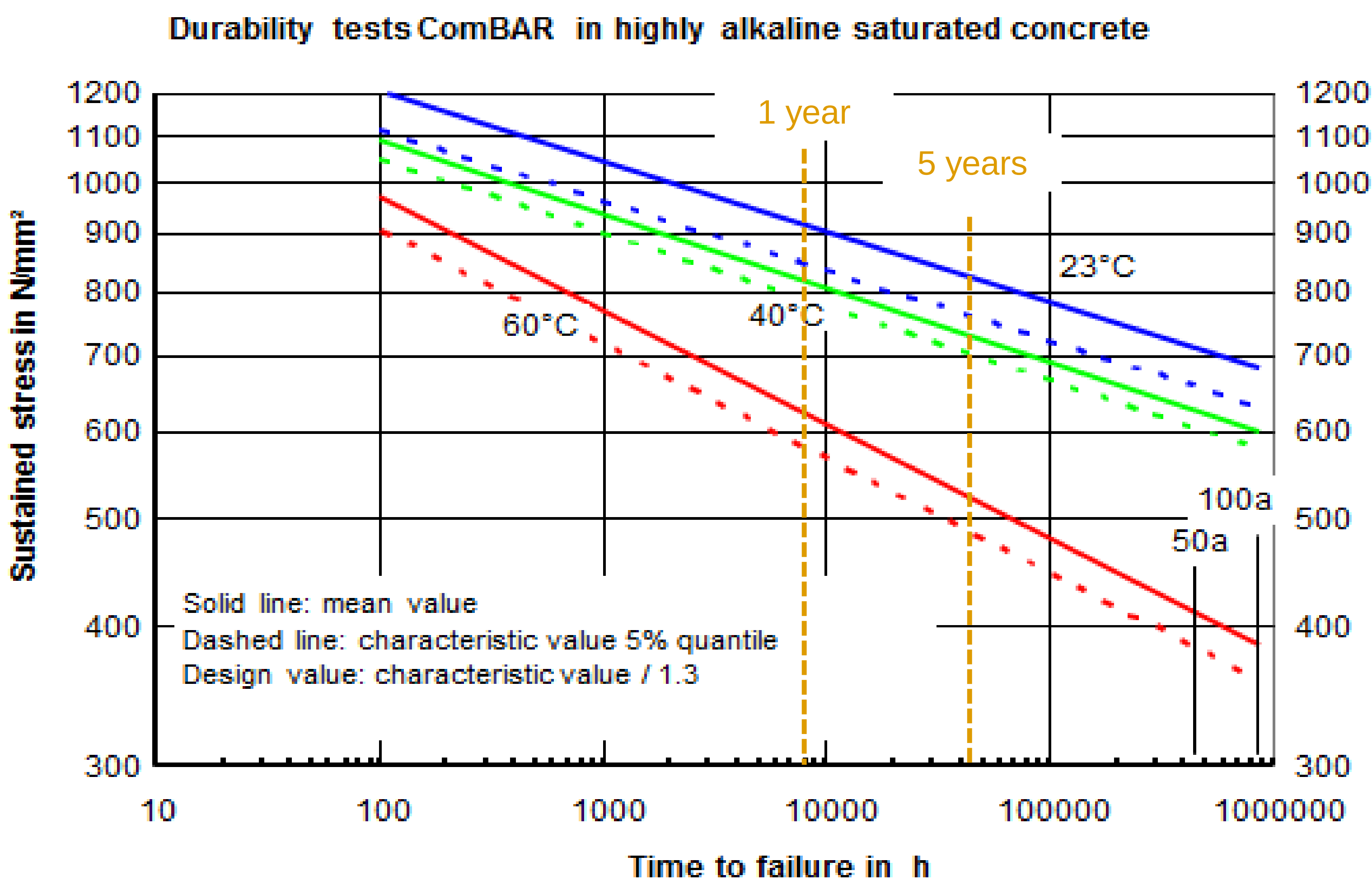




black: steel
blue: glass fibre

Design Value Tensile Strength

fib (log. stress vs. log. time)



Influence of Codes and Guidelines

ACI 440.1R-06	EC2 / fib (German approval)	*CNR DT 203/2006*
Global safety concept *(ca. 1.8 = 1.35 *1.35)* *Environmental factor: 0.7 (0.8)* *ULS : Strength reduction factor 0.55 …. 0.65* $f_{fd,u} = x*0.7*0.65/1.35 = 0.34x$ *SLS : deformation, crack width,* ***DURABILITY*** $f_{fd,s} = x*0.7*0.2*1.35 = 0.19x$ *For a material with tensile strength of 1000 Mpa (a factor of 1.35 is taken into account for Load side for proper comparison with EC2 values)*	Test concept: "Time-to-failure" Long term effects for sustained stresses are already included in the design values. Basis is semi-probabilistic concept as in EC2 with values determined under realistic conditions. Partial safety factor for material resistance is 1.3 Different materials will show different design values according to test results under permanent loads	*Environmental factor : 0,7(0,8)* *ULS :* $\gamma = 1,5/0,9 = 1,67$ *SLS :* $\gamma = 1.0$ *Long term effects:* *ULS : 1,0* *SLS : 0,3 (1,0 for up to 1 year)* *ULS :* $f_{fd,u} = x*0,7/1,67 = 0,42x$ *SLS :* $f_{fd,s} = x*0,7*0,3/1,0 = 0,21x$ *for up to one year: 0,3x*
$F_{fd\ (equivalent)}$ = 190 Mpa	**f_{fd},100a = 445 Mpa** **($f_{fd,5a}$ = 500 Mpa – 5 years)**	***$f_{fd\ (equivalent)}$= 210 Mpa*** ***($f_{fd,1a}$ = 300 Mpa – one year)***

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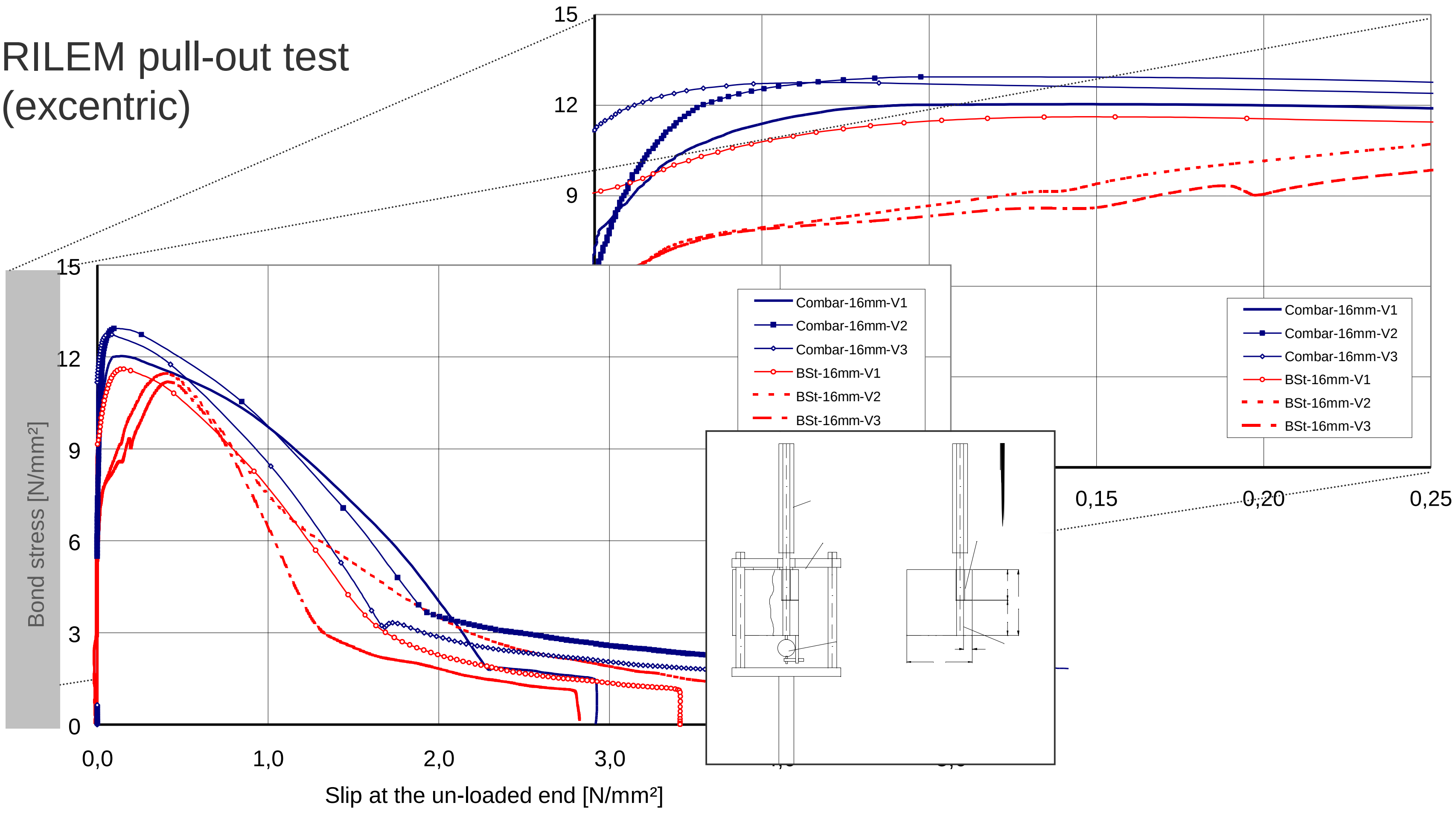
Bond (short-term)

RILEM pull-out test
(excentric)



$f_{bd\ ComBAR} \cong f_{bd\ BSt}$

Resumee

Design Basics

- Differen stress and strain distribution than for steel
- Strong influence of design concept
- Only performance based comparison of different materials suitable

Material properties

- E-Modulus lower than for steel
- Bond similar to steel
- Linearly elastic until failure, no plastification.

Codes and Guidelines

- logarithmic relationship of stress and time under load - No prediction of long term behaviour on basis of short term tests
- Codes not to be mixed
- EC2 basis available for design

Applications

- Machinability for tunnelling
- No conductivity for electric power infrastructure and research
- Corrosion resistance for longer lifetimes