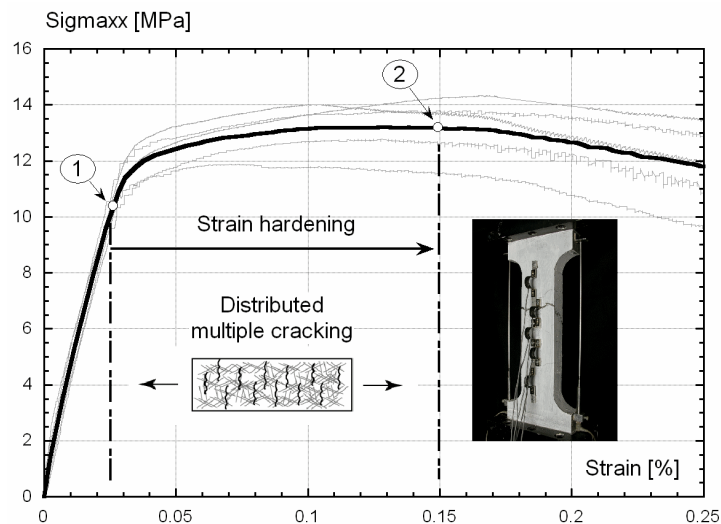


Exercise 9: Ultra High-Performance Fiber Reinforced Concrete - dimensioning

A lightweight floor for a building is to be constructed from 1 m wide prefabricated UHPFRC plate elements. A total live load of 5 kN/m², an overall safety coefficient $\gamma_G = 1.35$, and a span of 2 m between the beams supporting the UHPFRC slabs are assumed. The average uniaxial tensile strength of the UHPFRC, i.e. 14 MPa, was determined by inverse analysis of 5 4 PT bending tests on plates. The corresponding standard deviation is around 1.1 MPa for 5 specimens tested in uniaxial tension (see figure below). The density of this UHPFRC is approximately 28 kN/m³ and its modulus of elasticity 45 GPa.



Work to be carried out - basis: AFGC recommendation (2013):

1. Determine the 5% fractile (Student's law) of uniaxial tensile strength for this UHPFRC. For 5 specimens, a Student's coefficient of 2.0 can be assumed.
2. Determine the design value after AFGC guidelines of the uniaxial tensile strength of a structural element for this UHPFRC (global loads and local loads), see appendix 1.
3. What is the required thickness of the UHPFRC plate? Let's assume that the position of the neutral axis at the peak is approximately 80% of the total height, from the tensioned side, and that the effective tensile strength of the UHPFRC is reached at the flexural strength peak, with rectangular and contiguous stress blocks, in tension and compression.
4. Check the deflection at SLS for this UHPFRC plate ($f = 5ql^4/384EI$ for uniform load).
5. What would be the plate thickness and reinforcement required for the same application if reinforced concrete were chosen? – You can assume $f_{ct,d} = 2.5$ MPa and $E = 35$ GPa for the concrete.
6. Discuss the results.

Appendix 1

Design values according to AFGC recommendations

1 - End lin. elast domain

$$f_{td,el} = \frac{f_{ctk,el}}{\gamma_{cf}}$$

Partial safety factor (ULS)

$\gamma_{cf} = 1.3$ (sustainable project situations)

$\gamma_{cf} = 1.05$ (accidental project situations)

Transfer coefficient $K \geq 1$ (orientation effect of the fibers)

2 – Hardening domain

$$f_{td} = \frac{f_{ctfk}}{\gamma_{cf} \cdot K}$$

$K_{local} = 1.75$ (local forces)

$K_{global} = 1.25$ (global forces)

*(recommended in the absence of
experimental data, otherwise based on tests on
representative structural elements)*

➔ $f_{ctk,el}$ and f_{ctfk} = 5% fractile according to Student's law on laboratory specimens

Reference

AFGC (2013), "Bétons Fibrés à Ultra Hautes Performances", Recommendations, Association Française de Génie Civil, revised edition, June 2013.

ED/ed - 11.2024