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Mechanical Properties of Reinforcing Bars Heated up Under Steady Stress Conditions



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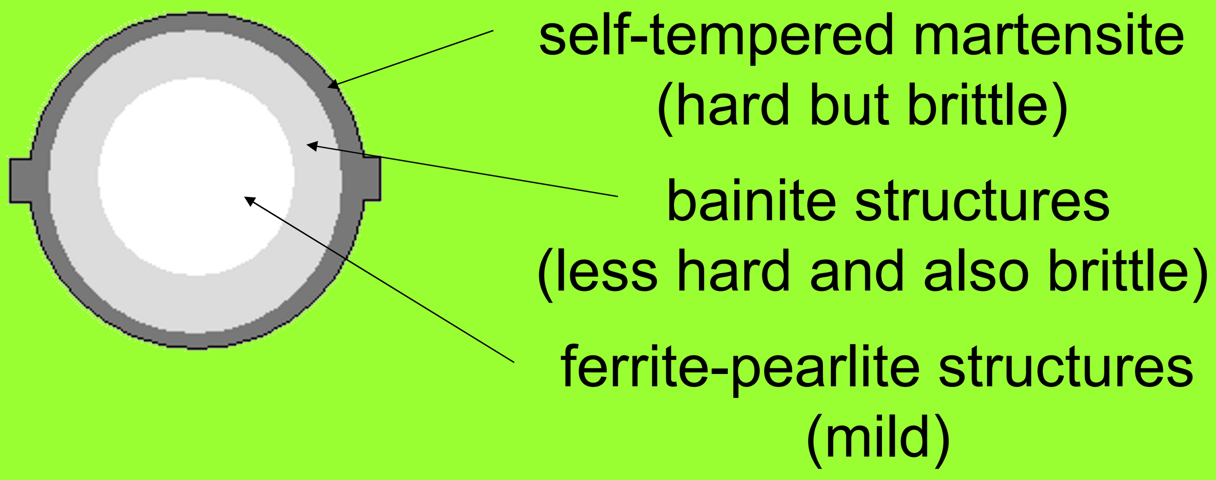
What was the reason of research?

The bars, which are nowadays most frequently used for reinforced concrete structures, are produced in a process of quenching and self-tempering; such method results in diversified mechanical properties in several zones of bar cross-section.



- Is the recommendation given in EN 10002-5:1998 code, which states that mechanical properties of reinforcing steel may be tested on specimens turned from bars of bigger diameter proper?
- Would the decrease of mechanical properties in high temperature for bars with various diameters be the same?

Test procedure and results

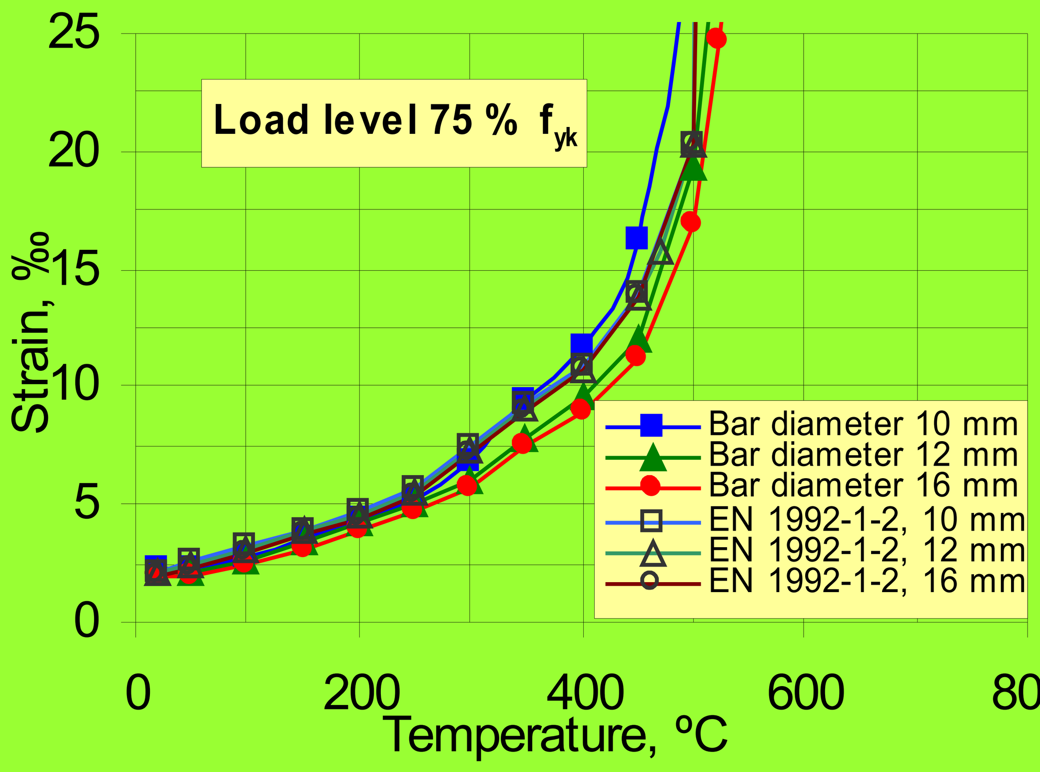
Method:

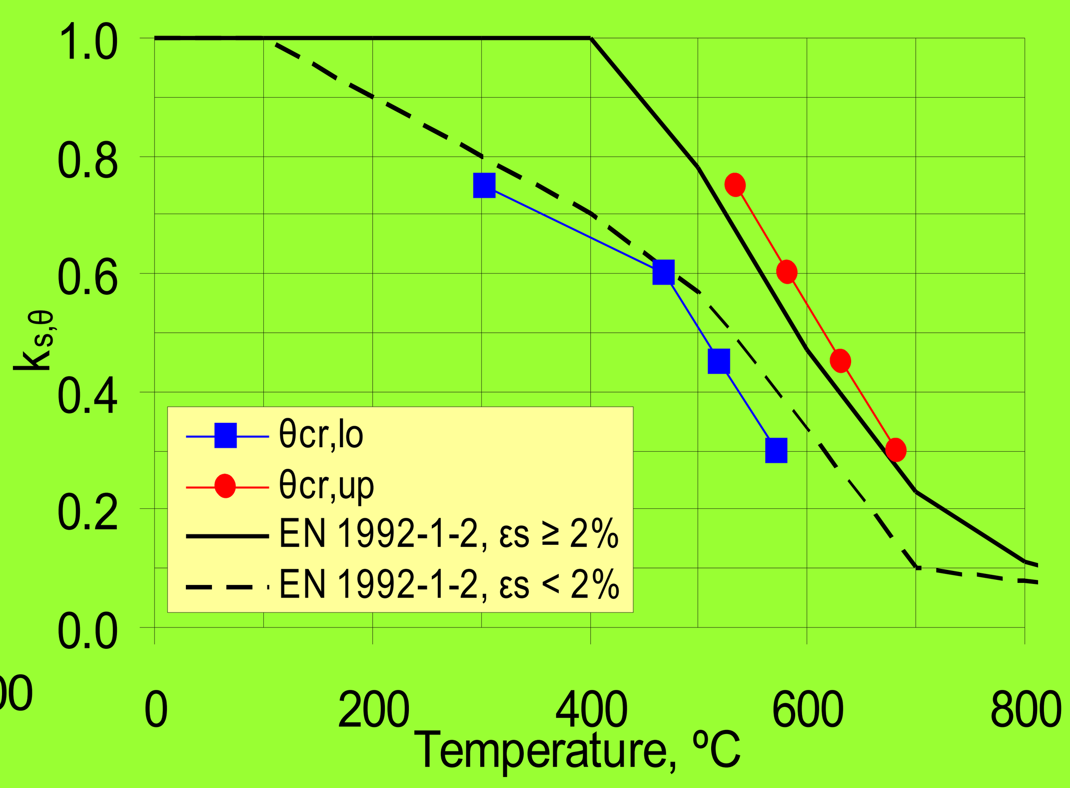
- Tests performed at variable (increasing) temperature; 10 ºC/min heating rate,
- Hydraulic testing machine, onto which an electrically heated furnace was mounted,

- 10, 12 and 16 mm diameter bars, made of B500SP thermal strengthened steel, commonly used in Poland,
- Yield strength claimed by the manufacturer: 500 MPa, tensile strength: 575 ÷ 675 MPa (verified in room temperature tensile tests),
- 80 mm gauge length,
- Load levels of: 0, 30, 45, 60 and 75% of average yield strength determined experimentally at room temperature,
- total: 75 tests.

Results:

- Obtained strain-temperature relationships for every load level; an example shown below,
- Two separate temperatures were featured: critical lower temperature ($\theta_{cr,lo}$), in which obtained relationship stops to be linear, critical upper temperature ($\theta_{cr,up}$), in which real destruction of specimen occurs,
- A graph presenting steel strength reduction factor ($k_{s,\theta} = f_{y,\theta}/f_{yk}$) prepared upon the average values of critical temperatures.





Conclusions

- The obtained strain-temperature relationships that range from the beginning of heating process to reaching a critical value of temperature, are close to linear. Afterwords, one may observe an impetuous increase of strain, leading to the breaking of tested bar.
- The obtained strain-temperature relationships are accordant to the relationships found in the EN 1992-1-2 recommendations; despite the fact, that EN 1992-1-2 model assumptions are based on tests carried out in steady (constant) temperature.
- Experimentally evaluated temperature-strain relationships and values of the steel strength reduction factor deems not to be diameter-dependent.
- While predicting a behaviour of thermal strengthened reinforcement in bent RC elements in fire, it seems justified enough, to take into consideration the sum of free thermal strain and the strain caused by stress.