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MATERIAL MODELLING OF THE POST-PEAK RESPONSE OF REINFORCED CONCRETE AT ELEVATED TEMPERATURES

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MOTIVATION

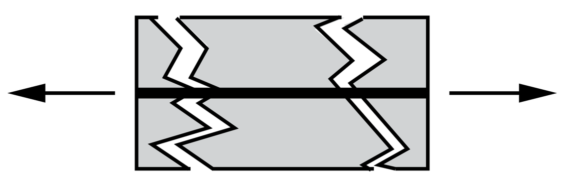
For FE-analysis of reinforced concrete at elevated temperatures the current material models yield convergence problems for different mesh sizes. For ambient conditions, it has been established that using a **fracture energy** based material model circumvents this issue. It is therefore relevant to extend these models to the elevated temperature conditions.

FRACTURE ENERGY

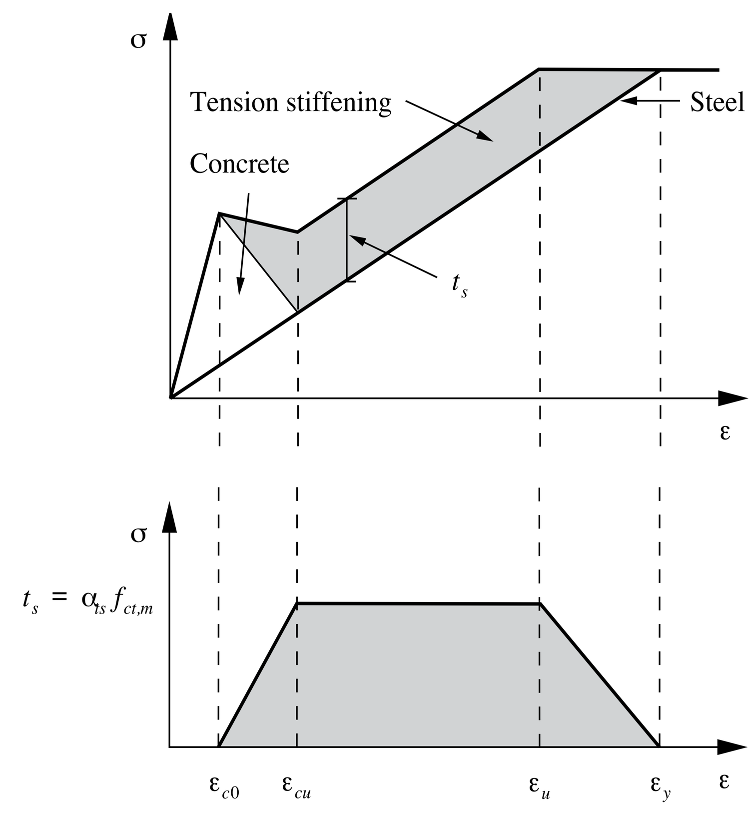
The fracture energy is a material invariant that coresponds to the area beneath the stress-plastic displacement (or cracking) diagram.

TENSION STIFFENING

The uncracked part of the concrete still contributes to the strength after cracking is initiated.



This can be modelled based on the fracture energy by an interaction stress contribution as suggested by Cervenka et al. and Feenstra and de Borst.



Problems in the Ambient Condition

A **validity range for the element size** and a **minimum reinforcment ratio** is formulated.

EVOLUTION OF FRACTURE ENERGY WITH TEMPERATURE

The inherent fracture energies are found as function of temperature for the existing elevated temperature behaviour models for concrete.

Tensile Fracture Energy

Based on the model by Terro, G_{fT} follows the decay of tensile strength;

$$G_{fT} = \xi(T) \cdot G_f$$

Compressive Fracture Energy

G_{cT} is found for the models by;

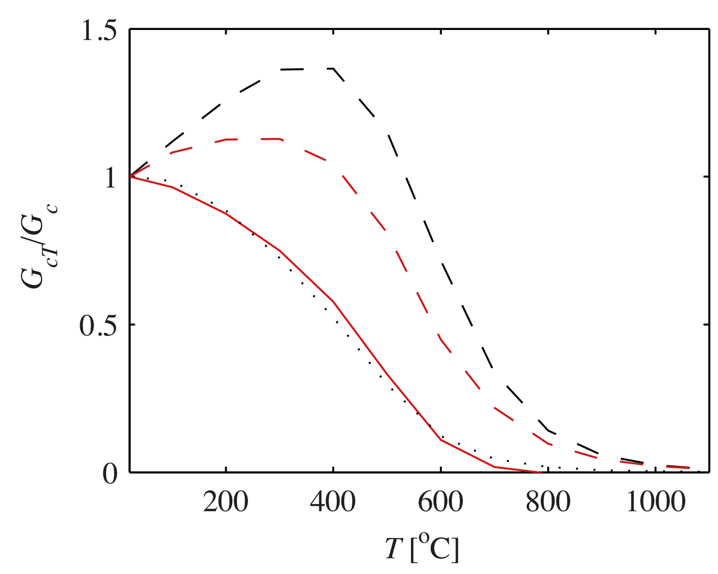
– – – Lie and Lin

—— Anderberg and Thelandersson

And the models including the effect of the load induced thermal strains (LITS) by;

· · · · · · Li and Purkiss

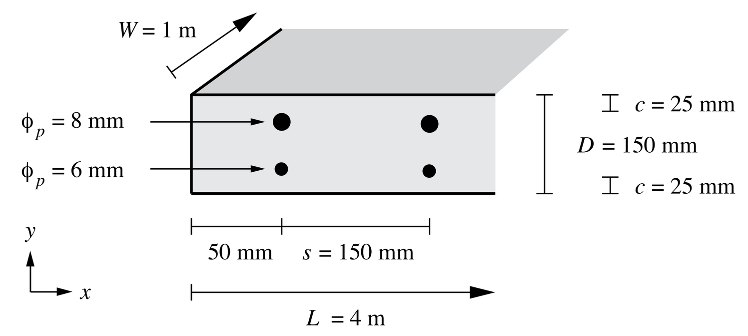
– – – Eurocode 2



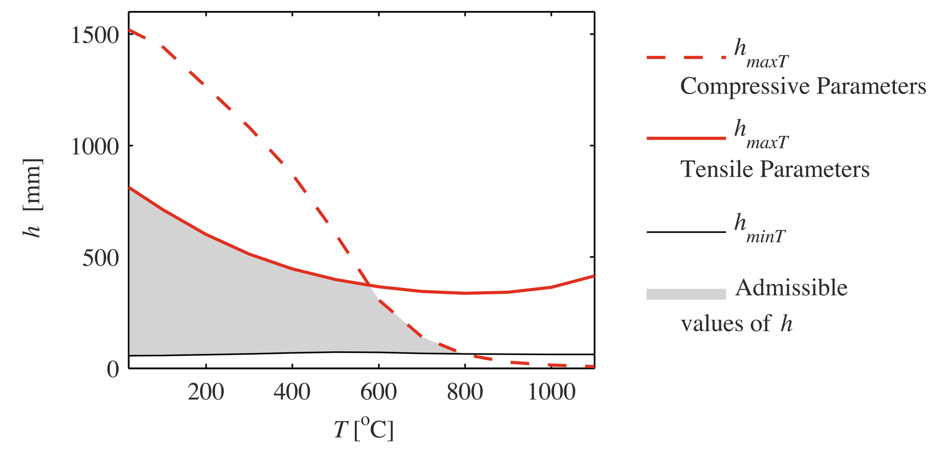
EXAMPLE

REINFORCED CONCRETE SLAB

Concrete grade C30 and steel Grade 500 and G_{cT} as is computed as inherent in Eurocode 2.



The validity range for the element size:



T_{max} = 715 °C and the hence

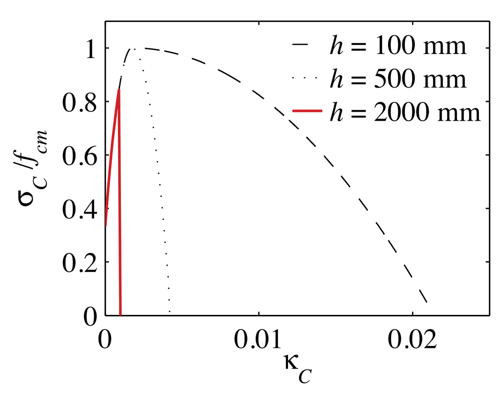
72.5 mm < h < 129.6 mm

The level of reinforcement is found to be sufficient.

CONCLUSION

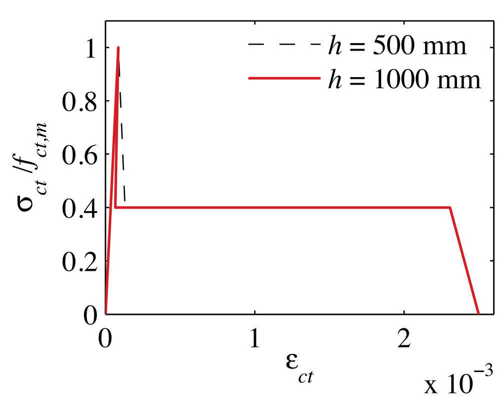
- G_{fT} follows the decay of material strength.
- There is a significant spread in the existing compressive post-peak behaviours.
- The LITS does not appear to influence G_{cT}.
- For the considered example, analysis above 800 °C will not converge.

Compressive behaviour

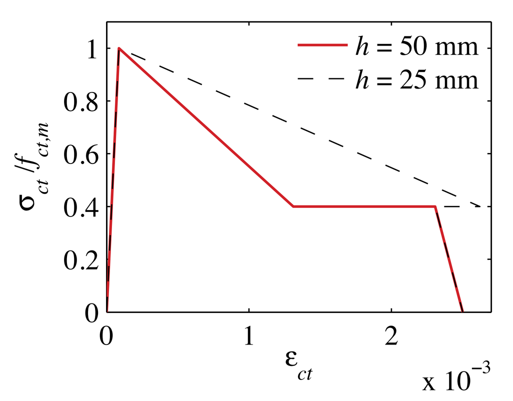


Element is too large

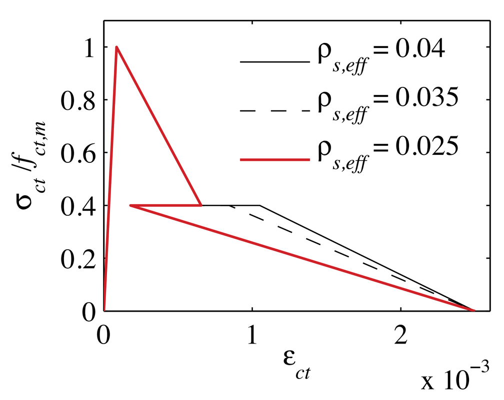
Tensile behaviour; combined concrete and interaction stress contribution



Element is too large



Element is too small



The reinforcement ratio is too small

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