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## Constitutive Laws

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### ABSTRACT

1. The contribution of constitutive laws to the theory of structures
2. Constitutive laws and design stages – design and review
3. Are design and research models opposites?
4. Safety considerations resulting from constitutive laws
5. Open questions



## 1. THE CONTRIBUTION OF CONSTITUTIVE LAWS TO THE THEORY OF STRUCTURES

The role of constitutive laws in continuum theory, and for non-homogenous materials is demonstrated. Constitutive laws may start at micro level regarding e.g. the strength resulting from atomic interaction, may go to a meso level or macro level. How exact is exact? Problem orientation.

"A model has to be as simple as possible, but not simpler."

## 2. CONSTITUTIVE LAWS AND DESIGN STAGES - DESIGN AND REVIEW

### Strength Design:

Compressive and tensile forces or their combination in moments for conceptual design (theme 2.3, A. Scordelis).

Simplified stress blocks, strut-and-tie models for preliminary or final design.

A "compressive strength of reinforced concrete" may be reasonable.

More sophisticated constitutive laws for review (theme 2.2, J. Schlaich).

### Non-Strength Relevant Problems:

The order with regard to complexity - or what is declared as such - may be reversed when usual shorttime strength is not relevant as e.g. in cases of explosions, dynamic vibrations, temperature etc.

## 3. ARE DESIGN AND RESEARCH MODELS OPPONENTS?

A nowadays sophisticated dynamic or strain rate model may become a design model still trying "to be as simple as possible" e.g. in case of dynamic loads. If neglected, the behaviour of young concrete including shrinkage, creep and their temperature dependence may lead to obsolete serviceability checks in the usual design format.

## 4. SAFETY CONSIDERATIONS RESULTING FROM CONSTITUTIVE LAWS

Regarding non-linear material behaviour leads to a more economic design. Using simplified plasticity methods member capacities instead of cross sections may be the basis of design. An appropriate safety concept is necessary, as EC 2 is not consistent in this sense.

Unreliable tensile strength, multiaxial stress conditions, over reinforced concrete due to former load-histories need special safety considerations.

## 5. OPEN QUESTIONS

Among others we need stress-strain-laws regarding strain rate effects and constitutive laws regarding the influence of concrete age especially for young concrete. Extreme loading situations will be discussed.



