Damage prediction in a concrete bar due to extreme dynamic loading

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Introduction

Security-sensitive structures, such as military facilities, government buildings, strategic industrial infrastructures, bridges, dams, etc. should be designed to withstand explosions and high velocity impacts, both from terrorist attacks and other acts of war. Since concrete is the most widely used construction material understanding concrete material behaviour under high strain loading rates is crucial.

Objective

The overall purpose of this research is to understand and model the geometrical and physical nonlinear material behaviour of RC structures under highly dynamic loadings from micro-mechanical damage to structural failure.

Methodology

The first step was the comparison and analysis of the three most advanced concrete models implemented in LS-DYNA (a commercial hydro code): the Karagozian & Case Concrete (KCC) model, the Continuous Surface Cap Model (CSCM) and the Riedel, Hiermaier and Thoma (RHT) model. The models were evaluated for a wide range of stress states and loading rates. Attention is focussed on damage development in compression and tension. Bar impact tests were modelled in order to explore the material model's dynamic response in a basic configuration/set-up (see figure 1).

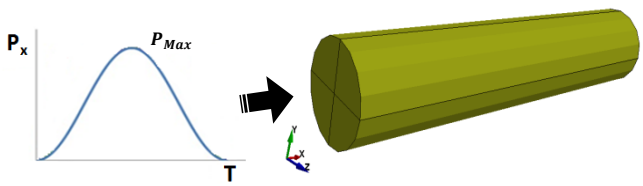

Figure 1: Bar impact test

Results

Figure 2 shows the damage prediction and the stress evolution in several points of the concrete bar ($250L \times 50\emptyset$ and $f_c = 45MPa$) along the specimen core, for a sinusoidal pressure load with $T = 60\,\mu s$ and $P_{Max} = 150MPa$ applied on the free edge. These results illustrate the dynamic response of the models.

Conclusions

1) The KCC, CSCM and RHT models belong to the same class (phenomenological, plastic/damage, rate dependent, etc.) but the dynamic responses are significantly different.
2) Damaged material acts as a filter. The characteristics of the transmitted, dispersed wave depend on the residual characteristics of the damaged material.
3) The damage definition differs per model. This parameter does not represent actual damage. It is not objective and therefore not directly suitable for model comparison.

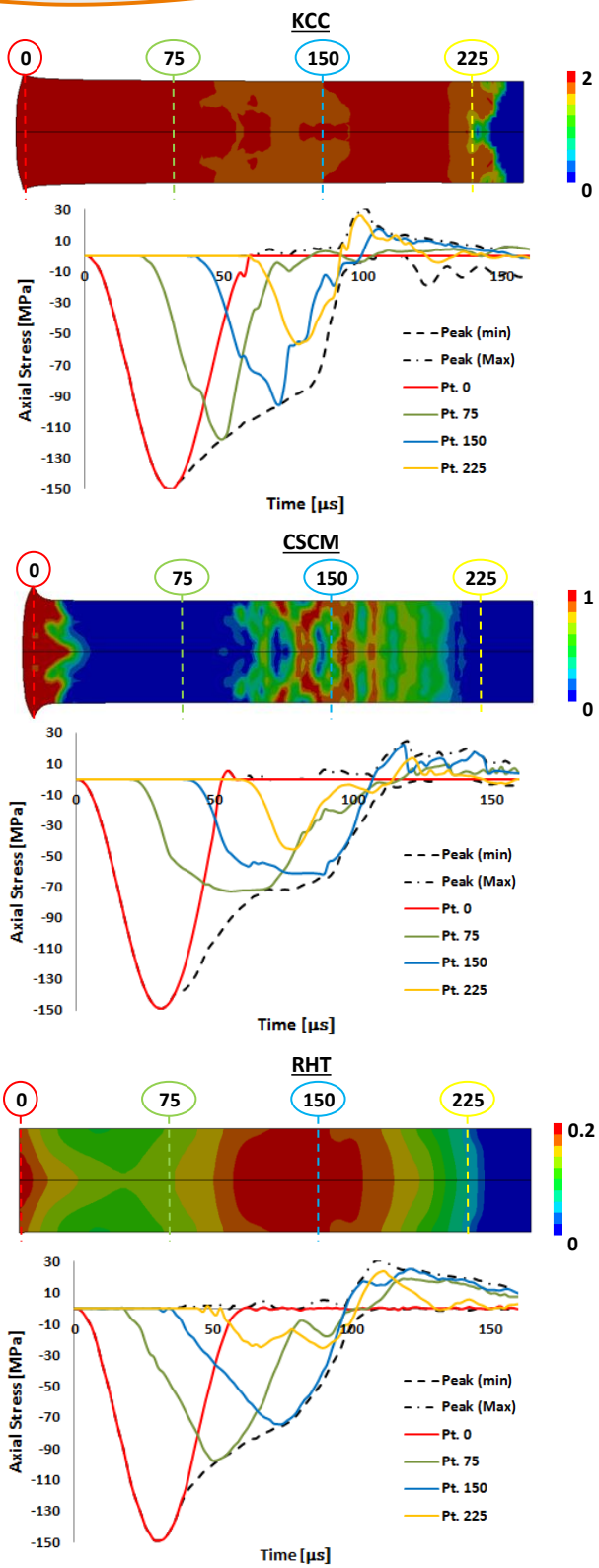

Figure 2: Damage prediction and stress evolution KCC (top), CSCM (centre) and RHT (bottom)