Limitation of the delay damage model in dynamics

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Prediction of damage of structure is still a great challenge until now, especially for dynamic loading. During these last years, many models were proposed to describe damage in structure for dynamic loading. We can cite the Thick Level set damage model [Moreau2015], phase field damage model [Borden2012] and delay damage model [Allix1997, zghal2020]. In this work, we will focus on the delay damage model for dynamic loading.

The delay damage model was introduced by Allix et Deü [Allix1997] as a model that permits to overcome spurious mesh dependency in failure analysis involving damage and dynamic loading. The damage rate is bounded through a time scale which, combined with the wave speed, introduces implicitly a length scale. In this work, we analyze whether or not the model was keeping its promises on three different loading scenarii. We investigate, so, the delay damage model through numerical experiments on three different loading cases of a bar: a slow loading leading to a dynamic failure, pulses, and impact. We observe and discuss the load level needed for failure (and the dependence of this load level with respect to the loading rate), as well as the dissipation and extent of the fully damaged zone at failure [zghal2020]. Observations lead to the following conclusions:

1. First, the delayed damage model has no regularization effect for a dynamic failure initiated from rest.
2. Second, for pulse loadings, the loading rate has no influence on the minimal load level needed for failure (even though the delayed damage model is a time-dependent model), and beyond this minimal load level for failure, the extent of the fully damage zone rises, proportionally to the length scale.
3. Third, regarding the impact, the velocity needed to reach failure depends only on the time-independent parameters of the models and not the ones linked to the delayed damage.

References

[Allix1997] O. Allix, J.-F. Deü, Delayed-damage modelling for fracture prediction of laminated composites under dynamic loading, Eng. Trans. 45 (1997) 29–46.

[Moreau2015] K. Moreau, N. Moes, D. Picart, L. Stainier, Explicit dynamics with a non-local damage model using the Thick Level Set approach, International Journal for Numerical Methods in Engineering 102 (2015) 808–838.

[Borden2012] Michael J. Borden, Clemens V. Verhoosel, Michael A. Scott, Thomas J.R. Hughes, Chad M. Landis, A phase-field description of dynamic brittle fracture, Computer Methods in Applied Mechanics and Engineering 217–220 (2012) 77–95.

[zghal2020] J. ZGHAL, N. Moes, Analysis of the delayed damage model for three one-dimensional loading scenariis, Comptes Rendus Physique 21 (2020) 527–537.