



HAL
open science

Fracture in viscoelasticity: comparison of a phase field and a lip field approach

Rajasekar Gopalsamy, Nicolas Chevaugeon, Olivier Chupin, Ferhat Hammoum

► To cite this version:

Rajasekar Gopalsamy, Nicolas Chevaugeon, Olivier Chupin, Ferhat Hammoum. Fracture in viscoelasticity: comparison of a phase field and a lip field approach. 7th International Conference on Computational Modeling of Fracture and Failure of Materials and Structure (CFRAC 2023), Czech Technical University, Jun 2023, Prague, Czech Republic. pp.232. hal-04426994

HAL Id: hal-04426994

<https://hal.science/hal-04426994>

Submitted on 18 Mar 2024

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Fracture in viscoelasticity: Comparison of a phase-field and a lip-field approach

Rajasekar GOPALSAMY¹, Nicolas CHEVAUGEON², Olivier CHUPIN¹, and Ferhat HAMMOUM³

¹Univ Gustave Eiffel, MAST-LAMES, F-44344 Bouguenais, France, rajasekar.gopalsamy@univ-eiffel.fr

²École Centrale de Nantes, GeM Institute, UMR CNRS 6183,1 rue de la Noe, 44321 Nantes, France

³Univ Gustave Eiffel, MAST-MIT, F-44344 Bouguenais, France

Conference paper CFRAC 2023

The 7th International Conference on Computational Modeling of Fracture and Failure of Materials and Structures,
Prague, Czech Republic, 21–23 June 2023

The present work provides a comparison of one particular phase-field damage model and a lip-field damage model for viscoelastic fracture. Fracture in viscoelasticity is a complex phenomenon due to a) its highly rate-sensitive behavior b) a significant amount of viscous dissipation happening in the bulk of the material around the crack tip c) added fracture toughness due to inertial effects for rapid crack growth. In this context, we are interested in the quasi-static response of a viscoelastic material subjected to damage. An incremental variational formalism has been proposed which allows embedding the local constitutive equations into a global incremental potential. The local constitutive equations to describe the viscoelastic behavior are represented using the Generalized Kelvin Voigt (GKV) model. The minimization of the global incremental potential with respect to the state variables then gives the solution to the mechanical problem. The definition of this incremental potential is such that only free energy contributes to damage growth. The potentials considered for both phase-field [1, 2] and lip-field [3, 4] models are quite similar locally. Damage models in the local sense are well known to introduce spurious mesh-dependent results due to the loss of ellipticity of the mathematical problem. Introducing length scales into the model is the common way to circumvent this issue. The length scale in the phase-field model is introduced by the addition of a gradient term in the potential. In contrast, the lip-field preserves the potential in local form and the introduction of length scale is through the addition of a new space called Lipschitz

space and constraining the lip-damage field to lie in this space. The potentials considered for phase-field and lip-field models are convex with respect to each state variable separately. Moreover, the admissible spaces for the state variables are also convex. Hence an alternating minimization is used to solve for state variables at each time step until convergence. In contrast to phase-field, the minimization to find the lip-damage field is greatly simplified by the use of local/non-local minimization split [4]. This allows performing the expensive non-local minimization only in the region where the damage gradient is higher than the admissible value. The length scales of both models are selected to have similar damage profiles. The model parameters are also calibrated to obtain the same surface fracture energy. Numerical results are then provided for the bi-dimensional tests. Both models are able to capture the rate-dependent effects typically observed in viscoelastic fracture. Moreover, qualitatively similar results are observed for both models. However, the phase-field model is found to be more dissipative in nature.

References

- [1] Christian Miehe, F Welschinger, and M Hofacker. “Thermodynamically consistent phase-field models of fracture: Variational principles and multi-field FE implementations”. In: *International Journal For Numerical Methods in Engineering* 83.10 (2010), pp. 1273–1311. DOI: 10.1002/nme.2861.
- [2] Christian Miehe, Martina Hofacker, and Fabian Welschinger. “A phase field model for rate-independent crack propagation: Robust algorithmic implementation based on operator splits”. In: *Computer Methods in Applied Mechanics and Engineering* 199.45-48 (Nov. 2010), pp. 2765–2778. ISSN: 00457825. DOI: 10.1016/j.cma.2010.04.011.
- [3] Nicolas Moës and Nicolas Chevaugeon. “Lipschitz regularization for softening material models: The Lip-field approach”. In: *Comptes Rendus - Mécanique* 349.2 (Mar. 2021), pp. 415–434. ISSN: 18737234. DOI: 10.5802/CRMECA.91. HAL: hal-03806305.
- [4] Nicolas Chevaugeon and Nicolas Moës. “Lipschitz regularization for fracture: The Lip-field approach”. In: *Computer Methods in Applied Mechanics and Engineering* 402 (A Special Issue in Honor of the Lifetime Achievements of J. Tinsley Oden 2022), p. 115644. ISSN: 0045-7825. DOI: 10.1016/j.cma.2022.115644. HAL: hal-03927211.