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Felino: Extension of an open-source phase-field framework to geomaterial fracture

Daniel T. Chou [1]

1 Georgia Institute of Technology, United States

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Software

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Editor: Anjali Sandip

Reviewers:

- @pmocz
- @shahchiragh

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Summary

This work presents an extended version of Felino (Chou & Darabi, 2025), an open-source phase-field fracture framework. Felino is implemented as an application built on top of the MOOSE finite-element framework (Permann et al., 2020), which uses libMesh as its underlying numerical library (Kirk et al., 2006). The extension introduces constitutive models for geomaterials, enabling simulations where tensile and compressive strengths differ.

- Installation instruction: README or Felino official website
- Official website of Felino: Felino official website
- Benchmark example (this extension): Uniaxial Compression on Composite Material

Statement of need

Phase-field fracture models have been widely used in metallic fatigue simulations. However, geomaterials exhibit asymmetric mechanical behavior, especially under compressive-shear loading, which requires more advanced energy-splitting formulations. This updated version implements three constitutive models that capture this asymmetry:

1. **Representative Crack Element (RCE)** – interpolates between intact and cracked states using strain jump projections(Storm et al., 2020).
2. **Drucker–Prager Decomposition** – derives activated and inactivated energy parts from a pressure-dependent failure criterion(Navidtehrani et al., 2022).
3. **Extra Driving Force Formulation** – introduces an additional compressive-shear resistance term to the phase-field equation(Liu & Kumar, 2025).

Details of each model: Tension-Compression Asymmetry Details of programming objects: (AD)LinearElasticPFFractureStress and (AD)ComputePFFStress

Key features

- Extended constitutive models for geomaterials.
- Support for asymmetric tensile/compressive fracture behavior.
- Benchmark examples for uniaxial compression tests.
- Fully integrated with MOOSE automatic differentiation.

References

Chou, D. t, & Darabi, R. (2025). Felino: A modular open-access software for high-cycle fatigue simulation via phase-field methods. *Available at SSRN 5291375*.

Kirk, B. S., Peterson, J. W., Stogner, R. H., & Carey, G. F. (2006). libMesh: A c++ library for parallel adaptive mesh refinement/coarsening simulations. *Engineering with Computers*, *22*, 237–254.

Liu, C., & Kumar, A. (2025). Emergence of tension–compression asymmetry from a complete phase-field approach to brittle fracture. *International Journal of Solids and Structures*, *309*, 113170.

Navidtehrani, Y., Betegon, C., & Martinez-Paneda, E. (2022). A general framework for decomposing the phase field fracture driving force, particularised to a drucker–prager failure surface. *Theoretical and Applied Fracture Mechanics*, *121*, 103555.

Permann, C. J., Gaston, D. R., Andrs, D., Carlsen, R. W., Miller, J. M., & etc. (2020). MOOSE: Enabling massively parallel multiphysics simulation. *SoftwareX*, *11*, 100430.

Storm, J., Supriatna, D., & Kaliske, M. (2020). The concept of representative crack elements for phase-field fracture: Anisotropic elasticity and thermo-elasticity. *International Journal for Numerical Methods in Engineering*, *121*(5), 779–805.