PRISMS-Plasticity: Constitutive Models Library

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Introduction

PRISMS-Plasticity has different crystal plasticity model in its library. In this manual, the procedure one should take to use each model is elaborated. Furthermore, a brief description of each model is presented.

How to use different crystal plasticity models available in the library?

In Prisms-Plasticity v1.1.0 (current version), different crystal plasticity models are available besides the main model in the software. The models are saved in the folder *plasticity/src/materialModels/crystalPlasticity/MaterialModels/*. All models are implemented as a *calculatePlasticity.cc* file. They may also come with a *userFunctions.cc* file which includes the auxiliary functions which are used inside the *calculatePlasticity.cc*. To use these models, one should replace the original *calculatePlasticity.cc* inside the folder *plasticity/src/materialModels/crystalPlasticity/* with these files inside the material library. Also, one need to copy the *userFunctions.cc* file if there is any to the *plasticity/src/materialModels/crystalPlasticity/* folder. Finally, they need to recompile the PRISMS-Plasticity.

One should remember that the acting *calculatePlasticity.cc* is always the one inside the folder *plasticity/src/materialModels/crystalPlasticity/* at the time of code compiling.

Brief description of crystal plasticity models

Default model

In Prisms-Plasticity v1.1.0 (current version), the default constitutive model is a rate-independent crystal plasticity model with kinematic and isotropic hardening and PTR scheme twinning model. The file for this model is located at *plasticity/src/materialModels/crystalPlasticity/*. The basics of the rate-independent crystal plasticity model is presented by:
L. Anand, M. Kothari, A computational procedure for rate independent crystal plasticity, J. Mech. Phys. Solids, 44 (1996), pp. 525-558.

The implementation of this model in PRISMS-Plasticity software with all details is elaborated in:
M. Yaghoobi, S. Ganesan, S. Sundar, A. Lakshmanan, S. Rudraraju, J.E. Allison, V. Sundararaghavan, "PRISMS-Plasticity: An open-source crystal plasticity finite element software" Computational Materials Science 169 (2019) 109078.

Rate-independent crystal plasticity model 2

This model has the same formulation as the default model, but different numerical implementation scheme is used, which is slower but more stable. The details of this implementation is elaborated in:

S. Ganesan, Microstructural Response of Magnesium Alloys: 3D Crystal Plasticity and Experimental Validation, PhD thesis, University of Michigan, Ann Arbor, 2017.

The *calculatePlasticity.cc* file for this model is located in folder *plasticity/src/materialModels/crystalPlasticity/MaterialModels/RateIndependentModel2/*.

The input file for this model is similar to the default model.

Rate-dependent crystal plasticity model

This model is based on the following rate-dependent crystal plasticity formulation:
SR Kalidindi, Polycrystal plasticity: constitutive modeling and deformation processing, PhD thesis, MIT, 1992.

This model includes a *calculatePlasticity.cc* and *userFunctions.cc* which are located in the folder:
plasticity/src/materialModels/crystalPlasticity/MaterialModels/RateDependentModel/.

A sample input file for this model is put inside applications located in the following folder:
plasticity/applications/crystalPlasticity/fcc/FCC_UserDefinedMaterialModel/prm.in

Rate-independent crystal plasticity model with multiscale twinning-detwinning mechanisms

This model includes a multiscale scheme to capture the twinning and detwinning mechanisms during cyclic loading of HCP polycrystals. The model is based on the following rate-independent crystal plasticity model:

Mohammadreza Yaghoobi, John E. Allison, Veera Sundararaghavan, Multiscale modeling of twinning and detwinning behavior of HCP polycrystals, International Journal of Plasticity, December 2019, 102653.

A sample input file for this model is put inside applications located in the following folder:
plasticity/applications/crystalPlasticity/hcp/advancedTwinModel-Cyclic/prm.in