

A finite strain discrete dislocation plasticity model

Citation for published version (APA):

Irani, N., Remmers, J. J. C., & Deshpande, V. S. (2014). *A finite strain discrete dislocation plasticity model*. Poster session presented at Mate Poster Award 2014 : 19th Annual Poster Contest, .

Document status and date:

Published: 01/01/2014

Document Version:

Accepted manuscript including changes made at the peer-review stage

Please check the document version of this publication:

- A submitted manuscript is the version of the article upon submission and before peer-review. There can be important differences between the submitted version and the official published version of record. People interested in the research are advised to contact the author for the final version of the publication, or visit the DOI to the publisher's website.
- The final author version and the galley proof are versions of the publication after peer review.
- The final published version features the final layout of the paper including the volume, issue and page numbers.

[Link to publication](#)

General rights

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal.

If the publication is distributed under the terms of Article 25fa of the Dutch Copyright Act, indicated by the "Taverne" license above, please follow below link for the End User Agreement:

www.tue.nl/taverne

Take down policy

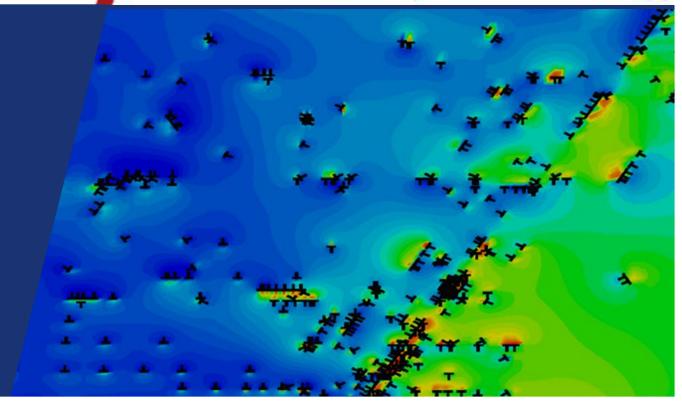
If you believe that this document breaches copyright please contact us at:

openaccess@tue.nl

providing details and we will investigate your claim.

A Finite Strain Discrete Dislocation Plasticity Model

Nilgoon Irani, Joris J.C. Remmers, Vikram S. Deshpande



Introduction

For a wide range of ductile materials, plastic deformation occurs as a consequence of the **collective motion of dislocations gliding on slip planes**. This motion may lead to **finite lattice rotations**. Although the significance of lattice reorientations has long been recognized, **discrete dislocation plasticity framework has been restricted to infinitesimal deformations**.

Goal

Our goal is to develop a discrete dislocation (DD) framework which is capable of capturing **finite lattice rotations** and **shape changes due to slip**. This method gives us the tools for modelling different phenomena such as crack tip blunting, where the lattice rotations are not negligible (Fig.1).

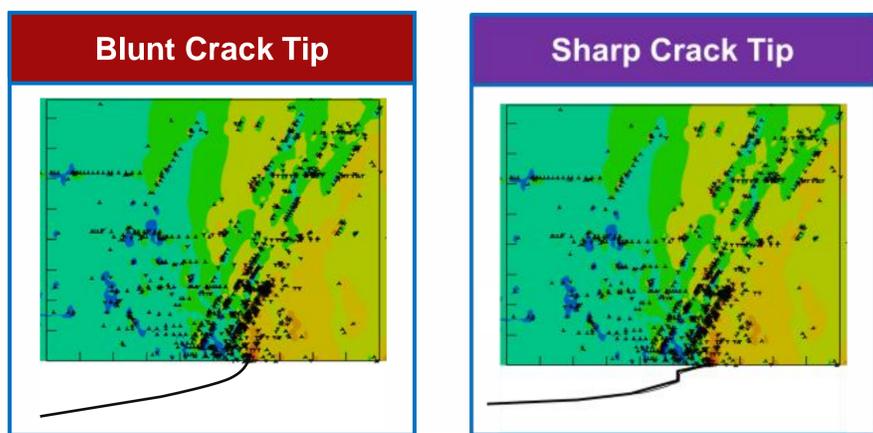


Figure 1: Sharp and blunt crack resemble the possibility of brittle and ductile fracture, respectively. **By using small strain theory we can only model sharp crack tips.**

Challenges

As **the displacement field on the slip plane is not unique**, the derivatives of the displacement field and therefore the strain and stress fields become singular. Hence when solving for these fields we have to deal with singularities.

Method

The nonlinear finite deformation problem is solved by extending the superposition method of Giessen and Needleman [1] and applying a **Total Lagrangian** setting.

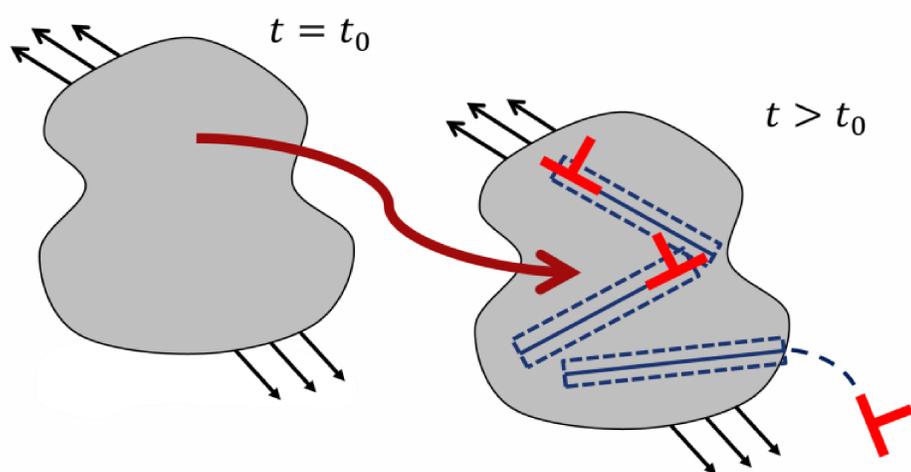


Figure 2: We must keep track of all areas which were subjected to singularity. These areas consist of the points which were touched by dislocations during their slip.

As it was mentioned the displacement field is only piecewise continuous and therefore an iterative **finite element** procedure which is **capable of detecting areas with singularities** is needed (Fig. 2). At time $t = t_0$, our domain is in its undeformed configuration. As we increase the loading, dislocations start to appear and they continue to deform our domain by gliding.

Results

Using the new framework we were able to capture the shape changes due to slip and finite lattice rotations. Fig. 3 and 4 compare the results obtained for a tension-compression simulation based on small strain and finite strain assumptions respectively.

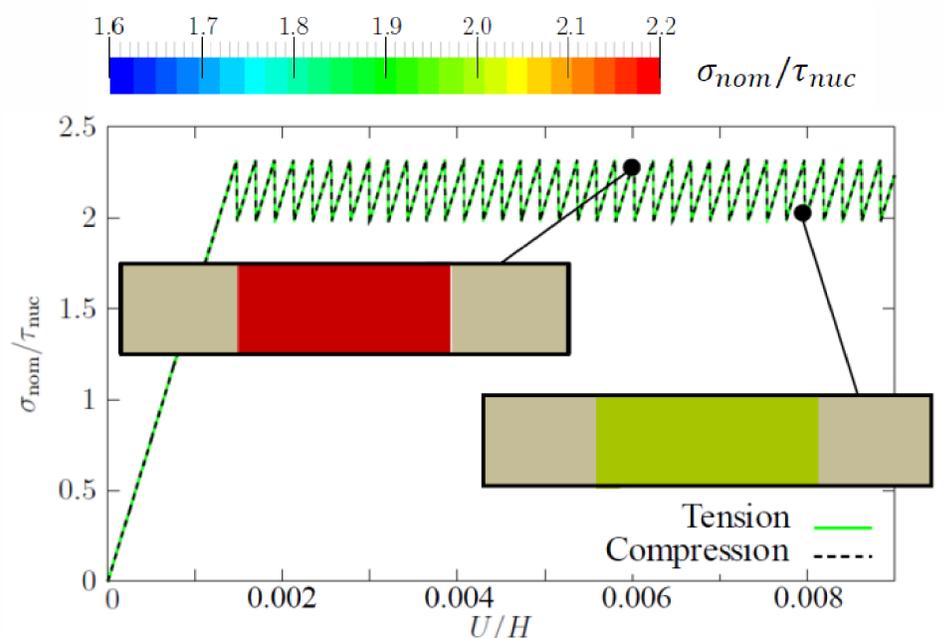


Figure 3: Small Strain predictions of the tensile and compressive response of an initially rectangular specimen.

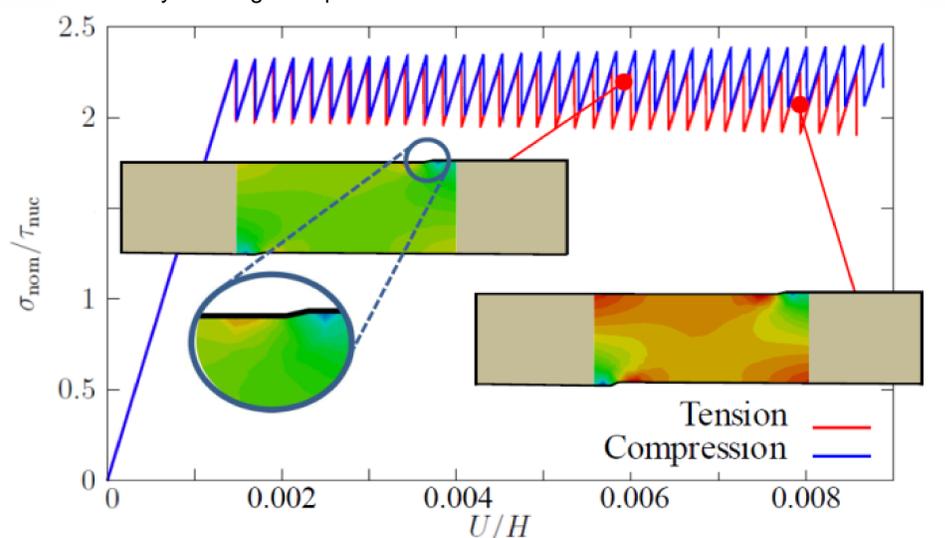


Figure 4: Finite Strain predictions of the tensile and compressive response of an initially rectangular specimen.

Conclusions

- 1) We have presented a finite strain DD formulation capable of capturing shape deformations caused by dislocation slip.
- 2) Our results show that unlike in small strain DD, finite strain effects result in a size dependent tension-compression asymmetry.

References

- [1] E. van der Giessen, A. Needleman, 1995
- [2] N.Irani, J.J.C. Remmers, V.S. Deshpande, 2015