A numerical investigation of two elasto-plastic bodies in contact with a rigid particle

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In this work we look at a simple scenario within the field of abrasive wear, where the surfaces of two bodies are in contact with a rigid circular particle. The well-known Hertzian contact theory can be used to analyze the behavior of this case for elastic materials, while for elasto-plastic materials the analysis has proven more difficult to model due to the non-linear nature of the problem. Here we use numerical simulations to investigate the effect of certain geometrical and material characteristics on the resulting ratio of displacements between said bodies for a static loading scenario.

Keywords (from 3 to 5 max): Contact, elasto-plastic, abrasive wear

1. Introduction

Wear caused by particle abrasion between surfaces can be a major contributor to material removal early on in contact scenarios. Efforts to quantify abrasive wear thus far has been focused on black-box experiments (example [1]), in which outputs such as a wear rate is sought for specific geometrical and material parameters, with similar efforts being made in the analytical (such as [2]) and numerical domains.

This contribution takes a stab at the numerical part, using simple simulations to identify important relations between system parameters and the resulting system behavior.

2. Methods

2.1 Simulation setup

The setup simulates two static symmetric bodies being pushed against a rigid circular particle by an amount u_{top} (see Fig. 1a). The displacement of the body nodes that are initially in contact with the particle is tracked and used to compute a displacement ratio $u' = u^1/u^2$ of said bodies.

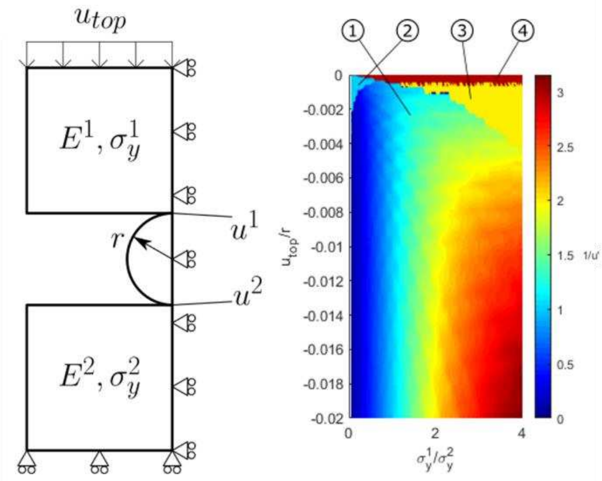
2.2 results

Early results of the analysis are shown in Fig 1b, in which we use a bilinear flow-rule and set elastic moduli of the bodies to the same value, $E^1 = E^2$. Already we can identify a symmetric response of u' about $\sigma_y^1/\sigma_y^2 = 1$, which is also reflected in four plotted regions that represent whether body 1 or body 2 is seeing elastic/plastic deformation at the current displacement step (see Table 1). Region 1 encompasses everything not covered by regions 2-4.

Table 1: Regions of elastic/plastic response

Region	Body 1	Body 2
1	Plastic	Plastic
2	Elastic	Plastic
3	Plastic	Elastic
4	Elastic	Elastic

The results can be used to identify important transitions between e.g. linear and nonlinear domains, and provide clues as to how the nonlinear domain in particular might be described using combinations of simple functions.



a **b**

Figure 1: Simulation setup of two bodies and a rigid particle (a). Results showing $1/u'$ as a function of the yield stress ratio and the top displacement normalized by the radius of the particle (b).

3. Discussion

This work is a steppingstone towards a better understanding of abrasive wear scenarios through the development of empirical formulas. The general field of wear has for a long time relied on experimental knowledge for specific wear scenarios and materials, and only recently has advanced numerical simulations been breaking ground in terms of simulating materials undergoing abrasive wear in high resolution. In summation, analyzing simple empirical knowledge in-depth can still yield useful results and knowledge.

4. References

[1] R. Prehn, F. Haupert and K. Friedrich, "Sliding wear performance of polymer composites under abrasive and water lubricated conditions for pump applications," *Wear,* pp. 693-696, 2005.

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