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A truly variationally consistent and symmetric mortar-based contact formulation for finite deformation solid mechanics

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Abstract

In this work two mortar-based segment-to-segment contact formulations will be developed for the frictionless finite deformation case: While the first one is derived by consistent variation of all active contributions of a scalar-valued potential subject to inequality constraints, thus resulting in a truly variationally consistent and symmetric formulation, the second approach is designed in such a way that it is less computationally expensive, but still conserves important quantities such as linear and angular momentum. Since both formulations are derived side by side, the introduced simplifications and errors can be specifically analyzed and quantified. Based on a Lagrange multiplier approach the corresponding inequality constraint terms are introduced in two popular ways: Firstly, in form of a standard Lagrangian formulation and, secondly, via an augmented Lagrangian formulation. Both variational forms as well as both solution procedures will be consistently linearized and discussed. Finally, the obtained results will be compared to each other as well as to a well-established, yet slightly inconsistent, mortar-based contact formulation.

Keywords: Variationally consistent, augmented Lagrangian, mortar, Lagrange multiplier, contact, segment-to-segment.

1. Introduction

Contact mechanics is a field of continuing wide interest. This research interest often stems from problems arising during the numerical simulation of complex real-world applications, where one source of complexity is the efficient computational treatment of the non-linear contact conditions. Therefore, it is not surprising that many researchers have an engineering background and several interesting research developments are primarily built up on heuristic observations and ideas. One outstanding and very successful representative of such a heuristic idea is e. g. [1], where a start-up procedure for contact problems with large load steps is presented. Even though interesting results are often given, the underlying theory may lack rigorous mathematical proofs. At the same

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