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Effect of numerical artificial corners appearing when using BEM on contact stresses

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ABSTRACT

It has long been established that when a small-displacement problem involving contact between two or more bodies is solved, conforming algorithm approaches based on BEM are reliable and robust. Nevertheless, the authors have shown in a previous paper that a relative sliding between the bodies in contact, even if small, can originate a fictitious corner in the numerical model, which may alter the stress and the displacement predictions. This problem disappears if a non-conforming algorithm is employed. In this paper a new problem with different features but also presenting artificial alteration of the results is addressed. The compression of a rounded punch on a foundation is analysed for many fillet radii. Conforming and non-conforming algorithms are used. Comparison of results shows that effects of an artificial 'numerical corner' may alter even the traction distribution relatively far from it. Consequently, the assumed connection between small displacements and initially conforming discretizations with the use of a conforming approach disappears. An adequate knowledge of the contact problem under consideration is then essential to determine whether the singularity is inherent to the problem or is artificial, a non-conforming algorithm then being recommended in this second case.

1. Introduction

In the field of solid mechanics, loads are usually applied or transmitted through contact between solids. Thus, contact problems appear extensively in engineering. Although some cases can be solved analytically, they are very simple configurations [1], the use of a numerical method usually being necessary. Nowadays there are many procedures that use numerical methods (primarily FEM or BEM) to deal with these problems. All these procedures can be classified into two groups: on the one hand, those that apply contact conditions directly between nodes (using FEM [2,3] and BEM [4,5] could be considered pioneering works among many others), which requires the use of conforming meshes along the potential contact surfaces in both solids; and, on the other hand, those that can deal with non-conforming discretizations (using FEM [6,7] and BEM [8–10]).

Blázquez et al. [8] set out three situations where attention is drawn to non-conforming algorithm: (1) avoiding the work associated to the elaboration of conforming meshes versus arbitrary meshes, (2) modelling bodies of different stiffnesses with appropriate and in general different meshes, and (3) solving large displacement problems where these algorithms are compulsory. Nevertheless, for small-displacement problems, the extra work associated to (1) and the extra cpu time associated to (2) do not justify the significant effort required to develop a non-conforming algorithm, which is obviously much more complex. Thus, this kind of algorithm is typically reserved for (3): general large-displacement problems.

Recently, Blázquez and París [11] have shown that there are small displacement contact problems in which the updating of the geometry is required, a non-conforming algorithm then being compulsory. An analysis of Iosipescu test was presented in that paper assuming that the grips are rigid. When a conforming algorithm was used, a 'numerical corner' appeared and originated a local perturbation of the traction distribution. This is especially important for BEM because of the sensitivity of this method to singularities.

In this paper, another situation is presented where non-conforming procedures are required for a small displacement problem. The problem is the compression of a punch with rounded corner over a foundation. Both solids are now elastic and it will be shown that the use of a conforming algorithm has a harmful effect on the value of the contact traction far from the 'numerical corner', a fact that is, in the view of the authors, even more serious than the other effects previously shown. The analysis presented here is an extension and an in-depth study of that presented in [12].

The next section summarises the contact algorithm used in this work. Section 3 describes the problem analysed and shows the numerical results obtained. Finally, Section 4 presents the conclusions.

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