LOCKING IN ANALYSIS OF SHELLS: ACCOMPLISHMENTS AND OPEN ISSUES

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Elimination of locking in the finite element analysis of structural problems has been a research topic for more than two decades. Within that time very significant advances have been made. However, various types of structures have enjoyed vastly different degree of success. For one-dimensional structural problems, for example, a number of different successful formulations have been developed and applied in both linear and nonlinear regime; many robust elements of any order can be derived in this case. In other cases, similar generality may only exist in the analysis of linear problems, but not in the large deformation range, or may elude the analyst altogether, leaving only a small number of relatively well tested options to chose form.

Numerical analysis of shells is one area in which a sufficient level of generality has not been achieved. There are few numerical formulations of shell problems that enjoy a relatively high degree of acceptance among researchers and practitioners. It seems fair to say, however, that even with regard to those more popular approaches some discomfort persists. Such a situation is (obviously) caused by the complexity of shell structures, both in terms of their actual response and in terms of their mathematical description. In spite of that, the research related to numerical analysis of shells subsided.

From the practical point of view the situation existing in the analysis of shells may be satisfactory – all one needs to solve practical problems is a single, acceptable and robust formulation. From the academic standpoint, however, the inability to be sufficiently general indicates lack of full understanding of the problem and the need for further research.

After a brief introduction to the problem, in this talk the current status of the finite element analysis of shells will be reviewed. Several formulations, both those based on intuitive engineering approach and those motivated mathematically, adopted in the past to eliminate locking in analysis of shells, will be included. In this context outline of those approaches that dominate commercial structural mechanics software will be presented and possible reason for their popularity discussed.

Following the initial historical part of the talk, the discussion will focus on some less explored possibilities to eliminate locking. These will include the finite difference approach, meshless methods, the discontinuous Galerkin approach and the assumed strain concept based on the weak enforcement of the kinematic compatibility conditions. Experience with some of these approaches have been positive in applications other than analysis of shells, but their application to shells has been scant. Others are being investigated presently. The main concepts behind those formulations and the available results will be presented during the talk.

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