Delft University of Technology

Aerospace Structures & Computational Mechanics
Ph.D. Seminar Series

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A Koiter-Newton arc-length method for buckling-sensitive structures

Thin-walled structures possess a high strength-to-weight and stiffness-to-weight ratio, and therefore are used as the primary components in some weight critical structural applications. These structures are prone to be limited in their load carrying capability by buckling, while staying in the linear elastic range of the material. Buckling of thin-walled structures is an inherently nonlinear phenomena. Thus, the analysis of nonlinear response of structures is important for determining their load carrying capability. Nowadays, with the expanding computational power of modern computers nonlinear finite element analysis is becoming the standard technique used to obtain the nonlinear response of complex structures, however, the repeated analyses that are needed in the design phase are still computationally intensive. For this reason, reduced order techniques that reduce the problem size are attractive whenever repetitive analyses are required.

In this thesis, a new approach called the Koiter-Newton is presented for the numerical solution of a class of elastic nonlinear structural analysis problems. The method combines ideas from Koiter's initial post-buckling analysis and Newton arc-length methods to obtain an algorithm that is accurate over the entire equilibrium path of structures and efficient in the presence of buckling and/or imperfection sensitivity.

The basic premise behind the proposed approach is the use of Koiter's asymptotic expansion from the beginning rather than using it only at the bifurcation point in contrast to the traditional Koiter approaches. The proposed approach is performed in a step by step manner to trace the entire equilibrium path. In every expansion step, the approach works by combining a prediction step using a nonlinear reduced order model based on Koiter's initial post-buckling expansion with a Newton correction procedure. This nonlinear prediction provided by the reduced order model is much better compared to linear predictors used by the classical Newton-Raphson method, thus allowing the algorithm to use fairly large step sizes.

Various numerical examples of beam and shell models are presented and used to evaluate the performance of the method. The Koiter-Newton analysis using the co-rotational kinematics and the Von Karman kinematics are accurate and more computational efficient, compared with the results obtained using ABAQUS which adopts a full nonlinear analysis. The improved efficiency demonstrated by the Koiter-Newton technique will open the door to the direct use of detailed nonlinear finite element models in the design optimization of next generation flight and launch vehicles.

time: **Tuesday, May 21st, 2013, 16:00**

location: **Lecture room B**

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