Complementarity in structural dynamics: A new procedure for bounding eigenfrequencies

J.P. Moitinho de Almeida* and Edward A.W. Maunder†

* Department of Civil Engineering, Architecture and Georesources
Instituto Superior Técnico, Universidade de Lisboa
Av. Rovisco Pais, 1049-001 Lisboa, Portugal
e-mail: moitinho@civil.ist.utl.pt

† College of Engineering, Mathematics, and Physical Sciences,
University of Exeter,
Exeter UK
Email: E.A.W.Maunder@exeter.ac.uk

ABSTRACT

Pairs of approximations of complementary nature, one being compatible and the other equilibrated, are commonly used for the determination of bounds of the exact solution of elastic problems. The main advantage of the application of this approach is that, provided the fundamental conditions are respected, a strict bound of the error is obtained and, therefore, an interval containing the exact solution can be computed.

In modern applications the compatible approximation is typically computed using a displacement based finite element model, while the equilibrated one may be either recovered from the weak form of equilibrium present in the finite element solution or computed from a complementary, stress based, finite element model. Furthermore the quality of the solutions and of its bounds is greatly influenced by the quality of the approximations, i.e. when both are good (close to the exact one) a sharp bound is obtained, whereas bad approximations lead to very large intervals.

While the formulation of compatible finite element models for the dynamic analysis of structures is covered in most textbooks, its complementary models, strictly enforcing dynamic equilibrium, which were developed from the 1970's by Tabarrok [1] are not so well known. Furthermore the application of pairs of eigensolutions for the determination of bounds of the eigenfrequencies, as formulated by Ladevèze [2], never gained a widespread application.

In this communication we will discuss the application of a new approach, based on two complementary models, wherein, instead of solving two separate eigenvalue problems, both finite element models are combined. Preliminary results indicate that from the solution of this combined model it is possible to obtain bounds of the structural eigenfrequencies.

REFERENCES

[1] B. Tabarrok, "Complementary variational principles in elastodynamics." *Computers & Structures,* 19(1), 239-246, 1984.

[2] P. Ladevèze and J.P. Pelle, *Mastering Calculations in Linear and Nonlinear Mechanics*. Springer, New York, 2005.