Updating the Craig-Bampton Reduction Basis for Efficient Structural Optimization

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Introduction

The Craig-Bampton (CB) method is a widely used Component Mode Synthesis technique which is employed for dynamic sub-structuring and reduction. The CB method uses the fixed interface normal modes and the constraint modes as a reduction basis for the condensation of the substructure models. In a parameterized Finite Element model, whenever the design variables change, the CB reduction basis changes as well. In this research, computationally efficient reanalysis methods for updating the CB reduction basis are studied. The enriched Craig-Bampton (ECB) method [1] is improved in accuracy by including the efficient reanalysis of constraint modes using the Combined Approximations (CA) approach.

The Reanalysis Method

When a substructure is modified, the solution of the initial model does not conform the new system equations. This causes residual forces and residual displacements to appear. This information can be used to update the solution, thereby solving the complete set of new equations are avoided.

In [1], the fixed interface normal mode set is extended by including the effects of the residual forces acting on the initial substructure. Therefore, dynamic analysis for generating the new normal mode set is avoided.

The constraint modes are calculated by static analysis. In the method we propose, the CA approach is used for updating the constraint modes. In this method, the residual displacements are computed in a smaller space and added to the initial constraint mode set.

Validation

For the validation of the proposed reanalysis method, a theoretical test problem illustrated in figure 1 is analyzed using various methods. The cross section width and height of the stiffeners h_{s_i} in each component are defined as design variables. In the initial design, $\mathrm{h}_{s_i} = 0.05$m, $i = 1, 2, \ldots, 8$.

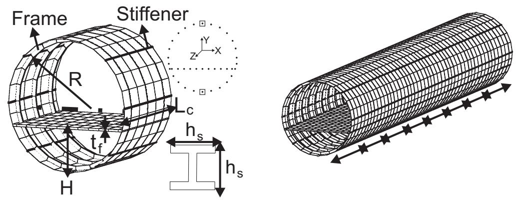

Figure 1 : Theoretical test problem.

The results that correspond to the first dynamic mode of the structure for varying values of the design variables are illustrated in figure 2.

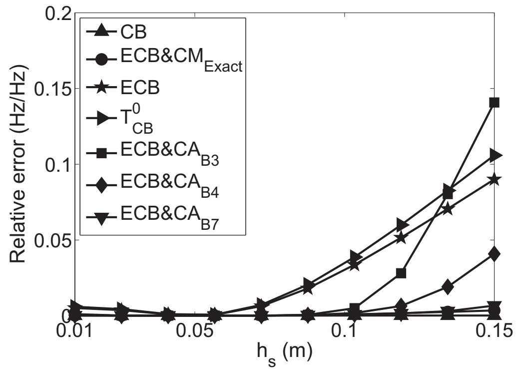

Figure 2 : Results.

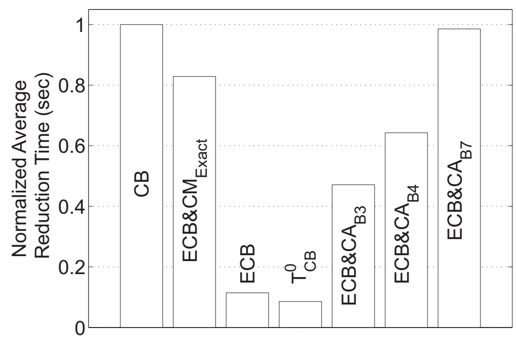

Figure 3 : Normalized reduction times.

Conclusions

Based on the results of the selected test problem, it is concluded that the proposed updating method is computationally very efficient and the accuracy of its results are very satisfying for wide range of perturbations in the design variables.

References

1. G. Masson, B. Ait Brik, S. Cogan and N. Bouhaddi, Component Mode Synthesis (CMS) based on an Enriched Ritz Approach for Efficient Structural Optimization, *Journal of Sound and Vibration*, Vol. 296, 2006, 845-860.