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Computational Assessment of FE-based Reduction Methods in Structural Dynamics

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The dynamic frequency response of linear structures to time-harmonic load is computed from the system

$$\left[\mathbf{K} + \mathrm{i}\Omega\mathbf{D} - \Omega^2\mathbf{M}\right]u = p.$$

State-of-the art FE solvers offer several methods for dimensional reduction of the matrices, including the traditional method of Component Mode Substructuring (CMS) and the more recent approach of Automated Multilevel Substructuring (AMLS). All reduction methods can be represented by specific reduction operators T, leading to the reduced system

$$\left[\tilde{\mathbf{K}} + \mathrm{i}\Omega\tilde{\mathbf{D}} - \Omega^2\tilde{\mathbf{M}}\right]q = \tilde{p}$$

The reduction methods are usually combined with modal enrichment by residual vectors, which can be identified as Ritz vectors for residual loads. From a mechanical viewpoint, the reduction bases represent the inherent dynamic features of the structure while the residual vectors capture the dynamics of the applied load. We give a unified theoretical review and cost estimates of the reduction and enrichment approaches and present results of computational evaluation on small-scale model problems and large-scale industrial applications.

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