31. ACCELERATING AMLS BASED SUBSTRUCTURE GENERATION PROCEDURE THROUGH HIGH-PERFORMANCE COMPUTING

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SUMMARY

Substructuring techniques (or Component Mode Synthesis) are commonly employed in the finite element framework for analyzing large, complex structural systems since these techniques make local design modifications easier and accelerate the model assembly process. Especially, in the design stage of large vehicle models, substructuring techniques are frequently used to reduce the size of assembled systems and the cost of subsequent analyses with the assembled system. To reduce the size of a large system using substructuring techniques, truncated normal modes are commonly used. To satisfy the increased accuracy requirement for the finite element models at higher frequencies, the model system size grows significantly and many substructure eigenmodes are required. The automated multilevel substructuring (AMLS) technique, which is a state-of-the-art method for solving large-scale eigenvalue problems, is used to speed up the eigensolution process for large substructure generation. However, generating substructures, which includes projecting the substructure system matrices on to the substructure modal space that includes eigenmodes and constraint modes, takes significant computational times and requires a huge amount of computer resources since the full substructure modes for a large substructure need to be stored for recovery later and retrieved for the condensed matrix computation in the substructure generation process.

Within a conventional dynamic substructure generation procedure for large-scale models, computing full eigenmodes is mandatory, and the costs of computing constraint modes and projecting system matrices (stiffness, mass, damping matrices, and force vectors) onto substructure modal space are very high because the projection is performed using full substructure modes in the physical space, the size of which can easily be more than tens of millions degrees of freedom.

In this paper, a new algorithm which combines the AMLS eigensolution procedure with substructure generation process is proposed. With this new algorithm, substructure normal modes and constraint modes, and condensed substructure system matrices are computed during the AMLS eigensolution process with very little additional computational costs. Hence, not only does this new algorithm significantly improve substructure generation process performance, but it also reduces the computational resource usage by eliminating the use of full substructure modes. As a result, this new algorithm extends computational capability of generating large and accurate substructures with many retained nodes and eigenmodes. The performance of new AMLS based substructure generation procedure on HPC hardware was demonstrated for several industrial automotive models. Performance improvement by this new algorithm ranges from a factor of 3 to 50 depending on the size of the model, number of retained nodes and eigenmodes, and the number of nodes where the results are recovered (output request).