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Effective High-Fidelity Nonlinear Analysis of Large-Scale Structures using Parallel Domain Decomposition

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High-fidelity nonlinear analysis of civil engineering structures has potentially important applications in the development of new structural solutions and in the assessment, design and retrofitting of structures under extreme loading. Yet, despite huge advances in nonlinear structural analysis methods, mostly with the continuous development and proliferation of powerful finite element modelling techniques, the utilisation of high-fidelity modelling for large-scale structures has been hampered by excessive computational demands, in relation to both unrealistic run times and hardware resource bottlenecks.

This lecture presents recent developments undertaken by the author and his CSM Research Group at Imperial College London, which have been aimed at making high-fidelity nonlinear analysis of real large-scale structural systems practicable. An advanced hierarchic domain decomposition method is described, which is shown to map directly onto the hierarchic nature of hardware resources in High Performance Computing systems, and which can effectively upgrade existing sequential finite element analysis programs with powerful parallel processing capabilities. Several applications of the developed capability, implemented within the nonlinear structural analysis program ADAPTIC, are presented to demonstrate the range of nonlinear structural modelling problems that can now addressed, including i) the seismic assessment and retrofitting of real reinforced concrete buildings that are not originally designed for earthquake resistance, ii) the assessment of masonry structures under service and extreme loading, and iii) the assessment and development of all-metal sandwich panel systems for application in offshore topside structures.