The numerical solution of large scale dynamic soil-structure interaction problems

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ABSTRACT

In civil engineering, and more particularly in structural mechanics, computational tools are used to understand and predict the behaviour of complete structures (bridges, buildings, …) or their individual components (cables, floors, …) in several limit states. A major complexity lies in the fact that many civil engineering structures, if not all, are in direct contact with the surrounding soil domain. The dynamic interaction between the structure and its environment often plays a crucial role and should be accounted for in numerical models. An efficient solution of dynamic soil–structure interaction (SSI) problems is indispensable, for example, for the assessment of damage to structures (buildings, nuclear power plants, bridges, tunnels) caused by earthquakes, the evaluation of annoyance in the built environment due to vibrations originating from road and railway traffic, or the design of offshore structures (wind turbines, oil and gas platforms) subjected to wind and wave loadings. These problems are of large societal and economic importance but are challenging from a computational point of view. Despite the advance of high performance computers, the numerical solution of large scale dynamic SSI problems remains very challenging and in many cases beyond current computer capabilities [1].

This talk gives an overview of computational techniques that have been developed within the frame of the first author's doctoral research for solving large dynamic SSI problems [2]. A domain decomposition approach is employed, where finite elements for the structure(s) are coupled to boundary elements for the soil, accounting for the soil's stratification. A fast boundary element method is developed, resulting in a significant reduction of the required memory and CPU time with respect to traditional formulations. This allows for an increase of the problem size by at least one order of magnitude. Furthermore, innovative algorithms for an efficient coupling of finite and boundary elements are presented, considering three–dimensional as well as two–and–a–half–dimensional formulations. The computational performance of the proposed procedures is assessed and their suitability is illustrated through numerical examples.

The novel techniques are subsequently employed for the solution of challenging problems related to the prediction of railway induced ground vibrations [3]. In particular, the efficiency of a stiff wave barrier for impeding the propagation of Rayleigh waves from the railway track to the surrounding buildings is studied in detail, providing fundamental insight in the underlying physical mechanism. The numerical results are validated by means of a full scale experimental test, confirming the efficacy of the proposed type of barrier.

REFERENCES

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