F7. Modeling in Dynamics

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Because of the continuous and unconfined nature of geomaterials, the treatment of dynamic problems in "soil" media differs from the treatment of dynamic problems associated with classical civil engineering structures. While for most of the latter, mechanical modeling through the assembly of masses and discrete sources of stiffness seems sufficient to understand their dynamic behavior, geomaterials must be handled as continuous and unconfined media. Their dynamic response must be studied as a wave propagation mechanical problem.

Concerning the numerical methods used in soil dynamics, it should first be noted that modeling wave propagation requires to use of a range of modeling and calculation methods, which differ from conventional geotechnical calculations using the FE method. Although the FE method has an important place in the inventory of methods available to the engineer for soil dynamics problems, it is often coupled with, or replaced by, other numerical computation methods that are better suited to model wave propagation in unbounded environments.

Additionally, the equations that describe dynamic problems involve a new variable (apart from spatial variables): time. The computational algorithms are formulated in the time domain, and alternatively, in the frequency domain. The methods used to solve soil dynamics problems are implemented in specific software that requires the user to have a very good understanding of the underlined theory, and specific skills to determine the parameters, the calibration of numerical models and constitutive laws, the optimization of calculations, etc.

Among the common soil dynamics problems, the following ones can be cited:

- the study of vibrations in the soil due to construction (e.g. during pile driving),
- the study of the soil’s response to the vibratory behavior of structures (rotating machines, vibrations due to wind effects, insulation and reduction of vibratory effects of equipment, etc.),
- vibrations generated by shocks, impacts, explosions,
- vibrations due to moving loads, especially traffic loads,
- the seismic response of geomaterials and the seismic propagation of waves in soil media, with the characterization of seismic motion for the earthquake-proof design of structures,
- soil-structure interaction and the consideration of settlement (if any) in the dynamic response of structures,
- the calculation of impedance functions of foundation systems,
- the characterization of the cyclic behavior of soils and the development of adapted constitutive laws,
- verification of the seismic stability of geotechnical structures (foundations, earth structures, retaining structures, underground structures),
- modeling of the coupling with the fluid phase in the soil (liquefaction) etc.

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