**Inelastic static and seismic response of deeply embedded foundations**

Large caissons are often employed as foundations for long bridges spanning over land or water. Owing to their massive dimensions, they constitute the technically feasible solution when the foundation soil has inadequate bearing capacity to support the superstructure on a shallow or piled foundation. Though primarily used to transfer vertical loads (N) safely into soft ground, caissons are also subjected to significant horizontal (Q) and overturning moment (M) loads imposed from severe environmental or seismic events. The response under combined loading involves complex three-dimensional stress distribution along the caisson shaft and at the circumference. Strikingly, however, although notable work has been published regarding the combined capacity of shallow and skirted foundations, with embedment ratios (embedment depth, D, to foundation width, B) $D / B \leq 1$, solutions for deeply embedded foundations ($D / B \geq 1$) are missing from the literature. It is in this respect that the present Dissertation aspires to shed light on the inelastic static and seismic response of deeply embedded foundations. More specifically:1.By means of an extensive parametric investigation with finite elements in 3D, a generalized failure criterion is developed and proposed, accounting for material (soil) and caisson-soil interface nonlinearities. The failure criterion is validated for various soil and interface conditions, and it is given in terms of, currently the State-of-the-Art in foundation design, three-dimensional N-Q-M failure envelopes.2.Motivated by some rather interesting aspects that were revealed from the response of deeply embedded foundations under combined loading, and in particular regarding the "overstrength" that the foundation was shown to exhibit under certain loading combinations (a response that cannot be captured by the conventionally employed analysis methodologies, in which the foundation is substituted with a set of linear, or even nonlinear, usually uncoupled, springs attached at the base of the superstructure), it is shown that accounting for nonlinear foundation stiffness when soil–foundation–structure interaction (SFSI) effects are significant is essential for reproducing the accurate response. By means of a numerical study of caisson foundations supporting bridge pier-deck systems (of varying pier-to-deck joint stiffness) subjected to lateral loading, the importance of incorporating nonlinear SFSI effects into the geotechnical assessment of foundations is stressed, and a seismic design methodology for caisson foundations is developed.3.Finally, by means of powerful numerical techniques (Spectral Matching, and Incremental Dynamic Analysis), the seismic nonlinear inelastic response of caisson foundations was extensively examined, with due consideration to soil and interface nonlinearities. The analysis involved the comparison, in Performance Based Design terms, of the response of seismically under-designed and seismically over-designed caissons supporting bridge piers. The results highlighted the efficacy of "rocking isolation" that dominates the response of the seismically under-designed caissons with a high static safety factor.