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SNAP-BACK TESTING OF PILES TO ESTIMATE NONLINEAR LATERAL STIFFNESS AND DAMPING PROPERTIES

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ABSTRACT

The design of pile foundations likely to be subject to earthquake loading requires information about the nonlinear lateral load behaviour of the pile and also the damping properties during cyclic loading. We are researching methods for analysing the earthquake response of foundations that make use of Soil-Foundation-Structure-Interaction (SFSI) as a means of incorporating nonlinear soil deformation effects and nonlinear geometrical effects into the earthquake resistant design of foundations. There are three challenges in this work. First, to incorporate adequately the nonlinear response of the soil during the earthquake. Second, to account for geometrical nonlinearity during the earthquake - that is loss of contact between various parts of the foundation and the underlying and/or adjacent soil. Examples of this are the gapping that develops between a pile shaft and the surrounding soil during cyclic lateral loading and the uplift beneath parts of a shallow foundation subject to rocking. Third, to obtain appropriate values for the soil parameters which describe the nonlinear response of the foundations. The main thrust of this paper is to show how snap-back testing is an effective means of evaluating the cyclic behaviour of a pile foundation. An appealing feature of snap-back testing is that the pull-back part of the test gives data on the static nonlinear load deformation properties of the pile. This information is of use in push-over analyses which are often done as part of the design of piles subject to earthquake loading.

Keywords: Deep foundations, snap-back testing, dynamic properties, nonlinear soil response.

1 INTRODUCTION

We have been working on the development of methods for analysing the earthquake response of foundations that make use of Soil-Foundation-Structure-Interaction (SFSI) modelling as a means of incorporating nonlinear soil deformation effects and nonlinear geometrical effects into the earthquake resistant design of foundations. SFSI differs from the well-known SSI (soil-structure interaction) in that SSI is confined to linear response, whereas SFSI incorporates nonlinear responses. We regard our work as a contribution to the development of performance-based design in earthquake geotechnical engineering. Our progress to date has been documented in the following papers: Pender (2007), Pender et al (2009), Wotherspoon (2009), Orense et al (2010), and Pender et al (2010). A feature of the work has been the modelling of the foundation and the structure supported by the foundation in an integrated manner so that a single numerical model of the structure-foundation system is developed for design analysis. There are three challenges in this work. First, incorporation of the nonlinear response of the soil during the earthquake. Second, accounting for geometrical nonlinearity during the earthquake - that is loss of contact between various parts of the foundation and the underlying soil. An example of this is the gapping that develops between a pile shaft and the surrounding soil during cyclic lateral loading. Third, obtaining appropriate values for the soil parameters that describe the nonlinear response of the foundations. This paper is concerned with the third of these challenges.

We have conducted field experiments at a site in Auckland where both shallow and deep foundations have been subject to cyclic loading. The first batch of tests used an eccentric mass shaking machine to excite the foundations with sinusoidal oscillations at a range of frequencies. Although successful we recognise the limitations to this approach for the following reasons. First, a given level of excitation force