Proceedings of the Ninth Pacific Conference on Earthquake Engineering
Building an Earthquake-Resilient Society
14-16 April, 2011, Auckland, New Zealand

# Snap-back testing for estimation of nonlinear behaviour of shallow and pile foundations

M.J. Pender, T.B. Algie, R.P. Orense & L.M. Wotherspoon

*Department of Civil and Environmental Engineering, University of Auckland, New Zealand.*

N. M.Sa'Don

*Department of Civil Engineering, University of Malaysia Sarawak.*

**ABSTRACT:** We are working on the development of 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. 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 a most effective means of evaluating nonlinear soil behaviour. We consider that snap-back testing is more convenient than using a shaking machine which applies sinusoidal excitation. The results from rocking of a shallow foundation and cyclic lateral loading of a single pile enable damping and stiffness to be estimated at increasing levels of lateral loading.

## 1 INTRODUCTION

We have performed field experiments at a site in Auckland where both shallow and deep foundations have been subject to cyclic loading, Algie et al (2010), M.Sa'Don et al (2010). 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 limitations to this approach for the following reasons. First, a given level of excitation force cannot be obtained until the shaker frequency has been increased from zero to the frequency required to generate the force. Second, the response of the system is measured under steady state excitation at a fixed frequency. In this way what is obtained from the use of a shaking machine is not representative of what happens during earthquake excitation.

An alternative, described here, is the use of snap-back testing. This test is simpler than using an eccentric mass shaking machine. It gives the response of the system to one impulsive excitation instead of continuous excitation; it is more representative of what occurs during an earthquake. An added bonus is the static load-deflection curve obtained during the pull-back phase of the test. The initial pull-back can generate a force of comparable magnitude to the maximum force that can be produced by the shaking machine we used.

Below we present results obtained for the nonlinear stiffness and damping of shallow and deep foundations from snap-back testing. Tests were done at a site with Auckland residual clay. The shallow and deep foundations were within about 10 m of each other. A series of snaps from different initial loads shows how the nonlinear behaviour of the foundation develops as the applied load increases. It is found that the damping for the snap-back response of the shallow foundations was generally larger than that of the pile foundations.