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A comparison of static and cyclic loading responses of foundations on geocell-reinforced sand

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ABSTRACT

The results of laboratory-model tests on strip footings supported on unreinforced and geocell-reinforced sand beds under a combination of static and repeated loads are presented. The influences of various parameters are studied including reinforcement width, height of the geocell below the footing base and various amplitudes of repeated load. Mostly, a stable, resilient response is observed once incrementally accumulated plastic strain has ceased (usually during the first 10 cycles of loading). The reinforcement reduces the magnitude of the final settlement, acts as a settlement retardant, permits higher loads or increased cycling. The reinforcement's efficiency in reducing the maximum footing settlement decreased as the height and width of geocell were increased. Plastic deformation was limited by geocells more under repeated loading than under a similar static loading, with the reduction being greatest when more reinforcement was present and when the loading rate was fastest. It is deduced that the greater resilient stiffness of a rapidly loaded polymeric geocell attracts load to itself thereby protecting the soil from some of the more challenging stress states and, hence, reduces deformation. Simple dimensional analysis showed the need for an increased stiffness of the geosynthetic components in order to deliver full-scale performance similitude.

1. Introduction

Soils are periodically subjected to cyclic shear stresses in situ in many circumstances such as earthquakes, storm waves for offshore structures, wind forces in high buildings, pile construction, traffic loads and machine vibrations. Foundations under repeated loads are, therefore, of interest where in addition to permanent loads due to the external static load and the weight of foundation, loads are dynamic in nature due to the action of (for example) earthquakes or moving parts of a machine installed on a foundation. While these dynamic loads are generally small, as compared to the static load, they are applied repetitively over a very large number of loading cycles. The investigation and design of footings under dynamic loadings still remains a challenging task for the geotechnical engineer.

Many researchers have studied the behaviour of unreinforced sandy or clayey soil beneath the foundations under repeated or transient loads (e.g. Cunny and Sloan, 1961; Raymond and Komos, 1978). They reported that significant initial rapid settlement due to repeated load application takes place during the first ten cycles of loading and that an equilibrium response is reached after up to 20,000 load cycles. An equilibrium response to repeated loading has been given the general term "Shakedown" (Sharp and Booker, 1984) with the term "plastic shakedown" being used to label the development of such an equilibrium state after a number of cycles of response in which plastic strain is incrementally accumulated (Werkmeister et al., 2001, 2005).

In recent decades, due to its economy, ease of construction and performance, reinforced soil has been widely exploited in geotechnical engineering applications such as in the construction of roads, railway embankments, retaining wall, stabilization of slopes and improvement of soft ground (Shin and Das, 2000; Bathurst et al., 2003, 2009; Blatz and Bathurst, 2003; Deb et al., 2005; Sitharam et al., 2005, 2007; Dash et al., 2007; Guler et al., 2007; Laman and Yildiz, 2007; Madhavi Latha and Rajagopal, 2007; Chen and Chiu, 2008; Yoon et al., 2008; Zhou and Wen, 2008; Sireesh et al., 2009; Wesseloo et al., 2009; Ling et al., 2009; Madhavi Latha et al., 2009; Zhang et al., 2010; Pokharel et al., 2010; Leshchinsky et al., 2010; Lambert et al., 2011; Moghaddas Tafreshi et al., 2011; Yang et al., 2011).

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