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Research Paper

Insights from a shallow foundation load-settlement prediction exercise

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ABSTRACT

This paper describes an international exercise aimed at assessing the geotechnical engineering profession's ability to predict the response of shallow foundations on soft clay subjected to undrained loading. Predictions of bearing capacity varied by more than an order of magnitude and settlement by more than two orders of magnitude. Average and median predicted values deviated significantly from measured values. The results of this exercise highlight the need to develop tools to assist engineers to process site investigation data. The development of predictive models that connect directly to site investigation data is discussed.

1. Introduction

The design of shallow foundations on soft clay subject to undrained centric vertical loading is a routine task for the geotechnical engineering profession. To satisfy the ultimate limit state, the designer is required to ensure that applied loads remain remote from the ultimate bearing capacity of the foundation. Design for the serviceability limit state requires that settlement of the foundation under working loads will be small enough to ensure satisfactory performance of the structure it supports. Foundation design therefore requires an ability to predict both the ultimate bearing capacity and settlements under working loads.

As part of the activities of the Australian Research Council (ARC) Centre of Excellence for Geotechnical Science and Engineering (CGSE), an international shallow foundation prediction exercise was conducted with the aim of assessing the predictive capabilities of the geotechnical engineering profession. This paper describes the exercise and compares predictions received from 50 submissions with measured foundation performance of field tests carried out at the Australian National Field Testing Facility (NFTF). It was found that participants significantly overestimated the bearing capacity of the foundation, with the average predicted bearing capacity exceeding the measured value by around 100%. On average, predicted settlement values exceed measured values by more than 600%. To examine reasons for the poor prediction results, a review of strength and stiffness data from the site is presented. It is shown that the site data provides a good indicator of foundation performance via simple foundation models. This suggests that poor predictions cannot be attributed to inaccurate or insufficient information. An assessment of the sources of over prediction of bearing capacity and settlement is presented and the use of technology to automate the processing of soil data interpretation or development of predictive models that connect directly to soil data are discussed as possible solutions.

2. Description of foundation tests

2.1. Site description

Supported by the Australian Research Council (ARC), the Centre of Excellence for Geotechnical Science and Engineering (CGSE) established the Australian National Field Testing Facility (NFTF) in Ballina, Northern New South Wales (see Fig. 1). The site is approximatley 6.5 Ha and lies on the Richmond River floodplain, located south of Emigrant Creek and west of Fishery Creek.

The ground conditions comprise a crust of alluvial clayey silty sand to a depth of about 1.0–1.5 m, underlain by soft estuarine clay, underlain by a transition zone of clay, silt and sand, then sand of varying thickness [1]. The thickness of the soft estuarine clay increases from approximately 12–22 m from west to east. The engineering geology at the site is described in detail by Bishop [2], Bishop and Fityus [3], Kelly et al. [4]. Fig. 2 shows results from cone penetration tests (CPT) from the site classified using the Robertson [5] soil behaviour index (*Ic*).

2.1.1. Geotechnical data

A comprehensive site investigation has been conducted at the NFTF involving drilling and logging over 15 boreholes with high quality soil samples collected and tested in a range of laboratory

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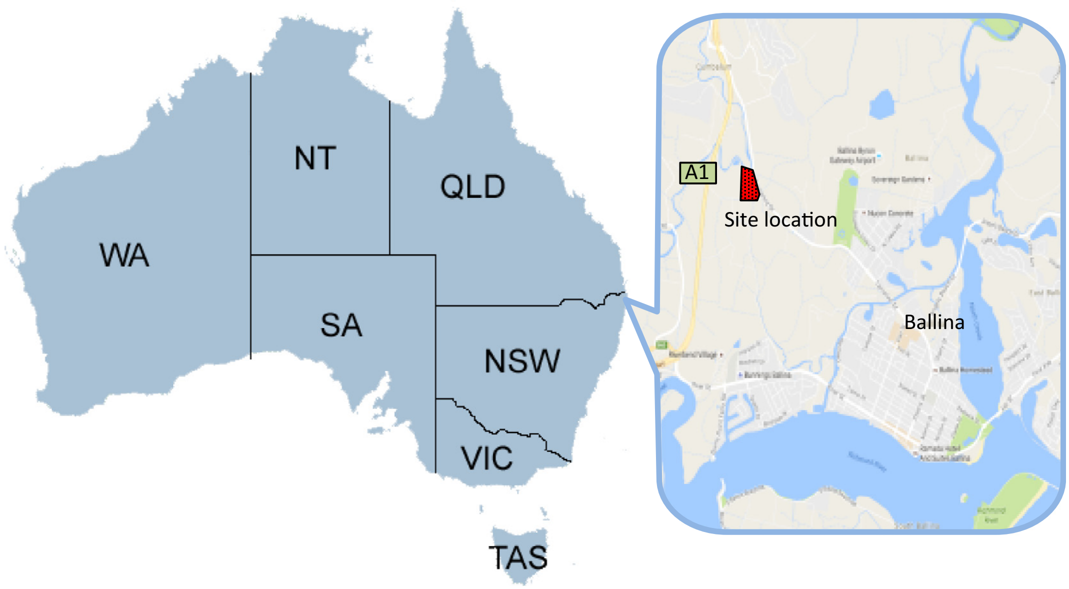

Fig. 1. Location of the Australian National Soft Soil Field Testing Facility (NFTF) at Ballina (NSW).

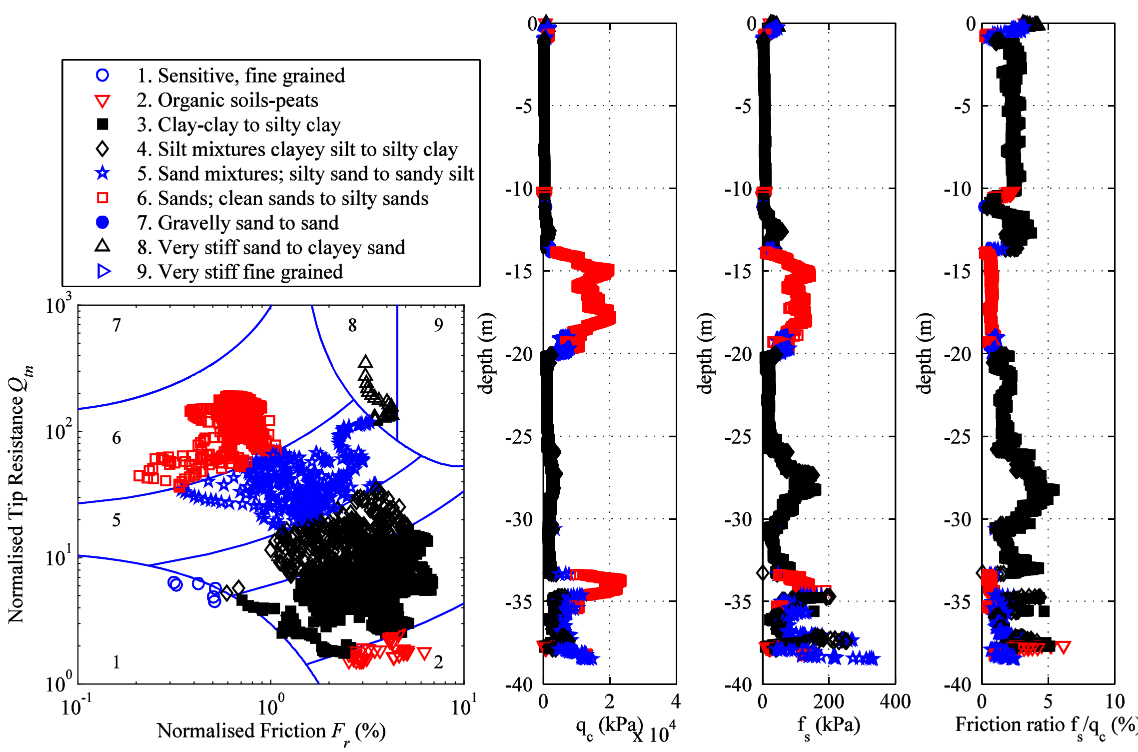

Fig. 2. CPT tests interpreted using *Ic* soil behaviour chart.

apparatus [6–8]. A range of in situ tests including cone penetration tests [4,9,10], ball and T-bar penetrometer tests [11] and self-boring pressuremeter tests [12,13] have also been conducted. A web based application (see Fig. 3) was developed to store, manage and publically share all data [14]. Participants in the foundation prediction exercise were able to access the data by registering as a user at www.geocalcs.com/datamap, and then using the project registration details given in Table 1. The data will continue to be made freely available on this data sharing platform. Further details can be found in Doherty et al. [14].

2.2. Foundation construction and loading details

Two load tests were conducted on almost identical foundations. The foundations, 1.8 m square by 0.6 m high, were constructed in excavated pits 1.5 m deep by 2.4 m square (Fig. 4). Approximately 1 month after construction, the foundations were centrically loaded to failure with precast concrete blocks. Loading of each foundation to failure took approximately 1 h to complete, ensuring undrained conditions. Fig. 5 shows the measured load-settlement response of both foundations. Full details of the field tests are