A SHORT COURSE IN
**SOIL-STRUCTURE
ENGINEERING**
OF DEEP FOUNDATIONS, EXCAVATIONS AND TUNNELS

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Cover photograph

Lion Yard excavation showing a vertical concrete bored pile and horizontal steel props

Preface

This book is divided into three parts – effectively three short courses – focusing on the following three major geotechnical challenges of static soil–structure interaction problems:

- Part 1 Deep foundations – piles and barrettes
- Part 2 Multi-propped deep excavations
- Part 3 Bored and open-face tunnels below cities.

Part 1 *Deep foundations – piles and barrettes* concentrates on axially loaded long piles and barrettes. We were unable to include laterally loaded piles because of space limitations. The introductory sections of Part 1 draw mainly on the state-of-the-art papers by Poulos (1989) and Randolph and Wroth (1979). We then focus on the long piles that are typical in the Far East. Long piles have a particular character because their elastic shortening under load makes the pile head load–displacement test more difficult to interpret. Pile failure load criteria, therefore, need re-examining and we provide new displacement failure criteria based on many pile tests. For ‘floating’ barrettes and long piles, where their load capacity is derived from side resistance only, the degree of mobilisation of side resistance is clearly critical and so Mobilisation Rating is a key concept that is explained.

Part 2 *Multi-propped deep excavations* uses an extended case study as the vehicle for explaining the design concepts – this is Lion Yard, Cambridge. Preliminary design methods are presented as ‘handwritten’ Short Course Notes. Plastic mechanisms of failure are explained drawing on the work of Bolton (1993). Numerical modelling is used to obtain vertical and horizontal ground movements associated with the separate effects of panel trenching and installation (including bentonite support and tremie concreting), and of propping and excavating deep excavations retained by diaphragm walls. In particular, the realistic Wall-Installation-Modelled (WIM) method is introduced and compared with the more common and unrealistic Wished-In-Place (WIP) method of analysis.

Part 3 *Bored and open-face tunnelling below cities* begins with an introduction from Bolton (1979) showing how easily soil arching supports

tunnels – making sprayed concrete linings quite acceptable as used by the New Austrian Tunnelling Method (NATM). The main body of Part 3 draws extensively on the state-of-the-art paper by Mair and Taylor (1997) and concentrates on the evaluation of the surface settlement trough above a tunnel heading. The settlement trough shape follows the classic Gaussian probability curve – all that is required to define the trough are the parameters of either maximum settlement or ground loss, and the point of inflexion of the Gaussian curve. Numerical modelling is used to model the interaction between two parallel tunnels being driven with one lagging behind the heading of the other. The left and right tunnels are even driven in left and right drifts. This demonstrates the quite detailed and numerous installation steps that can be numerically modelled. We also show the effect of driving a tunnel near a pile tip. The pile capacity is first assessed by modelling an axial loading test and so providing a load–displacement curve from which a working load is found. A tunnel is driven near the tip of the pile where plastic yielding then occurs. The loss of working load is found to be an alarming two-thirds!

Several detailed case studies are considered. These include a well-instrumented test barrette in Hong Kong together with 15 other test barrettes, plus an extensive review of 28 large-diameter floating bored pile tests. These studies help to establish the Mobilisation Ratings that are critical in design. We also include the extended case studies of the Heathrow Express Trial Tunnel (Deane and Bassett, 1995) and the Lion Yard deep excavation (Ng, 1992, 1998). Finally, we briefly review the precautions taken to protect the Big Ben Clock Tower from ground movements caused by the Jubilee Line Extension tunnels (Burland *et al.*, 2001). These measures included monitoring of the Tower tilt and compensation grouting by *tubes à manchette* (TAMs).

This book will give both student and practising civil engineers a useful review of the state-of-the-art of designing deep foundations, excavations and tunnels. In addition, the case studies and numerical modelling presented will give valuable insights into the challenges of soil–structure engineering.

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Dedication

Professor Noel Simons FREng, 1931–2006

Noel Simons, who developed the University of Surrey into one of the UK's leading centres of geotechnical learning and research, and who inspired the Short Course Series of geotechnical books, died on August 10th 2006. He was aged 75.

He was not only a wonderful teacher, mentor, colleague and co-author, but was also a dear friend. This book is dedicated to his memory.

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