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Performance of braced excavation in residual soil with groundwater drawdown

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Abstract

In densely built-up Singapore, relatively stiff secant-bored piles and diaphragm walls are commonly used in cut-and-cover works to minimize the impact of ground movement on the adjacent structures and utilities. For excavations in stiff residual soil deposits, the associated wall deflections and ground settlements are generally smaller than for excavations in soft soil deposits. However, if the residual soil permeability is high and the underlying rock is highly fissured or fractured, substantial groundwater drawdown and associated seepage-induced settlement may occur. In this study, the excavation performance of four sites in residual soil deposits with maximum excavation depths between 20 and 24 m is presented. The maximum wall deflections were found to be relatively small compared to the significantly larger maximum ground settlements, owing to the extensive lowering of the groundwater table. In this paper, details of the subsurface conditions, excavation support system, field instrumentation, and observed excavation responses are presented, with particular focus on the large groundwater drawdown and associated ground settlement. Specific issues encountered during the excavation, as well as the effectiveness of various groundwater control measures, are discussed. The case studies will provide useful references and insights for future projects involving braced excavations in residual soil.

Keywords: Residual soil; Braced excavation; Wall deflection; Ground settlements; Groundwater drawdown; Strut force

Introduction

In a dense, built-up environment, damage to buildings and utilities may occur because of excessive ground movement arising from excavation activities nearby. Consequently, in Singapore, for deep excavation projects, stiff diaphragm walls and bored pile walls with multiple strut levels are commonly used to minimize lateral wall movement and ground settlement, even in fairly stiff residual soil deposits. However, if the residual soil permeability is high and the underlying rock is highly fissured or fractured, substantial groundwater drawdown and associated seepage-induced settlement may occur, as reported by Wen and Lin (2002) and Goh, Lim, Chen, and Wen (2014) for various deep excavation projects in Singapore. In this study, the excavation performance of four sites in residual soil deposits with maximum excavation depths between 20 and 24 m is presented. The maximum wall deflections were found to be relatively small, significantly larger than the maximum ground settlements. A possible reason for the large ground settlements is the lowering of the groundwater table at these sites (Goh et al., 2014; Wen & Lin, 2002).

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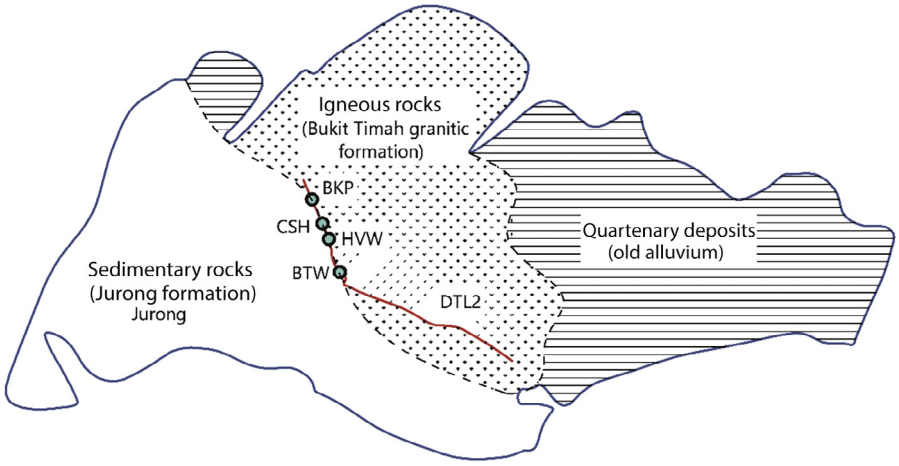

Fig. 1. Simplified geological map of Singapore and locations of the four sites.

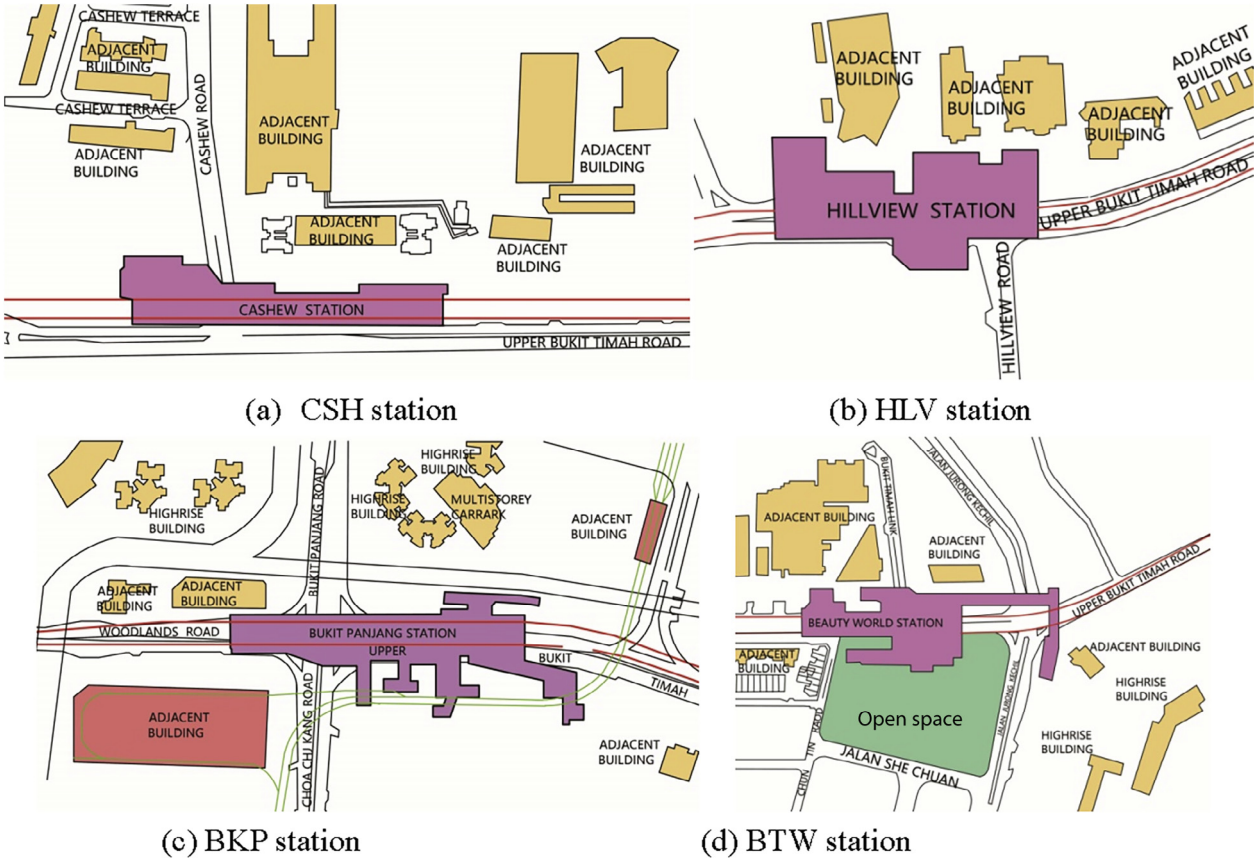

Fig. 2. Plan layout of four stations.

Fig. 1 illustrates the locations of the four cut-and-cover excavations for the construction of mass rapid transit stations, which form part of the Downtown Line 2 (DTL2) project that was recently completed. The stations are: Cashew (CSH), Hillview (HLV), Bukit Panjang (BKP), and Beauty World (BTW). In this paper, details of the subsurface conditions, excavation support system, field instrumentations, and observed excavation responses are presented, with focus on the large groundwater drawdown and associated ground settlements. The measured wall deflections, ground surface settlement values, settlement profiles, as well as strut forces, are also compared with empirical methods/charts from the literature. Specific issues encountered during excavation are presented, and the effectiveness of various groundwater control measures is discussed.

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