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Influence of existing tunnels on compressibility characteristics of London Clay

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1.INTRODUCTION

London Clay is a stiff, overconsolidated soil which was deposited in marine environmental in the early Eocene across the London and Hampshire Basins in southeast England. The stratigraphy of London Clay and associated deposits were first proposed by King (1981) and the recent case study of the Jubilee line extension by Burland and Standing (2006) has drawn engineers' attention to the soil properties. The project focuses on investigating the consolidation characteristics of London Clay at three distances from the westbound Central line tunnel beneath Hyde Park, London to access its influence.

2. OBJECTIVES

- Obtain and compare compressibility characteristics for comparative samples at various distances from the Central line tunnel.
- Compare the intact properties with the intrinsic properties to highlight the influence of structure of the natural material

3. METHODOLOGY

In this research, sample characterisation tests and oedometer tests were carried out according to the methods in BS 1377:1990(Standard). Sample characteristic tests, including water content and Atterberg limits, give a more general idea of the intrinsic properties of the intact London Clay. The oedometer test can produce one-dimensional compression curve which can be used to access how the ground is influenced by an existing tunnel.

4. BASIC INFORMATION

The samples used in this project were taken prior to the Crossrail tunnel construction. Three depths of interest spaced at different distance from the Westbound Central line tunnel were selected. The sample names and their corresponding locations are summarized in Table 1.

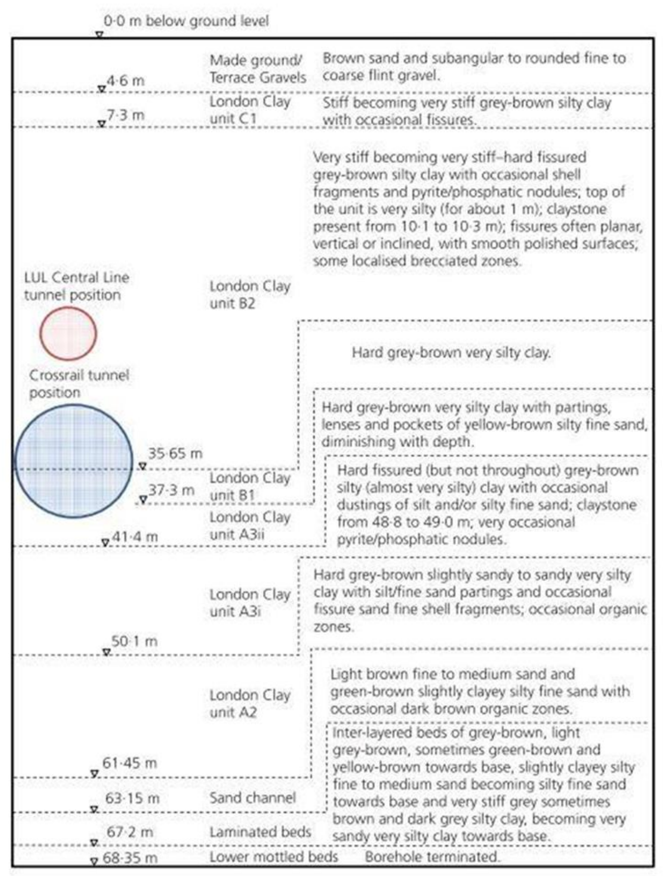

Figure 1: soil descriptions (Wan & Standing, 2014)

Table 1: Basic information of the samples

London clay unit	Sample name	Distance from the Central Line tunnel (m)	Depth below the ground level (m)	Depth below the ground level (m)
B2	B (c1)	6.9	20.45-20.55	20
	B (c2)	8.1	20.65-20.75	
	B (c3)	39.4	18.36-18.46	
	B (b1)	6.9	25.30-25.40	25
	B (b2)	8.1	25.70-25.80	
	B (b3)	39.4	26.55-26.75	
	B (a1)	6.9	29.52-29.62	30
	B (a2)	8.1	30.30-30.40	
	B (a3i)	39.4	28.55-18.65	
	B (a3ii)		31.20-31.30	

The tunnel is located 22.5 metres below ground level. The research focused on Division B2 in which the Central Line tunnel was constructed and so is the division most affected by it.

5. RESULTS AND ANALYSES

In Figure 2, the sample from an elevation close to the Central Line tunnel crown shows very high plasticity characteristic, the samples at elevation below the invert show high plasticity, although still very close to the very high plasticity range. Figure 3 shows the oedometer test result of B (b1) in e-logσ' space. The range of the void ratio of the samples is 0.45 to 0.8 during the test. The blue curves are plotted using forward calculation while orange curves are plotted using back calculation.

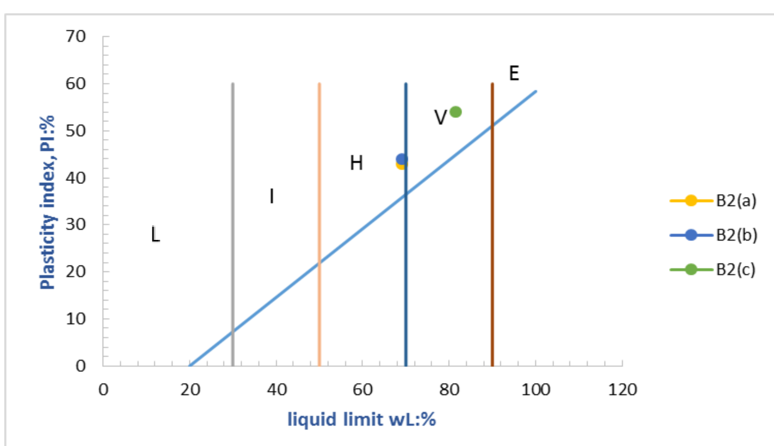

Figure 2: Samples on Casagrande chart

Figures 4 (a) and (b) show how void ratios of undisturbed samples vary with the distances from the Central Line tunnel, there is a sharp decrease in void ratio for the clay closer to the tunnel. The reason for this is that after excavation there would be a decrease in pore water pressure close to the tunnel, eventually leading to consolidation and long-term seepage into the tunnel is also likely to happen.

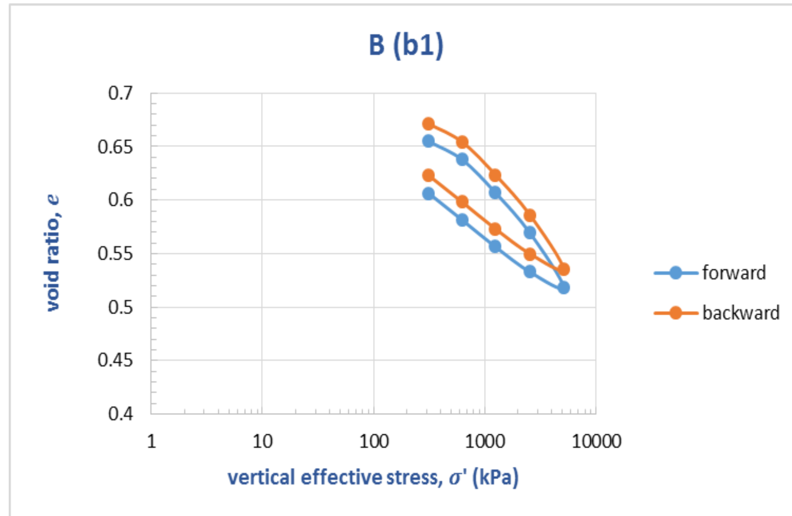

Figure 3: The individual oedometer test path

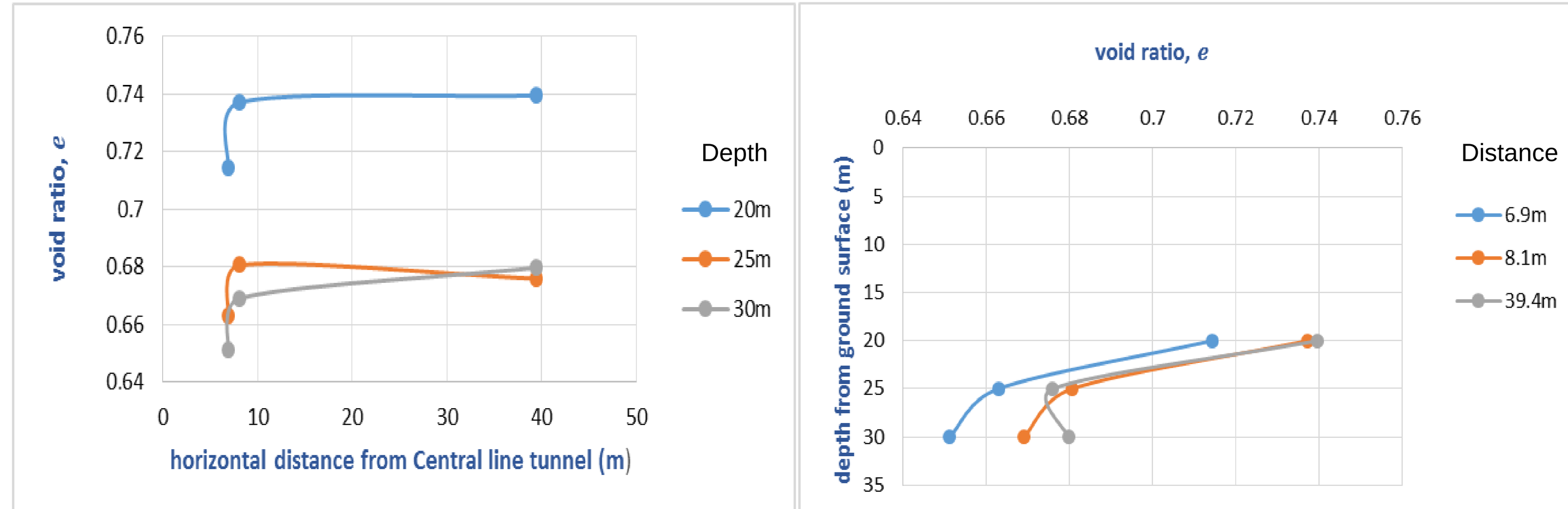

Figure 4 (a) & (b): relationship between voids ratio (e) and distances from Central line tunnel

Three coefficients have been derived from the oedometer test paths: m_v-coefficient of volume compressibility; c_v-coefficient of consolidation and k-coefficient of permeability. Figure 5 shows the data of samples B(a1), B(a2) and B(a3ii), the coefficients decrease as the loads increase. Samples were also trimmed horizontally to investigate anisotropy by comparing the vertical and horizontal compressibility characteristics of the samples (Figure 6). The maximum c_v values are found to be 5 times larger than c_v in vertical compression, and k is marginally greater. In Figure 7, by using the void index equation along with the void ratios at the liquid limit, the oedometer compression curves are compared with the ICL and the SCL. These curves cross the ICL and there is no sign of them converging to the ICL, indicating that the London Clay is overconsolidated.

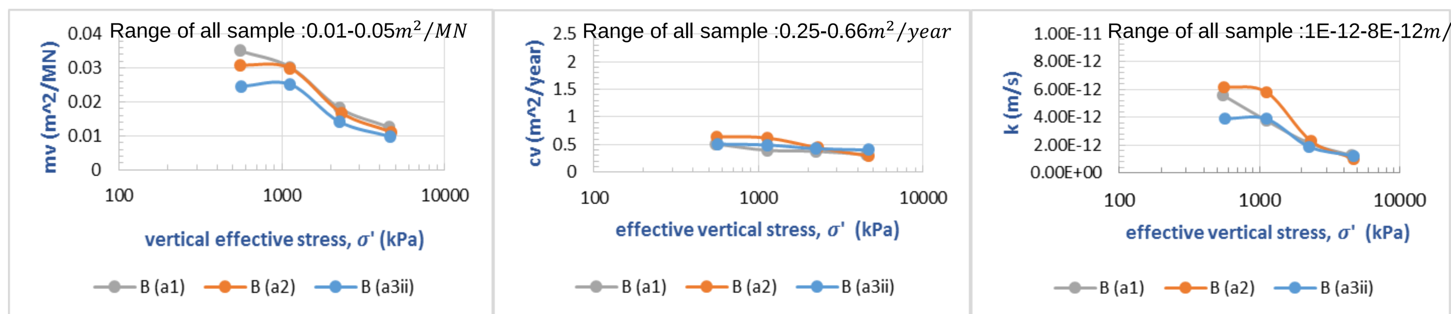

Figure 5. relationship between vertical effective stress σ' and m_v, c_v, k

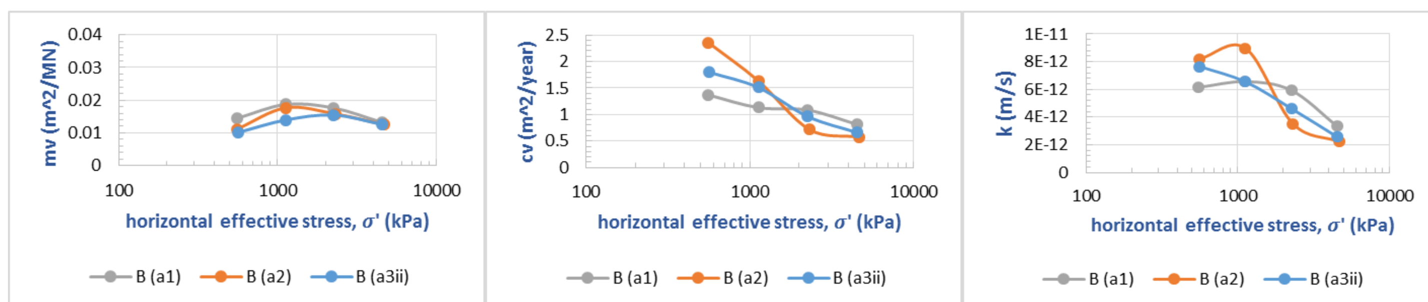

Figure 6. relationship between horizontal effective stress σ' and m_v, c_v, k

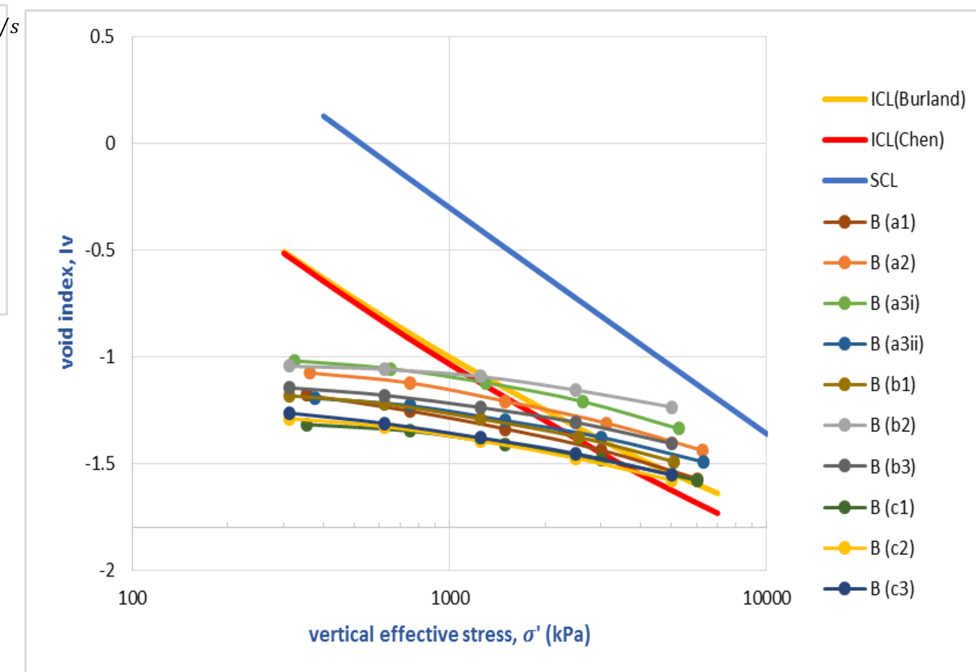

Figure 7: oedometer test on London Clay

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