1.364 ADVANCED GEOTECHNICAL ENGINEERING

HOMEWORK NO. 4

Due: Monday November 24th

Question 1

Two circular concrete piles each 0.4m in diameter were installed through thick soft to firm clays underlain by dense coarse silty sand at depth. The subsoil profile and the variation of the soil properties with depth from the ground surface is given in Figure 1 and 2. The characteristic strength and Young's modulus of the pile concrete was 30 MPa and 20 GPa respectively. Pile No.1 was driven to a set at 20.8m in the dense silty sand layer, whilst Pile No.2 was terminated 1m above the top of the dense silty sand layer within the firm silty clay/clayey silt. After completion of piling, the platform was subsequently raised by 2m and compacted to a density of $20kN/m^3$. The embankment can be considered as wide in relation to the thickness of the clay layer. The piles were debonded from the embankment by applying a bituminous slip coating.

TASKS

1.1 For Pile No.1,

a. Calculate the ultimate capacity of the pile in end bearing and the factor of safety for a working load of 970 kN, without considering effects of downdrag
b. Obtain the profile of vertical pile displacement with depth under the applied working load of 970 kN, assuming that no downdrag occurs
c. Compute the free field ground settlement under the surcharge weight of the embankment at 1m depth intervals
d. Assess the location of the neutral axis due to downdrag
e. What will be the factor of safety of the pile as a result of the downdrag force?
f. Estimate the additional vertical displacement at the pile head due to downdrag

1.2 For Pile No.2,

a. Calculate the working load of the pile if a factor of safety of 2.0 is required, without consideration of downdrag
b. Obtain the vertical pile displacement with depth under the working load calculated in (a), assuming no downdrag occurs
c. Estimate the resulting vertical displacement of the pile head due to the surcharge imposed by the embankment
d. What is the factor of safety of the pile in this case?

Note that in Figure 2, values of m_v were obtained for two load increments (σ'_{vo} and $4\sigma'_{vo}$). For simplicity, assume that the lower values apply if OCR<1 and the higher values apply for OCR>1.

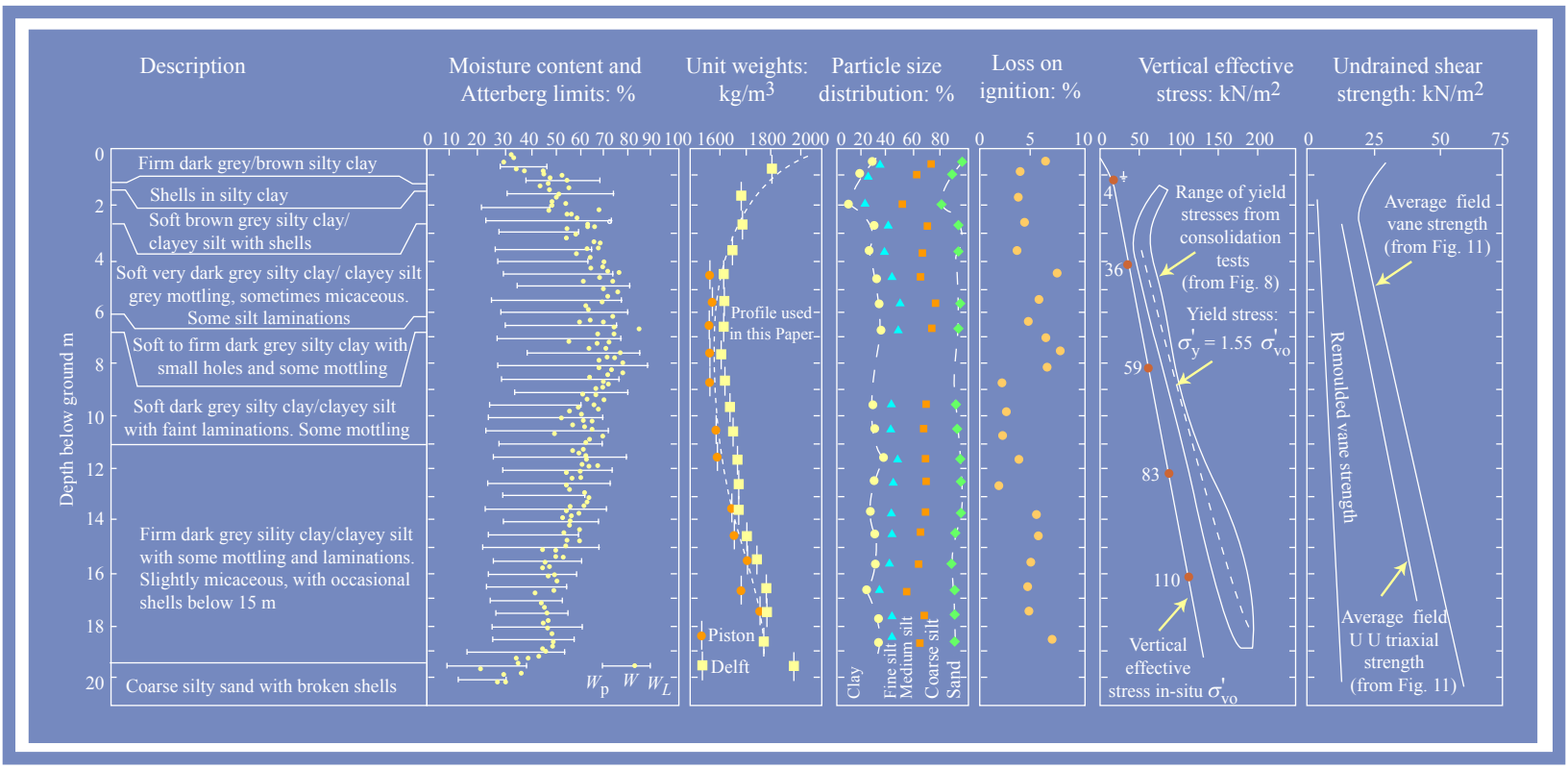

Figure 1. Soil profile and geotechnical parameters, Bothkennar site

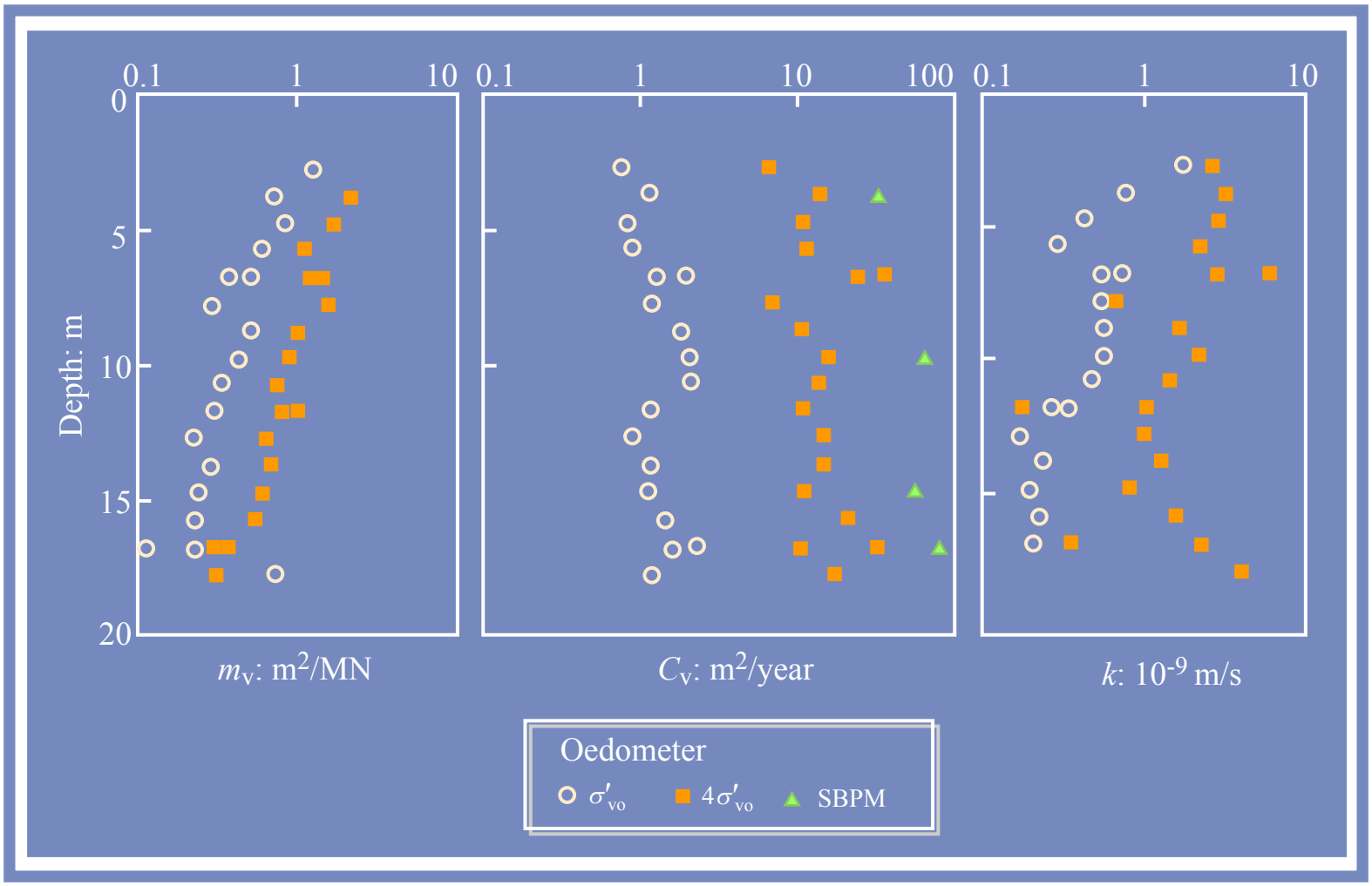

Figure 2. Compressibility, consolidation and hydraulic conductivity parameters, Bothkennar

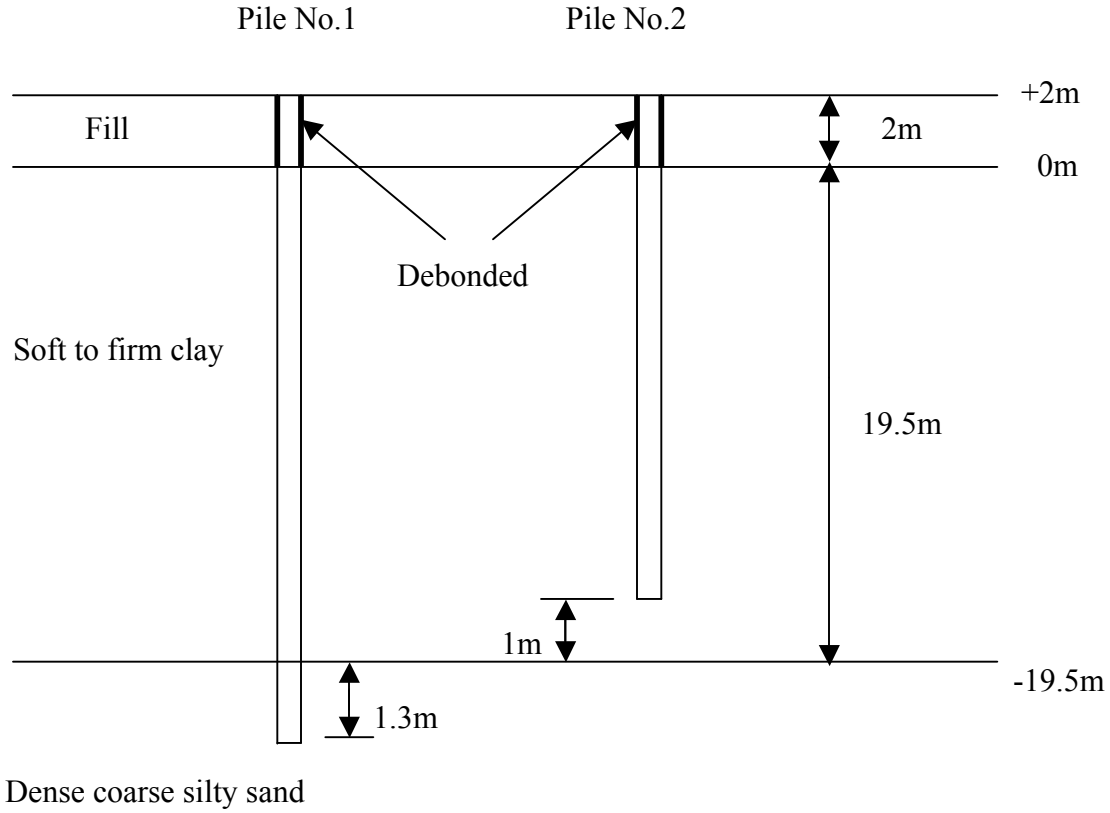

Figure 3 Schematic of piles installed

Question 2

A bridge pier is to be founded on the same soil profile as question 1. The pier will be supported on 13m deep drilled shaft foundations. Each drilled shaft is 1m diameter and will be constructed with reinforced concrete of characteristic strength 35 MPa. The pile modulus was determined to be 20 GPa. The ultimate structural moment capacity of each pile was 3750 kNm. Assuming that the head of each pile is fixed against rotation and that the elastic shear modulus of the clay , $G = 100s_u$, find the following:

a. Use the method of Fleming et al (1985) to compute the maximum working lateral load that can be applied to the pile head without exceeding a factor of safety of 1.5 on the ultimate lateral geotechnical capacity
b. For the value of the working load obtained, predict the lateral deflection and bending moment along the pile shaft using the Wrinkler model.
c. Compare the results of (b) with those calculated using the elastic continuum model of Randolph (1981).