Eurocode 7
Soil Characterization – ULS Parameters

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EC7

- background – UK practice
- shallow foundations, bearing capacity checks
  - sample/lab test methods
  - spatial variability
- slope engineering
- EC7 – implications for UK practice (ULS Geo)

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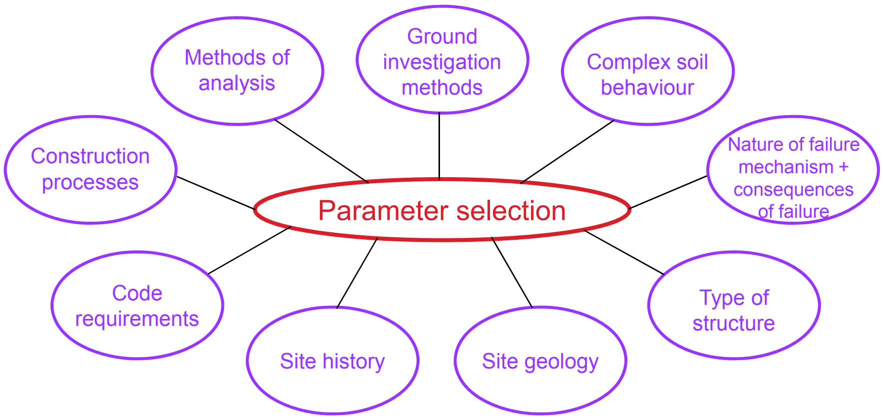
Parameter selection – why difficult?

Depends on a lot of factors!



Does EC7 provide flexibility to make site specific judgements?

Background – UK practice

- UK Geology – very complex
- ground investigation methods – crude
- British Standards and design guides
  - BS8004: high Factor of Safety (~3)
  - BS8002: critical state for o/c deposits (worst credible, FoS=1.0)
  - CIRIA C574, Chalk: bearing pressure, qb < yield stress, qy
- above use simple "ULS Calcs" ensure SLS ok
  - specific SLS analyses become less critical
- EC7 – allow for above challenges?

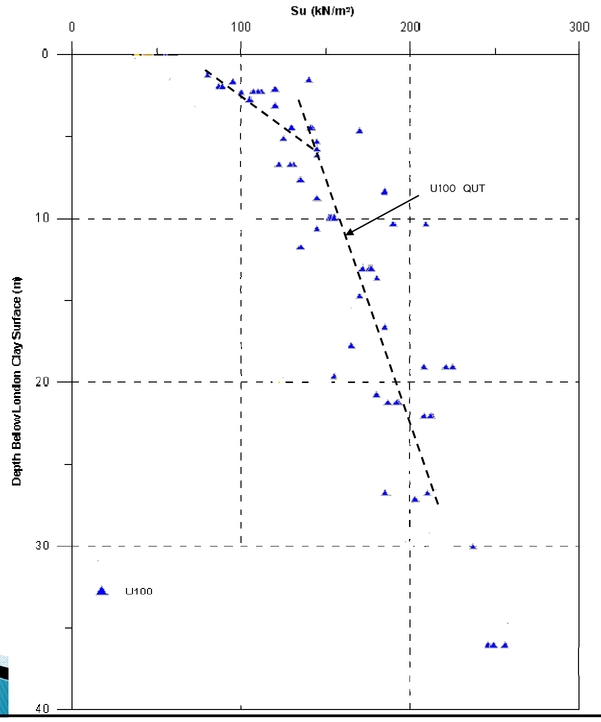
Shallow foundations, bearing capacity checks

1. Influence of sample and lab test methods, o/c clays
   Compare "simple" vs. "sophisticated" approach

"Simple"
- driven samples
- quick undrained triaxial, t_f ~ 1 to 3 minutes
- basic bearing capacity theory (constant Su with depth)

"Sophisticated"
- high quality samples (thin wall/push-in, rotary core, block)
- slow undrained triaxial, t_f ~ 1day
- modern bearing capacity theory (increasing Su with depth)

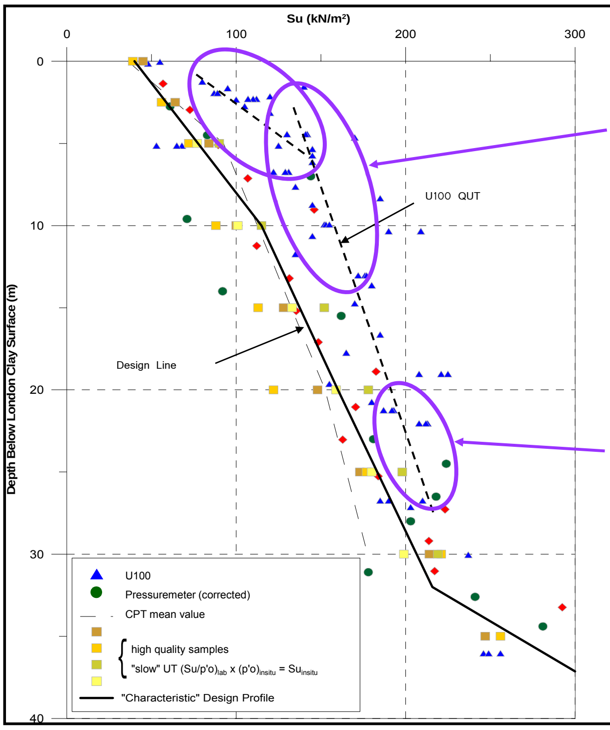
Compare BS8004 vs. EC7 (DA1-2)



For square pad/raft B = 1.5m, 3m, 6m, 16m
"Simple" approach

Width, B (m)	"Safe" Bearing Pressure (kN/m²)	
	BS8004 (FoS = 3)	EC7*
1.5	135	270
3	150	300
6	185	370
16	225	450

* EC7, DA1-2, partial factor = 1.4 on undrained strength



QUT

- high strain rate
- high mean effective stress (sampling induced)

QUT

- increasing depth
  - loss of structure

Width (m)	Safe Bearing Pressure, kN/m² (Settlement, mm)		
	Simple		Sophisticated
	BS8004	EC7	EC7
1.5	135 (10)	270 (20)	190
3	150 (18)	300 (36)	195
6	185 (37)	370 (74)	200
16	225 (100)	450 (200)	220

Note. Settlement – based on linear elasticity and empirical correlations. Unconservative at high bearing pressures.

"simple" approach – systematic bias

- overestimate bearing capacity (DA1-2, PMF = 1.4)
- SLS checks become critical

Appropriate for routine "simple" design?

Shallow foundations, bearing capacity checks

2. Influence of spatial variability

- EC7 statements
  - Cl. 2.4.5.5, para (7)

The zone of ground governing the behaviour of a geotechnical structure at a limit state is usually much larger than a test sample or the zone of ground affected in an in situ test. Consequently the value of the governing parameter is often the mean of a range of values covering a large surface or volume of the ground. The characteristic value should be a cautious estimate of this mean value.

- BUT
  - Cl. 2.4.5.2, para (11)

If statistical methods are used, the characteristic value should be derived such that the calculated probability of a worse value governing the occurrence of the limit state under consideration is not greater than 5%.

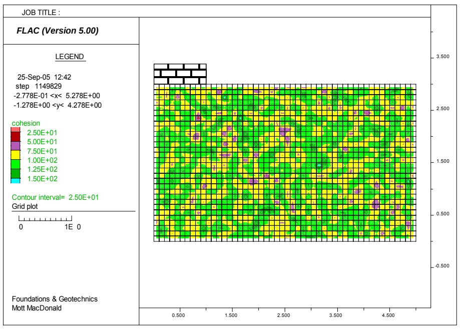
Note: In this respect, a cautious estimate of the mean value of the selection of the mean value of the limited set of geotechnical parameter values, with a confidence level of 95%; where local failure is concerned, a cautious estimate of the low value is a 5% fractile.

Practical implications?

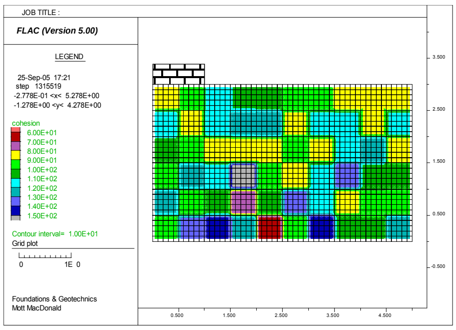
FLAC analysis

- considered the ultimate bearing capacity of a 2m wide strip footing at the ground surface on a cohesive soil
- the undrained shear strength was defined by: (mean = 100kPa, standard deviation = 20kPa)
- each zone ("block") was assigned a different value of undrained strength using the FLAC property distribution function
- where bigger blocks of soil were required, properties were copied to adjacent zones
- 100 analyses were run for each block size

Undrained strength distribution

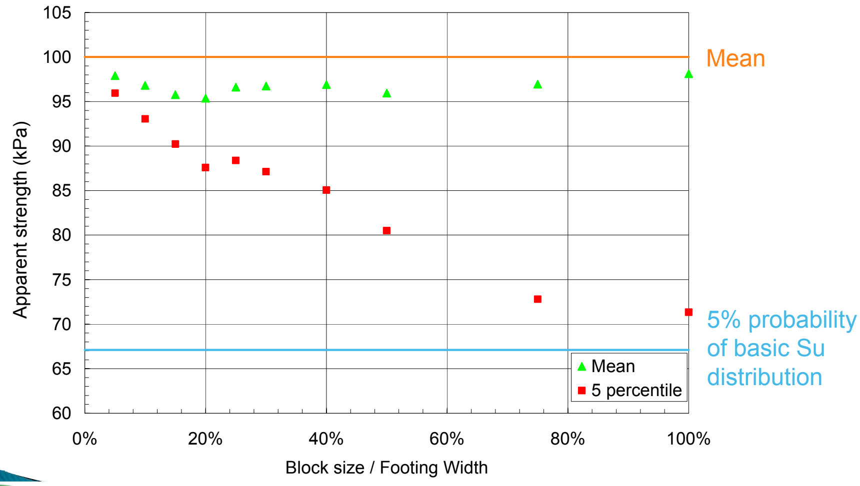


0.1m wide blocks



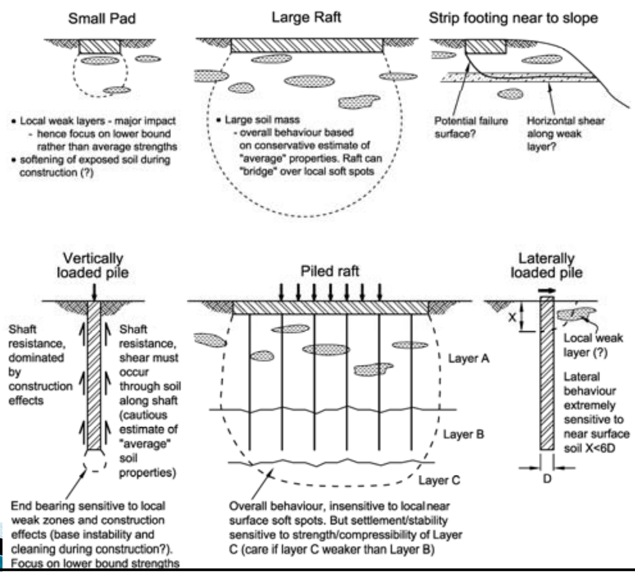
0.5m wide blocks

Variation of mobilised strength along failure surface with "block" size



Spatial variability – practical implications

- soil properties within D < $^{2}/_{3}$ B critical
- small foun's, continuous sampling/ profiling (CPT) important

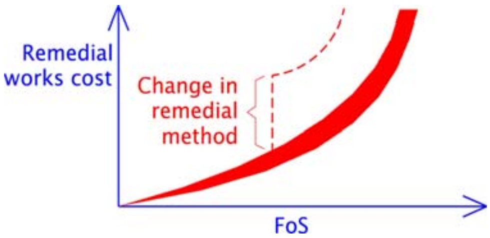


Slope engineering

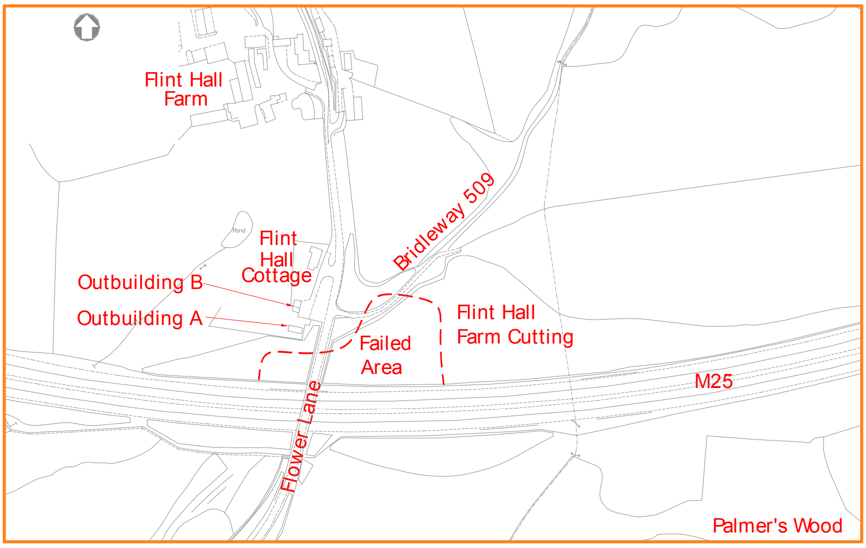
Many design situations

1. Consequence of failure
   - embankment dams (large loss of file)
   - minor slopes, rural (inconvenience)
2. Relevant soil parameters – peak to residual
3. Groundwater conditions
4. Appropriate Factors of Safety vs. Cost

- UK experience
  - FoS varies 1.5 to 1.05 (depending on risk, parameter selection etc)
- NR/071
  - mod. con. parameters, FoS = 1.3
  - worst credible parameters, FoS = 1.1



Slope engineering – Flint Hall Farm Cutting, M25



- 2000/2001 – wet weather, induced large landslip

Hard shoulder heave

Investigation (1)

- desk study
  - identified previous instability in this area
- stereoscopic aerial photograph interpretation
  - identified landslide features crossing motorway
- geological and geomorphological mapping
  - confirmed presence of fossil landslides

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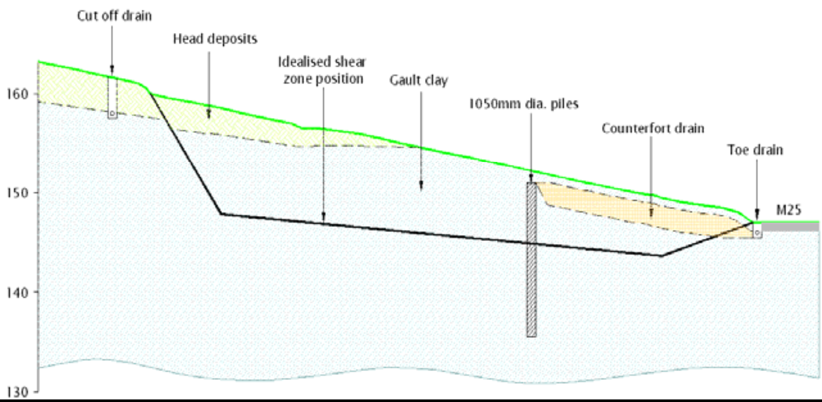
Design philosophy, remedial works

- 20% increase in FoS → 1.05m dia piles
- FoS after remedial ~ 1.13 to 1.21
  - (if minimum FoS = 1.25 all sections, >> remedial works!)



EC7 – implications for UK practice

- flexible?
- too much emphasis on
  - characteristic strength
  - tables of partial factors
- EC7 also states
  - Cl. 2.4.1 para (2) — It should be considered that knowledge of the ground conditions depends on the extent and quality of the geotechnical investigations. Such knowledge and the control of workmanship are usually more significant to fulfilling the fundamental requirements than is precision in the calculation models and partial factors.
  - Cl. 2.4.1 para (4) — If no reliable calculation model is available for a specific limit state, analysis of another limit state shall be carried out using factors to ensure that exceeding the specific limit state considered is sufficiently improbable.
  - Cl. 2.4.6.2 — P design values of geotechnical parameters (Xd) shall either be derived from characteristic values using the following equation: $X_d = X_k / \gamma_M$

    OR SHALL BE ASSESSED DIRECTLY.

Conclusions

1. UK designers face many different situations, both "simple" and "sophisticated" approaches are needed
2. When "simple" GI methods and analyses are used, either higher partial factors, or appropriately conservative, directly derived design parameters should be used
3. Spatial variability can be important, especially for small foundations. Commonly used sampling frequencies are inadequate. More use of CPT/Geophysics?
4. Slope engineering – use of "characteristic" parameters and partial factors often inappropriate. Directly derived strength parameters often a better option