T250/SC7 – EG7
FPS/AGS Mirror Group
Design of Piles in the UK
Using EC7 and the NA

Aim: To define the UK position on the geotechnical design of piles to EC7 for inclusion into the work of EG7.

By: Establishing a consensus on the UK position based on actual (and desired) industry practice on the geotechnical design of piles to EC7.

At this stage only considering the geotechnical design of bearing piles.

We must obtain a consensus – points where this can not be achieved will not be addressed at this time!

Scope:

Pile types:

Bored - CFA, rotary bored, rotary displacement.

Displacement – concrete precast, other pre-formed (e.g. steel piles), driven cast insitu.

Also micro-piles as appropriate.

Design situations:

Single piles - axial compression , axial tension, lateral loading, (NSF & heave not explicitly covered today - to be considered in the future – along with pile groups, embedded retaining walls.)

Margin of safety – to maintain the current UK levels of safety commensurate with level and type of pile testing. (i.e. in 'old money' FOS = 3.0 – no testing, 2.5 – 1% working tests, 2.0 – non-working tests + 1% working tests).

Do we agree?

(Is there a case for allowing lower margins of safety IF SLS is explicitly considered?)

UK Design Philosophy

UK Design is predominantly based on '*Design by calculation'.* Usually:-

- based on ground properties from ground investigation
- Utilising established design formulae
  - From published sources (EC7 should not get into the detail of what formulas are used and where – this is for the geotechnical design engineer to consider/select)
  - based on testing/comparable experience in similar conditions (e.g. LDSA)
- Validated by site specific pile testing commensurate with margin of safety adopted (i.e. as we do now – do we want to change this?).

UK Practice?

7.4 Design methods and design considerations

7.4.1 Design methods

(1)P The design shall be based on one of the following approaches:

— ~~the results of static load tests, which have been demonstrated, by means of calculations or otherwise, to be consistent with other relevant experience;~~

— empirical or analytical calculation methods whose validity has been demonstrated by static load tests in comparable situations;

— the results of dynamic load tests whose validity has been demonstrated by static load tests in comparable situations;

— ~~the observed performance of a comparable pile foundation, provided that this approach is supported by the results of site investigation and ground testing.~~

?

- Empirical or analytical calculation methods supported by dynamic testing whose validity has been demonstrated by static load tests in comparable situations.

7.6.3.2 for tensile resistance

7.6.2.2 Ultimate compressive resistance from static load tests

(1)P The manner in which load tests are carried out shall be in accordance with 7.5 and shall be specified in the Geotechnical Design Report.

(2)P Trial piles to be tested in advance shall be installed in the same manner as the piles that will form the foundation and shall be founded in the same stratum.

Not really relevant to UK practice – suggest remove from EC7/discourage in UK NAD?

7.6.2.3 Ultimate compressive resistance from ground test results

(1)P Methods for assessing the compressive resistance of a pile foundation from ground test results shall have been established from pile load tests and from comparable experience as defined in 1.5.2.2.

Nearly what we do routinely in the UK – but needs rewording?

- Was written with displacement pile design from CPTs in mind (I think)
- Add in process of site wide ground model development & derivation of parameters to be used in industry accepted design formula i.e. not having to do a design for each bore hole.

No tension equivalent?

7.6.2.4 Ultimate compressive resistance from dynamic impact tests

(1)P Where a dynamic impact (hammer blow) pile test [measurement of strain and acceleration versus time during the impact event (see 7.5.3(1))] is used to assess the resistance of individual compression piles, the validity of the result shall have been demonstrated by previous evidence of acceptable performance in static load tests on the same pile type of similar length and cross-section and in similar ground conditions.

Does anyone in the UK use this approach?

If so any changes required?

Are NAD factors appropriate?

No tension equivalent?

7.6.2.5 Ultimate compressive resistance by applying pile driving formulae

(1)P Pile driving formulae shall only be used if the stratification of the ground has been determined.

(2)P If pile driving formulae are used to assess the ultimate compressive resistance of individual piles in a foundation, the validity of the formulae shall have been demonstrated by previous experimental evidence of acceptable performance in static load tests on the same type of pile, of similar length and cross-section, and in similar ground conditions.

(3)P For end-bearing piles driven into non-cohesive soil, the design value of the compressive resistance, $R_{c;d}$, shall be assessed by the same procedure as in 7.6.2.4.

Does anyone in the UK use this approach?

If so any changes required?

Are NAD factors appropriate?

No tension equivalent?

7.6.2.6 Ultimate compressive resistance from wave equation analysis

(1)P Wave equation analysis shall only be used where stratification of the ground has been determined by borings and field tests.

(2)P Where wave equation analysis is used to assess the resistance of individual compression piles, the validity of the analysis shall have been demonstrated by previous evidence of acceptable performance in static load tests on the same pile type, of similar length and cross-section, and in similar ground conditions.

(3)P The design value of the compressive resistance, $R_{c;d}$, derived from the results of wave equation analysis of a number of representative piles, shall be assessed by the same procedure as in 7.6.2.4, using ξ–values based on local experience.

NOTE Wave equation analysis is based on a mathematical model of soil, pile and driving equipment without stress wave measurements on site. The method is usually applied to study hammer performance, dynamic soil parameters and stresses in the pile during driving. It is also, on the basis of the models, possible to determine the required driving resistance (blow count) that is usually related to the expected compressive resistance of the pile.

Does anyone in the UK use this approach?

If so any changes required?

Are NAD factors appropriate?

Design Approach

- Are we happy with DA1, C1 & C2? (see following slides)

Design Approaches & Combinations?

Brian Simpson proposal – remove the 3 DA's and replace with a single approach ….

2.4.7.3 Verification of resistance for structural and ground limit states in persistent and transient situations

2.4.7.3.1 General

(1)P When considering a limit state of rupture or excessive deformation of a structural element or section of the ground (STR and GEO), it shall be verified that:

$$E_d \leq R_d \qquad (2.5)$$

where:

$$E_d = \gamma_E \, E\{\gamma_F \, F_{rep}; X_k/\gamma_M; a_d\}$$

$$R_d = R\{\gamma_F \, F_{rep}; X_k/\gamma_M; a_d\} / \gamma_R$$

This includes all the possible factors

Problems with the present text

- Text in Section 2 is too complicated.
  - Replace by a single inequality, including all the possible factors

- Tables of partial factors in Annex A are confusing.
  - Replace by a single table
  - Easy to follow when doing calculations
  - Will need footnotes or other explanations to show when each column is used.
  - Allows flexibility to each nation, including requirements to check more than one column.

- No fundamental change here – merely presentation.

Implies still require C1 & C2??

UK National Annex

Case	1	2	3	4	5	9	10
Limit state [a]	EQU	EQU	STR/GEO	STR/GEO [e]	STR/GEO	UPL	HYD
γ_G (actions)			1.35/1.0				
γ_Q (actions)			1.5/0.0	1.1	1.3		
$\gamma_{G,E}$ (effects) [b]				1.35			
$\gamma_{Q,E}$ (effects) [b]				1.35			
γ_ϕ					1.25		
$\gamma_{c'}$					1.25		
γ_{Cu}					1.4		
γ_{qu}					1.4		
Spread foundations – bearing $\gamma_{R,v}$							
Spread foundations – sliding $\gamma_{R,h}$							
Driven piles, base (compression) γ_b					1.7/1.5		
Driven piles, shaft (compression) γ_s					1.5/1.3		
Driven piles total (compression) γ_t					1.7/1.5		
Driven piles (tension) $\gamma_{s,t}$					2.0/1.7		
Bored piles, base (compression) γ_b					2.0/1.7		
Bored piles, shaft (compression) γ_s					1.6/1.4		
Bored piles total (compression) γ_t					2.0/1.7		
Bored piles (tension) $\gamma_{s,t}$					2.0/1.7		
CFA piles, base (compression) γ_b					2.0/1.7		
CFA piles, shaft (compression) γ_s					1.6/1.4		
CFA piles total (compression) γ_t					2.0/1.7		
CFA piles (tension) $\gamma_{s,t}$					2.0/1.7		
Ground anchors					???		
Retaining structures – bearing $\gamma_{R,v}$							
Retaining structures – sliding $\gamma_{R,v}$							
Retaining structures – earth $\gamma_{R,v}$							

Design Approach

- Are we happy with the way partial factors are applied?
  - If no what do we want?
  - Consider axial & lateral loading
- Are we happy with the partial factor values?

Design Approach

- Are we happy with the partial factor values?
  - Margin of safety (uncertainty in parameters, geometry)
  - Degree of testing
  - Model factor
  - Control of displacement

Feedback to EG7 UK Representative

- EG7 work to date has been essentially covering technical issues and differences across Europe
- Need to start making recommendations for harmonisation and simplification
- We need a UK position on what is wanted in EC7 and what can be provided elsewhere
- Where should the lines be drawn?

Feedback to EG7 UK Representative

- UK position on Design Approaches
- Are the NA Partial Resistance Factors working?
- What needs to be done to EC7 to allow the UK NA to be withdrawn (for piling matters)?
- What other guidance to users is required?
  - Negative shaft friction
  - Pile groups
  - Horizontal loading
- Any other items?

THE END