PILE DESIGN IN ACCORDANCE WITH CODE REQUIREMENTS

AUSTRALIAN PILING CODE AS 2159 - 1995

CODE CONTENTS

- Scope & general
- Site investigation
- Design requirements & procedures
- Geotechnical design
- Structural design
- Design for durability
- Materials & construction requirements
- Testing

CODE IS IN LIMIT STATE FORMAT

LOAD COMBINATIONS FOR STRENGTH DESIGN

- Factored structural loads which produce the most adverse effect on the piles
- Dead loads of pile + cap
- Loads induced by soil movement
  - For structural design, loads & moments are factored by 1.2-1.5
  - For geotechnical strength design, are not considered
- Handling
- Installation
- Other additional loads (e.g. impact, dynamic, etc.)

STRUCTURAL STRENGTH DESIGN

- Criterion is that design structural strength must equal or exceed the “design action effect”, i.e. the worst combination of factored loadings:

$$\mathbf{Rs^* \geq S^*}$$

where $Rs^* = \phi_s . Rus$

ϕ_s = structural strength reduction factor

Rus = ultimate structural strength

GEOTECHNICAL STRENGTH DESIGN

- Criterion is that design geotechnical strength (capacity) must equal or exceed the "design action effect", i.e. the worst combination of factored loadings:

$$\mathbf{Rg^* \geq S^*}$$

where $Rg^* = \phi_g . Rug$

ϕ_g = geotechnical strength reduction factor

Rug = ultimate geotechnical strength (capacity)

GEOTECHNICAL STRENGTH DESIGN

TABLE 4.1

RANGE OF VALUES FOR GEOTECHNICAL STRENGTH REDUCTION FACTOR ϕ_g

Method of assessment of ultimate geotechnical strength	Range of values of ϕ_g
Static load testing to failure	0.70–0.90
Static proof (not to failure) load testing (NOTE 1)	0.7–0.90
Dynamic load testing to failure supported by signal matching (NOTE 2)	0.65–0.85
Dynamic load testing to failure not supported by signal matching	0.50–0.70
Dynamic proof (not to failure) load testing supported by signal matching (NOTES 1 and 2)	0.65–0.85
Dynamic proof (not to failure) load testing not supported by signal matching (NOTE 1)	0.50–0.70
Static analysis using CPT data	0.45–0.65
Static analysis using SPT data in cohesionless soils	0.40–0.55
Static analysis using laboratory data for cohesive soils	0.45–0.55
Dynamic analysis using wave equation method	0.45–0.55
Dynamic analysis using driving formulae for piles in rock	0.50–0.65
Dynamic analysis using driving formulae for piles in sand	0.45–0.55
Dynamic analysis using driving formulae for piles in clay	Note 2
Measurement during installation of proprietary displacement piles, using well established in-house formulae	0.50–0.65

GEOTECHNICAL STRENGTH DESIGN

NOTES:

1 ϕ_g should be applied to the maximum load applied.

2 Signal matching of the recorded data obtained from dynamic load testing should be undertaken on representative test piles using a full wave signal matching process.

3 Caution should be exercised in the sole use of dynamic formulae (e.g. Hiley) for the determination of the ultimate geotechnical strength of piles in clays. In particular, the dynamic measurements will not measure the 'set-up' which occurs after completion of driving. It is preferable that assessment be first made by other methods, with correlation then made with dynamic methods on a site-specific basis if these latter are to be used for site driving control.

4 For cases not covered in Table 4.1, values of ϕ_g should be chosen using the stated values as a guide.

TABLE 4.2

GUIDE FOR ASSESSMENT OF GEOTECHNICAL STRENGTH REDUCTION FACTOR (ϕ_g)

Circumstances in which lower end of range may be appropriate	Circumstances in which upper end of range may be appropriate
Limited site investigation	Comprehensive site investigation
Simple method of calculation	More sophisticated design method
Average geotechnical properties used	Geotechnical properties chosen conservatively
Use of published correlations for design parameters	Use of site-specific correlations for design parameters
Limited construction control	Careful construction control
Less than 3% piles dynamically tested	15% or more piles dynamically tested
Less than 1% piles statically tested	3% or more piles statically tested

ASSESSMENT OF ULTIMATE GEOTECHNICAL STRENGTH

- Static analysis using site investigation data
- Static analysis using static load test data
- Static analysis using dynamic load test data
- Dynamic analysis
  - Wave equation analysis
  - Pile driving formulae
  - Closed form dynamic solution

STATIC ANALYSIS

- Ultimate geotechnical strength (capacity) is sum of ultimate shaft & base resistances.
- For pile groups, ultimate strength R_{ug} is taken as lesser of:
  - Sum of ultimate strengths of individual piles
  - Strength of block of piles + soil
- Allowance to be made for soft material at depth

OTHER CONSIDERATIONS

- Negative friction
- Soil swelling

  (in both cases, Rug is unaffected)
- Lateral loading
  - Short-pile failure
  - Long-pile failure
- Cyclic loading
- Dynamic loading
- Earthquake loading

SERVICEABILITY DESIGN

- **Geotechnical Parameters**
  - NO reduction factor applied
- **Pile Displacements**
  - Via calculation or from load test
- **Allow for:**
  - Group action
  - Underlying compressible layers
  - Variable stiffness of individual strata
- **Combined Pile & Raft Foundation:**
  - Use analysis to take account of pile-soil-raft interaction

PERMISSIBLE SETTLEMENT OF PILES AND PILE GROUPS

- Australian code has NO quantitative specifications.

- "Limits for the total and differential settlement, lateral deflection and rotation of both a pile and a pile group … shall be appropriate to the structure and its intended use".

- Thus, the designer has to set the limits.
- Published criteria are used as a guide.

DESIGN FOR DURABILITY

- Criteria are given for:
  - Concrete
  - Steel
  - Timber piles.
- Design requirements depend on exposure classification for the site environment.

STATIC LOAD TESTING

- Provisions are given for:
  - Preparation for testing
  - Reaction system
  - Equipment for loading & measurement
  - Test procedure.
- Default specification for incremental sustained load test. Designer can over-ride this with appropriate specific requirements.

STATIC LOAD TESTING- ACCEPTANCE CRITERIA

Load	*Max. Deflection (mm)*
Serviceability Load (SL)	15[1]
0 (after removal of SL)	7[1]
1.5 S*	50
0 (after removal of 1.5S*)	30

If criteria not met, need to re-assess design geotechnical strength.

[1] Not more than 3mm creep over 5 hours

DYNAMIC LOAD TESTING

Used for:

- Proof test
- Prediction of ultimate geotechnical strength
- Indication of resistance distribution
- Monitoring of pile stresses during installation.

DYNAMIC LOAD TESTING- ACCEPTANCE CRITERIA

Load	*Max. Deflection (mm)*
Serviceability Load (SL)	12
1.5 S*	35

Alternative criteria can be specified in the test schedule,& take precedence over default values.