GEOTECHNICAL ENGINEERING GROUP

PROJECT NO. GEO-2026-014

FOUNDATION & SOIL ANALYSIS

Geotechnical Design Basis Report

Proposed Mid-Rise Development

Illustrative Urban Site / Dhaka, Bangladesh

CLIENT	ABC Development Limited
STATUS	Illustrative design report — not for construction
REVISION	Rev 0 / 02 August 2026
PREPARED BY	Geotechnical Engineering Group

This document demonstrates a complete engineering-report format using an assumed dataset. Site-specific design requires a commissioned investigation, laboratory certificates and review by the Engineer of Record.

Document control

Revision	Date	Purpose / description	Status
0	02 Aug 2026	Initial issue; illustrative design basis and foundation assessment	For technical review

	Name / role	Discipline	Signature
Prepared by	Geotechnical Engineer	Geotechnical	—
Checked by	Senior Geotechnical Engineer	Geotechnical	—
Approved by	Project Director	Civil / Structural	—

Important status note

No project-specific borehole logs, survey, structural reactions or laboratory certificates were provided. All dimensions, soil parameters and calculations in this report are a coherent *worked design basis*, not measured site data. They shall be replaced and independently verified before tender, permitting or construction.

Contents

Executive summary

The assumed ground model comprises uncontrolled fill over soft to firm alluvial clay, underlain by medium-dense and then dense silty sand. Groundwater is expected near 2.2 m below existing grade and may fluctuate seasonally. The clay immediately below the proposed foundation level has low undrained strength and is settlement-sensitive.

Recommended foundation strategy

Adopt cast-in-place bored piles, nominally 600 mm diameter and 17.5 m long from existing grade, founded at least 5 m into the dense sand stratum. Use a preliminary allowable axial compression resistance of **900 kN per pile**. Confirm resistance, settlement and construction method with a maintained-load preliminary pile test and site-specific pile design.

GROUNDWATER	PILE LENGTH	ALLOWABLE LOAD
2.2 m	**17.5 m**	**900 kN**
below grade	preliminary	compression

Issue	Engineering finding / required control	Risk
Shallow foundations	Predicted primary consolidation settlement is about 85 mm; conventional pads or an untreated raft are not recommended.	HIGH
Pile performance	Dense sand provides a competent combined shaft-and-base bearing layer; actual performance depends on bore stability and base cleaning.	MEDIUM
Groundwater	Excavation extends below the assumed water table. Use staged, filtered dewatering and monitor drawdown at adjacent property lines.	MEDIUM
Seismic response	Preliminary classification is a soft-soil profile; site response and liquefaction screening require CPT/Vs data and the governing seismic parameters.	MEDIUM
Aggressivity	No chemical results are available. Test groundwater and soil for sulfate, chloride, pH and resistivity before specifying concrete durability class.	MEDIUM

Hold points before detailed design

Complete project-specific drilling and CPT, survey groundwater for at least one wet season, receive service and factored column reactions, complete chemical testing, and load-test a non-working pile. The structural and geotechnical designers shall jointly check group effects, total and differential settlement, pile-cap punching, lateral response and seismic actions.

1 Introduction

1.1 Purpose and scope

This report establishes an illustrative geotechnical design basis for a reinforced-concrete mid-rise building with one basement. It demonstrates the evaluation of a ground model, foundation alternatives, axial pile resistance, settlement, groundwater risks and construction quality controls. The assessment covers:

- interpretation of a representative three-borehole investigation to 25 m depth;
- selection of characteristic engineering parameters;
- screening of pads, raft and deep-foundation options;
- preliminary geotechnical sizing of bored piles; and
- requirements for verification, monitoring and quality assurance.

This report does not design retaining walls, permanent basement waterproofing, pile caps, structural reinforcement or temporary works. Those items require coordinated design after the project geometry and actions are confirmed.

1.2 Assumed development

Table 1: *Assumed project design basis.*

Item	Adopted basis
Building	Eight-storey reinforced-concrete frame with one basement
Plan dimensions	Approximately 22 m by 30 m
Basement / pile-cap level	About 2.7 m below existing grade
Service column reactions	700–1800 kN; core reaction about 9000 kN
Settlement criteria	40 mm total; angular distortion preferably less than 1:500
Adjacent assets	Low-rise buildings and buried utilities near the property boundary
Design life	50 years, subject to confirmation by the owner

1.3 Information hierarchy

Where conflicts arise, project-specific survey, certified field logs and laboratory results take precedence over this illustrative basis. Design should follow the governing building code and the contract-adopted editions of recognized geotechnical standards. Parameter selection should use engineering judgment and load-test back-analysis rather than uncorrected SPT values alone [3, 1].

2 Illustrative site investigation

2.1 Field programme

The assumed investigation includes three rotary wash boreholes (BH-01 to BH-03), standard penetration testing at approximately 1.5 m intervals, disturbed and thin-wall samples, and temporary standpipes. For a real project, the final scope should be set after reviewing column locations, basement geometry and access constraints.

Table 2: *Illustrative exploration schedule.*

Point	Depth (m)	Ground level (m datum)	Water level (m below grade)	Principal tests
BH-01	25.0	100.20	2.1	SPT, classification, strength
BH-02	25.0	100.05	2.3	SPT, consolidation, chemistry
BH-03	25.0	99.90	2.2	SPT, classification, strength

2.2 Subsurface profile

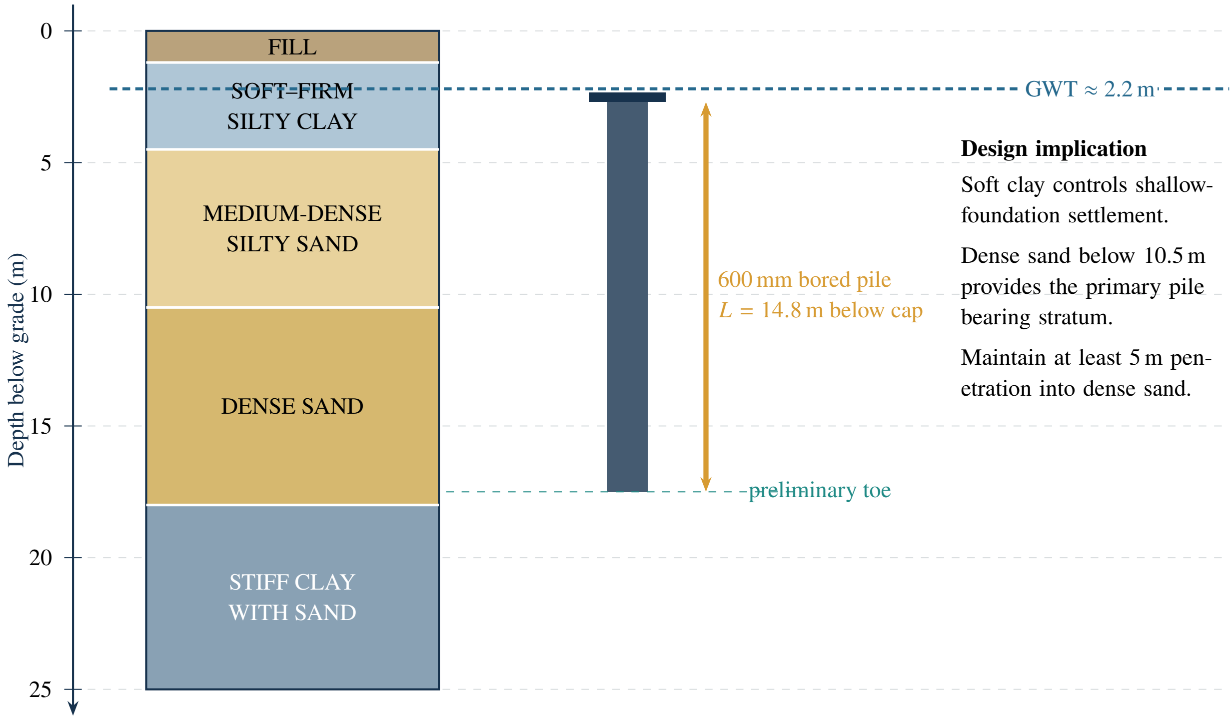

Figure 1: *Generalized ground model and recommended pile concept. Layer boundaries may vary between exploration points.*

2.3 Groundwater

The interpreted groundwater level is 2.1–2.3 m below grade. A single reading after drilling may be affected by the drilling method and does not define the seasonal high. Piezometers should therefore be installed and monitored before basement and temporary-works design. For preliminary uplift and construction checks, use a conservative groundwater level of 1.0 m below grade unless monitoring demonstrates a lower design level.

3 Engineering properties

3.1 Field and laboratory trends

The following results are internally consistent assumed values. SPT blow counts are corrected to an energy-normalized value, N_{60}, for interpretation. In cohesive soils, undrained shear strength is based primarily on high-quality sampling and strength tests rather than SPT correlations [2].

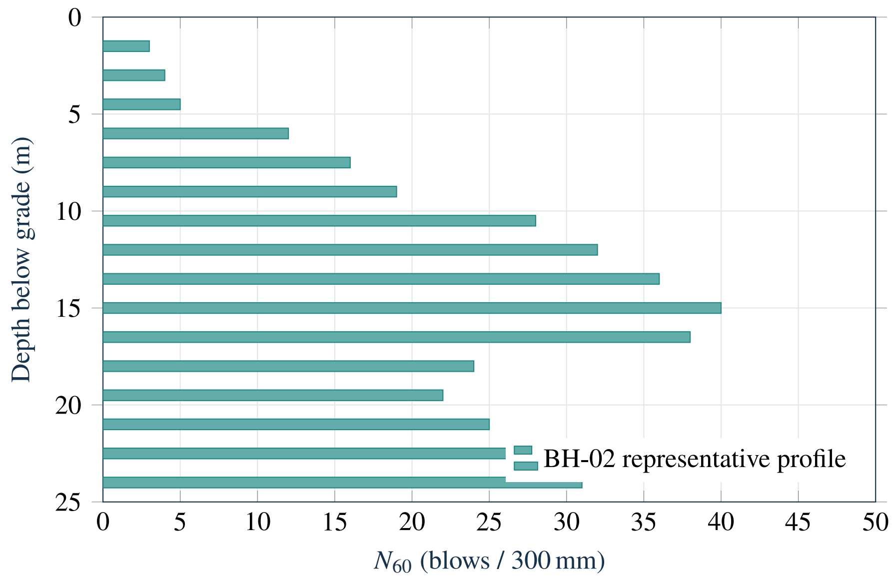

Figure 2: *Representative normalized SPT profile used for preliminary interpretation.*

Table 3: *Summary of assumed laboratory index and strength results.*

Material	w (%)	LL (%)	PI (%)	c_u (kPa)	C_c	USCS
Fill	18–30	–	–	–	–	ML/CL, variable
Soft–firm silty clay	32–42	48	25	25–38	0.24	CL
Medium-dense silty sand	18–24	NP	NP	–	–	SM
Dense sand	15–20	NP	NP	–	–	SP–SM
Stiff clay with sand	22–30	42	20	90–140	0.14	CL

3.2 Characteristic design parameters

Parameters in table 4 are cautious characteristic values for preliminary design. They are not lower bounds; the selection considers test scatter, scale and the likely zone of influence. Effective-stress strength is used for drained and long-term analyses, while c_u is used for short-term total-stress checks.

Table 4: *Preliminary geotechnical design parameters.*

Unit	γ (kN/m^3)	c_u (kPa)	c' (kPa)	ϕ' (deg)	E_s (MPa)	Design note
Fill	18	–	0	27	5	Remove below foundations
Soft–firm clay	18	30	3	24	4	Settlement-sensitive
Medium-dense sand	19	–	0	31	22	Use submerged unit weight below GWT
Dense sand	20	–	0	36	55	Primary pile-bearing layer
Stiff clay / sand	19.5	110	5	28	35	Confirm continuity

For earth-pressure screening, the normally consolidated at-rest coefficient may be estimated as $K_0 = 1 - \sin\phi'$. Permanent wall design shall account for stress history, compaction, surcharge, construction sequence and groundwater; the tabulated values alone are insufficient.

4 Foundation alternatives

4.1 Screening assessment

Table 5: *Foundation option comparison.*

Option	Advantages	Constraints	Outcome
Isolated / strip footings	Simple and economical construction	Very low bearing resistance in clay; large and differential settlement	Reject
Untreated raft	Load redistribution; simple basement integration	Consolidation settlement exceeds criterion; sensitive to nonuniform fill	Reject
Improved-ground raft	Can reduce pile count and embodied material	Requires trial area, specialist design and settlement verification	Reserve option
Driven precast piles	Good displacement-pile resistance; rapid installation	Vibration, noise and heave risk near adjacent assets	Conditional
Bored cast-in-place piles	Low vibration; adaptable length and diameter	Needs slurry/casing control, base cleaning and integrity testing	**Preferred**

4.2 Shallow bearing resistance

At a notional founding depth $D_f = 1.8\,\mathrm{m}$ within the soft–firm clay, the undrained net ultimate bearing resistance for a wide footing is screened as

$$q_{\mathrm{net,ult}} = N_c c_u = 5.14(30) = 154\,\mathrm{kPa}. \tag{1}$$

With a global factor of safety of 3 and overburden γD_f, the corresponding gross allowable pressure is only

$$q_{\text{allow,gross}} = \frac{154}{3} + 18(1.8) \approx 84\,\text{kPa}. \tag{2}$$

This is a bearing-capacity screen only; settlement governs at an even lower practical pressure. Footings near excavations or sloping ground would also require reduced resistance.

4.3 Raft settlement screen

For a 2.7 m thick consolidating clay layer, the one-dimensional primary consolidation estimate is

$$S_c = \frac{C_c H}{1 + e_0} \log_{10}\left(\frac{\sigma_0' + \Delta\sigma'}{\sigma_0'}\right). \tag{3}$$

Using $C_c = 0.24$, $H = 2.7$ m, $e_0 = 0.80$, $\sigma_0' = 58$ kPa and average $\Delta\sigma' = 42$ kPa gives

$$S_c = \frac{0.24(2.7)}{1.80} \log_{10}\left(\frac{100}{58}\right) = 0.085\,\text{m} \approx 85\,\text{mm}. \tag{4}$$

Immediate settlement and construction variability would add to this value. The untreated raft therefore does not satisfy the adopted 40 mm criterion.

5 Preliminary bored-pile design

5.1 Geometry and design approach

The preferred concept uses nominal 600 mm diameter rotary bored piles with toe level at approximately 17.5 m below existing grade. Piles extend through the weak near-surface soils and develop resistance primarily in the two sand units. The preliminary compression resistance is evaluated by the static sum

$$Q_u = Q_s + Q_b = \sum_i \pi D L_i f_{s,i} + \frac{\pi D^2}{4} q_b, \tag{5}$$

where $f_{s,i}$ is the unit shaft resistance and q_b is the unit base resistance. Values are deliberately capped to reflect bored-pile construction effects [4].

5.2 Axial compression resistance

Table 6: *Static axial resistance calculation for one 600 mm pile.*

Component	Length / area	Unit resistance	Resistance	Basis
Clay shaft	2.5 m	22 kPa	104 kN	Adhesion capped
Medium-dense sand shaft	6.0 m	45 kPa	509 kN	Effective-stress screen
Dense-sand shaft	7.0 m	80 kPa	1056 kN	Bored-pile cap
Dense-sand base	0.283 m^2	3500 kPa	990 kN	Clean, sound base
		Calculated ultimate resistance, Q_u	**2659 kN**	
		Global factor of safety	2.5	
		Calculated allowable resistance	1064 kN	
		Adopted preliminary allowable load	**900 kN**	test required

The adopted load is less than the static calculation to provide an initial allowance for layer variability, group interaction, construction tolerance and settlement. It is not a substitute for code-compliant resistance factors or load testing. Structural axial capacity, reinforcement, durability, handling of accidental eccentricity and pile-cap connection shall be checked separately.

5.3 Pile groups and settlement

Pile groups should use a preliminary center-to-center spacing of at least $3D$ (1.8 m) and preferably $3.5D$ where pile-cap geometry allows. Each group shall be checked for:

- sum of individual-pile resistances and block failure;
- group settlement under sustained service load, including consolidation of clay below and around the equivalent raft;
- load redistribution from pile-position tolerance and cap stiffness;
- downdrag from new fill, groundwater lowering or settling upper clay; and
- minimum edge distance, cap punching shear and reinforcement anchorage.

For concept design, expect single-pile service settlement of approximately 10–18 mm and pile-group settlement of 20–35 mm. These ranges shall be replaced by a calibrated numerical or equivalent-raft analysis after the preliminary load test.

5.4 Uplift and lateral loading

Do not apply the compression value to uplift. For preliminary proportioning only, limit allowable tension to 400 kN per pile, ignoring base resistance and checking the weight of the pile-cap/structure. Lateral resistance depends strongly on pile-head fixity, group spacing, cyclic degradation and the weak upper clay. A site-specific p–y or continuum analysis is required once shear, moment and head-displacement criteria are issued by the structural engineer.

Preliminary pile schedule

Nominal diameter	600 mm
Toe level	17.5 m below existing grade, subject to bore log
Minimum dense-sand socket	5.0 m
Allowable compression	900 kN per pile
Allowable tension	400 kN per pile, preliminary only
Minimum spacing	$3D$; prefer $3.5D$
Working-load test	1.5 MN proof load unless governing code requires more
Preliminary test pile	Load to geotechnical failure or at least 2.5 times working load

6 Groundwater, excavation and seismic considerations

6.1 Basement excavation and water control

The assumed excavation base is approximately 0.5 m below the observed water level. Open pumping without filters can cause piping, loss of fines and settlement outside the site. The contractor's temporary-works design should include:

- a cut-off or internally filtered wellpoint / sump arrangement matched to the sand layers;
- piezometers inside and outside the excavation, with trigger levels tied to response actions;
- stability checks for basal heave, piping, uplift and wall toe embedment;
- recharge or staged pumping where drawdown at adjacent foundations is unacceptable; and
- discharge permits, treatment and a standby power/pump plan.

Permanent basement design shall assume hydrostatic pressure to the project design groundwater level unless a maintainable permanent drainage system is deliberately adopted. Buoyancy should be checked for both completed and temporary construction stages.

6.2 Liquefaction and cyclic response

The medium-dense silty sand below the water table is potentially susceptible to cyclic pore-pressure generation. A definitive liquefaction assessment cannot be made from the assumed data because design earthquake demand, fines plasticity and reliable energy-corrected SPT/CPT data are absent. Obtain seismic CPT and preferably shear-wave velocity measurements; evaluate triggering, post-liquefaction settlement, lateral deformation and pile kinematic demand using the governing hazard level. The preliminary soil profile should be treated conservatively until that assessment is complete.

7 Construction requirements

7.1 Bored-pile installation

The piling specification should be performance-based and submitted with the contractor's method statement. Minimum controls are:

1. Survey each pile center and establish a protected cut-off datum.
2. Use temporary casing and/or approved support fluid to maintain bore stability and prevent necking, inclusions or inflow.
3. Log penetration rate and arisings continuously. The geotechnical representative shall confirm at least 5 m penetration into competent dense sand.
4. Clean the base; measure cleanliness and support-fluid properties immediately before concreting.
5. Install the cage with centralizers. Place concrete continuously by tremie from the base, keeping the tremie embedded in fresh concrete.
6. Record theoretical and actual concrete volume against depth. Investigate unexplained overbreak, loss or interruption.
7. Remove contaminated head concrete to sound material after curing; do not damage the reinforcement or induce cracking.

7.2 Pile testing and acceptance

Table 7: *Recommended verification and quality-control schedule.*

Activity	Minimum concept frequency	Purpose / acceptance basis
Preliminary maintained-load test	One sacrificial pile	Establish load–settlement response and calibrate design
Working-pile proof test	At least 1% of piles, minimum two	Demonstrate performance at specified proof load
Low-strain integrity test	100% of piles	Screen for major discontinuity; interpret with construction log
Cross-hole sonic logging	Large / critical piles as specified	Higher-resolution integrity assessment
Concrete testing	Each pour / delivery sequence	Slump or flow, temperature, strength and traceability
Pile position and level survey	100% of piles	Confirm plan tolerance, verticality and cut-off

Project specifications must define test procedures, loading sequence, settlement limits, re-test rules and responsibility for remedial design. Integrity testing is a screening tool and does not demonstrate geotechnical capacity.

7.3 Earthworks and slabs

Strip vegetation, debris and uncontrolled fill from beneath ground-bearing slabs. Proof-roll the exposed formation where practical and undercut yielding zones. Place approved granular fill in thin, moisture-conditioned lifts and verify compaction by field density testing. Protect clay formation from rain, drying and construction traffic with a prompt blinding layer. Do not use pile boring spoil as engineered fill unless it is separately processed, tested and approved.

8 Risk register and observational controls

Table 8: *Geotechnical design and construction risk register.*

Hazard	Initial	Control / verification	Residual
Unrecognized weak lens at pile toe	HIGH	Additional CPT; log every pile; minimum dense-sand penetration; load test	MEDIUM
Excess pile settlement	HIGH	Calibrated group analysis; proof testing; cap-level monitoring	LOW
Bore collapse / inclusions	HIGH	Casing or support fluid; concreting records; integrity testing	MEDIUM
Drawdown-induced off-site settlement	HIGH	Piezometers, settlement points, staged pumping, recharge contingency	MEDIUM
Basement uplift	HIGH	Conservative water level; construction-stage and permanent buoyancy checks	LOW
Chemical attack on concrete	MEDIUM	Soil/water chemistry; specified exposure class and concrete mix	LOW
Liquefaction / cyclic softening	HIGH	Seismic CPT/Vs testing; code-based assessment; pile kinematic design	MEDIUM

Instrumentation should be installed before activities that may cause movement. Suggested starting trigger values are 8 mm horizontal wall movement, 10 mm adjacent-building settlement, and 0.5 m groundwater drawdown outside the excavation. These are placeholders: the temporary-works designer shall establish project-specific green, amber and red limits, survey frequency, notification routes and pre-agreed response actions.

9 Conclusions and recommendations

1. The illustrative ground model is fill to 1.2 m, soft–firm clay to 4.5 m, medium-dense silty sand to 10.5 m, dense sand to 18 m, and stiff clay with sand below. Groundwater is near 2.2 m depth.
2. Conventional shallow pads are unsuitable for the assumed mid-rise loads. An untreated raft has a screened primary consolidation settlement of about 85 mm, exceeding the adopted 40 mm criterion.
3. Use 600 mm bored piles approximately 17.5 m long, with a minimum 5 m penetration into dense sand, as the preferred concept.
4. Use 900 kN allowable axial compression per pile for preliminary layout only. Confirm the final resistance and load–settlement curve by a preliminary maintained-load test and code-compliant design.
5. Assess group settlement, downdrag, lateral and seismic loading, pile-cap stiffness and construction

tolerances using the final structural reactions.

6. Manage groundwater with filtered, monitored dewatering. Design basement slabs and walls for the confirmed long-term water level and all temporary stages.
7. Complete site-specific drilling, CPT, groundwater monitoring, chemical testing and seismic characterization before detailed design.

Design release condition

The concept may proceed to coordinated preliminary layout. It shall **not** be released for construction until the assumed ground model has been replaced by certified project data, pile testing has validated the design model, and the geotechnical and structural designers have signed the final foundation schedule.

10 Limitations

This report is an illustrative engineering document prepared without project source data. It is intended to demonstrate analysis and reporting structure only. Subsurface conditions are inherently variable, and conditions between investigation points may differ from those shown. The conclusions apply only to the assumed development and design basis in table 1.

No party should use the numerical values for procurement, regulatory submission, construction, property transaction or assessment of an actual site. A licensed/registered geotechnical professional familiar with the local geology and governing regulations must review the site, specify and supervise the investigation, interpret certified results and issue the construction design. The contractor remains responsible for means, methods, temporary works and safe execution.

A Calculation summary

A.1 Pile resistance arithmetic

For $D = 0.60\,\text{m}$, shaft perimeter $p = \pi D = 1.885\,\text{m}$ and base area $A_b = \pi D^2/4 = 0.2827\,\text{m}^2$. Applying equation (5):

$$\begin{aligned}
Q_{s,\text{clay}} &= 1.885(2.5)(22) = 104\,\text{kN}, \\
Q_{s,\text{med sand}} &= 1.885(6.0)(45) = 509\,\text{kN}, \\
Q_{s,\text{dense sand}} &= 1.885(7.0)(80) = 1056\,\text{kN}, \\
Q_b &= 0.2827(3500) = 990\,\text{kN}, \\
Q_u &= 104 + 509 + 1056 + 990 = 2659\,\text{kN}, \\
Q_{\text{allow,calc}} &= 2659/2.5 = 1064\,\text{kN}, \\
Q_{\text{allow,adopted}} &= 900\,\text{kN}.
\end{aligned}$$

The calculation omits shaft resistance in uncontrolled fill and does not count pile self-weight as resistance. Final partial factors, load combinations and downdrag treatment shall follow the governing code.

A.2 Example pile count

For a service column reaction $N_s = 1800\,\text{kN}$, the arithmetic minimum is

$$n = \left\lceil \frac{N_s}{Q_{\text{allow}}} \right\rceil = \left\lceil \frac{1800}{900} \right\rceil = 2.$$

A two-pile cap may be unsuitable where moments act in both directions; the structural designer may require three or four piles to achieve stability and acceptable load distribution. Pile count shall be based on the complete service and ultimate action envelopes, including cap self-weight, uplift, eccentricity and seismic combinations.

B Design verification checklist

No.	Verification item	Close-out evidence
1	Final survey, building grid and founding levels	Approved civil / architectural drawings
2	Boreholes and CPT at representative foundation zones	Factual and interpretive geotechnical reports
3	Seasonal groundwater and design water level	Piezometer record and designer approval
4	Soil and groundwater aggressivity	Certified chemical laboratory results
5	Service and factored reaction envelopes	Signed structural foundation schedule
6	Axial, group and settlement analyses	Checked calculation package
7	Lateral, seismic and liquefaction assessment	Checked specialist analysis
8	Preliminary pile load test	Accepted test report and back-analysis
9	Piling method statement and trial records	Engineer's acceptance / inspection plan
10	Working-pile proof and integrity testing	Accepted QA dossier
11	As-built pile coordinates and cut-off levels	Signed survey
12	Groundwater and movement monitoring close-out	Instrumentation report and trigger close-out

References

[1] J. E. Bowles, *Foundation Analysis and Design*, 5th ed. McGraw–Hill, 1996.

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[3] R. B. Peck, W. E. Hanson, and T. H. Thornburn, *Foundation Engineering*, 2nd ed. John Wiley & Sons, 1974.

[4] M. Tomlinson and J. Woodward, *Pile Design and Construction Practice*, 5th ed. Taylor & Francis, 2008.

END OF REPORT