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Technical Code for Building Pile Foundations

建筑桩基技术规范

Issued on: April 22, 2008

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Issued by Ministry of Housing and Urban-Rural Development of the People's
Republic of China



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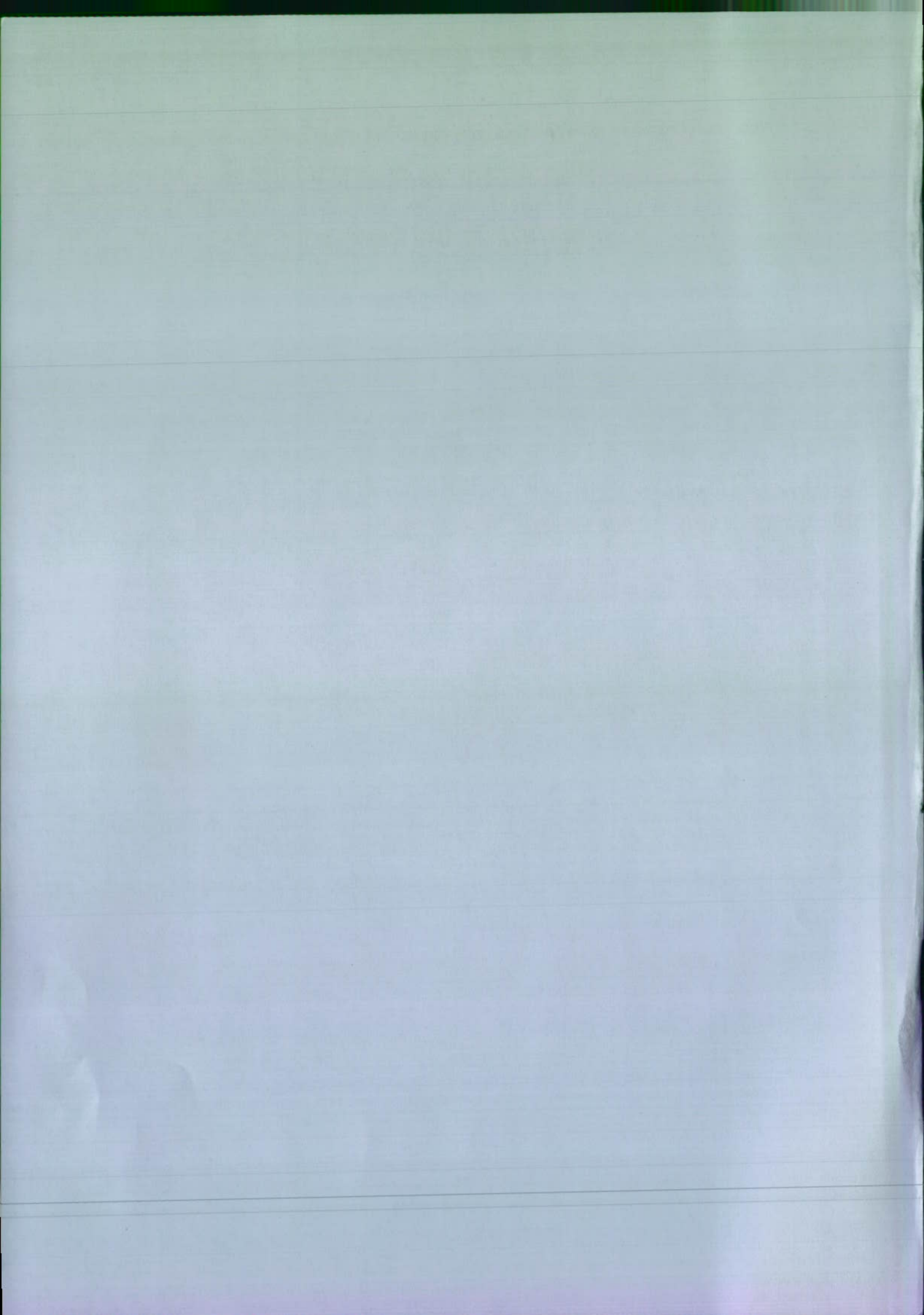
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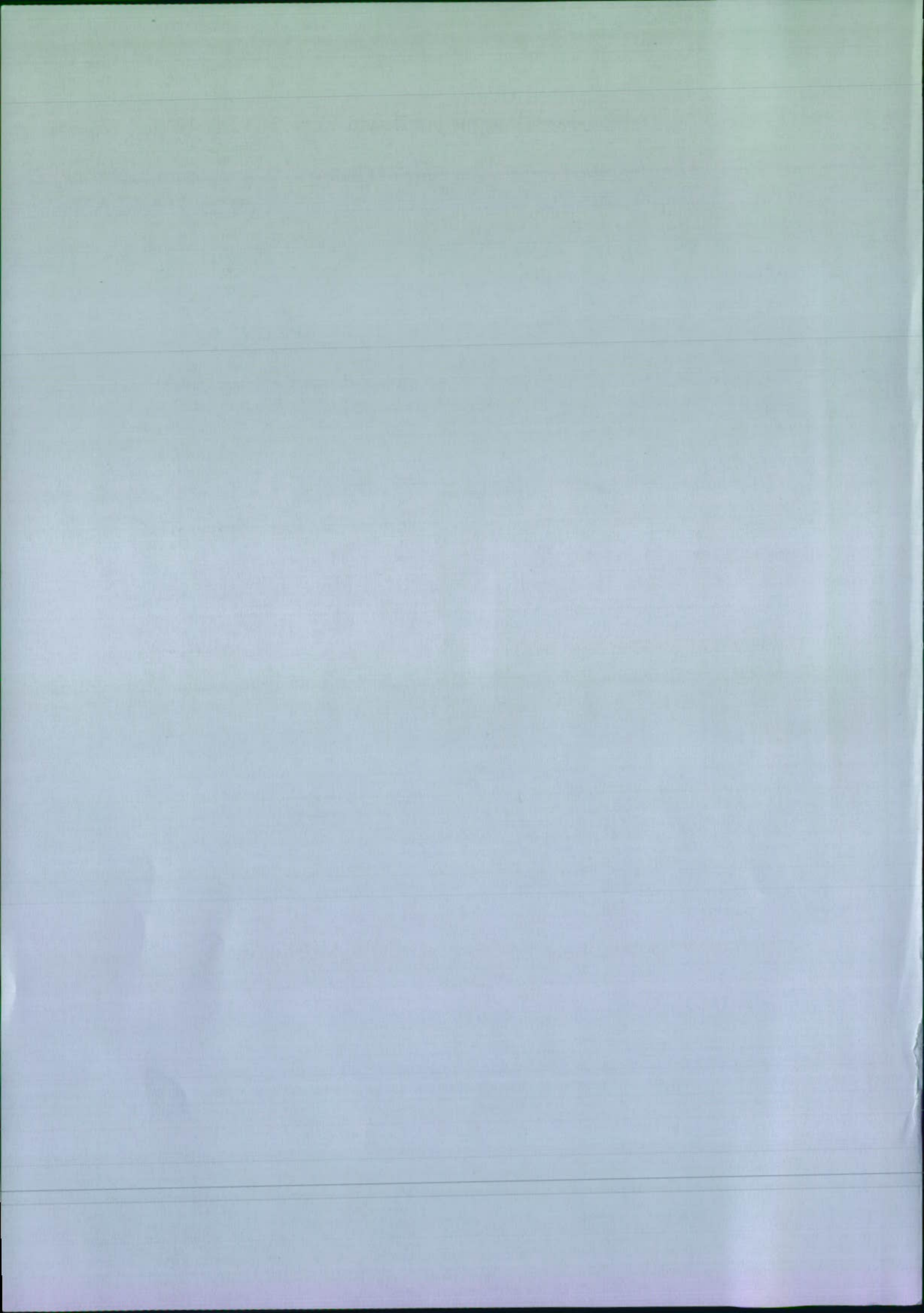
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NOTICE

This is the English translation of *Technical Code for Building Pile Foundations*. In case of any inconsistency between the Chinese version and the English version, the Chinese one shall prevail.



**Announcement Ministry of Housing and Urban-Rural Development
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No. 18

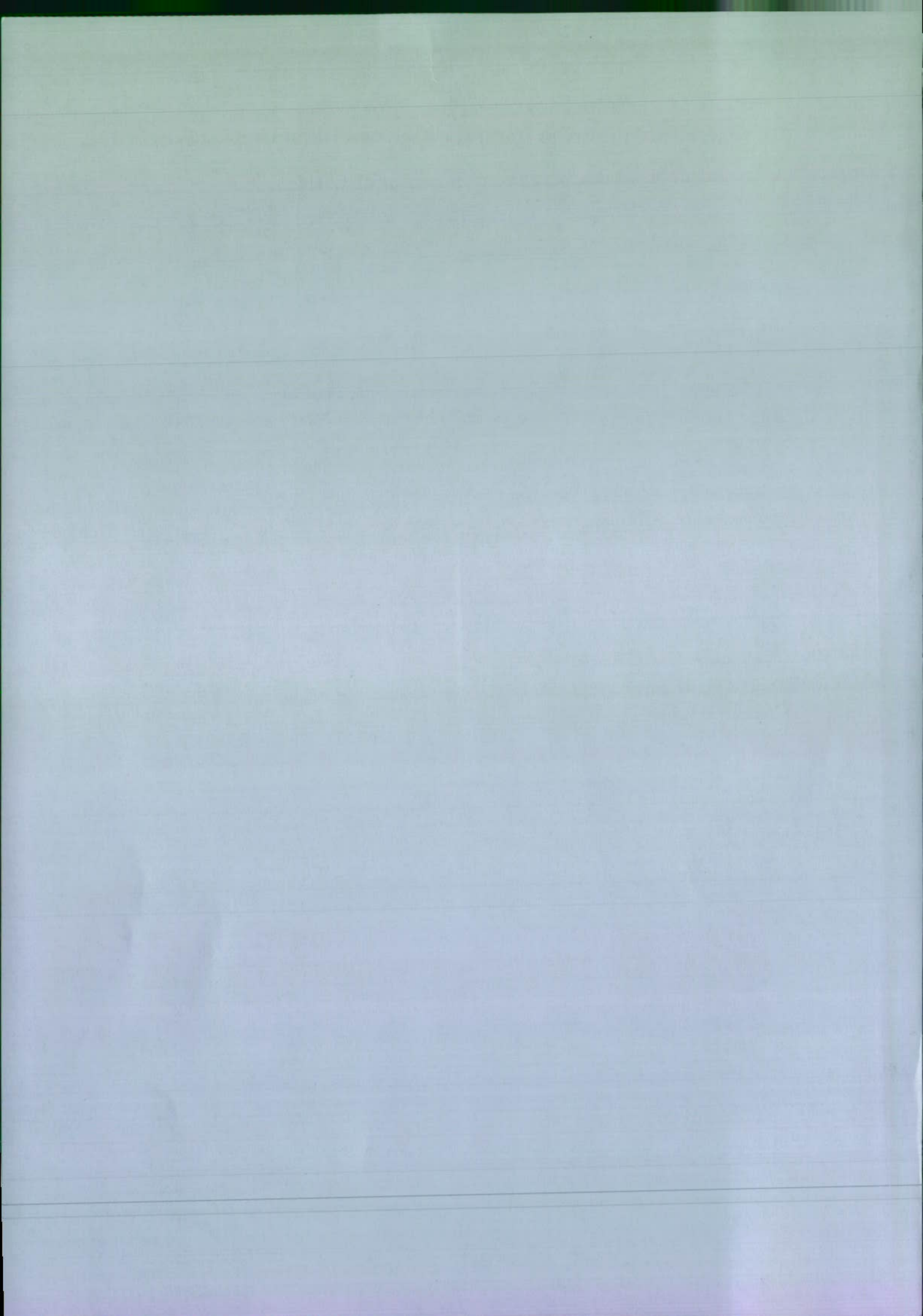
**Announcement of publishing the Professional standard "*Technical Code
for Building Pile Foundations*"**

Approve the issuance of "*Technical Code for Building Pile Foundations* is Professional standard, numbered JGJ 94-2008, with implemented on October 1, 2008. Where articles 3.1.3, 3.1.4, 5.2.1, 5.4.2, 5.5.1, 5.5.4, 5.9.6, 5.9.9, 5.9.15, 8.1.5, 8.1.9 and 9.4.2 are compulsory provisions and must be enforced strictly. At the same time, it is abolished for "*Technical Code for Building Pile Foundations*" JGJ 94-94 which the primitive professional standard.

The code is published by the Plan publishing company, which is organized for the Institute of standard and quota of Ministry construction.

Ministry of Housing and Urban-Rural Development of the People's Republic of China

April 22, 2008



Foreword

According to the requirements of Document Jian Biao [2003] No.104 issued by Ministry of Construction (MOC), this code is revised from "Technical Code for Building Pile Foundations" JGJ 94-94 by China Architecture Scientific Research Institute together with relative design, investigation, construction, research and teaching organizations.

Special research and comprehensive diagnosis are taken out during the revision process. The revision sums up design and construction experiences of our country's pile foundation in recent years, absorbs scientific research achievements in this field, and solicits ideas from related organizations throughout the country in various ways. Trial design and repeated revisions on key points are taken out. Based on the above, the code is reviewed and finalized.

The code contains following key technical contents: provisions on pile foundation basic design, pile foundation structure, calculation or checking computations for bearing capacity limiting state and limiting state on normal condition of pile foundation, pile foundation construction, pile foundation engineering quality examination and acceptance, and relative appendixes.

The code is supplemented with following contents: Optimized Design of Pile Foundation Stiffness to Reduce Differential Settlement of reduced differential settlement and cushion cap internal force; provisions on pile foundation durability; bearing capacity calculation and construction process of post-grouting filling pile; composite foundation with settlement reducing piles for soft soil foundation; calculation of settlements for single pile, single-row and thinned Pile Foundations; Calculation for bearing capacities of compressive pile and uplift pile; construction scheme of long auger drilling guncreting inserted with reinforcing cage filling pile; bearing capacity calculation and pile-sinking of prestressed concrete hollow pile etc. The regulated contents are as: taking-value and calculation of foundation pile and composite foundation pile bearing capacities; empiric parameters of individual pile side resistance and end resistance; comprehensive coefficient of rock-socketed piles rock-socket section side resistance and end resistance; calculation for empirical coefficients of pile foundation settlement through equivalent acting layerwise summation method; drilled and grouted pile hole toe sediment thickness control standard etc.

The Ministry of Construction is in charge of the management of the code and the explanation of compulsory provisions. And China Architecture Scientific Research Institute is responsible for the explanation of specific technical contents.

This specification is mainly drafted by the China Architecture Scientific Research Institute (Address: No. 30, Beisanhuang East Road, Beijing, China 100013).

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1 General Provision

1.0.1 The code is established to enable pile foundation engineering and construction to comply with national technical economy politics, and to be of safety and usability, state-of-art technology, economic feasibility, quality guaranteeing and environment protection.

1.0.2 The code is applicable to design, construction and acceptance for pile foundations of all sorts of buildings (including structures).

1.0.3 For engineering and construction of pile foundation, engineering geological and hydro geological conditions, topside structure type, functions of use, load characteristics, and construction load condition and envelopment shall be considered comprehensively; and local experiences and conceptual design shall be highly valued, the design shall adapt to local conditions, and pile type, pile-making process and cushion cap type shall be adopted reasonably to optimize the pile arrangement and save the resources; construction quality control and management shall be reinforced.

1.0.4 Besides this code, the engineering and construction of pile foundation shall comply with provisions of relative current standards.

2 Terms and Symbols

2.1 Terms

2.1.1 Pile Foundation

It is referred to a foundation composed of pile arranged in rock-soil and cushion cap braced with pile top, or an individual pile foundation formed through the direct connection of column and pile.

2.1.2 Composite Piled Foundation

It is referred to the pile foundation loaded by the foundation pile and foundation soil under the cushion cap.

2.1.3 Foundation Pile

It is referred to an individual pile in the pile foundation.

2.1.4 Composite Foundation Pile

It is referred to the composite bearing foundation pile composed by an individual pile and foundation soil under the cushion cap of the area the individual pile corresponds to.

2.1.5 Composite Foundation with Settlement-reducing Piles

It is referred to the composite piled foundation composed of reducing friction-type pile to decrease settlement in the case of basic satisfied requirement of soft soil natural foundation bearing capacity.

2.1.6 Ultimate Vertical Bearing Capacity of a Single Pile

It is referred to the peak load that an individual pile is close to the collapse condition or appears the deformation that is not suitable to kept bearing under the vertical load or, and this value depends on the supporting resistance of soil on the pile and the bearing capacity of the pile foundation.

2.1.7 Ultimate Shaft Resistance

It is referred to the rock-soil resistance generated by the lateral surface of the pile foundation under the critical load of pile top acting.

2.1.8 Ultimate Tip Resistance

It is referred to the rock-soil resistance generated by the pile tip under the critical load of pile top acting.

2.1.9 Characteristic Value of the Vertical Bearing Capacity of a Single Pile

It is referred to the bearing capacity value that the ultimate vertical bearing capacity of a single pile is divided by the safety factor.

2.1.10 Optimized Design of Pile Foundation Stiffness to Reduce Differential Settlement

It is referred to the design method that, according to the topside structure type, load and stratigraphic distribution, the bearing rigidity distribution of the foundation pile is changed through the adjustments of pile diameter, pile length and pile spacing to make building settlement uniform and reduce the cushion cap internal force.

2.1.11 Pile Cap Coefficient

It is referred to the exertion rate of the bearing capacity of the foundation soil below the cushion cap under the vertical load.

2.1.12 Negative Skin Friction, or Negative Shaft Resistance

It is referred to the downward frictional resistance on pile surface caused by that the pile-periphery soil appears the settlement larger than the foundation pile because of the pile-periphery soil self consolidation, collapse and ground load acting.

2.1.13 Down Drag

It is referred to the sum of negative shaft resistance acted on higher than the neutral point of an individual pile.

2.1.14 Plugging Effect

It is referred to the influence on the tip resistance exertion, which is caused by the soil plug formed by soil that flow over into the tube during the pile-sinking of open hollow pile.

2.1.15 Post Grouting for Cast-in-situ Pile

It is referred to that, after filling piling, cement grout is poured through grouting conduits pre-arranged in the pile foundation, pile tips connected with the conduits and pile-side grouting valve to reinforce pile tip and pile-side earth mass (including sediment and clay coating), and to improve the bearing capacity of individual pile and decrease the settlement.

2.1.16 Equivalent Settlement Coefficient for Calculating Settlement of Piled Foundations

It is referred to the ratio of the settling volume w_M of the clustered piles foundation in elastic semi-infinite body calculated through Mindlin, and the settling volume w_B of the equivalent pier foundation calculated through Boussinesq, which used to reflect the influence of the stress distribution calculated through Mindlin to the calculated sediment.

2.2 Symbols

2.2.1 Action and Action Effects

F_k —The vertical force acted on the top surface of the cushion cap, that is calculated according to the standard combination of the loading effect;

G_k —The standard value of pile foundation cushion cap and cushion cap soil dead weights;

H_k —The horizontal force acted on the base surface of the cushion cap, that is calculated according to the standard combination of the loading effect;

H_{ik} —The horizontal force acted on the i foundation pile or Composite Foundation Pile, that is calculated according to the standard combination of the loading effect;

M_{xk}, M_{yk} —Moments of x and y main axis, through the pile group centroid around, of external force acted on the cushion cap base surface calculated according to the standard combination of the loading effect;

N_{ik} —Vertical forces of the i foundation pile or Composite Foundation Pile under the eccentric vertical force of loading effect standard combination;

Q_g^n —Down drag acted on a foundation pile in clustered piles;

q_f —Foundation pile tangential frozen-heave force.

2.2.2 Resisting Force and Material Property

E_s —Soil compressive modulus;

f_t, f_c —Design values of concrete tensile and compression resisting strength;

f_{rk} —Standard value of rock saturated uniaxial compressive strength;

f_s, q_c —Average side resistance and average end resistance of static cone penetration double-bridge probe;

m —Proportionality coefficient of pile-side foundation soil horizontal resistance coefficient;

P_s —Specific penetration resistance of static cone penetration single-bridge probe;

q_{sik} —Ultimate shaft resistance of the i layer soil of the individual pile;

- q_{pk} —Ultimate tip resistance of individual pile;
- Q_{sk}, Q_{pk} —Total ultimate side resistance and total ultimate tip resistance of individual pile;
- Q_{uk} —Ultimate vertical bearing capacity of a single pile;
- R —Characteristic value of vertical bearing capacity of foundation pile or Composite Foundation Pile;
- R_a —Characteristic value of the vertical bearing capacity of a single pile;
- R_{ha} —Characteristic value of horizontal bearing capacity of individual pile;
- R_h —Characteristic value of horizontal bearing capacity of foundation pile;
- T_{gk} —Standard value of ultimate foundation pile pullout resisting bearing pressure on the condition of clustered piles integral failure;
- T_{uk} —Standard value of ultimate foundation pile pullout resisting bearing pressure on the condition of clustered piles non-integral failure;
- γ, γ_e —Soil weight density and soil effective weight density.

2.2.3 Geometric parameter

- A_p —Pile tip area;
- A_{ps} —Pile foundation cross sectional area;
- A_c —Net area of cushion cap bottom corresponding to foundation pile;
- B_c —Cushion cap width;
- d —Pile foundation design diameter;
- d_s —Steel-pipe pile external diameter;
- D —Design diameter of pile tip enlarged base;
- l —Pile foundation length;
- L_c —Cushion cap length;
- S_a —Foundation pile center distance;
- u —Pile foundation perimeter;
- Z_n —Calculated settlement depth of pile foundation (calculated from the pile tip surface).

2.2.4 Calculation Coefficient

- α_E —The ratio of rebar elastic modulus and concrete elastic modulus;
- η_c —Pile Cap Coefficient;
- η_t —Frost heave influence coefficient;
- ζ_r —Side resistance and end resistance comprehensive coefficient of rock-socketed

segment;

ψ_s, ψ_p — Size effect coefficients of major-diameter pile side resistance and end resistance;

λ_p — Pile tip plugging effect coefficient;

λ — Foundation pile pullout resisting coefficient;

ψ — Pile foundation settlement calculation empirical coefficient;

ψ_c — Piling process coefficient;

ψ_e — Equivalent settlement coefficient for calculating settlement of piled foundations;

$\alpha, \bar{\alpha}$ — Subsidiary stress coefficient and average subsidiary stress coefficient calculated through Boussinesq.

3 Basic Design Provisions

3.1 General Provision

3.1.1 Pile foundations shall be designed in accordance with following two ultimate states.

1 Limit State of Bearing Capacity: the pile foundation bears the max carrying capacity, the integral body losses instability or has deformation that is unsuitable to keep bearing;

2 Ultimate state of normal service: the pile foundation reaches the deformation limit specified on the condition of building normal service, or a threshold value of life requirement.

3.1.2 In accordance with construction scale, functional characteristics, adaptability to diffuse deformation, complexity of site foundation and building shape, and possible construction failure or influence degree caused by pile foundation problems. In the pile foundation design, the design level shall be identified in accordance with Table 3.1.2.

Table 3.1.2 Design LEVEL of Building Pile Foundations

Design Level	Construction Type
Level I	(1) Important buildings (2) High-rise building which floor number is larger than 30 or the height exceeds 100m (3) High and low elevation difference jointed building with complex body type and over 10 floor number (4) Buildings with over 20 layers, framework-kernel barrel structure and special requirements in differential settlement (5) Normal building and buildings on sloping field and bank-side which layer number is larger than 7, and have complex site and foundation conditions (6) Buildings that have larger influence to adjacent existing engineering
Level II	Buildings except ones at Level I and Level II
Level III	Normal buildings which the site and foundation condition is simple, the load distribution is uniform and the layer number is 7 or less

3.1.3 For pile foundation construction, following carrying capacity calculation and stability factor checking computations shall be taken out respectively in accordance with actual conditions:

1 The vertical and horizontal bearing capacities calculation shall be carried out respectively in accordance with function and bearing characteristic of pile foundation;

2 The pile foundation and cushion cap structure bearing capacities shall be calculated; for pile which pile side soil undrained shear strength is less than 10kpa and the length-diameter ratio is larger than 50, the pile foundation lateral deflection checking computation shall be taken out; for concrete premolded pile, the pile

foundation bearing capacity checking computation shall be taken out according to hoisting, transporting and stamping acts; for steel-pipe pile, the local buckling checking computation shall be taken out.

3 The bearing capacity checking computation of the soft and weak subjacent bed shall be taken out, if the soft and weak subjacent beds exist under the pile tip surface.

4 The integral stability checking computation shall be taken out for pile foundation located on sloping field and shore-side;

5 The pullout resisting bearing capacity calculation of foundation pile and clustered piles shall be taken out for float-proof and pullout resisting pile foundations;

6 The checking computation of earthquake resistance bearing capacity shall be taken out for pile foundations located in earthquake protective area.

3.1.4 The calculation of foundation settlement shall be taken out for following Building Pile Foundations:

1 Rock-socketed piles which Design Level is Level I and building pile foundations in non deep and hard supporting course;

2 Building pile foundations which Design Level is Level II, the body type is complex and the load distribution is conspicuously non-uniform or weak soil layer exist under the pile tip surface;

3 Composite foundation with settlement-reducing piles of multistoried building with soft soil foundation.

3.1.5 For building pile foundations with larger horizontal load and close restraint to horizontal displacement, the horizontal displacement shall be calculated.

3.1.6 Crack resistance and crack width of pile and cushion cap right sections shall be calculated in accordance with pile foundation envelopment and corresponding crack control level.

3.1.7 In pile foundation design, adopted action effects combination and corresponding resisting force shall met following provisions:

1 The standard combination of loading effect transferred to the cushion cap base surface shall be adopted when the pile number and piling arrangement is identified; characteristic values of foundation pile or Composite Foundation Pile bearing capacity shall be adopted for corresponding resisting forces.

2 When settlement and horizontal displacement of pile foundation under the load acting are calculated, the quasi-permanent combination of loading effect shall be adopted; standard combinations of horizontal earthquake effect and wind load shall be adopted when the pile foundation horizontal displacement under earthquake effect and wind load is calculated.

3 When the integral stability of Building Pile Foundations located on sloping field and bank-side is calculated, the loading effect standard combination shall be adopted; and the standard combinations of earthquake effect and loading effect shall be adopted.

4 When the piling structure bearing capacity is calculated, and dimension and reinforcement assembly are identified, basic combination of loading effect transferred to the cushion cap shall be adopted. Loading effect standard combination and quasi-permanent combination shall be adopted respectively when checking computations of cushion cap and pile foundation crack control is taken out.

5 Piling structure design safety level, structural design service life and structural importance coefficient shall be adopted in accordance with relative current provisions in building structure. Except temporary buildings, the importance coefficient γ_0 shall not be less than 1.0.

6 When the checking computation of piling structure earthquake resistance is taken out, the bearing capacity adjustment coefficient γ_{RE} shall be selected in accordance with provisions in current national standard "Code for Seismic Design of Buildings" GB 50011.

3.1.8 The optimized design of pile foundation stiffness to reduce differential settlement that is to decrease the differential settlement and the cushion cap internal force should be implemented in accordance with actual conditions and following provisions:

1 When the main body of the tower-podium building has pile foundation, the rigidity of annex (including full basement) foundation or pile foundation can be relatively reduced, and natural foundation, composite foundation, pile reducing or stub foundation may be adopted.

2 For the pile foundation of framework-kernel barrel structured high-rise building, the rigidity of kernel-barrel pile foundation shall be reinforced properly (the pile length, pile diameter and pile number may be increased properly, and the post-grouting may be adopted etc.), and the rigidity peripheral pile foundations of kernel-barrel may be reduced properly (composite piled foundation may be adopted, or the pile length may be reduced properly according to the stratigraphic condition).

3 If the natural foundation bearing capacity of framework-kernel barrel structured high-rise building can meet the requirements, the rigidity should be increased for the kernel-barrel position to reduce the sedimentary friction-type piles.

4 For friction-type pile foundation of larger measuring cylinder storehouse and storage

tank, the pipes should be arranged according to the principle of inner-rigidity and external weakness.

5 For above pile foundations formed according to the optimized design of pile foundation stiffness to reduce differential settlement, topside structure-cushion cap-pile-soil joint working analyzing should be taken out.

3.1.9 If the ground bearing capacity for multistory structure with soft soil foundation can meet the requirements, the composite foundation with settlement-reducing piles may be adopted.

3.1.10 For Building Pile Foundations that the calculation of foundation settlement shall be taken out according to the Item 3.1.4 of this code, the systemic settlement observation shall be kept during the construction and service and till the settlement is stable.

3.2 Basic Documents

3.2.1 The pile foundation design shall be provided with following materials:

1 Geotechnical engineering investigation documents:

- 1) Physical and mechanical parameters and in-situ measurement parameters required by that the pile foundation is designed under two ultimate states;
- 2) Definite judgment, conclusion and prevention and control proposals on building site disadvantageous geological actions like landslide, collapse, mud-rock flow, karst and earth cave;
- 3) Condition and type of groundwater level embedding, water level variation amplitude, float-proof design water level, corrosion evaluation of soil and water, design water level for buoyancy calculation of underground water;
- 4) Materials on fluidized soil layer provided in the earthquake protection area according to the fortification intensity;
- 5) Evaluation materials on foundation soil frost heave, collapsibility and dilatibility.

2 Related documents about building site and environmental conditions:

- 1) Current situation of building site including the distributions of transportation facilities, high-voltage overhead line, underground pipeline and underground structure;

- 2) Safety level, foundation type and buried depth of adjacent buildings;
 - 3) Materials on pile foundation trial piling of nearby sites with similar engineering geologic condition, and the design parameter of individual pile bearing capacity;
 - 4) Anti-vibration and anti-noise requirements of surrounding buildings;
 - 5) Slurry emission and spoiling condition;
 - 6) Earthquake protection intensity and building site type of building location.
- 3 Related documents about building:
- 1) General arrangement plan;
 - 2) Building structure type, load and service condition, and requirements of implements on foundation vertical and horizontal displacement;
 - 3) Safety level of building structure.
- 4 Related documents on execution conditions:
- 1) Construction machine implement condition, pile-making condition, dynamic condition, and the adaptability of construction process to geologic conditions;
 - 2) Supply condition of water, electricity and relative constructional materials;
 - 3) Construction machine passing in and out and field operation conditions.
- 5 Materials on pile type and operative feasibility supplied for design comparison.

3.2.2 The detail investigation of pile foundation shall meet relative requirements in “Code for Investigation of Geotechnical Engineering” GB 50021, as well as following requirements:

1 Exploratory Point Spacing:

- 1) End-bearing pile (including rock-socketed piles): the spacing is determine by the gradient of pile tip supporting course top surface, and should be 12~24m. If the gradient of supporting course of pile tip exposed by two adjacent exploratory points is large than 10% or the supporting course undulates acutely, the stratigraphic distribution is complex, the exploratory points density shall be increased properly in accordance with specific engineering conditions.
- 2) Friction-type Pile: exploratory hole should be arranged according to the spacing

20~35m. The exploratory point density shall be increased properly when the property or situation changes greatly in horizontal direction, or soil layer may affect piling.

- 3) For foundation of individual pile under the columns in complicated geological conditions, the exploratory points shall be arranged along the column row line, and an exploratory point should be arranged for each pile.

2 Depth of Exploration:

- 1) 1/3~1/2 of exploratory holes should be arranged as control holes. For Building Pile Foundations with Design Level I, at least 3 control holes shall be arranged, and at least 2 control holes shall be arranged for Building Pile Foundations with Design Level II. Control holes shall be penetrate the thickness of the compact layer under the pile tip surface; normal exploratory holes shall penetrate deeply into 3~ times of the pile foundation design diameter under the expected pile tip surface, and the exploratory hole depth shall not be less than 3m; for major diameter pile, the exploratory hole depth shall not be less than 5m.

- 2) The control drills for rock-socketed piles shall penetrate more than 3~5 times of pile foundation design diameter under the expected pile tip surface, and normal drills shall penetrate more than 1~3 times of pile foundation design diameter under the expected pile tip surface. If the supporting course is relatively thin, partial drills shall drill through the supporting rock course. In karst and crush regions, distribution conditions of solution cavity, solution channel, solution slot and stalagmite shall be ascertained, drills shall be drill through solution cavity or crush zone and enter into stable soil layer, and the penetrating depth shall meet the requirements on above control drill and normal drill.

3 For each stratum within the depth of exploration, laboratory experiment for undisturbed sample shall be taken out, or effective in-situ measurement method shall be adopted according to the soil quality condition, which is to supply the parameters required by the design.

3.3 Type Selection and Arrangement of Pile

3.3.1 Foundation piled may be classified in accordance with following provisions:

1 By load-bearing properties:

- 1) Friction-type pile:

Friction pile: the pile-side resistance bears the vertical load of the pile top under the

condition of the bearing capacity limit, and the tip resistance is smaller to be neglected.

End-support Friction Pile: the pile-side resistance bears the pile top vertical load under the condition of the bearing capacity limit.

2) End-bearing Pile:

Point bearing pile: the pile tip resistance bears the vertical load of the pile top under the condition of the bearing capacity limit, and the pile-side resistance is smaller to be neglected.

Friction Point Bearing Pile: the pile-side resistance bears the pile top vertical load under the condition of the bearing capacity limit.

2 By piling method:

- 1) Non Displacement Pile: dry-drilled filling pile, slurry wall protection drilling filling pile and sleeve wall protection drilling filling pile;
- 2) Partial Displacement Pile: long spiral drilled press-grouting pile, impact-cone concrete pile, cast-in-place bored pile, mixing pile with stiffness core, prebored hole drilling premolded pile, drive-in (static pressure) open steel-pipe pile, open prestressed concrete hollow pile H section pile;
- 3) Displacement Pile: filling piles with sink-pipe, enlarging-grouting pile with sink-pipe, drive-in (static pressure) premolded pile, enclosed prestressed concrete hollow pile and enclosed steel-pipe pile.

3 By pile diameter size (Design Diameter d):

- 1) Pile with minor diameter: $d \leq 250\text{mm}$;
- 2) Pile with medium diameter: $250\text{mm} < d < 800\text{mm}$;
- 3) Pile with major diameter: $d \geq 800\text{mm}$.

3.3.2 Based on the principle of safety and usability, and economic feasibility, pile type and piling process shall be selected in accordance with building structure type, loading property, pile functions, crossing soil layer, pile tip supporting course groundwater level, construction equipment, construction envelopment, construction experience and pile material supply condition. The selection may be taken out in accordance with Appendix A of this code.

- 1 For pile-raft foundation with non-uniform load distribution like framework-kernel

barrel structure, pile type and process with larger foundation pile size and bearing capacity adjustability should be adopted.

2 When Displacement filling piles with sink-pipe is used in the silt and silt-type soil layer, the selection shall be restricted to the pile foundation for multilayer house building.

3 The prestressed concrete circular pile (PC) and the prestressed concrete hollow square pile should not be adopted in those regions where the anti-earthquake intensity is 8 degree or above.

3.3.3 The arrangement of foundation pile should meet following conditions:

1 The minimum center distance of the foundation pile shall meet the provisions in Table 3.3.3; reliable measures to reduce the squeezing effect in construction, the minimum center distance may be decreased properly according to local experience.

Table 3.3.3-1 Minimum Center Distance of Pile

Soil Type and Piling Process		Friction-type pile foundation which the row number shall not be less than 3, and the pile number shall not be less than 9	Other conditions
Non Displacement Filling Pile		$3.0d$	$3.0d$
Partial Displacement Pile		$3.5d$	$3.0d$
Displacement Pile	Unsaturated Soil	$4.0d$	$3.5d$
	Saturated Cohesive Soil	$4.5d$	$4.0d$
Boring and expanding bottom pile and club-footed pile		$2D$ or $D+2.0m$ (when $D>2m$)	$1.5D$ or $D+1.5m$ ($D>2m$)
Enlarging-grouting pile with sink-pipe, and hole expand pile	Unsaturated Soil	$2.2D$ and $4.0d$	$2.0D$ and $3.5d$
	Saturated Cohesive Soil	$2.5D$ and $4.5d$	$2.2D$ and $4.0d$

Note: 1 d —Log pile diameter square pile side length, D —Bell-end design diameter.

- 2 Vertical and horizontal pile spacing are unequal, the minimum center distance shall satisfy provisions in the column "Other Conditions".
- 3 If Non Displacement Filling Pile is end-bearing pile, the column "Other Conditions" value of the Non Displacement Filling Pile may be reduced to $2.5d$.

2 In the foundation pile arrangement, the point force concurrence of pile group bearing capacity should coincide with the force concurrence point of vertical permanent loads, and the foundation pile should have larger bending resistant section modulus in the direction of larger horizontal force and moment.

3 For pile-box foundation and pile-raft (including plate and beam slab cushion cap) foundation with shear wall structure, piles should be arranged under the wall.

4 For framework-kernel barrel structured pile-raft foundation, the interaction shall be considered in accordance with the load distribution, pile shall be arranged relatively intensively under the kernel-barrel and column, the peripheral framework columns should be arranged with composite piled foundation, and the pile length should be less than the pile foundation under the kernel-barrel (with proper pile tip supporting course).

5 Relatively solid ground shall be adopted as the pile tip supporting course. The depth that the pile tip gross section enters into the supporting course, should not be less than $2d$ for silty soil; should not be less than $1.5d$ for sandy soil; shall not be less than $1d$ for crackle soil. If the soft-weak subjacent bed exists, the thickness of hard supporting course under the pile tip should not be less than $3d$.

6 For the rock-socketed piles, the rock-socketed depth shall be identified according to many factors such as loading, upper covered soil layer, bedrock, pile diameter and pile length; the gross section depth of rock-socketed and oblique sound or relatively sound rocks should not be less than $0.4d$ (0.5m), and for normal weathered rock which the gradient is larger than 30%, the rock-socketed depth should be increases properly in accordance with the gradient and rock integrity; for plain and sound hard rock and relatively hard rock, the rock-socketed depth shall not be less than $0.2d$ (0.2m).

3.4 Pile Foundation in Exceptional Conditions

3.4.1 The design principle of pile foundations for soft soil foundation shall meet following provisions:

1 In selection of pile foundations in the soft soil, soil layer with low compressibility should be adopted as pile tip supporting course;

2 If pipe surrounding soft soil settlement caused by self consolidation, site filling, large-area ground stacking, falling groundwater level and large-area squeezing pile-sinking is larger than the foundation pile settlement, the influence of pile-side negative shaft resistance on foundation pile shall be analyzed and calculated in accordance with specific engineering conditions;

3 When the Displacement Pile is adopted, technical measures like reducing pore water pressure and squeezing effect shall be adopted to decrease the adverse effects of squeezing effect on piling quality, adjacent building, road, underground pipeline and foundation excavation side slope;

4 If the piling is previous to the foundation excavation, excavation sequence of foundation excavation shall be arranged properly and the depth of layering excavation shall be controlled to prevent the influence of earth mass displacement on piles.

3.4.2 The design principle of pile foundation in collapsible loess region shall meet following provisions:

1 The foundation pile shall penetrate the collapsible loess layer, the pile tip shall support on the cohesive soil, silty soil, normal-compact and close sand soil, and crackle soil layer with low compressibility;

2 In collapsible loess foundation, the individual pile ultimate bearing pressure of Building Pile Foundations with Design Level I and II should be based mainly on ponding loading test;

3 For the ultimate bearing pressure of individual pile in self weight collapse loess foundation, the influence of pile-side negative shaft resistance shall be analyzed and calculated in accordance with engineering physical circumstances.

3.4.3 The design principle of pile foundations in seasonally frozen soil and swelling soil foundation shall meet following provisions:

1 The depth that pile tip enters into the sharp atmospheric-effect layer of frost line or swelling soil shall meet the requirements of the checking computations for pullout resisting stability factor, and shall not be less than 4 times of pile diameter, and a bellend diameter. The minimum depth shall be larger than 1.5m;

2 In order to reduce and eliminate the effect of frost heave or swelling on building pile foundation, cast-in-place bored pile should be adopted;

3 When the ultimate vertical bearing pressure of foundation pile is identified, foundation soil frost heave and expansive action, and checking computations of pile foundation pullout resisting stability factor and pile foundation pulling bearing capacity shall be considered besides that pile-side resistance within frost heave and swelling depth range;

4 In order to eliminate the harm of frost heave or expansive action on pile foundation, freeze-proof and swelling-proof treatment shall be taken out along pile circle and cushion cap within the frost heave or swelling depth range.

3.4.4 The design principle of pile foundation in karst region shall meet following provisions:

1 Drilling and punching piles should be adopted for pile foundation in karst region;

2 Rock-socketed piles should be adopted when the load id individual pile is larger, and the buried depth of rock stratum is lighter;

3 When the bedrock surface waves greatly and the buried depth is larger, the

friction-type filling pile should be adopted.

3.4.5 The design principle of pile foundation on sloping field and bankside shall meet following provisions:

1 For pile foundation built on sloping field and shoreside, piles shall not be supported on the potential slide mass of the side slope. The depth that the pile tip enters into the stable rock-soil layer under the potential slip crack surface shall ensure the stability of the pile foundation;

2 Building Pile Foundations shall be kept certain distance away from the side slope; the side slope within building site must be a completely stable side slope. If the disadvantageous geologic conditions like Collapse and landslide exist, the treatment and control shall be taken out in accordance with provisions in current national standard "Technical Code for Building Slope Engineering" GB 50330 to guarantee the stability;

3 New Building Pile Foundations engineering on sloping field and bank-side shall be unifiedly planned and designed with Building Slope engineering, and the construction consequence shall be identified reasonably;

4 Displacement Pile should not be used;

5 The integral stability and horizontal bearing capacity of foundation piles under the most adverse loading effect combination shall be calculated.

3.4.6 The design principle of pile foundation in earthquake protection area shall meet following provisions:

1 The length (excluding pile tip) of pile entering into the stable soil layer under the fluidized soil layer shall be identified in accordance with the calculation; for soil aggregate, gravel, rough sand, medium sand, compact silty soil and hard cohesive soil, the depth shall not be less than $2\sim 3d$ times of the pile foundation diameter; for other non rocky soil, the depth should not be less than $4\sim 5d$ times of the pile foundation diameter;

2 Lime soil, graded sand and stone and compacted plain soil shall be adopted to backfill around the cushion cap and basement sidewall, and shall be tamped in layers. The plain concrete may also be feasible.

3 When around cushion cap is liquefiable soil or soft soil which the characteristic value of ground bearing capacity is less than 40kPa (or the undrained shear strength is less than 15kPa), and the horizontal bearing capacity of pile foundation cannot meet the calculation requirement, the soil within $1/2$ side length on both sides of the cushion cap may be reinforced.

4 In section with possible liquidating expansion, the stability of pile foundation under earth-flow sideway active force shall be calculated.

3.4.7 The design principle of pile foundation with possible negative shaft resistance shall meet following provisions:

1 In filling building site, the filling shall be taken out firstly and the filling compactness shall be ensured. The measures like pre-arranging plastic drain board shall be taken out before the filling of soft soil site. And the piling shall be taken out when the settlement of filling foundation is basically stable.

2 For building with large area ground stacking, the measures to reduce the influence of land subsidence on building pile foundation shall be taken out;

3 For self weight collapse loess foundation, heavy-tamping and compacting earth pile may be adopted to treat firstly to eliminate the dead weight collapse of upper soil or whole soil; for underconsolidated soil, measures like atmospheric dilution and precompaction at advanced stage should be adopted;

4 For squeezing sinking pile, the measures like reducing the excess pore pressure and controlling the pile-sinking speed shall be taken out;

5 For pile foundation above the neutral point, the surface may be treated to reduce the negative shaft resistance.

3.4.8 The design principle of uplift pile foundation shall meet following provisions:

1 The crack control level of the uplift pile shall be identified in accordance with many factors such as envelopment type, water and soil corrosion to rebar, rebar corrosive sensibility, and duration of load;

2 For crack control level I required no crack, prestressed bar shall be arranged in the pile foundation; for crack control level II required normally no crack, prestressed bar should be arranged in the pile foundation;

3 For crack control level II, the calculation for pile foundation crack width shall be taken out;

4 If the pullout resisting bearing capacity of the foundation pile is required higher, technical measures like pile-side post-grouting and enlarged base may be adopted.

3.5 Provisions on Durability

3.5.1 The durability of the piling structure shall be designed in accordance with the designed lifetime, provisions in envelopment type specified in current national standard "Code for Design of Concrete Structure" GB 50010, and evaluation on corrosivity of water and solid to steel and concrete.

3.5.2 In envelopments of Level II and Level III, the piling structure concrete which the designed lifetime is 50 years shall meet provisions in Table 3.5.2.

Table 3.5.2 Basic Requirements of Piling Structure Concrete Durability in Envelopments of Level II and Level III

Envelopment Type		Max Water-cement Ratio	Mini Cement Consumption (kg/m ³)	Mini Strength Grade of Concrete	Max Chloride Ion Content (%)	Max Alkali Content (kg/m)
II	a	0.60	250	C25	0.3	3.0
	a	0.55	275	C30	0.2	3.0
III		0.50	300	C30	0.1	3.0

Note: 1 The chloride ion content is referred to the percentage to the cement consumption;

- 2 The Max Chloride Ion Content of concrete for prestressed unit is 0.06%, the mini cement consumption is 300kg/m³; the Mini Strength Grade of Concrete shall be increased by two levels in accordance with provisions in the table;
- 3 When the concrete is added with active adulterant or admixtures to improve the durability, the cement consumption may be decreased properly;
- 4 When non alkali reactive aggregate is adopted, the alkali content of concrete is not limited;
- 5 When the reliable engineering experience is available, the Mini Strength Grade of Concrete can be reduced by a level.

3.5.3 The crack control level and the max crack width of pile foundation shall be selected in accordance with provisions in Table 3.5.3, and based on Envelopment Type and water-soil media corrosivity level.

Table 3.5.3 Crack Control Level and Max Crack Width Threshold Values of Pile Foundation

Envelopment Type		Reinforced Concrete Pile		Prestressed-concrete Pile	
		Crack Control Level	w _{lim} (mm)	Crack Control Level	w _{lim} (mm)
II	a	III	0.2 (0.3)	II	0
	a	III	0.2	II	0
III		0.2	I	0	III

Note: 1 If water and soil are of strong or medium corrosion, the Crack Control Level of uplift pile shall be increased by a level;

- 2 In Level IIa envelopment, the upper threshold value of crack width may be the values in the parentheses for the foundation pile below the stable underground water level.

3.5.4 The durability design of piling structure in envelopment Level IV and V may comply with current national standard “Code for Design of Concrete Structure - Harbor Engineering” JTJ 267 and “Code for Anticorrosion Design of Industrial Construction” GB 50046.

3.5.5 For piling structures in envelopments of Level III, IV and V, the bearing steel bar should be rib steel coated with epoxy resin paint.

4 Pile Foundation Structure

4.1 Foundation Pile Structure

I Filling Pile

4.1.1 The reinforcement assembly shall be arranged for the filling pile in accordance with following provisions:

1 Reinforcement Assembly Rate: if the pile foundation diameter is 300~2000mm, the reinforcement assembly rate of the normal section may be 0.65%~0.2% (the max value may be selected for the minor diameter pile); for piles, uplift piles and rock-socketed point bearing piles with larges load, the reinforcement assembly rate shall be identified based on the calculation, and shall be less than above specified value;

2 Reinforcement Length:

- 1) For end-bearing pile and foundation pile located on shore-side, reinforcement assembly shall be arranged along full length of pile foundation uniform cross section or variable cross-section;
- 2) The reinforcement length of friction-type pile which the pile diameter is larger than 600mm shall not be less than 2/3 of the pile length; if the pile is stressed by horizontal load, the reinforcement length should not be less than $4.0/\alpha$ (α is referred to the horizontal deformation coefficient);
- 3) For foundation pile affected by the earthquake effect, the reinforcement length of the pile foundation may go through liquefiable soil layer and soft-weak soil layer, and the depth of reinforcement assembly entering into the stable soil layer shall not be less than the depth specified in Item 3.4.6 of this code;
- 4) For pile affected by the negative shaft resistance, and pile that bounds with the foundation soil due to foundation excavation after piling, the reinforcement length shall go through the soft-weak soil layer and enter into the stable soil layer, and the entering depth shall not be less than $(2\sim3)d$ times of the pile foundation diameter;
- 5) For special uplift pile and pile acted by the pulling force caused by earthquake effect, frost heave or expansibility act, the reinforcement assembly shall be taken out along full length of uniform cross section or variable cross-section.

3 For the pile stressed by toward horizontal load, the main reinforcement shall not be less than $8\phi 12$; for compressive pile and uplift pile, the main reinforcement shall not be less than $6\phi 10$; main longitudinal reinforcement shall be arranged uniformly along the pile foundation cycle, the clear distance shall not be less than 60mm;

4 The hooped reinforcement shall be screw type, the diameter shall not be less than 6mm, and the spacing interval should be 200~300mm; When the calculation of the pressure bearing capacity of pile foundation stressed by larger load and pile foundation affected by horizontal earthquake effect is calculated due to the main reinforcement acting, the hooped reinforcements within $5d$ below the pile top shall be denser, and the spacing interval shall not be larger than 100mm; if the pile foundation is located in the liquidating soil layer, the hooped reinforcement density shall be increased; if the hooped reinforcement stress act is considered, the hooped reinforcement configuration shall meet relative regulations in current national standard "Code for Design of Concrete Structure" GB 50010; if the reinforcing cage length exceeds 4m, welded stiffening hooped reinforcement with larger than 12mm diameter shall be arranged every 2m length.

4.1.2 Pile foundation concrete and concrete protection thickness shall meet following requirements:

1 The strength grade of pile foundation concrete shall not be less than C25, and the strength grade of concrete premolded pile tip shall not be less than C30;

2 The thickness of concrete protective layer for filling pile main reinforcement shall not be less than 35mm, and the thickness of concrete protective layer for underwater filling pile main reinforcement shall not be less than 50mm.

3 The thickness of concrete protective layer for pile foundation in envelopments of Level IV and V shall meet relative provisions in current national standard "Design Code for Harbor Engineering Concrete Structures" JTJ 267 and "Code for Anticorrosion Design of Industrial Construction" GB 50046.

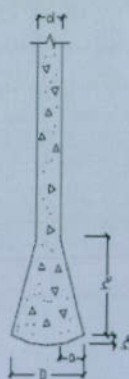


Figure 4.1.3 Pedestal Pile Structure

4.1.3 The size of enlarged base end of enlarged base filling pile shall meet following provisions (Figure 4.1.3):

1 For compressive pile that the bearing capacity of the supporting course is higher and the covered solid is poor, and uplift pile with preferable soil layer of certain thickness, the enlarged base may be adopted; the ratio D/d of the enlarged base end diameter and the pile

foundation diameter shall be identified in accordance with bearing capacity requirement, enlarged base end side-face, pile tip supporting course soil characteristic and enlarged base construction scheme; D/d for manual hole pile shall not be larger than 3, and the D/d for bored pile shall not be larger than 2.5;

2 The gradient of enlarged base end side-face shall be identified in accordance with practical pore-forming and earth mass conditions. For a/h_c , the gradient may be 1/4~1/2; for sandy soil, the gradient may be 1/4; for silty soil and cohesive soil, the gradient may be 1/3~1/2;

3 The base surface of compressive pile enlarged base end should be pan-bottom shaped, and the arrow height h_b may be (0.15~0.20) D .

II Concrete Premolded Pile

4.1.4 The cross section side length of concrete premolded pile shall not be less than 200mm; and the cross section side length of prestressed concrete prefabricate solid pile should not be less than 350mm.

4.1.5 The strength grade of concrete for premolded pile should not be less than C30; the strength grade of concrete for prestressed concrete solid pile shall not be less than C40; the thickness of concrete protective layer for premolded pile longitudinal reinforcement should not be less than 30mm.

4.1.6 The reinforcement assembly of premolded pile shall be identified through the calculation in accordance with conditions such as handling, piling and pile bearing in usage. When stamping method is adopted to sink pile, the mini steel ratio of premolded pile should not be less than 0.8%. When static pressure method is adopted to sink pile, the mini steel ratio should not be less than 0.6% and the diameter of the main reinforcement should not be less than $\phi 14$. Hooped reinforcements within 4~5 times of driven pile foundation diameter shall be denser, and arranged with rebar network sheet.

4.1.7 The segment length of premolded pile shall be identified in accordance with construction and traffic conditions; the joint number of each pile should not exceed 3.

4.1.8 For the tip of premolded pile, main reinforcements may be gathered up and welded on the auxiliary reinforcement of the pile tip. If the supporting course soil is close sand and crackle soil, steel sabot should be covered on the pile tip to reinforce the pile tip.

III Prestressed Concrete Hollow Pile

4.1.9 Prestressed concrete hollow pile may be classified as tubular pile and hollow square pile according to cross section type, and high-strong prestressed concrete (PHC) pile and prestressed concrete (PC) pile according to the strength grade of concrete. Sectional

dimension, reinforcement assembly, pile ultimate bearing moment and pile vertical bearing capacity design value of centrifugal pretensioning prestressed concrete pile may be identified in accordance with Appendix B of this standard.

4.1.10 The pile tip type of prestressed concrete hollow pile should be enclosed type or open type; the enclosed type is classified as flat bottom cross type and wimble type.

4.1.11 The quality level of prestressed concrete hollow pile shall meet provisions in current national standard "Pretensioned spun concrete piles" GB/T 13476, "Pretensioned Spun Thin-walled Concrete Piles" JC 888, "Prestressed Spun Concrete Square Piles" JG 197 and other relative standards.

4.1.12 Joints of prestressed-concrete pile may be connected through endplate welding, flange connection, mechanical joggle connection and screwed connection. Joint number of each pile should not exceed 3.

4.1.13 If prestressed concrete hollow pile is driven into softened intense weathering rock, full decayed rock and unsaturated soil, the scope 2m above the pile tip shall be treated with effective anti-seepage. Micro-swelling concrete may be adopted to fill the core or soft waterproof is coated on the inner wall.

IV Steel Pile

4.1.14 Steel pile may be pipe, H shaped or other special sections.

4.1.15 The segmenting size of the steel pile should be 12~15m.

4.1.16 Welding joint of the steel pile shall be equal-strength joint.

4.1.17 The tip type of steel pile shall be identified comprehensively in accordance with soil layer, supporting course property, pile dimension and squeezing effect, and shall be adopted according to following provisions:

1 Steel-pipe pile may be following types:

1) Open type:

With reinforced hoop (with internal partition plate or without internal partition plate); without reinforce hoop (with internal partition plate or without internal partition plate).

2) Enclosed Type:

Flat bottom; tapered bottom.

2 H section steel pile may be following types:

- 1) With endplate;
- 2) Without endplate:

Tapered bottom;

Flat bottom (with enlarged alae or without enlarged alae).

4.1.18 Anti-corrosion treatment of steel pile shall meet following provisions:

1 The corrosion rate of the steel pile may be identified in accordance with Table 4.1.18 if field data is unavailable;

2 The anti-corrosion treatment for steel pile may be that the surface is coated with erosion resistant coating, and corrosion allowance and cathodic protection are added; if the inner wall of the steel-pipe pile is isolated from the external environment, inner wall corrosion protection may be disregarded.

Table 4.1.18 Annual Corrosion Rate of Steel Pile

Envelopment		Single-sided Corrosion Rate (mm/y)
Above ground	Without corrosive gas or corrosive volatile media	0.05~0.1
Below Ground	Above the water level	0.05
	Below the water level	0.03
	Water-level fluctuation area	0.1~0.3

4.2 Cushion Cap Structure

4.2.1 The structure of pile foundation cushion cap shall satisfy die cutting resistance, shear resistance and bending resistance bearing capacity and topside structure requirements and shall also meet following requirements:

1 The minimum width of the pile foundation cushion cap under the insulated column shall not be less than 500mm, the distance from the side piling center and cushion cap edge shall not be less than the diameter or the side length of the pile, and the distance from the pile outside edge to the cushion cap edge shall not be less than 150mm. For strip-shaped cushion cap beam below the wall, the distance from the pile outside edge to the cushion cap beam edge shall not be less than 75mm. The minimum thickness of the cushion cap shall not be less than 300mm.

2 The minimum thickness of flatbed and beam-slab raft cushion cap for high-rise

buildings shall not be less than 400mm, and the minimum thickness of raft cushion cap of shear wall structure for piling under the wall shall not be less than 200mm.

3 The structure of box type cushion cap for high-rise building shall meet provisions in "Technical Code for Box Foundation and Raft Foundation of High-rise Buildings" JGJ 6.

4.2.2 Material and strength grade of cushion cap concrete shall meet requirements in structural concrete durability and impermeability.

4.2.3 Rebar arrangement of cushion cap shall meet following provisions:

1 The longitudinal bearing steel bar of independent pile cushion cap under the column shall be arranged along full length (detailed in Figure 4.2.3-a). for cushion cap with not less than 4 piles, the bearing steel bars shall be arranged uniformly and bidirectionally; for trigon cushion cap with three piles, bearing steel bars shall be arranged uniformly according to the three-way sheet strip, and the trigon formed by the three innermost rebars shall be within the column section (detailed in Figure 4.2.3-b). The anchorage length of longitudinal reinforcement accounted from side pile inside (when pile is log pile, the diameter shall be multiplied by 0.8 and equivalent as a square pile) shall not be less than $35d_g$ (d_g refers to the bar diameter); if the condition cannot be satisfied, longitudinal reinforcement shall be bent upward, and the length of the horizontal segment shall not be less than $25d_g$ and the bent segment length shall not be less than $10d_g$. The diameter of longitudinal bearing steel bar for cushion cap shall not be less than 12mm, and the spacing interval shall not be larger than 200mm. The critical steel ratio of independent pile cushion cap under the column shall not be less than 0.15%.

2 For two independent pile caps under the column, the longitudinal tensile bar, and horizontal and vertical distribution bars shall be arranged as member in deep bending in accordance with current national standard "Code for Design of Concrete Structure" GB 50010. Anchorage length and structure of the tip of longitudinal bearing steel bar for cushion cap shall be same to the provisions in multiple-pile cushion cap under the column.

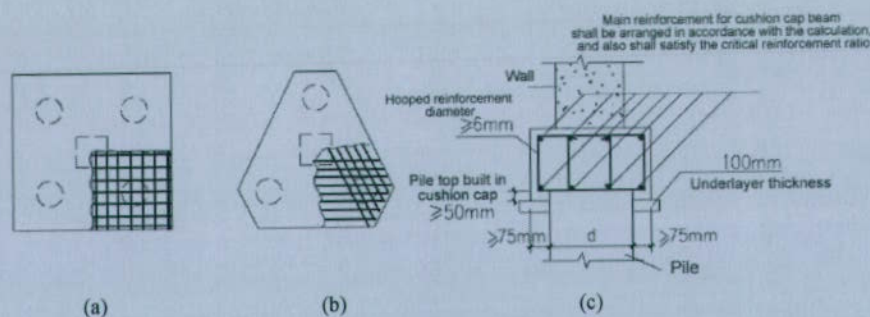


Figure 4.2.3 Cushion Cap Reinforcement Assembly

- (a) Rectangle cushion cap reinforcement assembly; (b) Three-pile Cushion Cap Reinforcement Assembly;
 (c) Reinforcement assembly of cushion cap beam under the wall

3 Longitudinal main reinforcement of strip cushion cap beam shall meet provisions of

current national standard "Code for Design of Concrete Structure" GB 50010 in critical steel ratio (Figure 4.2.3-c). the diameter of main reinforcement shall not be less than 12mm, the diameter of erection bar shall not be less than 10mm, and the diameter of hooped reinforcement shall not be less than 6mm. Anchorage length and structure of longitudinal bearing steel bar of cushion cap beam tip shall be same to the provisions in multiple-pile cushion cap under the column.

4 For raft cushion cap plate or box cushion cap plate, the reinforcement ratio of lower layers rebars at vertical and horizontal directions should not be less than 0.15% due to the influence of whole nending when the partial bending moment effect is considered; the upper rebars shall be connected totally in accordance with the calculated reinforcement ratio.

When the raft-plate thickness is larger than 2000mm, two-way reinforcement net which the diameter is not less than 12mm and the spacing interval is not larger than 300mm shall be arranged in the midposition of the plate thickness.

5 The thickness of concrete protective layer of cushion cap base-surface rebars, with concrete cushion, shall not be less than 50mm; without concrete cushion, the thickness shall not be less than 70mm; and the thickness shall not be less than the length of the pile head inserted into the cushion cap.

4.2.4 Joint structure of pile and cushion cap shall meet following provisions:

1 The length of the pile head inserted into the cushion cap, for pile with medium diameter, should not less than 50mm; for pile with major diameter, the length should not be less than 100mm.

2 The pile-top longitudinal main reinforcement of concrete piling shall be anchored into the cushion cap, and the anchoring length should not be less than 35 times of longitudinal main reinforcement diameter. For uplift pile, the anchorage length of pile top longitudinal main reinforcement shall be identified in accordance with current national standard "Code for Design of Concrete Structure" GB 50010.

3 For filling pile with major diameter, cushion cap may be arranged or pile and column are connected directly when a column correspond to a pile.

4.2.4 Joint structure of column and cushion cap shall meet following provisions:

1 For one-column-one-pile foundation, the length column longitudinal main reinforcement anchoring into pile foundation shall not be less than 35 times of the longitudinal main reinforcement diameter.

2 For multiple-pile cushion cap, the length of longitudinal main reinforcement anchoring into the cushion cap shall not be less than 35 times of the longitudinal main

reinforcement diameter; when the cushion cap height dissatisfies the anchorage requirement, the vertical anchorage length shall not be less than 20 times of longitudinal main reinforcement diameter and the longitudinal main reinforcement shall be bent forwards the column axis at the angle of 90 degree.

3 When earthquake protection is required, the anchorage length of longitudinal main reinforcement for columns with Class I and II aseismic grade shall be multiplied by the coefficient 1.15; for columns with Class III aseismic grade, the anchorage length of longitudinal main reinforcement shall be multiplied by the coefficient 1.05.

4.2.4 Joint structure between cushion caps shall meet following provisions:

1 If a column corresponds to a pile, joining beam shall be arranged at the directions of two principal axis of pile top. If the diameter ratio of pile and column cross sections is larger than 2, the joining beam may not be arranged.

2 For two-pile cushion cap, the joining beam shall be arranged on the shorter side.

3 For under-column pile foundation cushion cap with earthquake protection requirement, joining beam should be arranged along the directions of two principal axes.

4 The top surface of joining beam should be locates at same elevation with cushion cap top surface. The width of joining beam should not be less than 250mm, the height may be the 1/10~1/15 of the cushion cap center distance and should not be less than 400mm.

5 The joining beam reinforcement assembly shall be identified through the calculation, the reinforcement assembly of beam upper and lower position should not be less than two rebar's with 12mm diameter; longitudinal bar of joining beam on same axial line should be arranged along full length.

4.2.7 The clearance between the cushion cap and basement external wall or foundation excavation sidewall shall be filled with plain concrete, or tamped with lime soil, graded sand-stone mixture, and compacted earth in layers, and the compacting factor should not be less than 0.94.

5 Pile foundation calculations

5.1 Calculation for pile top acting effect

5.1.1 For clustered piles foundation of ordinary construction and high-rise building bearing smaller horizontal force (including moment and horizontal shear), it shall calculate their column, wall, pile top acting effect of foundation pile or composite foundation pile in core tube clustered piles:

1 Vertical force

Under acting of axle vertical force

$$N_k = \frac{F_k + G_k}{n} \quad (5.1.1-1)$$

Under acting of eccentrically vertical force

$$N_{ik} = \frac{F_k + G_k}{n} \pm \frac{M_{xk} y_i}{\sum y_j^2} \pm \frac{M_{yk} x_i}{\sum x_j^2} \quad (5.1.1-2)$$

2 Horizontal forces

$$H_{ik} = \frac{H_k}{n} \quad (5.1.1-3)$$

Where: F_k —Vertical force acting on superface of cushion cap under standard combination of load effect;

G_k —Pile foundation cap and normal value of soil sole weight on the pile cap shall recoup buoyancy of water for the part under stable groundwater table;

H_k —Average vertical force of foundation pile or composite foundation pile under acting of axle vertical force with standard combination of load effect;

H_{ik} —Vertical force of the i^{th} foundation pile or composite foundation pile under acting of eccentrically vertical force with standard combination of load effect;

M_{xk}, M_{yk} —Moment acting on bottom surface of pile cap and winding x and y main axis passing through pile group centroid under the standard combination of load effect;

x_i, x_j, y_i, y_j —Distance from i^{th} and j^{th} foundation pile or composite foundation pile to y and x axis;

- H_k —Horizontal force acting on bottom surface of pile foundation cap under standard combination of load effect;
- H_{ik} —Horizontal force acting on the i^{th} foundation pile or composite foundation pile under standard combination of load effect;
- n —Pile numbers in pile foundation.

5.1.2 For low piled cap foundation mainly bearing vertical load in earthquake protection district, when it satisfies the following conditions, calculation for cap acting effect may take no account of earthquake effect:

1 Buildings may not be checked up with seismic bearing capacity for their piled foundations according to current national standard “Code for Seismic Design of Buildings” GB 50011;

2 Building yard lies in favorable district for building seismic.

5.1.3 For piled foundation belongs to one of the following conditions, when calculating acting effect, internal force and displacement of pile for all the foundation piles, it should consider team working between pile cap (including underground walling) and foundation pile as well as elastic resistance acting of the soil, its calculation method may be made according to appendix C in this code:

1 For high-rise building lies in 8° or more than 8° seismic fortifying district and bearing other larger horizontal force, when their piled foundation cap stiffness is too large or enhance pile cap stiffness due to synergistic action of superstructure and pile cap;

2 High piled cap foundation bearing large horizontal force and 8° or more than 8° earthquake effect.

5.2 Calculation for vertical bearing capacity of piled foundation

5.2.1 Calculation for vertical bearing capacity of piled foundation shall meet the following requirements:

1 Standard combination of load effect:

Under acting of axle vertical force

$$N_k \leq R \quad (5.2.1-1)$$

It shall not conform to the above equation under acting of eccentrically vertical force, but shall also meet requirements for the following equation:

$$N_{kmax} \leq 1.2R \quad (5.2.1-2)$$

2 Earthquake effect and standard combination of load effect:

Under acting of axle vertical force

$$N_{Ek} \leq 1.25R \quad (5.2.1-3)$$

It shall not conform to the above equation under acting of eccentrically vertical force, but shall also meet requirements for the following equation:

$$N_{Ekmax} \leq 1.5R \quad (5.2.1-4)$$

Where: N_k — Average vertical force of foundation pile or composite foundation pile under acting of axle vertical force with standard combination for load effect;

N_{kmax} — Maximal vertical force of pile top under acting of eccentrically vertical force with standard combination of load effect;

N_{Ek} — Average vertical force of foundation pile or composite foundation pile under earthquake effect and standard combination of load effect;

N_{Ekmax} — Maximal vertical force of foundation pile or composite foundation pile under earthquake effect and standard combination of load effect;

R — Characteristic value of the vertical bearing capacity of foundation pile or composite foundation pile.

5.2.2 Characteristic value of the vertical bearing capacity of a single pile R_a shall be determined according to the following equation:

$$R_a = \frac{1}{K} Q_{uk} \quad (5.2.2)$$

Where: Q_{uk} — Normal value of vertical ultimate bearing pressure for a single pile;

K — Assurance coefficient, $K=2$.

5.2.3 For end bearing type piled foundation, when it should not consider pile cap effect for independent piled foundation under friction-type column with pile numbers are less than 4, or due to strata soil texture and working conditions, characteristic value of the vertical bearing capacity of foundation pile shall be characteristic value of the vertical bearing capacity of a single pile.

5.2.4 It should determine the characteristic value of the vertical bearing capacity of its composite foundation pile by considering pile cap effect for those friction-type piled foundations conforming to one of the following conditions.

- 1 Buildings (structures) with integral stiffness for superstructure is good and somatotype is simple;
- 2 Trestlework and flexible structures with strong flexibility for differential settlement;
- 3 Relative weak zone for optimized designed of piled foundation stiffness to reduce differential;
- 4 Composite foundations with settlement-reducing piles for soft soil foundation.

5.2.5 Considering characteristic value of the vertical bearing capacity of composite foundation pile with pile cap effect may be determined according to the following formulate:

$$\text{Take no account of earthquake effect: } R = R_a + \eta_c f_{ak} A_c \quad (5.2.5-1)$$

$$\text{Consider earthquake effect: } R = R_a + \frac{\zeta_a}{1.25} \eta_c f_{ak} A_c \quad (5.2.5-2)$$

$$A_c = (A - nA_{ps}) / n \quad (5.2.5-3)$$

Where: η_c —Pile cap coefficient may take value according to Table 5.2.5;

f_{ak} —Average value weighted according to thickness for characteristic value of the ground bearing capacity of the soil in each layer within 1/2 pile cap width under the pile cap and within the depth scope not exceeding 5 m;

A_c —Calculate net area of pile cap bottom corresponding with foundation pile;

A_{ps} —Cross-sectional area of pile;

A —Calculated field area of pile cap. A is total area of pile cap for independent piled foundation under the column; A is the area circled by 1/2 span of the wall raft plate and 2.5 times of raft plate thickness at cantilever side for pile raft foundation; A is area circled by 1/2 span of both sides of the wall for pile raft foundation concentric arranged under the monolithic wall, and calculate η_c according to strip footing;

ζ_a —Adjustment coefficient for foundation seismic bearing capacity shall be adopted according to current national standard “Code for Seismic Design of Buildings” GB50011.

When pile cap bottom is liquefcent soil, collapsible soil, soft soil with high fidelity, under consolidated soil and recent fill, and pile-sinking invoking excess pore pressure and soil mass upheaval, it shall take no account of pile cap effect and $\eta_c = 0$.

Table 5.2.5 Pile cap coefficient η_c

B_c/l \ s_a/d	3	4	5	6	>6
≤ 0.4	0.06~0.08	0.14~0.17	0.22~0.26	0.32~0.38	0.50~0.80
0.4~0.8	0.08~0.10	0.17~0.20	0.26~0.30	0.38~0.44	
>0.8	0.10~0.12	0.20~0.22	0.30~0.34	0.44~0.50	
Strip pile cap with single-row pile	0.15~0.18	0.25~0.30	0.38~0.45	0.50~0.60	

Note: 1 s_a/d in the table is ratio between pile center distance and pile diameter, B_c/l is ratio between pile cap width and pile length. When calculated foundation pile is arranged not in square shape, $s_a = \sqrt{A/n}$, A is calculated field area of pile cap, and n is overall pile numbers.

- 2 For tank and raft pile cap arranged under the wall for the pile, η_c may take value according to bar foundation of single-row pile.
- 3 For strip pile cap with single-row pile when pile cap width is less than $1.5d$, η_c shall take value according to non-bar pile cap.
- 4 For strip pile cap with single-row pile, when pile cap width is less than $1.5d$, η_c takes value according to non-bar pile cap.
- 5 For soil compacting piled foundation in saturated cohesive soil, piled foundation pile cap on soft soil foundation shall be with η_c is 0.8 times of the lower value.

5.3 Vertical ultimate bearing pressure of a single pile

I General requirements

5.3.1 Normal value of vertical ultimate bearing pressure for individual pile adopted for the design shall be in accordance with the following requirements:

1 Building piled foundation with design grade is Grade A shall be determined by static test for a single pile;

2 Building piled foundation with design grade is grade B may be determined referring to test pile information with same geological conditions and combining with integration of in situ test as static sounding, etc. and empiric parameters when geological condition is simple; others shall be determined by static test of a single pile;

3 Building piled foundation with design grade is grade C may be determined according to in situ test and empiric parameter.

5.3.2 Normal value of vertical ultimate bearing pressure for a single pile, ultimate shaft resistance, and ultimate tip resistance shall be determined according to the following requirements:

1 Vertical static test of a single pile shall comply with current professional standard

“Technical Code for Testing of Building Foundation Piles” JGJ 106;

2 End bearing pile with major diameter may determine ultimate tip resistance through load test for deep level slab (slab diameter shall be same with pore diameter);

3 Rock-socketed pile may determine ultimate tip resistance through batholith plate loading test with diameter is 0.3m or may determine ultimate shaft resistance and ultimate tip resistance through load test of rock-socketed stub abutment with diameter is 0.3m;

4 Ultimate shaft resistance and ultimate tip resistance of the piles should be determined by static test through testing component of shaft force of the buried pile. And it shall establish physical index between ultimate shaft resistance, ultimate tip resistance, and soil layer according to the test result, empirical relationship between saturated uniaxial compressive strength of rock and in situ test index of the soil such as static sounding, etc. shall determine vertical ultimate bearing pressure of a single pile according to empiric parameter method.

II In situ test method

5.3.3 When determining vertical ultimate bearing pressure of a single concrete premolded pile according to static sounding information of single-bridge probe, it may be calculated according to the following formulate if it is without local experience:

$$Q_{uk} = Q_{sk} + Q_{pk} = u \sum q_{sik} l_i + \alpha p_{sk} A_p \quad (5.3.3-1)$$

When $P_{sk1} \leq P_{sk2}$

$$P_{sk} = \frac{1}{2} (P_{sk1} + \beta \cdot P_{sk2}) \quad (5.3.3-2)$$

When $P_{sk1} > P_{sk2}$

$$P_{sk} = P_{sk2} \quad (5.3.3-3)$$

Where: Q_{sk} , Q_{pk} —Overall ultimate shaft resistance and overall ultimate tip resistance respectively;

u —Perimeter of pile;

q_{sik} —Ultimate shaft resistance of i^{th} soil for pile cycle estimated according to specific penetration resistance of static sounding;

l_i —Thickness of the i^{th} soil of pile cycle;

α —Correction coefficient of pile tip resistance may take value according

to Table 5.3.3-1;

p_{sk} —Specific penetration resistance of static sounding near pile tip (average value);

A_p —Pile tip area;

p_{sk1} —Average value of specific penetration resistance within scope of 8 times pile diameter higher than bulk cross-section of the pile tip;

p_{sk2} —Average value of specific penetration resistance within scope of 4 times pile diameter lower than bulk cross-section of the pile tip, when supporting course of the pile tip is compact sandy soil layer, and its average value of specific penetration resistance s_p exceeding 20MPa, it shall multiply by coefficient C in table 5.3.3-2 and then calculate p_{sk2} and p_{sk1} ;

β —Reduction coefficient, adopted according to table 5.3.3-3.

Table 5.3.3-1 Correction Coefficient α of Pile Tip Resistance

Pile length (m)	$l < 15$	$15 \leq l \leq 30$	$30 < l \leq 60$
α	0.75	0.75-0.90	0.90

Note: Pile length: $15 \leq l \leq 30$ m; α value is with linear interpolation according to l -value; l is pile length (excluding height of pile toe).

Table 5.3.3-2 Coefficient C

p_{sk} (MPa)	20-30	35	>40
Coefficient C	5/6	2/3	1/2

Table 5.3.3-3 Reduction Coefficient β

p_{sk2}/p_{sk1}	≤ 5	7.5	12.5	≥ 15
β	1	5/6	2/3	1/2

Note: Table 5.3.3-2 and Table 5.3.3-3 may take value through interpolation.

Table 5.3.3-4 Coefficient η_s

p_{sk}/p_d	≤ 5	7.5	≥ 10
η_s	1.00	0.50	0.33

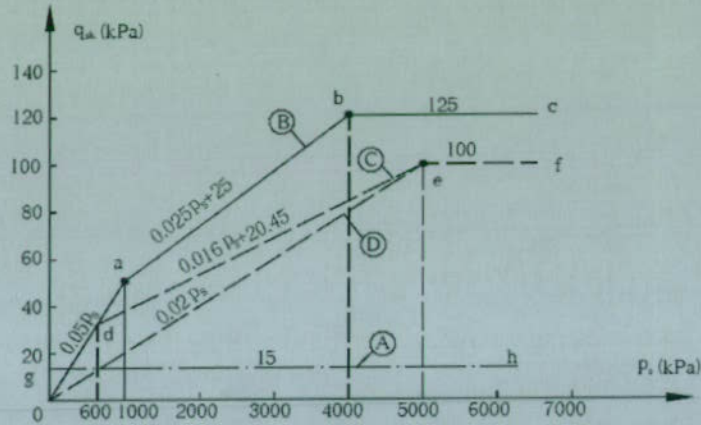


Figure 5.3.3 $q_{sk}-p_s$ Curve

- Note: 1 q_{sk} shall take value combining with soil test information and according to soil type, burial depth, sequence and according to broken line in figure 5.3.3; beeline (A) (line segment gh) in figure 5.3.3 is applicable to soil layer within 6 m under the subsurface; broken line (B) is applicable to cohesive soil above silty soil and sandy soil layer (or region with powderless soil and sandy soil layer); broken line (C) (line segment odef) is applicable to cohesive soil under silty soil and sandy soil layer; broken line (D) (line segment oef) is applicable to silty soil, mealy sand, fine sand and medium sand.
- 2 p_{sk} is average value of specific penetration resistance of middle dense-dense sandy soil and silty soil passing through pile tip; p_{sl} is average value of specific penetration resistance of soft underlying soil layer for sandy soil and silty soil;
- 3 Single bridge probe adopted shall be with taper base area is 15cm^2 and bottom is with 7cm high sliding bush as well as cone angle is 60° .
- 4 When pile tip is passing through bottom surface of silty soil, mealy sand, fine sand and medium sand layer, q_{sk} value estimated through broken line (D) shall multiply by coefficient η_s in table 5.3.3-4;

5.3.4 When determining vertical ultimate bearing pressure of a single concrete premolded pile according to static sounding information of double-bridge probe, it may be calculated according to the following formulat if there are no local experience for cohesive soil, silty soil and sandy soil:

$$Q_{uk} = Q_{sk} + Q_{pk} = u \sum l_i \cdot \beta_i \cdot f_{si} + \alpha \cdot q_c \cdot A_p \quad (5.3.4)$$

Where: f_{si} — Average tip resistance of probe in the i^{th} layer soil (kPa);

q_c — Upper and lower probe resistance on pile tip plane is averaged value of probe resistance weighted average (kPa) of the soil thickness within scope of $4d$ (d is diameter or side length of the pile) larger than the pile tip plane, and probe resistance within scope of less than $1d$ less than pile tip plane;

α — Correction coefficient of pile tip resistance: for cohesive soil and silty soil, it takes $2/3$ and for saturated sandy soil, it takes $1/2$;

β_i —Integrated correction coefficient of the i^{th} layer earth pile shaft resistance:
 for cohesive soil and silty soil: $\beta_i=10.04(f_{si})^{-0.55}$; for sandy soil: $\beta_i=5.05(f_{si})^{-0.45}$.

Note: Taper base area of double bridge probe is 15cm^2 , cone angle 60° , height of friction sleeve is 21.85cm and lateral area is 300cm^2 .

III Empirical parameter method

5.3.5 When determining vertical ultimate bearing pressure of a single pile according to empirical relationship between physical index and bearing capacity parameter of the soil, it should estimated according to the following formulate:

$$Q_{uk} = Q_{sk} + Q_{pk} = u \sum q_{sik} l_i + q_{pk} A_p \quad (5.3.5)$$

Where: q_{sik} —If ultimate shaft resistance of the i^{th} soil at pile shaft has no local experience, it may take value according to table 5.3.5-1;

q_{pk} —If ultimate tip resistance has no local, it may take value according to Table 5.3.5-2.

5.3.6 When determining ultimate bearing pressure of a single pile with major diameter pile according to empirical relationship between physical index and bearing capacity parameter of the soil, it may calculated according to the following formulate:

$$Q_{uk} = Q_{sk} + Q_{pk} = u \sum \psi_{si} q_{sik} l_i + \psi_p q_{pk} A_p \quad (5.3.6)$$

Where: q_{sik} —When ultimate shaft resistance of the i^{th} soil at pile shaft has no local empirical value, it may take value according to Table 5.3.5-1 of this article and for scope within $2d$ length above reduce section of pedestal pile, it shall not count in shaft resistance;

q_{pk} —Ultimate tip resistance with pile diameter is 800mm may be determined adopting to deep level loaded panel test for dry operated hole digging (cleaning up of bottom); when it cannot make deep level load panel test, it may take value according to Table 5.3.6-1;

ψ_{si}, ψ_p —Pile shaft resistance with major diameter and size effect coefficient of tip resistance take values according to Table 5.3.6-2.

u —Perimeter of pile: when breast wall around artificial dug pile is vibrating dense concrete, perimeter of pile may be calculated according to external conjugate diameter of the breast wall.

Table 5.3.5-1 Ultimate Shaft Resistance q_{sik} of Pile (kPa)

Soil designation _s	Soil state		Concrete premolded pile	Breast wall bored (punched) pile of slurry	Dry operated bored pile
Earth fill	—		22~30	20~28	20~28
Silt	—		14~20	12~18	12~18
Mucky soil	—		22~30	20~28	20~28
Cohesive soil	Flow plastic	$I_L > 1$	24~40	21~38	21~38
	Soft plastic	$0.75 < I_L \leq 1$	40~55	38~53	38~53
	Waxiness	$0.50 < I_L \leq 0.75$	55~70	53~68	53~66
	Hard waxiness	$0.25 < I_L \leq 0.50$	70~86	68~84	66~82
	Hard plastic	$0 < I_L \leq 0.25$	86~98	84~96	82~94
	Stiffness	$I_L \leq 0$	98~105	96~102	94~104
Red clay	$0.7 < a_w \leq 1$		13~32	12~30	12~30
	$0.5 < a_w \leq 0.7$		32~74	30~70	30~70
Silty soil	A little dense	$e > 0.9$	26~46	24~42	24~42
	Middle dense	$0.75 \leq e \leq 0.9$	46~66	42~62	42~62
	Dense	$e < 0.75$	66~88	62~82	62~82
Fine sand	A little dense	$10 < N \leq 15$	24~48	22~46	22~46
	Middle dense	$15 < N \leq 30$	48~66	46~64	46~64
	Dense	$N > 30$	66~88	64~86	64~86
Medium sand	Middle dense	$15 < N \leq 30$	54~74	53~72	53~72
	Dense	$N > 30$	74~95	72~94	72~94
Coarse sand	Middle dense	$15 < N \leq 30$	74~95	74~95	76~98
	Dense	$N > 30$	95~116	95~116	98~120
Gravel sand	A little dense	$5 < N_{63.5} \leq 15$	70~110	50~90	60~100
	Middle dense (dense)	$N_{63.5} > 15$	116~138	116~130	112~130
Round gravel and breccia	Middle dense and dense	$N_{63.5} > 10$	160~200	135~150	135~150
Gravel and pebble	Middle dense and dense	$N_{63.5} > 10$	200~300	140~170	150~170
Completely weathered soft rock	—	$30 < N \leq 50$	100~120	80~100	80~100
Completely weathered hard rock	—	$30 < N \leq 50$	140~160	120~140	120~150
Strong weathered soft rock	—	$N_{63.5} > 10$	160~240	140~200	140~220
Strong weathered hard rock	—	$N_{63.5} > 10$	220~300	160~240	160~260

Note: 1 It doesn't calculate the shaft resistance for earth fills not yet completing self consolidation and miscellaneous earthfill giving priority to household garbage;

2 a_w is water content ratio, $a_w = w/w_l$, w is natural moisture content of the soil and w_l is liquid limit of the soil;

- 3 N is normal blow counts; $N_{63.5}$ is dynamic sounding blow count of heavy taper;
- 4 Completely weathered, strong weathered soft rock and completely weathered, strong weathered hard rock refers to rocks with mother rock are $f_{rk} \leq 15\text{MPa}$ and $f_{rk} > 30\text{MPa}$ respectively.

Table 5.3.6-1 Ultimate Tip Resistance q_{pk} of Dry Operated Dug Pile (Cleaning up of Bottom, $D = 800\text{ mm}$) (kPa)

Soil designation		State		
		$0.25 < I_L \leq 0.75$	$0 < I_L \leq 0.25$	$I_L \leq 0$
Cohesive soil		800~1800	1800~2400	2400~3000
Silty soil		—	$0.75 \leq e \leq 0.9$	$e < 0.75$
		—	1000~1500	1500~2000
Sandy soil and gravel soil		A little dense	Middle dense	Dense
	Mealy sand	500~700	800~1100	1200~2000
	Fine sand	700~1100	1200~1800	2000~2500
	Medium sand	1000~2000	2200~3200	3500~5000
	Coarse sand	1200~2200	2500~3500	4000~5500
	Gravel sand	1400~2400	2600~4000	5000~7000
	Round gravel and breccia	1600~3000	3200~5000	6000~9000
	Gravel and gravel	2000~3000	3300~5000	7000~11000

Note: 1 When depth h_0 of pile entering into supporting course are $h_0 \leq D$, $D < h_0 \leq 4D$ and $h_0 > 4D$ respectively, q_{pk} may take low, middle and high values correspondently.

- 2 Sandy soil compactness may be determined according to SPT (standard penetration test) blow count, when $N \leq 10$, it is loose; $10 < N \leq 15$, a little dense; $15 < N \leq 30$, middle dense and $N > 30$, it is dense.
- 3 When length-diameter ratio of the pile is $l/d \leq 8$, q_{pk} should take lower value.
- 4 When the requirement for settlement is not so strict, q_{pk} may take the larger value.

Table 5.3.6-2 Size Effect Coefficient ψ_{si} of Shaft Resistance and Tip Resistance ψ_p for Filling Pile with Major Diameter

Soil types	Cohesive soil and silty soil	Sandy soil and gravel soil
ψ_{si}	$(0.8/d)^{1/5}$	$(0.8/d)^{1/3}$
ψ_p	$(0.8/D)^{1/4}$	$(0.8/D)^{1/3}$

Table 5.3.5-2 Ultimate Tip Resistance q_{pk} of the Pile (kPa)

Soil designation	Pile types		Length of concrete precast pile l (m)					Length of breast wall bored (punched) pile with slurry l (m)				Length of dry operated bored pile l (m)		
	Soil state		$l \leq 9$	$9 < l \leq 16$	$16 < l \leq 30$	$l > 30$	$5 \leq l < 10$	$10 \leq l < 15$	$15 \leq l < 30$	$30 \leq l$	$5 \leq l < 10$	$10 \leq l < 15$	$15 \leq l$	
Cohesive soil	Soft plastic	$0.75 < I_c \leq 1$	210-850	650-1400	1200-1800	1300-1900	150-250	250-300	300-450	300-450	200-400	400-700	700-950	
	Waxiness	$0.50 < I_c \leq 0.75$	850-1700	1400-2200	1900-2800	2300-3600	350-450	450-600	600-750	750-800	500-700	800-1100	1000-1600	
	Hard waxiness	$0.25 < I_c \leq 0.50$	1500-2300	2300-3300	2700-3600	3600-4400	800-900	900-1000	1000-1200	1200-1400	850-1100	1500-1700	1700-1900	
	Hard plastic	$0 < I_c \leq 0.25$	2500-3800	3800-5500	5500-6000	6000-6800	1100-1200	1200-1400	1400-1600	1600-1800	1600-1800	2200-2400	2600-2800	
Silty soil	Middle dense	$0.75 \leq e \leq 0.9$	950-1700	1400-2100	1900-2700	2500-3400	300-500	500-650	650-750	750-850	800-1200	1200-1400	1400-1600	
	Dense	$e < 0.75$	1500-2600	2100-3000	2700-3600	3600-4400	650-900	750-950	900-1100	1100-1200	1200-1700	1400-1900	1600-2100	
	A little dense	$10 < N \leq 15$	1000-1600	1500-2300	1900-2700	2100-3000	350-500	450-600	600-700	650-750	500-950	1300-1600	1500-1700	
Mealy sand	Middle dense and dense	$N > 15$	1400-2200	2100-3000	3000-4500	3800-5500	600-750	750-900	900-1100	1100-1200	900-1000	1700-1900	1700-1900	
	Fine sand		2500-4000	3600-5000	4400-6000	5300-7000	650-850	900-1200	1200-1500	1500-1800	1200-1600	2000-2400	2400-2700	
Medium sand	Middle dense and dense	$N > 15$	4000-6000	5500-7000	6500-8000	7500-9000	850-1050	1100-1500	1500-1900	1900-2100	1800-2400	2800-3800	3600-4400	
	Coarse sand		5700-7500	7500-8500	8500-10000	9500-11000	1500-1800	2100-2400	2400-2600	2600-2800	2900-3600	4000-4600	4600-5200	

Table 5.3.5-2 (continued)

Soil designation	Pile types		Length of concrete precast pile l (m)					Length of breast wall bored (punched) pile with slurry l (m)					Length of dry operated bored pile l (m)			
			Soil state					$l < 9$	$9 < l \leq 16$	$16 < l \leq 30$	$l > 30$	$5 \leq l < 10$	$10 \leq l < 15$	$15 \leq l < 30$	$30 \leq l$	$5 \leq l < 10$
	Gravel sand			$N > 15$	6000-9500	9000-10500		1400-2000	2000-3200		3500-5000					
Breccia and round gravel	Middle dense and dense		$N_{63.5} > 10$	7000-10000	9500-11500		1800-2200	2200-3600		4000-5500						
Gravel and pebble			$N_{63.5} > 10$	8000-11000	10500-13000		2000-3000	3000-4000		4500-6500						
Completely weathered soft rock			$30 < N \leq 50$	1000-1600	1200-2000		$30 < N \leq 50$	4000-6000		1000-1600						
Completely weathered hard rock			$30 < N \leq 50$	1200-2000	1400-2400		$30 < N \leq 50$	5000-8000		1200-2000						
Strong weathered soft rock			$N_{63.5} > 10$	1400-2200	1600-2600		$N_{63.5} > 10$	6000-9000		1400-2200						
Strong weathered hard rock			$N_{63.5} > 10$	1800-2800	2000-3000		$N_{63.5} > 10$	7000-11000		1800-2800						

Note: 1 Taken value for ultimate tip resistance of the sandy soil and gravel soil king-pile should comprehensive consider soil compactness, depth-diameter ratio h_p/d of pile tip entering into supporting course is direct proportional to soil compactness;

2 Rock ultimate tip resistance pressure of precast pile refers to ultimate tip resistance under condition of pile tip is supporting by middle and slightly weathered bedrock surface or entering into certain depth of strong weathered rock, soft rock.

3 Completely weathered, strong weathered soft rock and completely weathered, strong weathered hard rock refers to rocks with mother rock are $f_{rk} \leq 15\text{MPa}$ and $f_{rk} > 30\text{MPa}$ respectively.

IV Steel pipe pile

5.3.7 When determining vertical ultimate bearing pressure of steel pipe pile according to empirical relationship between physical index and bearing capacity parameter of the soil, it may be calculated according to the following formula:

$$Q_{uk} = Q_{sk} + Q_{pk} = u \sum q_{sik} l_i + \lambda_p q_{pk} A_p \quad (5.3.7-1)$$

$$\text{When } h_b/d < 5, \lambda_p = 0.16 h_b/d \quad (5.3.7-2)$$

$$\text{When } h_b/d \geq 5, \lambda_p = 0.8 \quad (5.3.7-3)$$

Where: q_{sik} and q_{pk} —Take same value with concrete premolded pile according to Table 5.3.5-1 and 5.3.5-2 of this code respectively;

λ_p —Pile tip soil plug coefficient: for enclosed steel pipe pile $\lambda_p=1$; for exposure steel pipe pile, it takes value according to formulas (5.3.7-2) and (5.3.7-3);

h_b —Depth of pile tip entering into supporting course;

d —Outside diameter of steel pipe pile.

Semi-exposure steel pipe pile with clapboard shall determine λ_p with equivalent diameter d_e replacing d : $d_e = d\sqrt{n}$; where n is partition number of pile tip clapboard (figure 5.3.7).

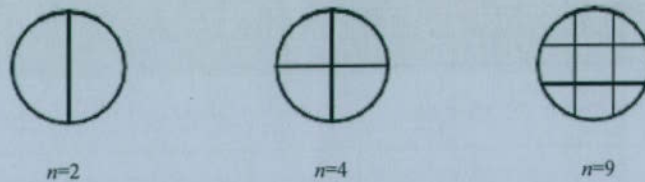


Figure 5.3.7 Clapboard Partition

V Concrete hollow pile

5.3.8 When determining vertical ultimate bearing pressure of exposure prestressed concrete hollow pile according to empirical relationship between physical index and bearing capacity parameter of the soil, it may be calculated according to the following formula:

$$Q_{uk} = Q_{sk} + Q_{pk} = u \sum q_{sik} l_i + q_{pk} (A_j + \lambda_p A_{pl}) \quad (5.3.8-1)$$

$$\text{When } h_b/d < 5, \lambda_p = 0.16 h_b/d \quad (5.3.8-2)$$

$$\text{When } h_b/d \geq 5, \lambda_p = 0.8 \quad (5.3.8-3)$$

Where: q_{sik} and q_{pk} —Take same value with concrete premolded pile according to Table 5.3.5-1 and 5.3.5-2 of this code respectively;

A_j —Net area of hollow pile tip:

$$\text{Tubular pile: } A_j = \frac{\pi}{4}(d^2 - d_1^2);$$

$$\text{Hollow square pile: } A_j = b^2 - \frac{\pi}{4}d_1^2;$$

$$A_{pl} \text{—Exposure area of hollow pile: } A_{pl} = \frac{\pi}{4}d_1^2;$$

λ_p —Pile tip soil plug coefficient;

d, b —Outside diameter and side length of hollow pile;

d_1 —Inside diameter of hollow pile.

VI Rock-socketed pile

5.3.9 Vertical ultimate bearing pressure of a single pile of rock-socketed pile with pile tip lied in intact and relatively intact bedrock and it is composed of overall ultimate tip resistance of soil around the pile and overall ultimate resistance of rock-socketed. When determining vertical ultimate bearing pressure of a single pile according to uniaxial compressive strength of the rock, it may calculate according to the following formulates:

$$Q_{uk} = Q_{sk} + Q_{rk} \quad (5.3.9-1)$$

$$Q_{sk} = u \sum q_{sik} l_i \quad (5.3.9-2)$$

$$Q_{rk} = \zeta_r f_{rk} A_p \quad (5.3.9-3)$$

Where: Q_{sk}, Q_{rk} —They are overall ultimate shaft resistance of the soil and overall ultimate resistance of rock-socketed respectively;

q_{sik} —If ultimate shaft resistance of the i^{th} soil around pile has no local experience, it may take value according to piling technology in table 5.3.5-1 of this code;

f_{rk} —Clay rock of rock saturated uniaxial compressive strength take normal value natural moisture uniaxial compressive strength;

ζ_r —Ratio between colligations coefficient of rock-socketed shaft resistance and tip resistance and depth- diameter of rock-socketed is h_r/d , rock hardness is related to piling technology, and it may be adopted according to table 5.3.9; numerical values in the table are

applicable to slurry breast wall piling, and for dry operated piling (cleaning up of bottom) and grouting after slurry breast wall piling, ζ_r shall be 1.2 times of the numerical value in the Table.

Table 5.3.9 Colligations Coefficient of Rock-socketed Shaft Resistance and Tip Resistance ζ_r

Depth-diameter ratio of rock-socketed h_r/d	0	0.5	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0
Dead-soft rock and soft rock	0.60	0.80	0.95	1.18	1.35	1.48	1.57	1.63	1.66	1.70
Relatively hard rock and hard rock	0.45	0.65	0.81	0.90	1.00	1.04	—	—	—	—

Note: 1 Dead-soft rock and soft rock refer to $f_{rk} \leq 15\text{MPa}$; relatively hard rock and hard rock refer to $f_{rk} > 30\text{MPa}$; if it is situated between the two, it may take value by interpolating.

2 h_r is rock-socketed depth of pile: when rock plane is slant, it is based on rock-socketed depth of lower part of the slope; when h_r/d is value not listed in the table, ζ_r may take value according to inner difference.

VII Post grouting and drilled grouting pile

5.3.10 Ultimate bearing pressure of a single pile of post grouting and drilled grouting pile shall be determined according to static test. Under the condition of conforming to the implementation specification of post grouting technology in article 6.7 of this code, its ultimate bearing pressure of a single pile for the post grouting is estimated according to the following formulate:

$$Q_{uk} = Q_{sk} + Q_{gsk} + Q_{gpk} = u \sum q_{sjk} l_j + u \sum \beta_{si} q_{sik} l_{gi} + \beta_p q_{pk} A_p \quad (5.3.10)$$

Where: Q_{sk} —Overall ultimate shaft resistance at non vertical enhancing section of post grouting;

Q_{gsk} —Overall ultimate shaft resistance at vertical enhancing section of post grouting;

Q_{gpk} —Overall ultimate tip resistance of post grouting;

u —Perimeter of pile;

l_j —Thickness of the j^{th} soil at non vertical enhancing section of post grouting;

l_{gi} —Thickness of the i^{th} layer soil at vertical enhancing section of the post grouting: for slurry breast wall pore-forming filling pile, when it is a single pile tip post grouting, vertical enhancing section is 12m above the pile tip; when it is pile tip and pile tip complex grouting, vertical enhancing section is 12m above the pile tip and 12m above all pile shaft the grouting sections, and the overlapping part shall be recouped; for dry operated filling pile, vertical enhancing section is above pile-tip, and up

and down 6m respectively of the pile shaft grouting section;

q_{sik}, q_{sjk}, q_{pk} — They are initial ultimate shaft resistance of the i^{th} soil layer at vertical enhancing section of post grouting, initial ultimate shaft resistance of the j^{th} soil layer of non vertical enhancing section and initial ultimate tip resistance; they are determined according to article 5.3.5 of this code;

β_{si}, β_p — They are shaft resistance of post grouting and amplification coefficient of tip resistance respectively, if they hasn't experience, they may take values according to Table 5.3.10. For pile with diameter is larger than 800mm, it shall correct shaft resistance and tip resistance dimension according to Table 5.3.6-2 of this code.

Table 5.3.10 Amplification Coefficient β_{si} of Post Grouting Shaft Resistance and Amplification Coefficient β_p of Tip Resistance

Soil layer designation	Silt Mucky soil	Cohesive soil Silty soil	Mealy sand Fine sand	Medium sand	Coarse sand Gravel sand	Gravel Pebble	Completely weathered rock Strong weathered rock
β_{si}	1.2~1.3	1.4~1.8	1.6~2.0	1.7~2.1	2.0~2.5	2.4~3.0	1.4~1.8
β_p	—	2.2~2.5	2.4~2.8	2.6~3.0	3.0~3.5	3.2~4.0	2.0~2.4

Note: β_p for dry operated bored pile and dug pile may be calculated according to value listed in the table multiply by reduction coefficient (less than 1.0). When pile tip supporting course is cohesive soil or silty soil, reduction coefficient takes 0.6; when it is sandy soil or soil aggregate, it takes 0.8.

5.3.11 Steel conduit of post grouting after flouting may replace longitudinal main reinforcement with constant section and constant strength.

VIII Joule-Thomson effect

5.3.12 For surrounding of low piled cap foundation with liquefied soil layer, when up and down bottom surface of the pile cap have non-liquefaction soil or non-soft soil layer with thicknesses are no less than 1.5m and 1.0m respectively, it may calculate ultimate bearing pressure of a single pile with soil layer ultimate shaft resistance of liquefied soil layer multiply by liquefied reduction coefficient of the soil layer. Liquefied reduction coefficient ψ_l of the soil layer may be determined according to Table 5.3.12.

Table 5.3.12 Liquefied Reduction Coefficient ψ_l of Soil Layer

$\lambda_N = \frac{N}{N_{cr}}$	Liquefied soil layer depth calculated from ground d_L (m)	ψ_l
$\lambda_N \leq 0.6$	$d_L \leq 10$	0
	$10 < d_L \leq 20$	1/3
$0.6 < \lambda_N \leq 0.8$	$d_L \leq 10$	1/3
	$10 < d_L \leq 20$	2/3
$0.8 < \lambda_N \leq 1.0$	$d_L \leq 10$	2/3
	$10 < d_L \leq 20$	1.0

Note: 1 N is measured value of saturated soil SPT (standard penetration test) blow count; N_{cr} is critical value of liquefied distinguishing SPT (standard penetration test) blow count; λ_N is relative liquidity index of the soil layer;

- 2 When pile spacing of displacement pile is less than $4d$, piles are no less than 5 rows and piles are no less than 25 sticks, coefficient of liquefaction of the soil layer may take $2/3-1$; when SPT (standard penetration test) blow count of soil in piles reaches N_{cr} , $\psi_l = 1$.

When thickness of non liquefied soil layer of pile cap bottom is less than 1m, liquefied reduction coefficient of the soil layer may take value by reducing one grade of λ_N in table 5.3.12.

5.4 Check up for vertical bearing capacity of the piled foundation under special conditions

I Check up for weak subsoil

5.4.1 For clustered piles foundation with pile spacing is not exceeding $6d$, when weak subsoil with bearing capacity is less than $1/3$ of the bearing capacity in pile tip supporting course is existing under the pile tip supporting course, it may check up bearing capacity of the weak subsoil according to the following formulate (figure 5.4.1):

$$\sigma_z + \gamma_m Z \leq f_{az} \quad (5.4.1-1)$$

$$\sigma_z = \frac{(F_k + G_k) - 3/2(A_0 + B_0) \cdot \sum q_{sik} l_i}{(A_0 + 2t \cdot \text{tg}\theta)(B_0 + 2t \cdot \text{tg}\theta)} \quad (5.4.1-2)$$

- Where: σ_z —Additional stress acting on superface of the weak subsoil;
 γ_m —Weighted average of thicknesses of soil layer weight density (it takes floating weight density under the groundwater Table) above weak subsoil superface;
 t —Thickness of hard supporting course;
 f_{az} —Characteristic value of ground bearing capacity corrected by depth z in the

weak subsoil;

A_0, B_0 — Side length of long and short sides of the rectangular bottom surface at exterior margin of the pile group;

q_{sik} — Ultimate shaft resistance of the i^{th} soil layer around pile without local experience, it may take value according to piling technology in Table 5.3.5-1 of this code;

θ — Pressure spread angle in hard supporting course of the pile tip; it takes value according to Table 5.4.1.

Table 5.4.1 Pressure Spread Angle θ in Hard Supporting Course of the Pile Tip

E_{s1} / E_{s2}	$t = 0.25B_0$	$t \geq 0.50B_0$
1	4°	12°
3	6°	23°
5	10°	25°
10	20°	30°

Note: 1 E_{s1} and E_{s2} are compressive modulus in hard supporting course and weak subsoil;

2 When $t < 0.25B_0$, $\theta = 0^\circ$, if necessary, it should be determined through test; when $0.25B_0 < t < 0.50B_0$, it may take value by interpolating.

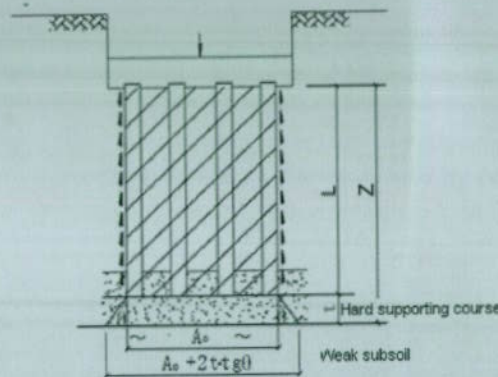


Figure 5.4.1 Check up for Bearing Capacity in Weak Subsoil

II Calculation for negative frictional resistance

5.4.2 For piled foundation conforms to one of the following conditions, when settlement generated by soil layer around pile exceeding settlement of foundation pile, it shall count in pile shaft negative frictional resistance when calculating bearing capacity for the foundation pile;

1 When pile is passing through thick and loose earth fill, self weight collapse loess and under consolidated soil as well as when liquefied soil layer is entering into relatively hard soil layer;

2 There exists soft soil layer around the pile, and adjacent pile shaft is bearing larger long-term load partially, or ground is piling with load in large area (including earth fill);

3 When it makes effective stress of soil around the pile increase and cause salient compression settlement due to falling groundwater level

5.4.3 When soil around the pile may cause pile shaft negative frictional resistance, it shall consider influence of negative frictional resistance to piled foundation bearing capacity and settlement according to physical circumstances of the engineering; when it is lacking of referential engineering experience, it may check up according to the following requirements:

1 For friction-type foundation pile, shaft resistance of parts above the calculated neutral point on pile may be 0 and it may check up bearing capacity of foundation pile according to the following formulate:

$$N_k \leq R_a \quad (5.4.3-1)$$

2 For end bearing type foundation pile, it shall not only meet requirement of the above formulate, but also consider pull-down load Q_g^n of foundation pile caused by negative frictional resistance, and it may check up bearing capacity of foundation pile according to the following formulate:

$$N_k + Q_g^n \leq R_a \quad (5.4.3-2)$$

3 When soil layer is uneven or buildings are sensitive for uneven settlement, it shall count pull-down load caused by negative frictional resistance in additional load and then check up piled foundation settlement.

Note: Characteristic value R_a of vertical bearing capacity of foundation pile only counts in shaft resistance and tip resistance of parts under the neutral point.

5.4.4 Pile shaft negative frictional resistance and pull-down load caused by it may be calculated according to the following requirements when there isn't measured data:

1 Negative frictional resistance of the i^{th} soil layer around a single pile above the neutral point may be calculated according to the following formulates:

$$q_{si}^n = \xi_{ni} \sigma'_i \quad (5.4.4-1)$$

When earth fill, self weight collapse loess collapse, and under consolidated soil layer generating consolidation and groundwater lowering: $\sigma'_i = \sigma'_{\gamma i}$.

When the ground is distributed with large area of load: $\sigma'_i = p + \sigma'_{\gamma i}$

$$\sigma'_{\gamma i} = \sum_{e=1}^{i-1} \gamma_e \Delta z_e + \frac{1}{2} \gamma_i \Delta z_i \quad (5.4.4-2)$$

Where: q_{si}^n — Pile shaft negative frictional resistance of the i^{th} soil layer; when calculated value according to formulate (5.4.4-1) is larger than positive frictional resistance, it is designed by taking positive frictional resistance;

ξ_{ni} — Negative frictional resistance coefficient of the i^{th} soil layer around pile may take value according to Table 5.4.4-1;

$\sigma'_{\gamma i}$ — Average vertical effective stress of the i^{th} soil around the pile caused by soil sole weight; pile outside pile group is calculated from the ground and pile inside of the pile group is calculated from pile cap bottom ;

σ'_i — Average vertical effective stress of the i^{th} soil around the pile;

γ_i, γ_e — Weight densities of the i^{th} calculated soil layer and e^{th} soil layer above it, it takes floating weight density under the groundwater table;

$\Delta z_i, \Delta z_e$ — Soil thickness of the i^{th} and e^{th} soil layer;

p — Evenly distributed load on the ground.

Table 5.4.4-1 Negative Frictional Resistance Coefficient ξ_n

Soil group	ξ_n
Saturated soft soil	0.15~0.25
Cohesive soil and silty soil	0.25~0.40
Sandy soil	0.35~0.50

Note: 1 In the same group of soil, displacement pile takes the larger value in the table and non-displacement pile takes the smaller value in the table;

2 Earth fill takes the larger value in the same group of soil according to its composition.

2 Pull-down load of foundation pile considering pile group effect may be calculated according to the following formulate:

$$Q_g^n = \eta_n \cdot u \sum_{i=1}^n q_{si}^n l_i \quad (5.4.4-4)$$

$$\eta_n = S_{ax} \cdot S_{ay} / \left[\pi d \left(\frac{q_s^n}{\gamma_m} + \frac{d}{4} \right) \right] \quad (5.4.4-5)$$

Where: n — Soil layer numbers above neutral point;

l_i —Thickness of the i^{th} soil layer above neutral point;

η_n —Pile group effect coefficient of negative frictional resistance;

S_{ax}, S_{ay} —Center distances of vertically and horizontally piles respectively;

q_s^n —Normal value of thickness weighted average negative frictional resistance of soil around piles above neutral point;

γ_m —Thickness weighted average weight density (it takes floating weight density under groundwater table) of soil layer around the piles above neutral point

When single pile foundation or pile group effect coefficient $\eta_n > 1$ is calculated according to formulate (5.4.4-5), $\eta_n = 1$.

3 Neutral point depth l_n shall be determined according to condition of soil layer settlement around the piles is equal to pile settlement, or it may be determined by referring to Table 5.4.4-2.

Table 5.4.4-2 Neutral point depth l_n

Property of supporting course	Cohesive soil and silty soil	Sand more than middle density	Gravel and pebble	Bedrock
Depth ratio of neutral point l_n/l_0	0.5~0.6	0.7~0.8	0.9	1.0

Note: 1 l_n, l_0 —Neutral point depth and lower limit depth of soft soil layer around the piles calculated from pile top respectively;

- 2 When pile is crossing self weight collapse loess layer, l_n may be increased by 10% according to value listed in the table (excluding supporting course is bedrock);
- 3 When soil layer consolidation around the piles and consolidation settlement of piled foundation are finished simultaneously, $l_n=0$;
- 4 When calculated settlement of soil layer around the piles is less than 20 mm, l_n shall be decreased according to values listed in the table multiply by 0.4~0.8.

III Check up for bearing capacity of uplift piled foundation

5.4.5 Piled foundation bearing pulling force shall also check up uplift bearing capacity of foundation pile when clustered piles foundation acts like integral destruction and non-integral destruction according to the following formulate:

$$N_k \leq T_{gk} / 2 + G_{gp} \quad (5.4.5-1)$$

$$N_k \leq T_{uk} / 2 + G_p \quad (5.4.5-2)$$

Where: N_k —Foundation pile pulling force calculated according to normal combination of load effect;

T_{gk} — Uplift ultimate bearing pressure of foundation pile when clustered piles acting like integral destruction, it may be determined according to article 5.4.6 of this code;

T_{uk} — Uplift ultimate bearing pressure of foundation pile when clustered piles acting like non-integral destruction, it may be determined according to article 5.4.6 of this code;

G_{gp} — Overall sole weight of piled soil in the envelop volume of clustered piles foundation is divided by overall pile numbers, and it takes floating weight density under groundwater table;

G_p — Sole weight of foundation pile, and it takes floating weight density under groundwater table and for pedestal pile, it shall determine perimeter pile and soil column as well as pile and soil sole weight according to Table 5.4.6-1 of this code.

5.4.6 Determination for uplift ultimate bearing pressure of clustered piles foundation and its foundation pile shall be in accordance with the following requirements:

1 For building piled foundation with design grade is Grade A and Grade B, uplift ultimate bearing pressure of foundation pile shall be determined through up-pull static load test with in-situ single pile. Normal value for single pile up-pull static load test and uplift ultimate bearing pressure may be in compliance with current professional standard "Technical Code for Testing of Building Foundation Piles" JGJ 106.

2 When there isn't local experience, uplift ultimate entrainment force of foundation pile for building piled foundation with clustered piles foundation and design grade is Grade C may be calculated according to the following requirements:

1) When clustered piles is acting like non-integral destruction, normal value for uplift ultimate bearing pressure of foundation pile may be calculated according to the following formulate:

$$T_{uk} = \sum \lambda_i q_{sik} u_i l_i \quad (5.4.6-1)$$

Where: T_{uk} — Normal value for uplift ultimate bearing pressure of foundation pile;

u_i — Perimeter of pile, for pile with equal diameter, $u = \pi d$; for pedestal pile, u takes value according to Table 5.4.6-1;

q_{sik} — Resist compression ultimate shaft resistance of the i^{th} soil at pile shaft surface may take value according to Table 5.3.5-1 of this code;

λ_i — Uplift coefficient may take value according to Table 5.4.6-2.

Table 5.4.6-1 Perimeter u_i of Destruction Surface of the Pedestal Pile

Length calculated from pile toe l_i	$\leq(4-10)d$	$>(4-10)d$
u_i	πd	πd

Note: l_i takes smaller value for soft soil and takes larger value for pebble; l_i is increased as increase of angle of internal friction.

Table 5.4.6-2 Uplift Coefficient λ

Soil group	λ value
Sandy soil	0.50-0.70
Cohesive soil and silty soil	0.70-0.80

Note: When ratio between pile length l and pile diameter d is less than 20, λ takes the smaller value.

- 2) When clustered piles is acting like non-integral destruction, normal value for uplift ultimate bearing pressure of foundation pile may be calculated according to the following formulate:

$$T_{gk} = \frac{1}{n} u_l \sum \lambda_i q_{sik} l_i \quad (5.4.6-2)$$

Where: u_l ——Perimeter of pile group outsider.

5.4.7 Short pile foundation of light construction on seasonally frozen ground shall check up its frost-resistant uplift stability according to the following formulate:

$$\eta_f q_f u z_o \leq T_{gk} / 2 + N_G + G_{gP} \quad (5.4.7-1)$$

$$\eta_f q_f u z_o \leq T_{uk} / 2 + N_G + G_P \quad (5.4.7-2)$$

Where: η_f ——Influence coefficient of the frozen depth is adopted according to Table 5.4.7-1;

q_f ——Tangential frozen-heave force is adopted according to Table 5.4.7-2;

z_o ——Standard frost penetration of seasonally frozen ground;

T_{gk} ——Normal value of uplift ultimate bearing pressure of foundation pile when clustered piles is acting like integral destruction under standard frost penetration line, it may be determined according to article 5.4.6 of this code;

T_{uk} ——Normal value of uplift ultimate bearing pressure of a single pile when clustered piles is acting like integral destruction under standard frost penetration line, it may be determined according to article 5.4.6 of this code;

N_G ——Building sole weight above pile cap bottom surface bearing by foundation pile, normal value of pile cap and soil weight on it.

Table 5.4.7-1 Value of η_f

Standard frost penetration (m)	$z_0 \leq 2.0$	$2.0 < z_0 \leq 3.0$	$z_0 > 3.0$
η_f	1.0	0.9	0.8

Table 5.4.7-2 Value of q_f (kPa)

Classifications of frost heaving Soil group	Weak frost heave	Frost heave	Strong frost heave	Extra strong frost heave
	Cohesive soil and silty soil	30~60	60~80	80~120
Sandy soil and gravel (clay and silt content >15%)	<10	20~30	40~80	90~200

Note: 1 Rough-surfaced filling pile shall be numerical value listed in the table multiply by coefficient 1.1~1.3;

2 This table is not applicable to frozen soil with salt content is larger than 0.5%.

5.4.8 Short piled foundation of light construction on expansive soil shall check up uplift stability of clustered piles foundation acting like integral destruction and non-integral destruction according to the following formulate:

$$u \sum q_{ei} l_{ei} \leq T_{gk} / 2 + N_G + G_{gP} \quad (5.4.8-1)$$

$$u \sum q_{ei} l_{ei} \leq T_{uk} / 2 + N_G + G_P \quad (5.4.8-2)$$

Where: T_{gk} — When clustered piles is acting like integral destruction, uplift ultimate bearing pressure of foundation pile in soilcement layer under layer with rapid atmospheric influence may be calculated according to article 5.4.6 of this code;

T_{uk} — When clustered piles is acting like non-integral destruction, uplift ultimate bearing pressure of foundation pile in soilcement layer under layer with rapid atmospheric influence may be calculated according to article 5.4.6 of this code;

q_{ei} — Ultimate swelling shear force of the i^{th} soil layer in layer with rapid atmospheric influence is determined by in-situ water immersion test;

l_{ei} — Thickness of the i^{th} soil layer in layer with rapid atmospheric influence.

5.5 Calculation for piled foundation settlement

5.5.1 Calculated value of piled foundation settlement deformation of the buildings shall not be larger than allowable value of piled foundation settlement deformation.

5.5.2 Piled foundation settlement deformation may be indicated with the following indexes:

1 Settling volume;

2 Differential settlements;

3 Integral slants: ratio between differential settlement and distance of both ends points in slanting direction of the building pile foundation;

4 Local slants: ratio between differential settlement and distance of the two points of pile foundation of bar pile cap under the wall along certain longitudinal length

5.5.3 When calculating piled foundation settlement deformation, piled foundation deformation index shall be adopted according to the following requirements:

1 Ground settlement deformation caused by uneven soil thickness and property, load difference, form intricacy and interaction, etc. shall be with local slant regulation for bricking-up bearing structure;

2 It shall be regulated by integral slanting value for multilayer or high-rise building and tower structure;

3 When its structure is frame, frame- shear wall, frame- core tube structure, it shall regulate differential settlement between columns (walls).

5.5.4 Allowable value of piled foundation settlement deformation for the building shall be adopted in accordance with those specified in Table 5.5.4.

5.5.5 Allowable value of piled foundation settlement deformation not included in table 5.5.4 of this code shall be determined according to adaptive faculty and operating requirement of superstructure to piled foundation settlement deformation.

Table 5.5.4 Allowable Value of Piled Foundation Settlement Deformation for the Buildings

Deformation behavior		Allowable value
Local slant of bricking-up bearing structure foundation		0.002
Differential settlement of adjacent columns (walls) foundation of all the buildings		
(1) Frame, frame- shear wall and frame- core tube structure		0.002 l_0
(2) Side organ timbering filled with bricking-up wall		0.0007 l_0
(3) When the foundation is settled uneven, it doesn't generate additional stress structure		0.005 l_0
Settling volume of monolayer trestlework (spacing of columns is 6m) piled foundation (mm)		120
Slanting of bridge crane rail surface (considering according to non-adjusted rail)		
Longitudinal		0.004
Lateral		0.003
Integral slant of multilayer and high-rise building	$H_g \leq 24$	0.004
	$24 < H_g \leq 60$	0.003
	$60 < H_g \leq 100$	0.0025
	$H_g > 100$	0.002
Integral slant of tower structure piled foundation	$H_g \leq 20$	0.008
	$20 < H_g \leq 50$	0.006
	$50 < H_g \leq 100$	0.005
	$100 < H_g \leq 150$	0.004
	$150 < H_g \leq 200$	0.003
	$200 < H_g \leq 250$	0.002
Settling volume of tower structure foundation (mm)	$H_g \leq 100$	350
	$100 < H_g \leq 200$	250
	$200 < H_g \leq 250$	150
Maximal settling volume of high-rise building piled foundation of shear wall structure with simple form (mm)		200

Note: l_0 is distance between two measuring point of adjacent columns (walls), H_g is building height calculated from outdoor ground.

I Piled foundation with pile center distance is no larger than 6 times pile diameter

5.5.6 For piled foundation with pile center distance is no larger than 6 times pile diameter, its final settling volume calculation may adopt equivalent acting layerwise summation method. Equivalent acting surface is lying on pile tip plane, equivalent active area is projected area of pile cap, and equivalent acting additional pressure is approximately taking average additional pressure of pile cap bottom. Stress distribution under equivalent acting surface adopts isotropy beeline deformable body theory. Computation schema sees figure 5.5.6, ultimate settling volume of any point of the piled foundation may be calculated according to the following formulate with angular point method:

$$s = \psi \cdot \psi_e \cdot s' = \psi \cdot \psi_e \cdot \sum_{j=1}^m p_{0j} \sum_{i=1}^n \frac{z_{ij} \bar{\alpha}_{ij} - z_{(i-1)j} \bar{\alpha}_{(i-1)j}}{E_{sj}} \quad (5.5.6)$$

- Where:
- s — Ultimate settling volume of piled foundation (mm);
 - s' — Settling volume of piled foundation calculated according to entity deep foundation layerwise summation method by adopting Boussinesq's solution;
 - ψ — Calculated empirical coefficient for piled foundation settlement may be determined according to article 5.5.11 of this code when it hasn't reliable local experience;
 - ψ_e — Equivalent settling ratio of piled foundation may be determined according to article 5.5.9 of this code;
 - m — Blocking numbers with angular point method calculating rectangular load with point correspondence;
 - p_{0j} — Additional pressure of the j^{th} rectangular bottom surface under would-be permanent combination of load effect (kPa);
 - n — Dividing soil layers within calculated depth range of piled foundation settlement;
 - E_{si} — Compressive modulus of the i^{th} soil layer under equivalent acting surface (MPa), it adopts compressive modulus of foundation soil under acting of sole weight pressure to sole weight pressure plus additional pressure;
 - $z_{ij}, z_{(i-1)j}$ — Distance from the j^{th} piece of load acting surface on pile tip plane to the i^{th} soil layer and $i-1^{\text{th}}$ soil layer bottom surface (m);
 - $\bar{\alpha}_{ij}, \bar{\alpha}_{(i-1)j}$ — Average additional stress coefficient of depth range from the j^{th} piece of load calculated point on pile tip plane to the i^{th} soil layer and $i-1^{\text{th}}$ soil layer bottom surface may be adopted according to Appendix D of this code.

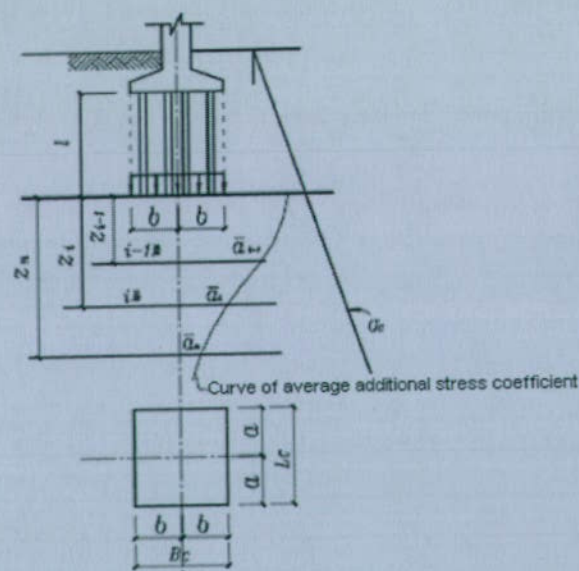


Figure 5.5.6 Schematic Figure of Piled Foundation Settlement Calculation

5.5.7 When calculating point settlement in rectangular piled foundation, settling volume of piled foundation may be simplified calculated according to the following formulate:

$$s = \psi \cdot \psi_e \cdot s' = 4\psi \cdot \psi_e \cdot p_0 \sum_{i=1}^n \frac{z_i \bar{\alpha}_i - z_{i-1} \bar{\alpha}_{i-1}}{E_{si}} \quad (5.5.7)$$

Where: p_0 —Average additional pressure of pile cap bottom under would-be permanent combination of load effect;

$\bar{\alpha}_i, \bar{\alpha}_{(i-1)}$ —Average additional stress coefficient, it may be adopted according to

rectangular length-width ratio a/b and depth-width ratio $\frac{z_i}{b} = \frac{2z_i}{B_c}$ and

$\frac{z_{i-1}}{b} = \frac{2z_{i-1}}{B_c}$, as well as according to Appendix D of this code.

5.5.8 Calculated depth z_n of piled foundation settlement shall be determined according to stress ratio method, that is additional stress σ_z and self-weight stress σ_c of soil at calculated depth section shall meet requirement of the following formulates:

$$\sigma_z \leq 0.2\sigma_c \quad (5.5.8-1)$$

$$\sigma_z = \sum_{j=1}^m a_j p_{0j} \quad (5.5.8-2)$$

Where: a_j —Additional stress coefficient: it may be adopted according to rectangular length-width ratio and depth-width ratio divided as angular point method, as well as according to Appendix D of this code.

5.5.9 Equivalent settling ratio ψ_e of piled foundation may be simplified calculated according to the following formulate:

$$\psi_e = C_0 + \frac{n_b - 1}{C_1(n_b - 1) + C_2} \quad (5.5.9-1)$$

$$n_b = \sqrt{n \cdot B_c / L_c} \quad (5.5.9-2)$$

Where: n_b —Short side pile layout number of rectangular pile layout may be proximately calculated according to formulate (5.5.9-2) when pile layout is irregular; when $n_b > 1$; $n_b = 1$, it may be calculated according to formulate (5.5.14) of

this code;

C_0, C_1, C_2 —According to distance- diameter ratio s_a/d , length-diameter ratio l/d and fundament length-width ratio L_c/B_c of clustered piles, they may be determined according to appendix E of this code;

L_c, B_c, n —They are length, wide and overall pile numbers of rectangular pile cap.

5.5.10 When pile layout is irregular, equivalent distance- diameter ratio may be proximately calculated according to the following formulates:

$$\text{Round pile } S_a / d = \sqrt{A} / (\sqrt{n} \cdot d) \quad (5.5.10-1)$$

$$\text{Square pile } S_a / d = 0.886 \sqrt{A} / (\sqrt{n} \cdot b) \quad (5.5.10-2)$$

Where: A —Overall area of piled foundation pile cap;

b —Side length of square pile cross-section.

5.5.11 When it is without local reliable experience, calculated empirical coefficient ψ of piled foundation settlement may be adopted according to Table 5.5.11. Calculated empirical coefficient of piled foundation settlement shall take the larger value according to supporting course type multiply by 0.7 (sand, gravel and pebble)~0.8 (cohesive soil and silty soil) reduction coefficient for filling pile of post grouting construction technology; when adopting (excluding retapping, repress operation and leading-hole pile-sinking), it shall take the larger value according to pile spacing, soil quality, pile-sinking velocity and sequence multiply by 1.3~1.8 soil compacting effect coefficient, low penetrability of the soil, small pile spacing, large pile quantity and rapid sedimentation velocity.

Table 5.5.11 Calculated Empirical Coefficient ψ for Piled Foundation Settlement

\bar{E}_s (MPa)	≤ 10	15	20	35	≥ 50
ψ	1.2	0.9	0.65	0.50	0.40

Note: 1 \bar{E}_s is equivalent value of compressive modulus within settlement calculated depth, it may be calculated according

to the following formulate: $\bar{E}_s = \sum A_i / \sum \frac{A_i}{E_{si}}$, where A_i is the integral quantity of additional pressure

coefficient of the i^{th} soil layer along soil thickness, it may be approximately calculated according to blocking area;

2 ψ may take value according to interpolation of \bar{E}_s .

5.5.12 When calculating piled foundation settlement, it shall consider influence of adjacent

foundations, and calculate with superposition principle; equivalent settlement coefficient of piled foundation may be calculated according to independent footing.

5.5.13 When piled foundation shapes are irregular, it may calculate equivalent settlement coefficient of piled foundation with equivalent rectangular area, and the length-width ratio of rectangular may be determined according to actual size and shape of pile cap.

II Single pile, single-row pile, and sparse pile foundation

5.5.14 Settlement calculation for single pile, single-row pile, and sparse pile foundation with pile center distance is larger than 6 times of the pile diameter shall be in accordance with the following requirements:

1 Piled foundation with foundation soil at pile cap bottom is not sharing the load. Additional stress created by foundation pile in foundation under pile tip plane is determined according to calculation Mindlin's solution influencing by pile diameter in appendix F. Superimpose additional stress generated by counter stress design point of all the foundation piles within horizontal plane influence scope of settlement design point and calculate soil layer settlement with unidirectional compression an d layerwise summation method, and count in pile compression s_e . Ultimate settling volume of piled foundation may be calculated according to the following formulates:

$$s = \psi \sum_{i=1}^n \frac{\sigma_{zi}}{E_{si}} \Delta z_i + s_e \quad (5.5.14-1)$$

$$\sigma_{zi} = \sum_{j=1}^m \frac{Q_j}{l^2} [\alpha_j I_{p,ij} + (1 - \alpha_j) I_{s,ij}] \quad (5.5.14-2)$$

$$s_e = \xi_e \frac{Q_j l_j}{E_c A_{ps}} \quad (5.5.14-3)$$

2 Composite piled foundations with foundation soil at composite pile cap bottom are sharing the load. Calculate additional stress generated by soil pressure of pile cap bottom to some point in foundation as Boussinesq solution (Appendix D) and superimpose with additional stress generated by foundation pile, as well as calculate settlement by adopting method equal to item 1 of this article. Its ultimate settling volume may be calculated according to the following formulates:

$$s = \psi \sum_{i=1}^n \frac{\sigma_{zi} + \sigma_{zci}}{E_{si}} \Delta z_i + s_e \quad (5.5.14-4)$$

$$\sigma / z_{ci} = \sum_{k=1}^u \alpha_{ki} \cdot p_{c,k} \quad (5.5.14-5)$$

- Where:
- m —Foundation pile numbers within the horizontal plane influence circle with circle center is settlement design point and radius is 0.6 times of pile length;
 - n —Calculated hierarchy numbers of soil layer within the settlement calculated depth; hierarchy number shall combine with soil layer property and the lift height shall not exceed 0.3 times of the calculated depth;
 - σ_{zi} —Sum of additional vertical stresses generated at 1/2 thickness of the i^{th} soil layer under the design point pile tip plane of the foundation pile counter stress within horizontal plane influence circle; stress design point shall be proximate pile centre with the settlement design point.
 - σ_{zci} —Stress generated at 1/2 thickness of the i^{th} calculated soil layer under design point pile tip plane of the pile cap pressure counter stress; it may divide pile cap sheet into u pieces of rectangular blocks and it may be calculated according to angular point method adopted in Appendix D of this code;
 - Δz_i —Thickness of the i^{th} calculated soil layer (m);
 - E_{si} —Compressive modulus of the i^{th} calculated soil layer (MPa), it adopts compressive modulus when foundation soil is under the acting of sole weight pressure to sole weight pressure plus additional pressure;
 - Q_j —Pile top additional load (kN) of the j^{th} pile under would-be permanent combination of load effect; when basement buried depth exceeds 5m, total load under would-be combination acting of the load effect act as equivalent additional load for considering rebound recompression;
 - l_j —Pile length of the j^{th} pile (m);
 - A_{ps} —Cross-sectional area of pile shaft;
 - α_j —Ratio between overall tip resistance and pile top load of the j^{th} pile, it is approximately taken ratio between ultimate overall tip resistance and ultimate bearing pressure of a single pile;
 - $I_{p,lj}, I_{s,lj}$ —They are stress affecting coefficients of tip resistance and pile shaft resistance of the j^{th} pile to 1/2 thickness section of the i^{th} calculated soil layer on the calculated shaft line, it may be determined according to appendix F of this code;
 - E_c —Elastic modulus of pile shaft concrete;
 - $p_{c,k}$ —Uniform pressure at pile cap bottom of the k^{th} block, it may take value according to $p_{c,k} = \eta_{c,k} \cdot f_{ak}$, where $\eta_{c,k}$ is pile cap effect coefficient of the k^{th} pile cap soleplate, it is determined according to Table 5.2.5 of this code; f_{ak}

is characteristic value of ground bearing capacity at pile cap bottom;

α_{ki} —Additional stress coefficient of 1/2 thickness for the i^{th} calculated soil layer under pile tip plane at section of base angle point of the k^{th} pile cap, it may be determined according to appendix D of this code;

s_e —Calculated pile shaft compression;

ξ_e —Compression coefficient of pile shaft; End bearing pile: $\xi_e=1.0$; friction-type pile: when $l/d \leq 30$, $\xi_e=2/3$; when $l/d \geq 50$, $\xi_e=1/2$; when the result is between the two, ξ_e may take linear interpolation;

ψ —Settlement calculated empirical coefficient, it may be 1.0 when there isn't local experience.

5.5.15 For ultimate settlement calculated depth of a single pile, single-row pile, sparse pile composite pile foundation, it may be determined according to stress ratio method, that is additional stress σ_z generated by pile at z_n section, additional stress σ_{zc} generated by pile cap soil pressure and soil self-weight stress σ_c shall meet the requirement of the following equation:

$$\sigma_z + \sigma_{zc} = 0.6\sigma_c \quad (5.5.15)$$

5.6 Composite foundation with settlement-reducing piles of soft soil foundation

5.6.1 When tier building and ground bearing capacity on soft soil foundation is meeting the challenge basically (calculate based on plane area of bottom layer), it may be set with sparse layout friction-type pile entering into better soil layer by passing through soft soil, the load is shared by pile and soil between the pile. This kind of composite foundation with settlement-reducing piles may be determined with pile top area and pile numbers according to the following equation:

$$A_c = \zeta \frac{F_k + G_k}{f_{ak}} \quad (5.6.1-1)$$

$$n \geq \frac{F_k + G_k - \eta_c f_{ak} A_c}{R_n} \quad (5.6.1-2)$$

Where: A_c —Overall net area of piled foundation cap;

f_{ak} —Characteristic value of bearing pressure on foundation at pile top bottom;

ζ — Control coefficient of pile top area, $\zeta \geq 0.60$;

n — Foundation pile numbers;

η_c — Effect coefficient of piled foundation cap, it may take value according to Table 5.2.5 of this code.

5.6.2 Midpoint settlement of composite foundation with settlement-reducing piles may be calculated according to the following equation:

$$s = \psi(s_s + s_{sp}) \quad (5.6.2-1)$$

$$s_s = 4p_0 \sum_{i=1}^m \frac{z_i \bar{\alpha}_i - z_{(i-1)} \bar{\alpha}_{(i-1)}}{E_{si}} \quad (5.6.2-2)$$

$$s_{sp} = 280 \frac{\bar{q}_{su}}{E_s} \cdot \frac{d}{(s_a/d)^2} \quad (5.6.2-3)$$

$$p_0 = \eta_p \frac{F - nR_a}{A_c} \quad (5.6.2-4)$$

Where: s — Settling volume of piled foundation midpoint;

s_s — Midpoint settlement generated under additional pressure of foundation soil at pile top bottom (figure 5.6.2);

s_{sp} — Settlement generated by pile-soil interaction;

p_0 — Average additional pressure of imaginary natural foundation calculated according to quasi-permanent value combination of load effect (kPa);

E_{si} — Compressive modulus of the i^{th} soil layer under pile top bottom, it shall be modulus value from deadweight pressure to between deadweight pressure and additional pressure section;

m — Soil layer numbers within foundation settlement calculated depth range; settlement calculated depth is determined according to $\sigma_{zc} = 0.1\sigma$ and σ_z may be determined according to article 5.5.8 of this code;

q_{su}, E_s — Average pile shaft ultimate resistance and compressive modulus weighted according to thickness within pile shaft scope;

d — Pile shaft diameter, when it is square pile, $d = 1.27b$ (b is sectional side length of square pile);

s_a/d — Equivalent distance-diameter ratio, it may comply with article 5.5.10 of this

code;

z_i, z_{i-1} — Distance from pile top bottom to bottom surface of the i^{th} and $(i-1)^{\text{th}}$ soil layer;

$\bar{\alpha}_i, \bar{\alpha}_{(i-1)}$ — Average additional stress coefficient of angular point from pile top bottom to the i^{th} and $(i-1)^{\text{th}}$ soil layer bottom; it is determined by Appendix D of this code according to calculated blocking rectangular length-width ratio a/b and depth-width ratio $z/b = 2z/B_c$ for equivalent area of the pile top; where pile top equivalent width $B_c = B\sqrt{A_c}/L$; B and L are width and length of the exterior margin plane for the building foundation;

F — Overall additional load acting on pile top bottom under quasi-permanent value combination of load effect (kN);

H_p — Stuck distortion influence coefficient for foundation pile; it is determined according to earthiness in pile tip supporting course, sandy soil is 1.0, silty soil is 1.15 and cohesive soil is 1.30.

ψ — Settlement calculated empirical coefficient may take 1.0 when it hasn't local experience.

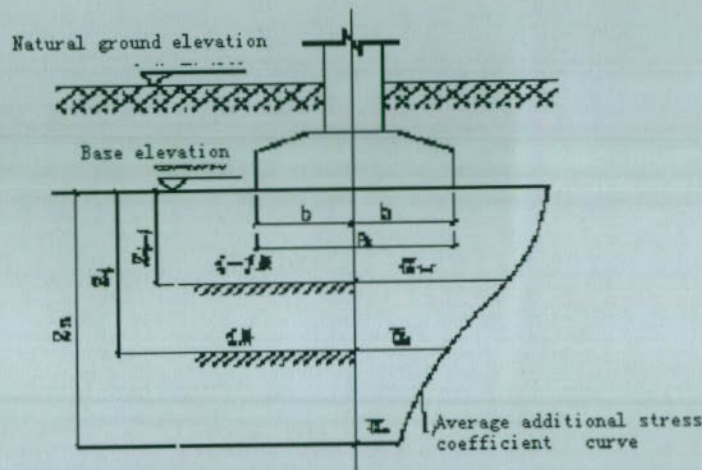


Figure 5.6.2 Calculated Stratified Schema Layout for Settlement of Composite Sparse Pile Foundation

5.7 Calculation for level bearing capacity and displacement of piled foundation

I Single piled foundation

5.7.1 Single piled foundation of ordinary construction bearing horizontal load and tall building bearing smaller horizontal load as well as foundation pile among clustered piles shall meet requirements of the following equation:

$$R_{ik} \leq R_h \quad (5.7.1)$$

Where: H_{ik} —Horizontal force acting on the i^{th} cap of foundation pile under standard combination of load effect;

R_h —Characteristic value of horizontal bearing capacity for the single piled foundation or foundation pile in clustered piles may take characteristic value R_{ha} of horizontal bearing capacity for the single pile.

5.7.2 Determination for characteristic value of horizontal bearing capacity of the single pile shall be in accordance with those specified in the following:

1 For construction piled foundation bearing larger horizontal load and with design grades are Grade A and Grade B, characteristic value of horizontal bearing capacity for the single pile shall be determined by horizontal static test for the single pile and the test method may comply with current professional standard “Technical Code for Testing of Building Foundation Piles” JGJ 106.

2 For reinforced concrete premolded pile, steel pile and filling pile with reinforcement ratio of pile shaft normal section is no less than 0.65%, characteristic value of horizontal bearing capacity for a single pile may be 75% load corresponding to 10mm horizontal displacement (take 6mm horizontal displacement for building with sensitive horizontal displacement) on the ground according to static test result.

3 For filling pile with pile shaft reinforcement ratio is less than 0.65%, its characteristic value of horizontal bearing capacity for a single pile may be 75% of the critical load according to the horizontal static test for a single pile.

4 When it lacks of horizontal static test information for a single pile, it may estimate characteristic value of horizontal bearing capacity for a single pile with filling pile of pile shaft reinforcement ratio is less than 0.65% according to the following equation:

$$R_{ha} = \frac{0.75\alpha\gamma_m f_t W_0}{v_M} (1.25 + 22\rho_g) \left(1 \pm \frac{\zeta_N N_k}{\gamma_m f_t A_n}\right) \quad (5.7.2-1)$$

Where: α —Horizontal deformation coefficient of piles may be determined according to article 5.7.5 of this code;

R_{ha} —Characteristic value of horizontal bearing capacity for a single pile, \pm is determined according to vertical force property of the pile top, and then pressure is “+” and pull force is “-”.

γ_m —Plastic coefficient of pile section modulus, round section $\gamma_m=2$, rectangular section $\gamma_m=1.75$;

f_t — Design value for tensile intensity of pile shaft concrete;

W_0 — Section modulus at in-tension margin of transformed section of the pile shaft, round section:

$$W_0 = \frac{\pi d}{32} [b^2 + 2(\alpha_E - 1)\rho_g b_0^2]$$

Square section: $W_0 = \frac{b}{6} [b^2 + 2(\alpha_E - 1)\rho_g b_0^2],$

Where d is pile diameter, d_0 is pile diameter recouping protective layer thickness; b is side length of the square section, b_0 is pile sectional width recouping protective layer thickness; α_E is ratio between elastic modulus of steel bar and concrete;

ν_M — Maximal moment coefficient of the pile shaft, it takes value according to Table 5.7.2, when direct-axis of single piled foundation and single-row piled foundation is perpendicular to its horizontal force direction, it is considered as cap swing joint;

ρ_g — Reinforcement ratio of pile shaft;

A_n — Transformed section area of pile shaft, round section: $A_n = \frac{\pi d^2}{4} [1 + (\alpha_E - 1)\rho_g],$

Square section: $A_n = b^2 [1 + (\alpha_E - 1)\rho_g];$

ζ_N — Influence coefficient of cap vertical force, vertical pressure takes 0.5; vertical pull force takes 1.0;

N — Cap vertical force under standard combination of load effect (kN).

5 Design pile diameter of digging pile with concrete as breast wall takes inside diameter of breast wall when calculating horizontal bearing capacity for a single pile.

6 When pile horizontal bearing capacity is controlled by horizontal displacement and it lacks of horizontal static test information for a single pile, it may estimate characteristic value of horizontal bearing capacity for a single pile with premolded pile, steel pile and filling pile with reinforcement ratio is less than 0.65% according to the following equation:

$$R_{ha} = 0.75 \frac{\alpha^3 EI}{\nu_x} x_{0a} \quad (5.7.2-2)$$

Where: EI — Flexural rigidity of pile shaft, for reinforced concrete pile, $EI = 0.85E_c I_0$, where E_c is the elastic modulus of concrete, I_0 is inertia moment of the transformed section; and for round section: $I_0 = W_0 d_0 / 2$; for rectangular

section, $I_0 = W_0 b_0 / 2$;

x_{0a} —Permissible horizontal displacement of the pile top;

v_x —Horizontal displacement coefficient of the pile top, its value is taken according to Table 5.7.2 and the value taking method is same as v_M .

Table 5.7.2 Maximum Bending Moment Coefficient v_M and Horizontal Displacement Coefficient v_x of Cap (shaft)

Cap constraint condition	Conversional buried depth of pile (αh)	v_M	v_x
Swing joint and free	4.0	0.768	2.441
	3.5	0.750	2.502
	3.0	0.703	2.727
	2.8	0.675	2.905
	2.6	0.639	3.163
	2.4	0.601	3.526
Rigid coupling	4.0	0.926	0.940
	3.5	0.934	0.970
	3.0	0.967	1.028
	2.8	0.990	1.055
	2.6	1.018	1.079
	2.4	1.045	1.095

Note: 1 v_M of swing joint (free) refers to maximum bending moment coefficient of the pile shaft and v_M of rigid coupling refers to maximum bending moment coefficient of the cap;

2 When $\alpha h > 4$, $\alpha h = 4.0$.

7 When checking horizontal bearing capacity of piled foundation controlled by permanent load, it shall make characteristic value of horizontal bearing capacity for a single pile determined by methods of items 2~5 in the above multiply by regulation factor 0.80; when checking horizontal bearing capacity of earthquake effect piled foundation, it should make characteristic value of horizontal bearing capacity for a single pile determined by methods of items 2~5 in the above multiply by regulation factor 1.25.

II Clustered piles foundation

5.7.3 Characteristic value of horizontal bearing capacity for the foundation pile of clustered piles foundation (excluding conditions with horizontal force perpendicular to direct-axis of the single-row piled foundation and with larger moment) shall consider pile group effect generated by interaction among pile top, pile group and soil, it may be determined according to the following equation:

$$R_h = \eta_h R_{ha} \quad (5.7.3-1)$$

When considering earthquake effect and $s_a/d \leq 6$,

$$\eta_h = \eta_i \eta_r + \eta_l \quad (5.7.3-2)$$

$$\eta_l = \frac{\left(\frac{S_a}{d}\right)^{0.015n_2+0.45}}{0.15n_1 + 0.10n_2 + 1.9} \quad (5.7.3-3)$$

$$\eta_l = \frac{m \cdot x_{0a} \cdot B'_c \cdot h_c^2}{2 \cdot n_1 \cdot n_2 \cdot R_{ha}} \quad (5.7.3-4)$$

$$x_{0a} = \frac{R_{ha} v_x}{\alpha^3 EI} \quad (5.7.3-5)$$

Other conditions:

$$\eta_h = \eta_i \eta_r + \eta_l + \eta_b \quad (5.7.3-6)$$

$$\eta_b = \frac{\mu P_c}{n_1 n_2 R_h} \quad (5.7.3-7)$$

$$B'_c = B_c + 1 \quad (5.7.3-8)$$

$$P_c = \eta_c f_{ak} (A - nA_{ps}) \quad (5.7.3-9)$$

- Where:
- η_h —Synthesize coefficient of pile group effect;
 - η_l —Interactive effect coefficient of piles;
 - η_r —Constraint effect coefficient of pile top (when the pile top is 50~100 mm embedding in the pile cap), it takes value according to Table 5.7.3-1;
 - η_l —Soil resistance effect coefficient at pile cap side (when earth backing at pile cap side is in loose condition, $\eta_l = 0$);
 - η_b —Friction effect coefficient at pile cap bottom;
 - s/d —Distance-diameter ratio along horizontal load direction;
 - n_1, n_2 —Pile numbers of each pile-row along horizontal load direction and vertical horizontal load direction respectively;

- m —Proportionality coefficient of earth horizontal reaction coefficient at pile cap side, when it hasn't test data, it may take value according to Table 5.7.5 of this code;
- x_{0a} —Allowable value for horizontal displacement of pile top (pile cap), when it is controlled with displacement, it may take $x_{0a}=10\text{mm}$ ($x_{0a}=6\text{mm}$ for structures sensitive to horizontal displacement); when it is controlled with pile shaft intensity (filling pile with low reinforcement ratio), it may be approximately determined according to equation (5.7.3-5) of this code;
- B'_c —Calculated width of pile cap bearing one side earth resistance;
- B_c —Pile cap width;
- h_c —Pile cap height (m);
- μ —Friction factor between pile cap bottom and underlying soil may take value according to Table 5.7.3-2;
- P_c —Vertical total load assumed by pile cap bottom foundation soil;
- η_c —Determined according to article 5.2.5;
- A —Total area of the pile cap;
- A_{ps} —Sectional area of the pile shaft.

Table 5.7.3-1 Constraint Effect Coefficient η_r on Pile Top

Converted depth αh	2.4	2.6	2.8	3.0	3.5	≥ 4.0
Displacement control	2.58	2.34	2.20	2.13	2.07	2.05
Intensity control	1.44	1.57	1.71	1.82	2.00	2.07

Note: $\alpha = \sqrt[5]{\frac{mb_0}{EI}}$, h is embedment length of piles.

Table 5.7.3-2 Friction Factor μ between Pile Cap Bottom and Underlying Soil

Soil type		Friction factor μ
Cohesive soil	Plastic	0.25-0.30
	Hard plastic	0.30-0.35
	Stiffness	0.35-0.45
Silty soil	Dense and middle dense (a little wet)	0.30-0.40
Medium sand, coarse sand and moulding gravel		0.40-0.50
Soil aggregate		0.40-0.60
Soft rock and soft quality rock		0.40-0.60
Rough-surfaced hard rock and stiff rock		0.65-0.7

5.7.4 When calculating horizontal displacement of piled foundation for tall buildings with

larger horizontal load and bearing horizontal earthquake effect and wind load as well as carrying with basement, it may consider interaction of sidewall, pile cap, pile group and soil in the basement; calculating internal force and deflection for foundation pile according to methods in appendix C, single-row pile foundation perpendicular to horizontal exogenic acting plane may be calculate according to Table C-2 in appendix C of this code.

5.7.5 Horizontal deformation coefficient of piles and horizontal reaction coefficient of foundation soil may be determined according to the following requirements:

1 Horizontal deformation coefficient α of piles (1/m)

$$\alpha = \sqrt[5]{\frac{mb_0}{EI}} \quad (5.7.5)$$

Where: m —Proportionality coefficient of horizontal reaction coefficient for the soil at side of piles;

b_0 —Calculated width for pile shaft (m);

Round pile: When diameter $d \leq 1$ m, $b_0 = 0.9(1.5d + 0.5)$;

When diameter $d > 1$ m, $b_0 = 0.9(d + 1)$;

Square pile: When side width $b \leq 1$ m, $b_0 = 1.5b + 0.5$;

When side width $b > 1$ m, $b_0 = b + 1$.

EI —Pile shaft flexural rigidity, it is calculated according to specification in article 5.7.2 of this code.

2 Proportionality coefficient m of horizontal coefficient of reaction for soil on pile side, it should be determined by horizontal static test for a single pile; when it hasn't any static test information, it may take value according to Table 5.7.5.

5.8 Calculation for bearing capacity and fracture control of pile shaft

5.8.1 Pile shaft shall be made with bearing capacity and fracture control calculation. When calculating, it shall consider pile shaft material strength, pile forming technology, handling and pile-sinking, constraint condition, environmental types, etc. unless comply with relevant regulations of this section, it shall also be in accordance with relevant regulations of "Code for Design of Concrete Structures" GB 50010, "Code for Design of Steel Structures" GB 50017 and "Code for Seismic Design of Buildings" GB 50011.

Table 5.7.5 Proportionality Coefficient m of horizontal Coefficient of Reaction for Foundation Soil

Serial number	Foundation soil type	Premolded pile and steel pile		Filling pile	
		m (MN/m ⁴)	Horizontal displacement of corresponding single pile on the ground (mm)	m (MN/m ⁴)	Horizontal displacement of corresponding single pile on the ground (mm)
1	Silt; silt saturated collapsible loess	2~4.5	10	2.5~6	6~12
2	Flow plastic ($I_L > 1$), soft plastic ($0.75 < I_L \leq 1$) cohesive soil; silty soil with $e > 0.9$; loose fine sand; loose and a little dense filling	4.5~6.0	10	6~14	4~8
3	Plastic ($0.25 < I_L \leq 0.75$) cohesive soil and collapsible loess; silty soil with $e = 0.75 \sim 0.9$; middle dense filling; a little dense fine sand	6.0~10	10	14~35	3~6
4	Hard plastic ($0 < I_L \leq 0.25$), stiff ($I_L \leq 0$) cohesive soil and collapsible loess; silty soil with $e < 0.75$, middle dense medium coarse sand; dense aged filling	10~22	10	35~100	2~5
5	Middle dense and dense moulding gravel as well as debris soil	—	—	100~300	1.5~3

Note: 1 When pile top horizontal displacement is larger than numerical value listed in the table or filling pile reinforcement ratio is too high ($\geq 0.65\%$), m shall be reduced properly; when premolded pile horizontal displacement is less than 10mm, m may be increased properly;

2 When horizontal load is long-term or frequently emergent load, it shall be adopted by the numerical value listed in the table multiply by 0.4;

3 When foundation is liquefiable soil layer, it shall make numerical value listed in the table multiply by corresponding coefficient ψ_1 in Table 5.3.12 of this code;

I Compressed piles

5.8.2 Bearing capacity on normal section of compressed piles in the reinforced concrete axle center shall meet the following requirements:

1 When auger-type stirrup spacing of pile shaft within $5d$ under the pile top is no larger than 100mm, and it meets the requirement of article 4.1.1 of this code;

$$N \leq \psi_c f_c A_{ps} + 0.9 f_y' A_s' \quad (5.8.2-1)$$

2 When pile shaft reinforcing bars cannot meet the requirement of the above item 1;

$$N \leq \psi_c f_c A_{ps} \quad (5.8.2-2)$$

Where: N —Design value for pile top axial pressure under basic combination of load effect;

ψ_c —Foundation pile forming technological coefficient, it takes value according to those specified in article 5.8.3;

f_c —Design value for compressive strength of the concrete axle center;

f_y' —Design value for compressive strength of longitudinal reinforcing bar;

A_s' —Sectional area of longitudinal reinforcing bar.

5.8.3 Foundation pile forming technological coefficient ψ_c shall take value according to the following requirements:

- 1 Concrete premolded pile and prestressed concrete hollow pile: $\psi_c = 0.85$;
- 2 Dry operating non-squeezing soil filling pile: $\psi_c = 0.90$;
- 3 Slurry breast wall and non-squeezing soil filling pile of thimble breast wall, part squeezing soil filling pile as well as squeezing soil filling pile: $\psi_c = 0.7 \sim 0.8$;
- 4 Squeezing soil filling pile in soft soil region: $\psi_c = 0.6$.

5.8.4 When calculating compressed bearing capacity on normal section of concrete piling with axial compression, it takes $\varphi = 1.0$. For high pile ca foundation pile and foundation pile of soft soil ground with pile shaft passing through liquefiable soil or undrained shear strength is less than 10kPa, it shall consider buckling influence, and may be decreased by bearing capacity on normal section of the pile shaft calculated according to equations (5.8.2-1) and (5.8.2-2) of this code multiply by φ . Its stability factor φ may be determined according to pile shaft buckling effective length l_c and pile design diameter d (or short side size b of rectangular pile). Pile shaft buckling effective length may be determined by constraint condition of pile top, free length l_0 exposed out of ground for pile shaft, embedment length h of piles, earthiness conditions for pile side and pile toe and shall be in accordance with those specified in Table 5.8.4-1. Stability factor of piles φ may be determined according to Table 5.8.4-2.

5.8.5 When calculating bearing capacity bearing on normal section of eccentric compressed concrete piling, it may take no account of augment influence of eccentric distance, but for soft soil foundation pile with high pile cap foundation pile and pile shaft passing through liquefiable soil or undrained shear strength is less than 10kPa, it shall consider influence of deflection in bending moment acting plane of the pile shaft for eccentric distance of axial force and it shall make initial eccentricity moment e_i of axial force for the sectional

orthocenter multiply by augmenting factor η of eccentricity moment; specific calculation procedure for augmenting factor η of eccentric distance may comply with current national standard "Code for Design of Concrete Structures" GB50010.

Table 5.8.4-1 Buckling Effective Length l_c of Pile Shaft

Pile top swing joint			
Pile toe is setting in non-rock soil		Pile toe is embedding in rock	
$h < \frac{4.0}{\alpha}$	$h \geq \frac{4.0}{\alpha}$	$h < \frac{4.0}{\alpha}$	$h \geq \frac{4.0}{\alpha}$
$l_c = 1.0 \times (l_0 + h)$	$l_c = 0.7 \times (l_0 + \frac{4.0}{\alpha})$	$l_c = 0.7 \times (l_0 + h)$	$l_c = 0.7 \times (l_0 + \frac{4.0}{\alpha})$
Pile top rigid coupling			
Pile toe is setting in non-rock soil		Pile toe is embedding in rock	
$h < \frac{4.0}{\alpha}$	$h \geq \frac{4.0}{\alpha}$	$h < \frac{4.0}{\alpha}$	$h \geq \frac{4.0}{\alpha}$
$l_c = 0.7 \times (l_0 + h)$	$l_c = 0.5 \times (l_0 + \frac{4.0}{\alpha})$	$l_c = 0.5 \times (l_0 + h)$	$l_c = 0.5 \times (l_0 + \frac{4.0}{\alpha})$

Note: 1 $\alpha = \sqrt{\frac{mb_0}{EI}}$ in the table;

- l_0 is length of high pile cap exposing out of the ground, for low pile cap filed foundation, $l_0=0$;
- h is embedment length of piles, when pile side has fluidized soil layer with thickness is d_f , length l_0 exposing out of the ground and embedment length h of piles are adjusted to be respectively $l_0' = l_0 + \psi_1 d_f$, $h' = h - \psi_1 d_f$, ψ_1 takes value according to Table 5.3.12.

Table 5.8.4-2 Stability Factor φ of Pile Shaft

l_0/d	≤ 7	8.5	10.5	12	14	15.5	17	19	21	22.5	24
l_0/b	≤ 8	10	12	14	16	18	20	22	24	26	28
φ	1.00	0.98	0.95	0.92	0.87	0.81	0.75	0.70	0.65	0.60	0.56
l_0/d	26	28	29.5	31	33	34.5	36.5	38	40	41.5	43
l_0/b	30	32	34	36	38	40	42	44	46	48	50
φ	0.52	0.48	0.44	0.40	0.36	0.32	0.29	0.26	0.23	0.21	0.19

Note: b is short side size of rectangular pile and d is pile diameter.

5.8.6 For drive-in steel pipe pile, it may check local buckling on pile shaft according to the following requirements:

1 When $t/d = \frac{1}{50} \sim \frac{1}{80}$, $d \leq 600$ mm, And maximal stamping compressive stress is less than design value for steels strength, it may not make local buckling checking;

2 When $d > 600$ mm, it may be checked according to the following equation:

$$t/d \geq f'_y / 0.388E \quad (5.8.6-1)$$

3 When $d \geq 900$ mm, it shall not only be checked according to equation (5.8.6-1), but also be checked according to the following equation:

$$t/d \geq \sqrt{f'_y / 14.5E} \quad (5.8.6-2)$$

Where: t, d —Wall thickness and outside diameter of steel pipe piles;

E, f'_y —Design values for elastic modulus and compressive strength of steel products.

II Uplift pile

5.8.7 Bearing capacity on normal section of uplift pile in the reinforced concrete axle center shall meet requirements of the following equation:

$$N \leq f_y A_s + f_{py} A_{py} \quad (5.8.7)$$

Where: N —Design value for pile top axial tension under basic combination of load effect;

f_y, f_{py} —Design values for tensile strength of regular reinforcement and prestressed reinforcement;

A_s, A_{py} —Sectional areas of regular reinforcement and prestressed reinforcements.

5.8.8 Calculation for uplift pile fracture control shall meet the following requirements:

1 For prestressed concrete foundation pile with first class fracture control (with strict requirement for disappearing of fractures), it shall not generate tension stress under standard combination of load effect and it shall meet requirement of the following equation:

$$\sigma_{ck} - \sigma_{pc} \leq 0 \quad (5.8.8-1)$$

2 For prestressed concrete foundation pile with second class fracture control (with general requirement for disappearing of fractures), tension stress under standard combination of load effect shall not be larger than strength standard value of concrete axial tension and it shall meet requirement of the following equation:

$$\text{Under standard combination of load effect: } \sigma_{ck} - \sigma_{pc} \leq f_{tk} \quad (5.8.8-2)$$

$$\text{Under quasi-permanent combination of load effect: } \sigma_{cq} - \sigma_{pc} \leq 0 \quad (5.8.8-3)$$

3 For foundation pile with third class requirement for allowing appearing fracture, calculated maximal fracture width under standard combination of load effect meet the following requirements:

$$\omega_{\max} \leq \omega_{\lim} \quad (5.8.8-4)$$

Where: σ_{ck}, σ_{cq} —Normal stress on normal section under standard combination and quasi-permanent combination of load effect;

σ_{pc} —Pile shaft concrete prestress after recouping all the stress loss;

f_{tk} —Normal value for tensile strength of concrete axle center;

ω_{\max} —Calculated maximal fracture width under standard combination of load effect, it may be calculated according to current national standard “Code for Design of Concrete Structures” GB 50010;

ω_{\lim} —Maximal fractures width limitation, taken according to Table 3.5.3 of this code.

5.8.9 When checking pile shaft uplift capacity by considering earthquake effect, it shall make adjustment for earthquake effect acting on pile top according to current national standard “Code for Seismic Design of Buildings” GB 50011.

III Pile bearing horizontal action

5.8.10 Checking for bending capacity and shear capacity of pile shaft of piles bearing horizontal load and earthquake effect shall meet the following requirements:

1 It shall check bending moment on pile top normal section for pile top with fixed end; and for pile top is free or with swing joint, it shall check normal section bending moment for maximum bending moment section of the pile shaft;

2 It shall check shear capacity for pile top oblique section;

3 Calculation for maximum bending moment and horizontal shear bearing by pile shaft may be in accordance with those specified in Appendix C;

4 When normal section of pile shaft is bearing bending capacity and oblique section is bearing shear capacity, it shall comply with current national standard "Code for Design of Concrete Structures" GB 50010.

5 When checking normal section of pile shaft bearing bending capacity and oblique section bearing shear capacity by considering earthquake effect, it shall make adjustment for earthquake effect acting on pile top according to current national standard "Code for Seismic Design of Buildings" GB 50011.

IV Checking for premolded pile handling and stamping

5.8.11 When handling premolded pile, arrangement for single hanging point and double hanging point shall be in accordance with principle of sagging moment among spans of hanging point (pivot) is equal to hogging moment at hanging point. When handling with premolded pile, it may be influenced by impaction and vibration; when calculating bending moment pull force of handling, it may make gravity force of pile shaft multiply by dynamic coefficient 1.5.

5.8.12 For concrete premolded pile with fracture control grades are grade one and grade two and prestressed concrete pipe pile, it may check stamping compressive stress and stamping tension stress of pile shaft according to the following requirements:

1 Maximal stamping compressive stress σ_p may be calculated according to the following equation:

$$\sigma_p = \frac{\alpha \sqrt{2eE\gamma_p H}}{\left[1 + \frac{A_c}{A_H} \sqrt{\frac{E_c \cdot \gamma_c}{E_H \cdot \gamma_H}} \right] \left[1 + \frac{A}{A_c} \sqrt{\frac{E \cdot \gamma_p}{E_c \cdot \gamma_c}} \right]} \quad (5.8.12)$$

Where: σ_p —Maximal stamping compressive stress of piles;

α —Stamping- type coefficient: free drop stamping is 1.0 and diesel stamping is 1.4;

e —Stamping efficiency coefficient: free drop stamping is 0.6 and diesel stamping is 0.8;

A_H, A_c, A —Actual sectional areas of stamping, pile cushion and pile;

E_H, E_c, E —Modulus of longitudinal elasticity for stamping, pile cushions and pile;

$\gamma_H, \gamma_c, \gamma$ —Density for stamping, pile cushions and pile;

H —Hammer dropping distance.

2 When piles require passing through soft soil layer or piles have variable cross-section, it may determine maximal stamping tension stress for pile shaft according to Table 5.8.12.

Table 5.8.12 Recommended Value for Maximal Stamping Tension Stress σ_t (kPa)

Stress type	Pile types	Recommended value	Emergent part
Axial stress in tension for piles	Prestressed concrete pipe pile	$(0.33\sim 0.5) \sigma_p$	① When pile steel is passing through soft soil layer; ② $(0.5\sim 0.7) l$ away from pile toe
	Concrete and prestressed-concrete piles	$(0.25\sim 0.33) \sigma_p$	
Tension stress of hoop stress or crossrange at pile section	Prestressed concrete pipe piles	$0.25 \sigma_p$	Corresponding sections of maximal stamping compressive stress
	Concrete and prestressed-concrete piles (crossrange))	$(0.22\sim 0.25) \sigma_p$	

3 Maximal stamping compressive stress and maximal stamping tension stress shall not exceed design value for compressive strength of concrete axle center and for tensile strength of axle center.

5.9 Pile cap calculation

I Bending calculation

5.9.1 Piled foundation cap shall be made with bending capacity calculation for normal section. Pile cap bending moment may be calculated according to articles 5.9.2~5.9.5 of this code and calculation for bending capacity and reinforcing bars may comply with current national standard "Code for Design of Concrete Structures" GB 50010.

5.9.2 Design value for normal sectional bending moment of independent piled foundation cap under the column may be calculated according to the following requirements:

1 Calculated section for bar pile cap of two piles and rectangular pile cap bending moment of multiple piles is near the column and at pile cap variable order section [figure 5.9.2 (a)], it may be calculated according to the following equation:

$$M_x = \sum N_i y_i \quad (5.9.2-1)$$

$$M_y = \sum N_i x_i \quad (5.9.2-2)$$

Where: M_x, M_y —Design values for bending moments at calculated section winding X -axis and Y -axis directions respectively;

x_i, y_i —Distance from direction perpendicular to Y -axis and X -axis to corresponding calculated section;

N_i —Vertical counterforce design value for the i^{th} foundation pile or composite foundation pile under basic combination of load effect when leaving out of pile cap and soil weight on it.

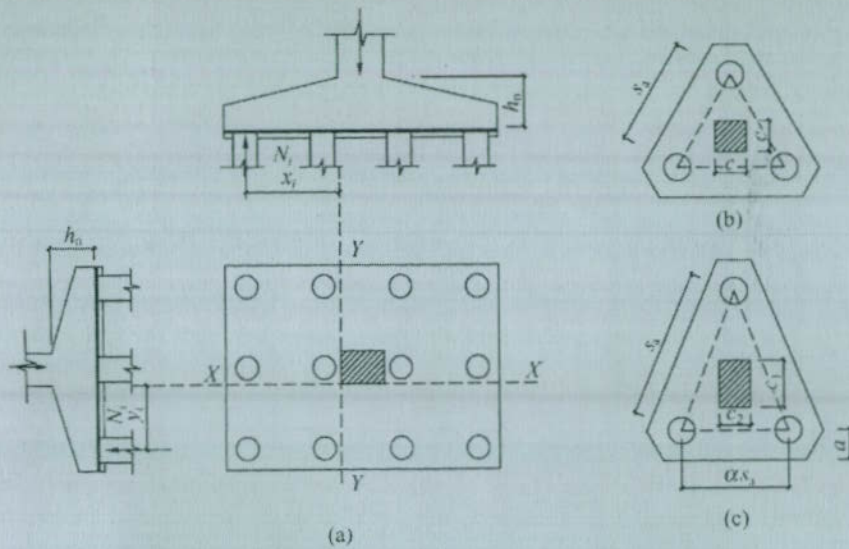


Figure 5.9.2 Calculated Schema for Bending Moment of Pile Cap

(a) Rectangular multiple-pile cap; (b) Equilateral three-pile cap; (c) Isosceles three-pile cap

2 Bending moment value of normal section of the three-pile cap shall meet the following requirements:

1) Equilateral three-pile cap [figure 5.9.2 (b)]

$$M = \frac{N_{\max}}{3} \left(s_a - \frac{\sqrt{3}}{4} c \right) \quad (5.9.2-3)$$

Where: M —Bending moment design value for sheet strip passing from pile cap centroid to perpendicular sections of all the side margins;

N_{\max} —Vertical counterforce design value for the maximal foundation pile or composite foundation pile among the three piles under basic combination of load effect when leaving out of pile cap and soil weight on it;

s_a —Pile center distance;

c —Square column side length, for column: $c = 0.8d$ (d is column diameter).

2) Isosceles three-pile cap [figure 5.9.2 (c)]

$$M_1 = \frac{N_{\max}}{3} \left(s_a - \frac{0.75}{\sqrt{4-\alpha^2}} c_1 \right) \quad (5.9.2-4)$$

$$M_2 = \frac{N_{\max}}{3} \left(s_a - \frac{0.75}{\sqrt{4-\alpha^2}} c_2 \right) \quad (5.9.2-5)$$

Where: M_1, M_2 —Bending moment design value for sheet strip passing from pile cap centroid to perpendicular sections of two waist margin and hemline margin;

s_a —Long-span pile center distance;

α —Ratio between short-span pile center distance and long-span pile center distance, when α is less than 0.5, it shall be designed according two-pile cap of the variable cross-section;

c_1, c_2 —Side lengths perpendicular to, parallel to column section of pile cap hemline respectively.

5.9.3 Bending moment of box pile cap and raft pile cap may be calculated according to the following requirements:

1 Bending moment of box pile cap and raft pile cap should consider soil layer property of foundation, foundation pile distribution, as well as pile cap and superstructure types and rigidity, and it shall make analytical calculation according to theory of foundation- pile- pile cap- superstructure combined action;

2 For box pile cap, when supporting course of pile tip is bedrock, dense debris soil, sandy soil and the depth and thickness is even. or when superstructure is shear wall, or superstructure is frame- kernel tube structure and pile layout is according to leveling for variable rigidity , box pile cap soleplate may only be calculated according to local bending moment action;

3 For raft pile cap, when supporting course of pile tip is deep, thick and stiff, superstructure rigidity is good and variance in column load and intercolumniation is not exceeding 20%, or when superstructure is frame- kernel tube structure and pile layout is according to leveling for variable rigidity, it may only be calculated according to local bending moment action.

5.9.4 Bending moment of bar pile cap beam under the column may be calculated according to the following requirements:

1 It may make analytical calculation according to beam on elastic foundation (computational model of foundation shall be selected according to characteristic of foundation soil layer);

2 When supporting course of pile tip is deep, thick and stiff and the pile column axial line is misaligning, it may regard piles as immobile hinged support and be calculated according to continuous beam.

5.9.5 Bar pile cap beam under masonry wall may calculate bending moment and shearing force according to inverse beam on elastic foundation and it shall meet the requirements of appendix G. For masonry wall on the pile cap, it shall also check local bearing strength for masonry on the pile top part.

II Punching calculation

5.9.6 Pile cap thickness of piled foundation shall meet the requirement for column (wall) to punching of pile cap and punching capacity of foundation pile to pile cap.

5.9.7 Piled foundation cap bearing punching from column (wall) under action of vertical force in axle center may be calculated according to the following requirements:

1 Punching failure cone shall be cone constituting of connecting line from column (wall) side or pile cap variable order to corresponding pile top margin and included angle between cone cant and pile cap bottom surface shall not be less than 45° (Figure 5.9.7).

2 Capacities bearing punching from column (wall) may be calculated according to the following equations:

$$F_l \leq \beta_{hp} \beta_0 u_m f_t h_0 \quad (5.9.7-1)$$

$$F_l = F - \sum Q_i \quad (5.9.7-2)$$

$$\beta_0 = \frac{0.84}{\lambda + 0.2} \quad (5.9.7-3)$$

Where: F_l —Design value for punching force acting on punching failure cone under basic combination of load effect leaving out of pile cap and soil weight on it;

f_t —Design value for tensile strength of pile cap concrete;

β_{hp} —Influence coefficient of cross-sectional height of pile cap bearing punching capacity, when $h \leq 800$ mm, β_{hp} is 1.0, when $h \geq 2000$ mm, β_{hp} is 0.9 and it takes value according to linear interpolation;

u_m —Perimeter at half effective height of punching failure cone for pile cap;

h_0 —Effective height of punching failure cone for pile cap;

β_0 —Column (wall) punching coefficient;

λ —Punching-span ratio, $\lambda = a_0/h_0$, a_0 is horizon distance from column (wall) side or variable order section of pile cap to pile side; when $\lambda < 0.25$, it takes $\lambda = 0.25$; when $\lambda > 1.0$, it takes $\lambda = 1.0$;

F —Vertical load design value of column (wall) bottom under basic combination action of load effect leaving out of pile cap and soil weight on it;

ΣQ_r —Sums of counterforce design value of foundation piles or composite foundation piles inside punching failure cone under basic combination of load effect leaving out of pile cap and soil weight on it.

3 Bearing capacity for rectangular independent pile cap under column bearing column punching may be calculated according to the following equation (figure 5.9.7):

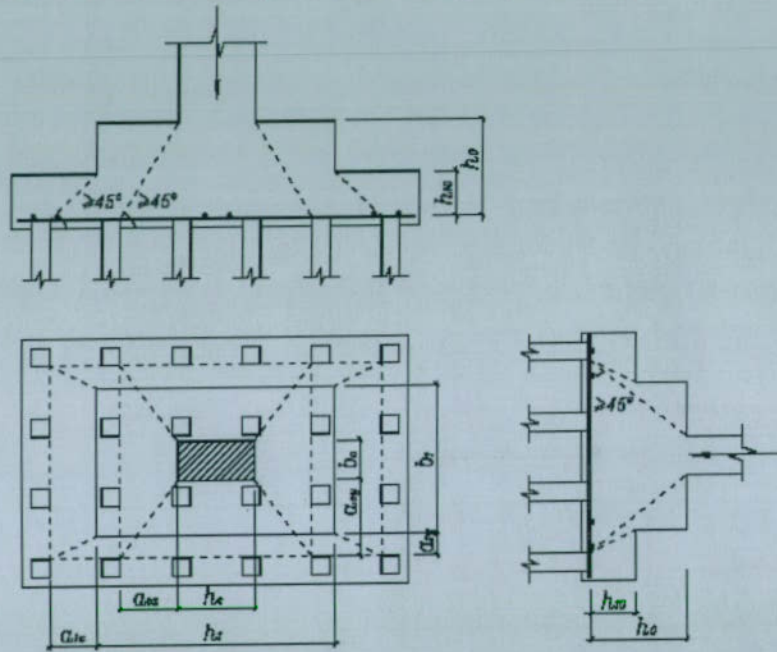


Figure 5.9.7 Calculated Schema for Punching on Column to Pile Cap

$$F_l \leq 2[\beta_{ox}(b_c + a_{oy}) + \beta_{oy}(h_c + a_{ox})]\beta_{hp}f_t h_0 \quad (5.9.7-4)$$

Where: β_{x0}, β_{y0} —Calculated according to equation (5.9.7-3), $\lambda_{x0} = a_{ox}/h$, $\lambda_{y0} = a_{oy}/h$; λ_{x0} and λ_{y0} shall meet the requirement of 0.25~1.0;

h_c, b_c —Side lengths of column section along x-axis and y-axis respectively;

a_{ox}, a_{oy} —Horizon distance from column side to nearest pile side along x-axis and y-axis respectively.

4 Bearing capacity with upper stepped of rectangular independent stepped pile cap under the column may be calculated according to the following equation (Figure 5.9.7):

$$F_l \leq 2[\beta_{1x}(b_1 + a_{1y}) + \beta_{1y}(h_1 + a_{1x})]\beta_{hp}f_t h_{10} \quad (5.9.7-5)$$

Where: β_{1x}, β_{1y} —Calculated according to equation 5.9.7-3, $\lambda_{1x} = a_{1x}/h$, $\lambda_{1y} = a_{1y}/h$; λ_{x0} and λ_{y0} shall both meet the requirement of 0.25~1.0;

h_1, b_1 —Side lengths of pile cap upper step along x -axis and y -axis respectively;

a_{1x}, a_{1y} —Horizon distance from pile cap upper-step side to nearest pile side along x -axis and y -axis respectively

For round column and round pile, it shall reduce its section to square column and square pile, that is section side length $b_c=0.8d_c$ (d_c is round column diameter) for conversional column, and side length $b_p=0.8d$ (d is diameter of round pile) for conversional pile section.

Two-pile cap under the column should be calculated with bending and shear capacity according to deep bending members ($l_0/h < 5.0, l_0=1.15 l_n, l_n$ is clear distance between two piles) and it shall not be made with calculation for punching capacity.

5.9.8 Foundation pile lying outside punching failure cone of column (wall) may be calculated with bearing capacity of pile cap bearing foundation pile punching according to the following requirements:

1 Bearing capacity of pile cap with more than four piles (including four piles) bearing angle column punching may be calculated according to the following equation (figure 5.9.8-1):

$$F_t \leq [\beta_{1x}(c_2 + a_{1y}/2) + \beta_{1y}(c_1 + a_{1x}/2)] \beta_{hp} f_t h_0 \quad (5.9.8-1)$$

$$\beta_{1x} = \frac{0.56}{\lambda_{1x} + 0.2} \quad (5.9.8-2)$$

$$\beta_{1y} = \frac{0.56}{\lambda_{1y} + 0.2} \quad (5.9.8-3)$$

Where: N_t —Counterforce design value for angle column (including composite foundation pile) under basic combination action of load effect when leaving out of pile cap and soil weight on it;

β_{1x}, β_{1y} —Angle column punching coefficients;

a_{1x}, a_{1y} —Horizon distance from pile top internal margin of pile cap basic angle leading a punching line with 45° angle with the crossover point of pile cap superface to internal margin of angle pile; when column (wall) side or pile cap variable order is lying within this 45° line, it takes connecting line of column (wall) side or pile cap variable order and pile anterior limb act as conical line for punching cone (Figure 5.9.8-1);

h_0 —Effective height for external margin of pile cap;

$\lambda_{x1}, \lambda_{y1}$ —Punching-span ratio of angle pile, $\lambda_{1x} = a_{1x}/h_0$, $\lambda_{1y} = a_{1y}/h_0$, its value shall meet the requirement of 0.25~1.0.

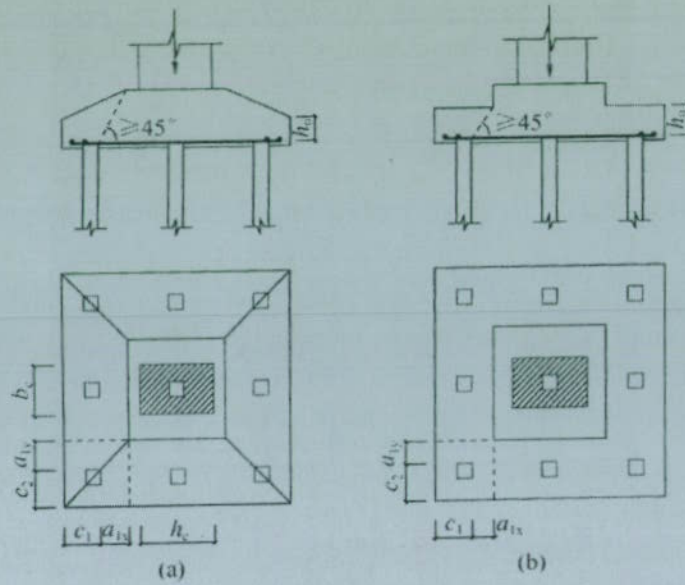


Figure 5.9.8-1 Calculated Schema for Pile Cap with more than Four Piles (including Four Piles) Bearing Angle Column Punching

(a) Conical pile cap; (b) Stepped pile cap

2 For three piles triangular pile cap, it may calculate bearing capacity bearing angle pile punching according to the following equations (Figure 5.9.8-2):

Bottom angle pile:

$$N_l \leq \beta_{11}(2c_1 + a_{11})\beta_{hp} \tan \frac{\theta_1}{2} f_t h_0 \quad (5.9.8-4)$$

$$\beta_{11} = \frac{0.56}{\lambda_{11} + 0.2} \quad (5.9.8-5)$$

Top angle pile:

$$N_l \leq \beta_{12}(2c_2 + a_{12})\beta_{hp} \tan \frac{\theta_2}{2} f_t h_0 \quad (5.9.8-6)$$

$$\beta_{12} = \frac{0.56}{\lambda_{12} + 0.2} \quad (5.9.8-7)$$

Where: $\lambda_{11}, \lambda_{12}$ —Angle pile punching-span ratio, $\lambda_{11} = a_{11}/h_0$, $\lambda_{12} = a_{12}/h_0$, their values shall meet the requirements of 0.25~1.0.

a_{11}, a_{12} —Horizon distance from pile top internal margin of pile cap basic angle leading a punching line with 45° angle with the crossover point of pile

cap superface to internal margin of angle pile; when column (wall) side or pile cap variable order is lying within this 45° line, it takes connecting line of column (wall) side or pile cap variable order and pile anterior limb act as conical line for punching cone;

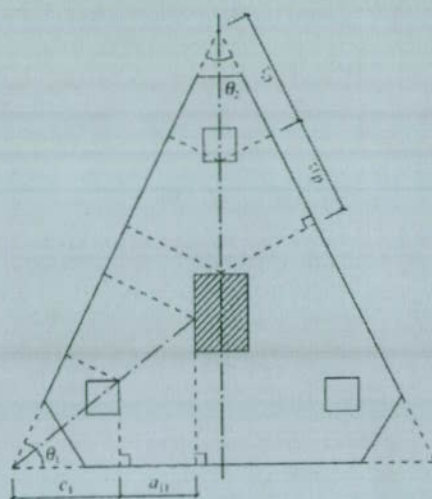


Figure 5.9.8-2 Calculated Schema for Angle Pile Punching on Three-pile Triangular Pile Cap

3 For box and raft pile cap, it may be calculated with punching capacity of pile cap bearing interior foundation pile according to the following equation:

- 1) It shall calculate punching capacity by foundation pile according to the following equation [Figure 5.9.8-3(a)]:

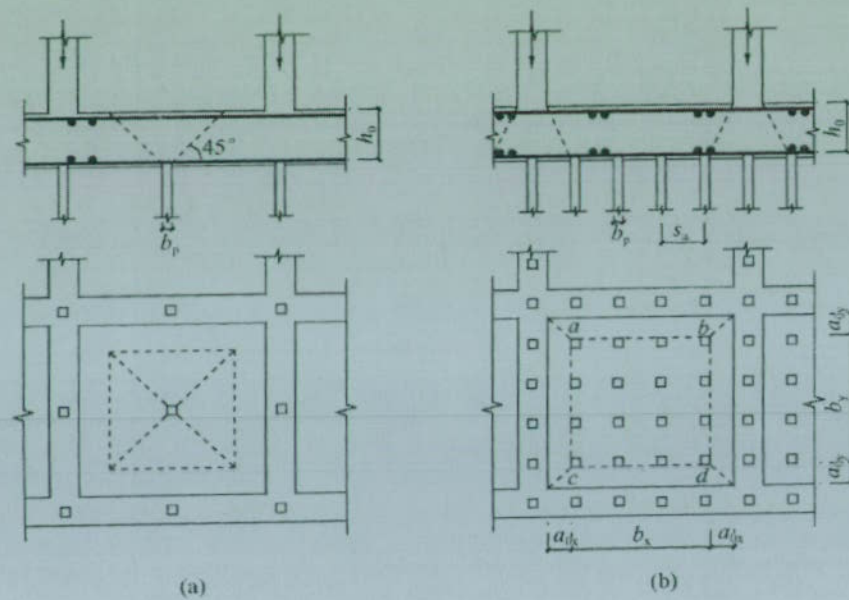
$$N_1 \leq 2.8(b_p + h_0)\beta_{hp}f_t h_0 \quad (5.9.8-8)$$

- 2) It shall calculate punching capacity by pile group according to the following equation [Figure 5.9.8-3(b)]:

$$\sum N_{1i} \leq 2[\beta_{0x}(b_y + a_{0y}) + \beta_{0y}(b_x + a_{0x})]\beta_{hp}f_t h_0 \quad (5.9.8-9)$$

Where: β_{x0}, β_{y0} —Calculated by equation 5.9.7-3, where $\lambda_{0x} = a_{0x}/h$ and $\lambda_{0y} = a_{0y}/h$; λ_{0x} and λ_{0y} shall meet the requirement of 0.25~1.0;

$N_1, \sum N_{1i}$ —Sums of counterforce design value for foundation pile or composite foundation pile and counterforce design value of all the foundation pile or composite foundation pile within punching cone under basic combination of load effect leaving out of pile cap and soil weight on it.



5.9.8-3 Calculated Schema for Punching on Foundation Pile to Raft Pile Cap and Wall to Raft Pile Cap

(a) Punching by foundation pile; (b) Punching by pile group

III Shearing calculation

5.9.9 Piled foundation pile cap under column (wall) shall check shear capacity for oblique section of run-through pile cap formed at column (wall) side, variable order section and pile side joint line. When overhanging side of pile cap has multi-row foundation pile and form multi-oblique section, it shall check shear capacity for all the oblique sections.

5.9.10 Shear capacity on oblique section of independent piled foundation cap under the column shall be calculated according to the following requirements:

1 Shear capacity on oblique section of pile cap may be calculated according to the following equation (Figure 5.9.10-1):

$$V \leq \beta_{hs} \alpha f_t b_0 h_0 \quad (5.9.10-1)$$

$$\alpha = \frac{1.75}{\lambda + 1} \quad (5.9.10-2)$$

$$\beta_{hs} = \left(\frac{800}{h_0} \right)^{1/4} \quad (5.9.10-3)$$

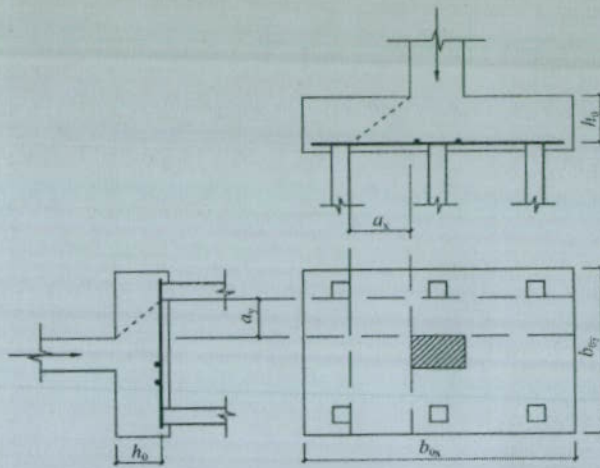


Figure 5.9.10-1 Calculated Schema for Oblique Section of Pile Cap Bearing Shear

Where: V —Design value for maximum shear of oblique section under basic combination of load effect leaving out of pile cap and soil deadweight on it;

f_t —Design value for tensile strength of pile cap axle center;

b_0 —Calculated width at pile cap calculated section;

h_0 —Effective height at pile cap calculated section;

α —Shearing factor of pile cap, it is determined according to equation (5.9.10-2);

λ —Shear-span ratio of calculated section, $\lambda_x = a_x/h$, $\lambda_y = a_y/h$, where, a_x and a_y are horizon distance from column side (wall side) or pile cap variable order section to calculated a row of pile side along y-axis and x-axis direction; when $\lambda < 0.25$, it takes $\lambda = 0.25$; when $\lambda > 3$, it takes $\lambda = 3$;

β_{hs} —Influence coefficient of cross-sectional height for shear capacity; when $h_0 < 800\text{mm}$, it takes $h_0 = 800\text{mm}$; when $h_0 > 2000\text{mm}$, it takes $h_0 = 2000\text{mm}$; where it takes value according to linear interpolation.

2 For stepped appearance pile cap, it shall make shear capacity calculation for oblique section at variable order section (A_1-A_1 and B_1-B_1) and column side section (A_2-A_2 and B_2-B_2) (figure 5.9.10-2).

When calculating shear capacity on oblique section of variable order section (A_1-A_1 and B_1-B_1), their sectional effective height are h_{10} and sectional calculated widths are b_{y1} and b_{x1} respectively.

When calculating shear capacity on oblique section of column side section (A_2-A_2 and B_2-B_2), their sectional effective height are $h_{10} + h_{20}$ and sectional calculated widths are:

$$\text{For } A_2-A_2, \quad b_{y0} = \frac{b_{y1} \cdot h_{10} + b_{y2} \cdot h_{20}}{h_{10} + h_{20}} \quad (5.9.10-4)$$

For B_2-B_2 ,

$$b_{x0} = \frac{b_{x1} \cdot h_{10} + b_{x2} \cdot h_{20}}{h_{10} + h_{20}} \quad (5.9.10-5)$$

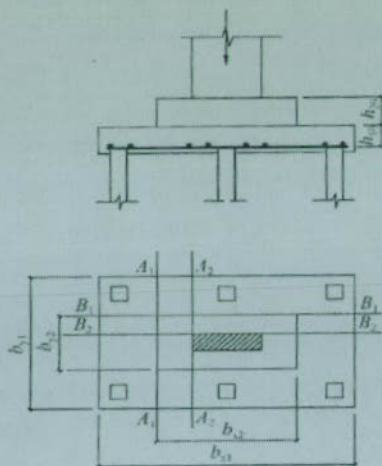


Figure 5.9.10-2 Shear Calculated Schema for Oblique Section of Stepped Pile Cap Figure

3 It shall make shear capacity calculation for two sections at variable order section and column side section ($A-A$ and $B-B$) for conical pile cap (Figure 5.9.10-3), and the sectional effective heights are h_0 and sectional calculates widths are:

For $A-A_1$

$$b_{y0} = \left[1 - 0.5 \frac{h_{20}}{h_0} \left(1 - \frac{b_{y2}}{b_{y1}} \right) \right] b_{y1} \quad (5.9.10-6)$$

For $B-B_1$

$$b_{x0} = \left[1 - 0.5 \frac{h_{20}}{h_0} \left(1 - \frac{b_{x2}}{b_{x1}} \right) \right] b_{x1} \quad (5.9.10-7)$$

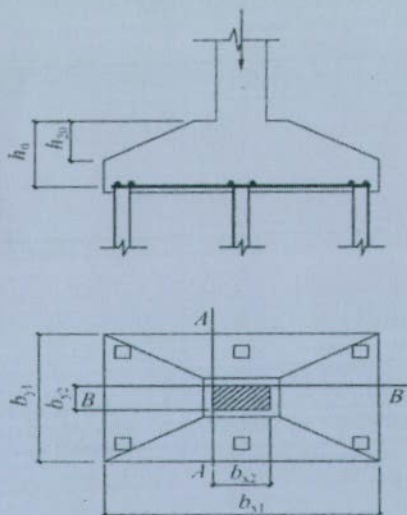


Figure 5.9.10-3 Shear Calculated Schema for Oblique Section of Conical Pile Cap

5.9.11 Shear capacity of beam slab-type raft pile cap beam may be calculated according to current national standard "Code for Design of Concrete Structures" GB 50010.

5.9.12 Bar pile cap beam under masonry wall is equipped with stirrup but, while if it hasn't bent steel bar, shear capacity of oblique section may be calculated according to the following equation:

$$V \leq 0.7 f_t b h_0 + 1.25 f_{yv} \frac{A_{sv}}{s} h_0 \quad (5.9.12)$$

Where: V —Design value for shearing force of calculated section under basic combination of load effect leaving out of pile cap and soil deadweight on it;

A_{sv} —Gross sectional area for limbs of stirrup deploying in the same section;

s —Spacing of stirrups along calculated oblique section;

f_{yv} —Design value for tensile strength of stirrup;

b —Calculated width at calculated section of pile cap beam;

h_0 —Effective height for calculated section of apron piece.

5.9.13 When pile cap beam under masonry wall is equipped with stirrup and bent bar, shear capacity oblique section may be calculated according to the following equation:

$$V \leq 0.7 f_t b h_0 + 1.25 f_y \frac{A_{sv}}{s} h_0 + 0.8 f_y A_{sb} \sin \alpha_s \quad (5.9.13)$$

Where: A_{sb} —Cross-sectional area of bent bar in the same section;

f_y —Design value for tensile strength of bent bar;

α_s —Included angle between bent bar and pile cap bottom surface on oblique section.

5.9.14 When bar pile cap beam under column is equipped with stirrup but not equipped with bent bar, its shear capacity of oblique section may be calculated according to the following equation:

$$V \leq \frac{1.75}{\lambda + 1} f_t b h_0 + f_y \frac{A_{sv}}{s} h_0 \quad (5.9.14)$$

Where: λ —Shear-span ration of the calculated section, $\lambda_0 = a/h_0$, a is horizontal distance from column side to pile side; when $\lambda < 1.5$, it takes $\lambda = 1.5$; when $\lambda > 3$, it takes $\lambda = 3$.

IV Calculation for local pressure

5.9.15 For piled foundation under column, when strength level of pile cap concrete is lower than that of column or pile, it shall check local pressure bearing capacity under column or above pile cap.

V Checking for earthquake resistance

5.9.16 When checking earthquake resistance for the pile cap, it shall comply with current national standard "Code for Seismic Design of Buildings" GB 50011 and make earthquake resistance adjustment for earthquake effect on pile cap superface and for bending, punching and shear capacity of pile cap.

6 Filling Pile Construction

6.1 Preparations for Construction

6.1.1 Filling pile construction shall be provided with following materials:

- 1 Geotechnical engineering reconnaissance report of building site;
- 2 Pile foundation engineering construction drawing and drawing trial summary;
- 3 Survey data about underground pipeline, underground structure, dangerous premise and precise instrument workshop of building site and neighboring areas;
- 4 Materials in technical performance of main construction machine and its associated facilities;
- 5 Preliminary work for pile foundation engineering construction;
- 6 Quality examination report for raw materials ad products such as cement, granule, rock and rebar;
- 7 Experiment reference data about load and construction process.

6.1.2 The selection of drilling machine and process shall be identified comprehensively in accordance with pile type, drilling depth, soil layer condition, slurry expelling and treatment conditions.

6.1.3 For preliminary work for construction, corresponding quality management measures shall be established on the base of engineering characteristic, and the measures shall covers following contents:

- 1 Construction plan: clearly indicate pile position, code, construction sequence, water and electricity lines and temporary facilities positions; clearly indicate slurrying facility and its circulation system when slurry encasing pore-forming is adopted;
- 2 Identify related documents on hole-making contender, associated facilities and proper construction process, and slurry encasing filling pile must be available with slurry handling measures;
- 3 Construction operation plan and work force organization plan;
- 4 Mechanical equipment, awaiting parts, tools and materials supply scheme;
- 5 During the pile foundation construction, measures for safety, labor protection, fire

prevention, rain protection, typhoon protection, blasting operation, historical relics protection and environmental protection shall comply with relative regulations;

6 Technical measures to guarantee engineering quality, safety in production and seasonal construction.

6.1.4 Piling machine must be qualified and ineligible ones shall not be applied.

6.1.5 Before the construction, drawing trial shall be taken out, and the trial summary combined with construction drawing shall be regarded as the manufacture bases and filed in the engineering record.

6.1.6 Temporary facilities including water supply power supply, road, drainage and tabernacles for pile foundation construction must be all set previous to the construction starting, and the flat set of construction site shall be taken out to ensure the normal operation of construction machines.

6.1.7 Control point and reference point of foundation pile axial line shall be arranged at the position free from the construction effects. Previous to the starting, the control point and the reference point shall be protected properly after rechecking, and re-surveyed often under the construction.

6.1.8 The performance index of instruments and devices for construction quality inspection shall meet provisions in relevant current national standards.

6.2 General Provisions

6.2.1 Applying conditions of different pile types shall meet following provisions:

1 Drilled and grouted pile with slurry encasing should be applied in cohesive soil, silty soil, sandy soil, filling soil, soil aggregate and decayed rock below underground water level;

2 Rotary drilling cast-in-place pile should be applied in cohesive soil, silty soil, sandy soil, filling soil, soil aggregate and decayed rock underground water level;

3 Besides above geologic conditions, impact-cone concrete pile may penetrate obstacles such as old foundation, builders rubbish filling or large lodestone.

But the impact-cone concrete pile shall be cautious to apply. If it is adopted, the density of test holes shall be increased

4 Long bolt cast in situ bored pile behind infixed with reinforcing cage should be applied in cohesive soil, silty soil, sandy soil, filling soil, uncompacted crackle soil and intense weathering rock;

5 Digging filling pile and dry work drilling should be applied in cohesive soil, silty soil, filling soil, medium compact sandy soil and decayed rock above underground water level;

6 If the underground water level is higher, manual digging filling pile shall not be adopted on sandy soil layer, aquiclude, thicker fluid plastic silt and silt soil layer with pressure water;

7 Filling piles with sink-pipe should be applied in cohesive soil silty soil and sandy soil; rammed pedestal pile should be applied in low-compressibility cohesive soil, silty soil, sandy soil and crackle soil that the buried depth of supporting course is not larger than 20m.

6.2.2 Pore-forming implements must be leveled and stabilized to prevent inclination and deviation on the pore-forming procedure. A ruler indicating the controlling depth shall be arranged on the pore-forming drilling tool and the indications shall be conveyed and recorded in the construction.

6.2.3 The controlling depth of pore-forming shall meet following requirements:

1 Friction-type pile: for friction pile, the pore-forming depth shall be controlled according to the design pile length; for end-support friction pile, the design pile length and the depth of pile tip entering into the supporting course must ensured. Sramming pipe-sinking pore-forming method is adopted, the buried depth of pile pipe shall be controlled mainly based on the elevation, and subsidiarily according to the length of penetration.

2 End-bearing pile: when drilling (punching) and digging pore-forming is adopted, the designed depth of pile tip entering into the supporting course must be ensured; if the sramming pipe-sinking pore-forming method is adopted, the pipe-sinking depth shall be controlled based on the length of penetration, and subsidiarily according to the design supporting course elevation.

6.2.4 The permissible deviation of filling pile pore-forming construction shall meet requirements in Table 6.2.4.

6.2.5 Manufacturing and installing quality of reinforcing cage shall meet following requirements:

1 Material and dimension of reinforcing cage shall meet the design requirements, and the permissible manufacturing deviation shall meet provisions in Table 6.2.5;

2 For reinforcing cage made by subsection, the joints should be welded or mechanical type (the bar diameter is larger than 20mm), and the joints shall meet provisions in current national standard "General Technical Specification for Mechanical Splicing of Bars" JGJ 10, "Specification for Welding and Acceptance of Reinforcing Steel Bars" JGJ 18 and "Code for Acceptance of Constructional Quality of Concrete Structures";

Table 6.2.4 Permissible Deviation of Filling Pile Pore-forming Construction

Pore-forming Method		Pile Diameter Deflection (mm)	Verticality Permissible Deviation (%)	Pile Position Permissible Deviation (mm)	
				1~3 piles, strip pile foundation along normal axis direction, and side piling of clustered-pile foundation	Strip pile foundation along axial direction and center pile of clustered-pile foundation
Slurry encasing drilling, digging and punching piles	$d \leq 1000\text{mm}$	≤ -50	1	$d/6$ and not larger than 100	$d/4$ and not larger than 150
	$d > 1000\text{mm}$	-50		$100+0.01H$	$150+0.01H$
Sramming (vibrating) pipe-sinking vibro-impact pore-forming	$d \leq 500\text{mm}$	-20	1	70	150
	$d > 500\text{mm}$			100	150
Spiral drill and automotive drive pipe dry-work pore-forming filling pile		-20	1	70	150
Manual hole pile	Cast-in-place concrete encasing	± 50	0.5	50	150
	Long steel sleeve encasing	± 20	1	100	200

Note: 1 The negative value of pile diameter permissible deviation refers to a few of sections;

2 H refers to the distance from the construction Site ground elevation to the pile top design elevation; d refers to the design pile diameter.

Table 6.2.5 Permissible Manufacturing Deviation of Reinforcing Cage

Item	Permissible Deviation (mm)
Main Reinforcement Spacing Interval	± 10
Stirrup Rebar Spacing	± 20
Reinforcing Cage Diameter	± 10
Reinforcing Cage Length	± 100

3 Stiffening hoop should be arranged on the exterior of the main reinforcement. And the stiffening hoops may be arranged on the inside of the main reinforcement if the construction process has special requirements.

4 The outside diameter of pipe joint shall be over 100mm less that the inner diameter of the reinforcing cage;

5 When the reinforcing cage is handled and hoisted, the deformation shall be prevented, and the emplacement shall aim at the hole site. Bumping the hole wall and free dropping shall be prevented and the reinforcing cage shall be fixed immediately after the emplacement.

6.2.6 The coarse aggregate may be pebble or crackle, and the aggregate size shall not be larger than the $\frac{1}{3}$ of the minimum clear distance of the reinforcing bar spacing.

6.2.7 Once the pore-forming is eligible, concrete shall be filled as soon as possible. For pile which the diameter is larger than 1m or the individual pile concrete volume exceeds 25m^3 , a group of test pieces shall be reserved for concrete of each pile foundation; for pile which the diameter is not larger than 1m or the pile which the individual pile concrete volume is not larger than 25m^3 , the each grouting working group shall not be less than one; 3 test pieces shall be reserved for each grouting group.

6.2.8 Previous to pile construction, trial pore-forming should be taken out.

6.2.9 Implement, facility, safety device, tool attachments and personal labor protection articles shall be inspected often to guarantee soundness and safety.

6.3 Slurry Encasing Pore-forming Filling Pile

I Slurry Preparation and Treatment

6.3.1 Except the cohesive soil layer that can prepare slurry by itself, slurry shall be prepared on other conditions. High-ductility clay or bentonitic clay shall be adopted for the slurry preparation. The mix design of slurry shall be taken out in accordance with construction machine, process and soil layer.

6.3.2 Slurry encasing shall meet following provisions:

1 The slurry in protecting tube shall be 1.0m higher than the underground water level during the construction; if the slurry is affected by the underground water level, the slurry level shall be 1.5m higher than the highest water level.

2 During the hole cleanout process, the slurry shall be replaced continuously till underwater concrete pouring;

3 Before placing concrete, the mud specific gravity within 500mm in the hole toe shall be less than 1.25; the sand factor shall not be larger than 8%; the viscosity shall not be larger than 28s;

4 The measures to maintain the stability of the hole wall shall be available for the soil layer that is easy to occur the slurry leaking.

6.3.3 Discarded slurry and residue shall be treated and shall pollute the envelopment.

II. Construction of normal and reverse circulation drilled and grouted pile

6.3.4 For end-bearing pile with larger hole depth and friction-type pile in the coarse-grained soil layer, reverse circulation process should be adopted to achieve pore-forming or hole cleanout, and normal circulation drilling and reverse circulation hole cleanout may be adopted according to the soil layer condition.

6.3.5 When slurry encasing pore-forming is taken out, hole open protecting tube shall be adopted, and the protecting tube shall be arranged in accordance with following provisions:

1 The protecting tube shall be buried accurately and stably, and the deflection from the protecting tube center to the pile position center shall not be larger than 50mm;

2 The protecting tube may be made of 4~8mm thick steel plate, and the inner diameter shall be 100mm larger than the bit diameter. The 1~2 overflow holes shall be arranged on the upper position;

3 The burying depth of protecting tube: in cohesive soil, it should not be less than 1.0m; in sandy soil, it should not be less than 1.5m. The lower end exterior of the protecting tube shall be sealed through clay soil; the height shall meet the requirements of the height of hole slurry level;

4 For drilled and grouted pile that is affected by water level fluctuation or is constructed under water, the protecting tube shall be heightened and deepened, and impermeable layer shall be driven in case of need.

6.3.6 When drilling is taken out in soft soil layer, the drill speed shall be controlled according to the slurry supply condition; the drill speed in hard coating or rock stratum shall be proper when the drilling machine does not jump.

6.3.7 The guiding device for the drilling machine shall meet following provisions:

1 The drill of diving driver shall be arranged with a guiding device which is not smaller than 3 times of Diameter length;

2 If the drill-compressive normal circulation slewing drilling machine is adopted, the drilling tool shall be arranged with the centralizer.

6.3.8 If phenomena like inclined hole, hole collapse, slurry overflowing around the protecting tube and instability occur, the drilling shall be suspended. When corresponding measures are taken out properly, the drilling is continued.

6.3.9 When the drilling reaches the designed depth, the thickness index of hole toe sediment shall meet following provisions before concrete grouting:

- 1 For end-bearing pile, the thickness shall not be larger than 50mm;
- 2 For friction-type pile, the thickness shall not be larger than 100mm;
- 3 For pullout resisting and water-resistant pile, the thickness shall not be larger than 200mm.

III Construction of impacting pore-forming filling pile

6.3.10 The equipment to ensure automatic steering of the drill shall be arranged between the drill cone apex and the hoisting cable.

6.3.11 For punching pile hole-open protecting tube, the inner diameter shall be 200mm larger than the bit diameter, and the protecting tube shall be arranged in accordance with Article 6.3.5 of this standard.

6.3.12 Preparation, usage and treatment of slurry shall meet provisions in Article 6.3.1~6.3.3 of this standard.

6.3.13 The quality control of impacting pore-forming shall meet following provisions:

1 When the pore is opened, hammer shall be hit fast and lower. if the surface soil is soft soils like silt and fine sand, clay block combined with little slabstone is adopted to repeatedly impact and build the wall, and the slurry in the hole shall be kept stable.

2 Pore-forming in different soil layers and rock stratum may be taken out in accordance with operating points specified in Table 6.3.13;

3 When the drilling enters the bedrock, impact of larger stroke and low frequency shall be adopted. if the pore-forming deviates, slabstones shall be backfilled 300~500mm position above the deviation hole, and punching is continued;

4 When the drilling meets boulder, pre-blasting or high and low stroke alternate impact may be adopted to shatter the large boulder or impact the boulder into the hole wall.

5 Effective technical measures shall be taken out to prevent harassing hole wall, hole collapse, enlarging hole, drill sticking, drill falling and slurry draining;

6 The hole shall be checked a time every 4~5m drilling, and the hole shall be checked before bit changing or on the position of easy shrinkage hole;

7 When the drilling enters into the bedrock, hole cleanout and sampling shall be taken out a time every 300~500mm drilling depth for non pile tip supporting course, and every 100~300mm drilling depth for pile tip supporting course, and hole cleanout and sampling shall be recorded.

Table 6.3.13 Operating Points of Impacting Pore-forming

Item	Operating Point
Within 2m blow the protecting tube foot blade	Little stroke about 1m, the mud specific gravity 1.2~1.5, clay block and little slabstone are put into the soft soil layer
Cohesive soil layer	Medium and little stroke 1m~2m, pump fresh water or thin mud, often clear away grog from the drill
Mealy sand or medium coarse sand layer	Large stroke 2m~3m, mud specific gravity 1.2~1.5, clay block is put into, washing and residue removing are taken out frequently
Granule pebble layer	Medium and high stroke 3m~4m, mud specific gravity about (density) 1.3, residue removing are taken out frequently
Soft-weak soil layer or hole collapse backfill redriling	Little stroke repeatedly impacts, clay block and little slabstone are put into the clay soil layer, mud specific gravity 1.3~1.5

Note: 1 If the soil layer is unfavorable, the mud specific gravity may be increased, or clay blocks may be added;

2 For Sticking-resisting drill, brickbats may be added.

6.3.14 For residue discharging, mud circulation or residue drawing tank may be adopted. If the residue drawing tank is adopted, slurry shall be supplied in time.

6.3.15 Phenomena like inclined hole, bent hole, plum blossom hole, hole collapse, slurry overflowing around the protecting tube and instability occur in hole punching, the drilling shall be suspended. When corresponding measures are taken out properly, the drilling construction may be continued.

6.3.16 The pore-forming of major-diameter pile hole can be achieved by level, and the pore-forming diameter of first level shall be 0.6~0.8 times of the design pile diameter.

6.3.17 The hole cleanout shall be taken out in accordance with following provisions:

1 For pile hole that is uneasy to suffer hole collapse, soil suction air may be adopted to clean up the hole;

2 For hole wall with poor stability, mud circulation or residue drawing tank shall be adopted to discharge residue, and the index of slurry before concrete grouting shall meet provisions of Article 6.3.1 of this standard;

3 During the hole cleanout, the slurry in the hole shall meet provisions in Article 6.3.2 if this standard;

4 Before concrete grouting, the allowable thickness of hole toe sediment shall meet provisions in Article 6.3.9 of this standard.

IV Construction of rotary drilling cast-in-place pile

6.3.18 For rotary drilling cast-in-place pile, dry-work pore-forming and slurry encasing pore-forming processes shall be adopted in accordance with different stratigraphy and underground water buried depth. The dry-work pore-forming process may comply with Section of this standard.

6.3.19 Slurry encasing rotary drilling machine pore-forming shall be equipped with slurry and slurry pond (tank) for pore-forming and hole cleanout, and the measures for maintaining the stability of the hole wall such as increasing the mud specific gravity, sawdust dosing and tackifier increasing the slurry viscosity may be adopted for soil layer with easy slurry leaking.

6.3.20 The ability for slurry preparation shall be larger than the demand volume of slurry in drilling, and the slurry reserve volume for each set drilling machine shall not be less than the volume of individual pile.

6.3.21 During the construction of rotary drilling machine, the stability and safe operation of machine shall be ensured, and steel plate or under-layer (roadbed plate) shall be arranged to ensure safe moving and operation if necessary.

6.3.22 Steel protecting tube shall be arranged for each pile, and the protecting tube shall meet provisions in Article 6.3.5 of this standard.

6.3.23 Before pore-forming and drawing-out drilling of each time, joint pin between drilling bucket and drill stem, drilling bucket door joint pin and steel wire rope shall be inspected, and residue in drill bit shall be removed.

6.3.24 For rotary drilling machine pore-forming, jump excavating shall be adopted. Soil spilled from the drilling bucket shall be larger than 6m away from the pile open, and shall be cleared away in time. The slurry shall be supplemented synchronously in accordance with the drill speed, and the slurry level shall be kept constant.

6.3.25 If the drilling reaches the designed depth, the scouring bit shall be adopted to do hole cleanout, and the hole cleanout shall meet requirements in Article 6.3.2 and 6.3.3 in this standard. The thickness control index of hole toe sediment shall meet provisions in Article 6.3.9 of this standard.

V Underwater Concrete Grouting

6.3.26 After the reinforcing cage hoisting is completed, secondary hole cleanout of conduit or air pump pipe shall arranged and combined with inspections of hole site, bore diameter,

verticality, hole depth and sediment thickness. If the inspections are all qualified, concrete grouting shall be taken out immediately.

6.3.27 Underwater concrete grouting shall meet following provisions:

1 Underwater concreting must be available with favorable placeability, the mixing proportion shall be identified through the experiment; the slump should be 180~220mm; the cement consumption shall not be less than 360kg/m^3 (when powdered coal ash is dosed, the cement consumption is not limited);

2 The sand content of underwater concreting should be 40%~50%, and medium coarse sand should be adopted; the maximum particle diameter of coarse aggregate shall be less than 40mm; above parameters shall meet requirements in Article 6.2.6 of this standard;

3 Admixtures should be dosed for underwater concreting.

6.3.28 Structure and usage of conduit shall meet following provisions:

1 The conduit wall thickness should not be less than 3mm, the diameter should be 200~250mm; the manufacturing deflection of the diameter shall not exceed 2mm, the segment length of conduit may be identified according to the process requirements, the length of floor tubes should not be less than 4m, and the joints should be double thread square-buckle quick joint;

2 Trial assemble and pressure test shall be taken out before the conduit usage, the test pressure and trial water pressure may be 0.6~1.0MPa;

3 Conduit inside and outside shall be cleaned after each grouting.

6.3.29 Adopted water exclusion faucet shall have favorable impermeability, and ensure water discharge smoothly; water exclusion faucet should be bladder type, and made of pea gravel concrete same to the pile foundation in concrete strength grade.

6.3.30 The quality control of underwater concrete grouting shall satisfy following requirements:

1 When the concrete grouting is started, the distance from the conduit bottom to the hole toe should be 300~500mm;

2 Enough concrete reserve volume shall be available, and the conduit shall be buried under the grouting level not less than 0.8m;

3 The depth of conduit burying into concrete should be 2~6m. The conduit must not be drawn out from the concrete grouting level, and the velocity of conduit drawing shall be controlled. and persons shall be specially assigned for measuring the conduit buried depth and

the height difference of conduit inside and outside concrete grouting level, and doing the records about underwater concrete grouting;

4 Underwater concrete grouting construction shall be taken out continuously, and the grouting time of each pile shall be controlled according to the initial setting time of last plate concrete, and the malfunction during the grouting process shall be recorded and filed;

5 The grouting volume for the last time shall be controlled, the overfilling height should be 0.8~1.0m, and after the bleeding height is reduced, the strength of pile top concrete must reach the Design Level.

6.4 Long Bolt Cast In-Situ Bored Pile

6.4.1 When the diving penetrates aged clay, heavy I sandy soil, soil aggregate and clay which the plasticity index is larger than 25, test drilling shall be taken out.

6.4.2 After rig spotting, rechecking shall be taken out, the deflection of drilling bit and pile site shall not be larger than 20mm, and the drill falling speed shall be lower; the reversal drilling and drier breakout should not be done.

6.4.3 In drilling progress, once drill pipe sticking, drilling machine swinging, deflexion or abnormal sound occur, the drilling shall be stopped immediately. When the reasons are ascertained and corresponding measures are taken out, the operation may be continued.

6.4.4 The proportioning of concrete shall be identified through the experiment in accordance with the design strength grade of pile foundation concrete; the slump of concrete shall be 180~220mm; the coarse aggregate may be pebble or crackle and the maximum particle diameter should not be larger than 30mm; powdered coal ash or admixtures may be dosed.

6.4.5 The type of concrete pump shall be selected in accordance with pile diameter, the pipes for concrete pump shall be arranged to reduce the pipe bending, and the distance from the concrete pump to the drilling machine shall not be larger than 60m.

6.4.6 Pumping grouting of pile foundation concrete shall be kept continuously, and concrete in concrete pump hopper shall be stirred continuously when drilling machine is moved, and the height of concrete in the hopper shall not be less than 400mm while the concrete is pumped.

6.4.7 The concrete pump pipes should be kept horizontal, and the pump pipes shall be padded solidly when the concrete is transferred by pump at long distance.

6.4.8 When the air temperature is higher than 30°C, the heat insulating material shall be covered on the transfer pump pipes, and the transfer pump pipes shall be cooled by watering at intervals.

6.4.9 When the drilling reaches the design elevation, the concrete shall be pumped in and paused for 10~20s, and the drill stem is lifted slowly. The velocity of drill stem shall be identified according to the soil layer condition, and shall cooperate with the transfer capacity of the concrete pump to ensure the certain height of concrete in the conduit.

6.4.10 When the drilling is taken out in sandy soil below the underground water level, the measures to prevent water incoming shall be prepared for drill stem bottom valve, and the guncreting shall be taken out continuously.

6.4.11 The filling coefficient of pumping bored pile should be 1.0~1.2. The overfill height of pile top concrete should not be less than 0.3~0.5m.

6.4.12 After piling, the residual concrete in drill stems and pump (soft) pipes shall cleared away in time. Drill stem, pump pipe and concrete pump shall be cleaned by fresh water if they are unused for a long time.

6.4.13 After finishing concrete filling, the reinforcing cage shall be inserted into the designed depth. Special steel dowel machine should be adopted for reinforcing cage inserting.

6.5 Filling Piles with Sink-pipe and Inner Ramming Filling Piles with Sink-pipe

I. Construction of sramming filling piles with sink-pipe

6.5.1 The construction of sramming filling piles with sink-pipe shall be taken out in accordance with soil quality condition and load requirement, and single sramming method, re-sramming method and back-insertion method may be adopted respectively.

6.5.2 The construction of sramming filling piles with sink-pipe shall meet following provisions:

1 For construction of clustered piles foundation, the technical measures of reducing negative squeezing effect shall be taken out to guarantee piling quality in accordance with soil quality and piling condition;

2 Processing quality and burial position of pile pipe, concrete pre-molded pile tip or steel pile tip shall match the design, and the connection of pile pipe and pile tip shall be sealed favorably.

6.5.3 Operation control of grouting concrete and tube drawing shall meet following provisions:

1 When the tub sinks to the design elevation, conditions like soil incoming, water incoming and swallowing pile tip shall be checked and treated immediately and the concrete grouting shall be taken out at once.

2 If the pile foundation is arranged with partial length of reinforcing cage, the concrete shall be firstly grouted to the cage bottom elevation and than to the pile top elevation. The height of first tube drawing shall be limited by the volume containing the volume of second concrete grouted-in, and the tube shall not be lifted to high. In tube drawing process, plumb bob or float shall be adopted to test the concrete level dropping condition;

3 The tube drawing velocity shall be kept uniform, the tube drawing velocity for normal soil layer should be 1m/min, and the tube drawing velocity for soft-weak solid layer and soft-solid soil juncture should be 0.3~0.8m/min;

4 The number of backward-strike tube drawing, for single-acting steam hammer, shall not be less than 50 times/min, for free dropping hammer little drop distance, the number shall not be less than 40 times /min; before the tube base has not drawn out to the pile top design elevation, backward-strike and rapping shall not be paused.

6.5.4 The filling coefficient of the concrete shall not be less than 1.0; for pile which the filling coefficient is less than 1.0, the full-length re-sramming shall be taken out. For pile with possible breaking and necking-down, partial re-sramming shall be adopted. The top surface of pile foundation concrete after piling shall be 500mm higher than the pile top design elevation. When the full-length re-ramming is taken out, the buried depth of pile pipe should be close to the original pile length, and the partial re-ramming shall be 1m higher than broken pile and necking-down.

6.5.5 The construction of full-length re-ramming pile shall meet following provisions:

- 1 First grouting concrete shall reach natural ground;
- 2 In the tube drawing process, concrete on pipe wall and round shall be cleared away in time;
- 3 The pile axis of first ramming and re-temping shall coincide with each other;
- 4 Re-sramming construction must be completed before the filled concrete initial set.

6.5.6 The slump of concrete should be 80~100mm.

II Construction of vibration and vibro-impact filling piles with sink-pipe

6.5.7 The construction of vibration and vibro-impact filling piles with sink-pipe shall be taken out in accordance with soil quality condition and load requirement, and single sramming method, re-sramming method and back-insertion method may be adopted respectively. The single ramming method may be adopted for the soil layer with less liquid-water content, and premolded pile tip should be adopted; back-insertion method and re-sramming may be adopted for saturated soil layer.

6.5.8 The quality control of the single ramming method for the construction of vibration and vibro-impact filling piles with sink-pipe shall meet following provisions:

1 Electric current and voltage of last 30s must be controlled strictly, and the values shall be identified in accordance with the design requirements or experiences of trial pile and local experience;

2 After the pile pipe is filled with concrete, the concrete shall be firstly vibrated for 5~10s, and then the tube is taken out. Vibrating and drawing are synchronous, the tube drawing is paused ever 0.5~1.0m drawing, and the vibration is done for 5~10s; the process is repeated once again till the pipe is drawn out completely.

3 For normal soil layer, the tube drawing velocity should be 1.2~1.5m/min. if the movable pile tip is adopted, the tube drawing velocity should be lower, for premolded pile tip, the velocity may be increased; for soft-weak soil layer, the tube drawing velocity should be 0.6~0.8 m/min.

6.5.9 The quality control of the back-insertion method for the construction of vibration and vibro-impact filling piles with sink-pipe shall meet following provisions:

1 After the pile pipe is filled with concrete, the concrete shall be vibrated firstly and then the tube drawing is taken out. the height of each tube drawing may be 0.5~1.0m, and the back-insertion depth may be 0.3~0.5m; in tube drawing process, the concrete shall be filled by subsection, the level of concrete in the pipe shall be always not be lower than the ground surface, or the level shall be 1.0~1.5m higher than the underground water level, and the tube drawing velocity shall be less than 0.5m/min;

2 Within 1.5m away from the pile tip, back-insertion should be taken out many a time to enlarge the pile tip section;

3 When the drilling permeates the silt interlayer, the tube drawing velocity shall be decreased, and the tube drawing height and the back-insertion depth shall also be reduced. The back-insertion method should not be adopted in liquid silt.

6.5.10 The construction of vibration and vibro-impact filling piles with sink-pipe re-ramming method may comply with provisions in Article 6.5.4 and 6.5.5 of this standard.

III Construction Of Inner Ramming Filling Piles with Sink-pipe

6.5.11 When the combination of outer tube and inner ramming pipe is adopted to stamp sinking tube for tamp pressure, base enlarging and hole enlargement, the ramming pipe shall be 100mm shorter than the outer tube, and the bottom of inner ramming pipe may be enclosed flat bottom or enclosed tapered bottom (detailed in Figure 6.5.11).

6.5.12 For outer tube bottom closing, no-slump concrete and anhydrous concrete proportioning may be adopted to be tamped as waterproofing and mud-blocking stopcock. The height may be 100mm. If clearance water inflow does not occur between inner and outer tubes, above bottom closing measure may be neglected.

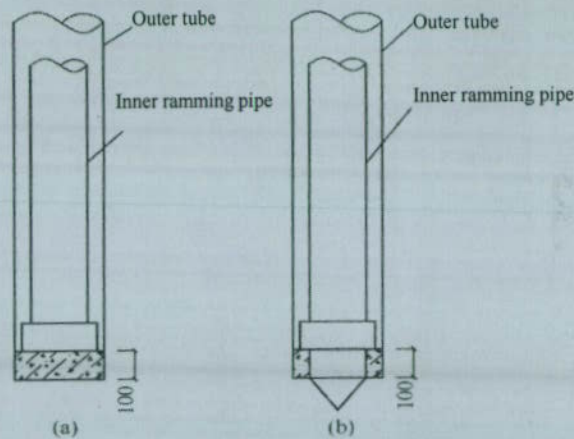


Figure 6.5.11 Inner and Outer Tubes and Stopcock

(a) Flat bottom inner ramming tube; (b) Tapered bottom inner ramming tube

6.5.13 The average diameter of pile tip ramming enlarged end may be calculated according to following formula:

First ramming enlarge

$$D_1 = d_0 \sqrt{\frac{H_1 + h_1 - C_1}{h_1}} \quad (6.5.13-1)$$

Second ramming enlarge

$$D_2 = d_0 \sqrt{\frac{H_1 + H_2 + h_2 - C_1 - C_2}{h_2}} \quad (6.5.13-2)$$

Where: D_1, D_2 —Average diameter of first and second ramming enlarged ends (m);

d_0 —Outer tube diameter (m);

H_1, H_2 —The height of grouted concrete in the outer tube that is counted from the pile toe in first and second ramming enlarge processes (m);

h_1, h_2 —The up-pull height of the outer tube that is counted from the pile toe in first and second ramming enlarge processes (m), may be respectively as $H_1/2$ and $H_2/2$;

C_1, C_2 —The distance (m) of sinking inner and outer tubes to the pile toe in first and second ramming enlarge processes, may be 0.2m (Figure 6.5.13).

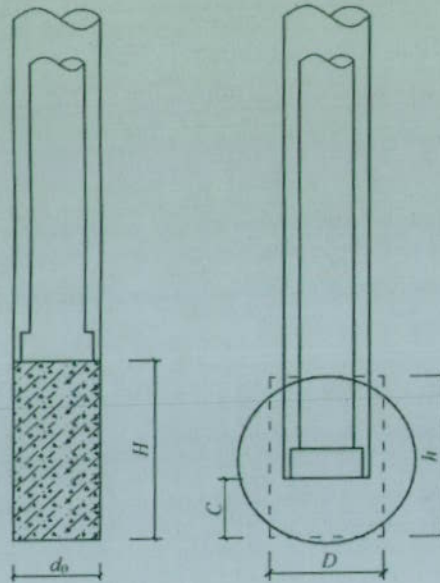


Figure 6.5.13 Enlarged Base End

6.5.14 The pile foundation concrete should be grouted by subsection; the inner ramming pipe and the drilling hammer shall press against the top surface of the concrete in the outer tube during tube drawing. The pressing is done while pulling.

6.5.15 Trial piling should be taken out before the construction, by-batch grouting volume, outer tube up-pull height, inner tube ramming frequency and double tubs synchronous sinking depth shall be recorded, and the bottom closing condition of the outer tube shall be inspected whether there is water incoming and mud overflow. The records data may be the construction control basis after checking and ratifying.

6.6 Dry-work Pore-forming Filling Pile

I Construction of drilling (enlarged base) filling pile

6.6.1 The drilling shall meet following provisions:

- 1 Drill stem shall be maintained perpendicular and stable. The position shall be accurate and the drill stem swinging shall be prevented on case of expanding hole diameter;
- 2 The drill speed shall be adjusted in time in accordance with current value variance;
- 3 On the drilling progress, the spoil around the hole open shall be cleared away any time. Abnormal conditions like underground water suffering, hole collapse and shrinkage hole shall be treated in time.

6.6.2 For the construction of drilling pedestal pile, the straight hole part shall comply with provisions in Articles 6.6.1, 6.6.3 and 6.6.4, and the enlarged base part shall meet following

provisions:

1 The soil chipping volume of hole reaming bit shall be adjusted according to the current value and the oil pressure value to prevent overload;

2 The enlarged base diameter and the thickness of hole toe loose soil shall meet the design requirements.

6.6.3 When the pore-forming reaches the designed depth, the hole open shall be protected, and the acceptance shall be taken out in accordance with provisions in Article 6.2.4 of this standard, and the record shall be achieved.

6.6.4 Before concrete grouting, funnel for protecting the open shall be arranged, and then the reinforcing cage is arranged. The thickness of loose soil in the hole shall be rechecked.

In grouting concrete of pedestal pile, first concrete grouting shall reach the top surface of the enlarged base, and the concrete shall be vibrated compact subsequently; when concrete is grouted to the position 5m below the pile top, grouting and vibrating shall go synchronously. The grouting height of each time shall not be larger than 1.5m.

II Construction of manual digging filling pile

6.6.5 The hole diameter of manual hole pile (excluding encasing) shall not be less than 0.8m and should not be larger than 2.5m; the hole depth should not be larger than 30m. When the pile is less than 2.5m, the interval excavation shall be adopted. The minimum construction clear distance of adjacent row pile jump excavating shall not be less than 4.5m.

6.6.6 The thickness of manual hole pile concrete encasing shall not be less than 100mm, the strength grade of concrete shall not be less than one of pile foundation, and the concrete shall be vibrated compact; the encasing shall be arranged with constructional reinforcement with not less than 8mm diameter, and the vertical rebar's shall be lap-jointed and pull-connected.

6.6.7 Following safety measure shall be available for the construction of manual hole pile:

1 The urgent soft climbing step shall be arranged in the hole for personnel's moving up and down; motor hoist and suspension cage shall be safe and stable and shall be equipped with auto-chuck safety device. Hemp rope and nylon cord shall not be adopted as well as feet stepping the flanches on the hole wall. The motor hoist should be equipped with press-button switch, and the safe lifting capacity must be inspected before normal service;

2 Toxic or harmful gases must be tested before daily starting, and enough Safety Countermeasures shall be available. When the pile hole is excavated more than 10m, the special air transmission implement shall be arranged and the airflow should not be less than 25L/s;

3 Guard rails must be arranged around the hole open, and the guard rail height should be 0.8m;

4 The excavated soil and rock shall be transported away from the hole open, and shall not be stacked within 1m away from the hole open. The traffic of motor vehicles shall not affect the safety of hole wall.

5 The installation and dismantle of all power supply and open circuit in the construction Site must comply with provisions in current professional standard "Technical Code for Safety of Temporary Electrification on Construction Site" JGJ 46.

6.6.8 Before hole opening, the pile position shall be located accurately, and the orientating reference pile shall be arranged out side of the pile position. For installation of encasing moldboard, the pile centre must be adopted to rectify the moldboard position. Persons shall be specially assigned for the encasing moldboard installation.

6.6.9 Walling crib encasing of first section shall meet following provisions:

1 The deflection of the walling crib center line and the design axial line shall not be larger than 20mm;

2 The top surface of the walling crib shall be 100~150mm higher than the site and the wall thickness shall be 100~150mm larger than the hole wall thickness.

6.6.10 Walling crib encasing construction shall meet following provisions:

1 The thickness of encasing, pull-connect rebar, reinforcement assembly and the strength grade of concrete shall meet the design requirements;

2 The lap length of two sections encasing shall not be less than 50mm;

3 Encasing of each section shall be completed by continuous maturity same day;

4 Encasing concrete must be vibrated compact, and flash setting admixture shall be dosed in accordance with soil layer water-percolation condition;

5 The dismantle of encasing moldboard shall be taken out 24h after concrete grouting;

6 Once phenomena like beehive and water leaking in the encasing, the reinforcement measures shall be taken out in time;

7 The extreme deviation of any walling crib diameter at same horizontal level shall not be larger than 50mm.

6.6.11 When partial liquid silt or liquid silt with not larger than 1.5m thickness, and possible soil and sand overflow occur, the encasing construction may be treated in accordance with following methods:

1 The height of each section encasing is decreased to 300~500mm, and excavation, testing and concrete grouting shall be taken out synchronously;

2 Protecting tube or effective measures to reduce water shall be adopted.

6.6.12 When the excavation reaches the design elevation, soil and water on the hole wall and hole toe sediment shall be removed, and the acceptance of concealed work shall be taken out. After quality inspection, bottom closing and concrete grouting for pile foundation shall be taken out immediately.

6.6.13 During pile foundation concrete grouting, the concrete must pass through flume; if the drop height exceeds 3m, tumbling barrel shall be adopted, and the height from the tumbling barrel end to the hole toe should not be larger than 2m; conduit pumping may be adopted; the concrete should be vibrated compact by internal vibrator.

6.6.14 If the water percolating volume is overlarge, effective measures like site water blocking, water reducing or underwater concreting shall be adopted. Pumping, excavation and grouting must not be taken out synchronously in the pile hole, including the grouting of adjacent piles.

6.7 Post Grouting for Cast-in-situ Pile

6.7.1 The method of post grouting for cast-in-situ pile is applicable to reinforce earth mass of sediments (loosen soil), clay coating, pile toe and pile side of drilling, digging, impact-cone concrete pile and underground diaphragm wall.

6.7.2 The arrangement of post-grouting equipments shall meet following provisions:

1 The post-grouting conduit shall be steel pipe, and shall be fixed or welded with stiffening rebars of reinforcing cage;

2 The quantity of conduit and grouting valve for pile tip post-grouting shall be arranged in accordance with the pile diameter size. For pile which the diameter is not larger than 1200mm, 2 conduits should be arranged symmetrically along the reinforcing cage; for pile which the diameter is larger than 1200mm and not larger than 2500mm, 3 conduits should be arranged symmetrically;

3 If the pile length is larger than 15m and the bearing capacity amplification is required higher, the pile-tip pile-side compound grouting should be adopted. The quantity of pile-side post-grouting tube valve shall be identified in accordance with stratigraphy, pile length and

the bearing capacity amplification, and a pile-side grouting valve may be arranged every other 6~12m, 5~15m above the pile toe and 8m below the pile top. When coarse-grained soil is available, the grouting valve should be arranged under the coarse-grained soil layer, and for dry-work pore-forming filling pile, the grouting valve should be arranged at the middle position of the coarse-grained soil layer;

4 For reinforcement assembly pile without full length, reinforcing cage formed of not less than main reinforcements with same length to the grouting pipe shall be arranged along full pile bottom;

5 The reinforcing cage shall be arranged to the bottom, and shall not be suspended. Compacting, attacking and wringing the cage shall not occur if the cage is blocked.

6.7.3 Post-grouting valve shall be provided with following performances:

1 The grouting valve shall near the hydrostatic pressure of more than 1mpa; the external protective layer of the grouting valve shall bear the scraping and compacting of rigid materials like grindstone and protect the tube valve from damaging;

2 The grouting valve shall be provided with back-stop function.

6.7.4 Parameters designs such as grout proportion, stop grouting pressure, flow and grouting volume shall meet following provisions:

1 The water cement ratio of slurry shall be identified slurry in accordance with soil saturation and penetrability. For saturated soil, the water cement ratio should be 0.45~0.65, for unsaturated soil, the water cement ratio should be 0.7~0.9 (for loose soil aggregate and grit, the water cement ratio should be 0.5~0.6); the slurry with low water cement ratio shall be dosed with water reducing agent;

2 The pile-tip grouting stop grouting pressure shall be identified in accordance with soil layer property and grouting point depth, for decayed rock, non-saturated cohesive soil and silty soil, the grouting pressure should be 3~10MPa; for saturated soil layer, the pressure should be 1.2~4MPa, and the low value shall be adopted for soft soil and the higher value should be adopted for compact cohesive soil;

3 The grouting flow should not be larger than 75L/min;

4 The grouting volume design of individual pile shall be identified in accordance with pile diameter, pile length, pile-tip pile-side soil layer property, individual pile bearing capacity amplification and compound grouting, and may be calculated according to following formula:

$$G_c = \alpha_p d + \alpha_s nd \quad (6.7.4)$$

Where: α_p, α_s —Empirical coefficients of pile tip and pile side grouting volumes, $\alpha_p=1.5\sim 1.8, \alpha_s=0.5\sim 0.7$; for pebble, gravel and medium coarse sand, higher value shall be adopted;

n —Quantity of the pile-side grouting section;

d —Foundation pile design diameter (m);

G_c —Grouting volume, counted according to the cement quality (t).

For independent individual pile, clustered piles which the pile spacing is larger than $6d$ and first several piles in clustered piles, the grouting volume shall be multiplied by the coefficient 1.2 based on above estimated value;

5 Before starting post-grouting initiation, grouting experiment should be taken out, and the grouting parameters shall be optimized and identified finally.

6.7.5 Post-grouting job initiation time, sequence and speed shall meet following provisions:

1 The grouting operation should start from $2d$ days after piling, but not later than $30d$ days;

2 The distance from the grouting operation to the pore-forming operation should not be less than 8~10m;

3 Compound grouting for saturated soil should be taken out from pile side to pile tip; for unsaturated soil, the compound grouting should start from pile tip to pile side; the grouting for multisection pile-side shall start from the upper to the lower; the grouting spacing interval of pile-side and pile-tip grouting should not be less than 2h;

4 Equal-volume grouting shall be taken out for each grouting conduit of same-pile pile-tip grouting in proper order;

5 Grouting for pile group should be taken out from the periphery to the inner.

6.7.6 Grouting may be stopped if one of following conditions is satisfied:

1 The total grouting value and the grouting pressure all reach the design requirements;

2 The total grouting volume has reached 75% of the design value, and the grouting pressure exceeds the design value.

6.7.7 When the grouting pressure is maintained lower for a long time, or slurry overflows from the ground, or surrounding pile hole communicate, interval grouting shall be taken instead, the interval should be 30~60min, or the slurry water cement ratio is decreased.

6.7.8 During post-grouting construction, all processing parameters for post-grouting shall be checked often, and corresponding measures shall be taken out in time once abnormal things are found out. When major parameters like the grouting volume cannot reach the design value, corresponding measures shall be taken out in accordance with engineering physical circumstances.

6.7.9 The inspection and acceptance for post-grouting pile foundation engineering quality meet following requirements:

1 After finishing the post-grouting construction, materials such as cement materials and quality inspection report, pressure gauge verification certificate, trail grouting record, design process parameter, post-grouting operation log and special case treatment record shall be provided;

2 If the strength of the pile foundation concrete meets the design requirements, the bearing capacity inspection shall be taken out 20d after post-grouting, and the Hardening accelerating admixture for slurry may be dosed 15d after grouting.

7 Concrete premolded pile and steel pile construction

7.1 Concrete Premolded Pile Manufacture

7.1.1 Concrete premolded pile can be prefabricated at the construction field, and the manufacturing field must be level and solid.

7.1.2 The template for pile manufacturing shall adopt steel template, which should possess adequate stiffness and is level with exact size.

7.1.3 Main reinforcement connection of the reinforcing cage shall adopt butt welding and arc welding, and when the bar diameter is no less than 20mm; it shall adopt mechanical joint connection. The number of main reinforcement joints set in the cross-section shall be in accordance with the following requirements:

1 When adopting butt welding or arc welding, the tension reinforcement shall not larger than 50%;

2 The distance between two main reinforcement joint sections shall be larger than $35d_g$ (d_g diameter of main reinforcement), and also be no less than 500mm;

3 It must conform to the provisions given in current professional standards "Specification for Welding and Acceptance of Reinforcing Steel Bars" JGJ 18 and "General technical specification for mechanical splicing of bars" JGJ 107.

7.1.4 Permissible variation for reinforcing cage of premolded pile shall be in accordance with those specified in Table 7.1.4.

Table 7.1.4 Permissible variation for the reinforcing cage of premolded pile

Item	Items	Permissible variation (mm)
1	Space between main reinforcements	±5
2	Centerline of pile tip	10
3	Stirrup space or pitch between spiral hoopings	±20
4	Slinger along the direction of longitudinal center line	±20
5	Slinger along the direction that is perpendicular to longitudinal center line	±20
6	Height of the slinger exposed out of the pile surface	±10
7	Distance between the main reinforcement and pile top	±5
8	Position of mat reinforcement at pile top	±10
9	Position of the embedded parts at top of multi-section pile	±3

7.1.5 The determination of the single section length shall be in accordance with the following requirements:

1 Satisfy the effective height of the pile holder, and the condition, transportation, and

handling capacity of the manufacturing field;

- 2 Avoid pile extension when the pile tip approaches to or at the hard supporting course.

7.1.6 When casting concrete premolded pile, it shall cast from the pile top, and also prevent that there accumulates too much sand grout at the other tip.

7.1.7 The aggregate size when hammering the premolded shall be 5~40mm.

7.1.8 When hammering premolded pile, the strength and age shall all reach the requirements before the hammering.

7.1.9 When manufacturing premolded pile with overlapping method, it shall be in accordance with the following requirements:

- 1 The contact surface between the pile, adjacent pile and bottom formwork shall have no adhesion;

- 2 The casting of the upper-layer pile or the adjacent pile only can be carried out when the concrete design strength of lower-layer pile or adjacent pile is more than 30%;

- 3 The superimposed layer number of the piles shall not be more than four.

7.1.10 Surface of the concrete premolded pile shall be level and solid, and the manufacturing permissible variation shall conform to the provisions given in Table 7.1.10.

Table 7.1.10 Manufacturing Permissible Variation of Concrete Premolded Pile (mm)

Pile types	Items	Permissible variation (mm)
Reinforced concrete solid pile	Side length of cross section	±5
	Difference of diagonal lines at pile top	≤5
	Thickness of protective layer	±5
	Vector height of pile body bent	Be no larger than 1‰ of the pile length and also no larger than 20
	Eccentricity of the pile tip	≤10
	Slant of the pile end face	≤0.005
	Length of pile section	±20
Reinforced concrete pipe pile	Diameter	±5
	Length	±0.5%L
	Wall thickness	-5
	Thickness of protective layer	+10, -5
	Vector height of pile body bent (angle)	1‰L
	Eccentricity of the pile tip	≤10
	Smoothness of the plate at pile head	≤2
Eccentricity of the plate at pile head	≤2	

7.1.11 Other requirements of prestressed-concrete pile and the evaluation methods for strength level of the centrifuging concrete that are not specified in this code shall conform to the provisions given in the current national standards "Pretensioned square concrete piles" GB/T 13476, "Pretensioned spun concrete thin wall piles" JC 888, and "Prestressed spun concrete square piles" JG 197.

7.2 Hoisting, Transportation and Storage of Concrete Premolded Pile

7.2.1 The hoisting and transportation of concrete solid pile shall be in accordance with the following requirements:

1 It can be hoisted only when the concrete design strength reach 70% and can be transported when 100%;

2 When hoisting the pile, take corresponding measures to ensure the safety and stability to protect the quality of the pile body;

3 Place the pile body stably during the horizontal transportation, strictly prohibit drag the pile body directly on the ground.

7.2.2 The hoisting and transportation of prestressed concrete hollow pile shall be in accordance with the following requirements:

1 Have ex-factory examination before leaving factory, its specification batch number, and manufacture date shall conform to the contents of the acceptance check batch number to which it belongs;

2 Be careful during the hoisting and transportation process, avoid acute collision;

3 Single section pile can have direct horizontal hoisting by adopting special hook hitching its inside wall at the both ends;

4 Have acceptance examination when it is shipped to the construction site, strictly prohibit using the unqualified pile and the pile have cracks during the handling process.

7.2.3 The storage of prestressed concrete hollow pile shall be in accordance with the following requirements:

1 The storage area should be level and solid, the sole timber between the bottom layer and the ground should have adequate width and height. The piles should be stored steadily without rolling;

2 Store them separately according to different specification, length and construction sequence;

3 Store the piles with monolayer when the condition at the field permits; When store with layers, the layers of the one with outside diameter of 500~600 mm shall not larger than four and of 300~ 400 mm shall not larger than five;

4 When store with layers, set two sole timbers on the ground the is perpendicular to the pile length direction, and the sole timbers shall be laid at the position 0.2 times of the pile length away from the pile tip; Chock the outer piles of the bottom layer at sole timber;

5 Sole timbers shall be the pressure-proof long wood or sleeper, can it is not allowed to use hardware with arris.

7.2.4 The pile taking shall be in accordance with the following requirements:

1 When the piles are stored with more than two layers, take the piles with crane, and it is strictly prohibited to drag the pile;

2 Three-point support automatic pile driver shall not drag the pile.

7.3 Concrete Premolded Pile Extension

7.3.1 Piles can be connected by welding, with flange or momentary connection by machines (screw thread type and mesh-type).

7.3.2 Pile extension materials shall be in accordance with the following requirements:

1 Pile extension by welding: steel plate shall adopt low-carbon steel, welding rod is of E43; and it shall conform to the requirements in the current professional standard "Technical specification for Welding of steel structure of building" JGJ 81. The joint shall have fault detection test, and the test amount of one project is no less than 3 joints.

2 Connection with flange: The steel plate and the screw bolt should be low-carbon steel.

7.3.3 The pile extension by welding shall not only conform to the relevant provisions in current professional standard "Technical specification for Welding of steel structure of building" JGJ 81, but also conform to the following requirements:

1 The pile head of the lower nodular pile part shall be above the ground with 0.5m;

2 Set guiding hoops at the pile head of the lower part pile. Keep the up and down section of nodular piles in the same direction, and the deviation should not be larger than 2mm. When correcting the error of the pile position, it is profited to knock the pile laterally with sledgehammer;

3 Before docking the piles, the plate surface of the up and down head shall be cleaned with iron brush, and brush the groove until it has metallic luster;

4 The welding shall be continued symmetrically around the pile, dismantle guiding hoop and weld with layers after the up and down piles have fixed; the welding layers shall be no less than two, clean the slag after welding the first layer before weld the second layer, and the welding seam should be continuous, the welding shall be continued symmetrically around the pile, dismantle guiding hoop and weld with layers after the up and down piles have fixed; the welding layers shall be no less than two, clean the slag after welding the first layer before weld the second layer, and the welding seam should be continuous and compact;

5 It can only continue hammering after welded pile joint cooling naturally, and the natural cooling time should not less than 8 min; it is strictly prohibit to adopt water cooling or to hammer after the welding immediately;

6 Adopt reliable rainproof measures when welding at rainy day;

7 The quality inspection of the welding joint, as for the same project, the fault detection samples shall be no less than three.

7.3.4 The operation and quality by adopting thread pile extension with machines shall be in accordance with the following requirements:

1 Check the manufacturing dimensional variation and junction parts of both end of the pile before installing it, start the hoisting and construction only when there is without damages, and the lower pile tip should be above the ground with 0.8m;

2 When connecting the piles, unload the protective device at the tips of up and down nodular piles, clean the leftovers at the joint and paint grease;

3 Adopt special conicity centering for the joint, align the up and down nodular pile and have the wounding connection;

4 Wound by special chain spanner, (Manual wound it after chucking with arm length of 1m and knock the plate arm with hammer,)and there should have gap of 1~2mm between plates at both ends after wounding it.

7.3.5 The operation and quality by adopting joggle joint pile connection with machines shall be in accordance with the following requirements:

1 Clean the up and down joint plates, screw the joint pin stick by stick with bituminous paint to the bolt hole of the I type end plate, can adjust the position of the joint pin with sheet steel form;

2 Eliminate the plastic foam protection piece in the spread groove at the II-end of the lower pile, fill bituminous paint into the spread groove, and wipe bituminous paint with width of 20mm and thickness of 3mm on the end plate; When there is corrosive medium above medium-scale in the underlying soil and groundwater, wipe the end plate with bituminous paint fully;

3 Hoist the upper pile, align the joints of the joint pin and II type end plate, and then insert the joint pin into the spread groove;

4 Add pressure to make the end plates of lower pile contact, and the pile extension is finished.

7.4 Hammering pile-Sinking

7.4.1 Must deal with the impediments in the air and on the ground before the pile-sinking, the field should be level and have good drainage equipment, and it shall satisfy the bearing capacity of the ground required at the pile driving.

7.4.2 Driving hammer shall be selected according to the factors such as the geological conditions, pile types, intensive degree of the pile, vertical bearing capacity of single pile, and existing execution conditions, or according to the Appendix H of this code.

7.4.3 The pile pressing shall be in accordance with the following requirements:

1 The gap between pile cap or pile following cap is 5~10mm away from their surrounding environment;

2 Add elastic gasket such as hardwood, sack and straw mattress between the hammer and pile cap, and pile cap and pile;

3 Driving hammer, pile cap or pile following cap should be at the centerline with the pile body;

4 The verticality deviation of the pile when inserting can not be larger than 0.5%.

7.4.4 The pressing sequence is required to be in accordance with the following requirements:

1 As for the dense piles group, press symmetrically from the middle to the two directions or to the surrounding environment;

2 When being close to the building with one side, press the pile from the side of the building to the other side;

3 According to design elevation, it shall start from the deep position to the shallow;

4 According to the specification for of the pile, it shall press from the larger one to the smaller one, and from the long one to the short one.

7.4.5 As for the pile position deviation of the pressed pile (pre-cast concrete square pile, prestressed concrete hollow pile and steel pile) shall conform to the provisions given in Table 7.4.5. The gradient deviation of the inclined pile is not allowed to be larger than 15% of the tangent value of the declination angle (the included angle between the longitudinal center line of inclined pile and the plumb line).

Table 7.4.5 Permissible variation of the pressed pile (mm)

Items	Permissible variation
Pile with foundation beam:	
(1) Centerline that is vertical to the foundation beam	$100+0.01H$
(2) Centerline along foundation beam	$150+0.01H$
Pile with 1~3 pile foundations	100
Pile with 4~16 pile foundations	1/2 pile diameter or side length
Pile with pile foundations that is larger than 16:	
(1) Pile at the ragged edge	1/3 pile diameter or side length
(2) Middle pile	1/2 pile diameter or side length

Note: H is the distance from the ground elevation at the construction site and the design elevation of the pile top.

7.4.6 The regulation for stopping the hammering of the pile shall be in accordance with the following requirements:

1 When the pile tip lies at the general soil layer, it shall give priority to control design elevation design elevation of the pile tip pile tip, and control the penetration latter;

2 When the pile tip reaches to the stiff and hard cohesive soil, silty soil, sandy soil gravel soil and weathered rock that are above middle density, it shall give priority to control the penetration and the elevation of the pile tip latter;

3 When the penetration has reached the design requirement but the elevation of the pile tip has not reached, it shall continue to hammer the three arrays and determine according to that the penetration with 10 times of hammering shall not be larger than designed value, and determine the construction control penetration through test if necessary.

7.4.7 When there are the conditions such as abrupt change of the penetration, the pile body has slant, displacement or severe rebounding, the pile top or pile body appear severe rupture and fracture; it shall suspend hammering the pile and analyze the reason to adopt corresponding measures.

7.4.8 When adopting pile-sinking with water jetting method, it shall be in accordance with the following requirements:

1 Pile-sinking with water jetting should be with sandy soil and soil aggregate;

2 When there is 1~2m at last, it shall stop jetting, and adopt hammering to the specified elevation, the ending hammer control standards may be implemented in accordance with relevant provisions given in Article 7.4.6 of this code.

7.4.9 When constructing and stricken large area dense pile group, it may adopt the following ancillary method:

1 For prebored hole pile-sinking, prebored hole aperture may be 50~100mm less than pile diameter (or diagonal line of square pile), and depth may be determined according to pile spacing and soil compactness, penetrability, and it should be 1/3~1/2 longer than piles; when construction, it shall drill in response to stricken; pile driver should be provided with drilling and stamping properties;

2 It shall set sand wick or plastic drain board. Sand wick diameter should be 70~80mm, spacing should be 1.0~1.5m and depth should be 10~20m; depth and spacing of plastic drain board is equal to that of sand wick;

3 It shall set separating sheeting pile or diaphragm wall;

4 It may excavate ground shockproof ditch and may be used together with other measures. Furrow width of shockproof ditch may take 0.5~0.8m and its depth may be determined according to earthiness conditions;

5 It shall confine piling velocity;

6 After pile-sinking, it should implement once retapping at large;

7 During the pile-sinking process, it shall strengthen observation and wardship for adjacent buildings and underground utilities, etc..

7.4.10 Overall blow counts and pile-sinking blow count in the last 1.0m prestressed concrete pipe pile shall be determined according to local engineering experience.

7.4.11 Pile follower for stamping pile-sinking shall be in compliance with the following requirements:

1 Pile follower depth should not be larger than 2.0m;

2 When pile top is stricken near to the ground and thus it requires pile follower, it shall measure squareness of the piles and inspect pile top quality, after eligibility, it shall follow pile in time;

3 Last penetration of pile follower shall refer to last penetration and correction of non-pile following under the same condition;

4 Remnant pile hole after pile follower shall backfill or cover immediately;

5 When pile follower depth exceeds 2.0m and is no larger than 6.0m, pile driver shall be self or walking gait type diesel pile driver with three-point support tracking; compartment between pile caps and driving hammer shall be with "cap block" of vertical stripe hardwood or coiled bar stacked wire rope, and its thickness should be 150~200mm.

7.4.12 Setting of long dolly and gasket shall be in compliance with the following requirements:

1 Long dolly should be made into cylinder and it shall be with adequate strength, rigidity and stricken proof. Long dolly length shall meet the requirement for pile follower depth and degree of curvature shall not be larger than 1/1000;

2 Upper and lower ends of long dolly shall be level off and perpendicular to central axis of the long dolly;

3 Lower end plane of the long dolly shall open pore and make intracavity of hollow pile connect with the surroundings;

4 Long dollies shall be matching with pile. Depth of sleeve in the lower end of telescope-feed long dolly should take 250~350mm, inside diameter of the casing shall be 20~30mm larger than outside diameter of piles, bolt length in the lower end of the bolt long dolly should take 200~300mm, and outside diameter of pole pin shall be 20~30mm less than inside diameter of (tube) pile. Tubular pile with surplus slurry in the intracavity should not adopt bolt long dolly;

5 When pile follower is in operation, compartment between long dolly and pile crown shall be set with 1~2 layers of gaskets as sack or hardboard, etc. Thickness of in-fill elastic packing after compaction should not be less than 60mm.

7.4.13 Construction site shall be provided with observation instrument for pile shaft squareness (strip leveling rod or theodolite) and observation staff, so to measure squareness for the pile shaft at any moment.

7.5 Static Pressure Pile-Sinking

7.5.1 When adopting static pressure pile-sinking, the ground bearing capacity shall be not less than 1.2 times of the earthing pressure of the pile press machine, and the site shall be level.

7.5.2 Static pressure pile pressing is appropriate to select the hydraulic and cord pile

pressing technology; it is appropriate to adopt top pressure and enfolding pressure hydraulic pressure pile press machine according to the length of the single section pile.

7.5.3 The parameters for selecting pile press machine shall contain following contents:

- 1 Type and quality (Excluding counterweight), maximal pile pressure, etc.;
- 2 Its external dimension and consignment size;
- 3 Its minimal side piling distance and maximal pile pressure;
- 4 Earthing pressure of long and short ship type covering boot;
- 5 Model of clamping device;
- 6 Corresponding relationship among the quantity and diameter of the hydraulic ram, reading of the pressure gauge after calibration and pile pressure;
- 7 Property and pile hoist capability of the pile hoist crane.

7.5.4 Each counterweight of the pile press machine must be verified with measuring device, and mark it on the exerted surface of this counterweight; the maximal pile pressure of hydraulic pressure pile press machine is that the product of the sum of its framework weight and counterweight multiplied by 0.9.

7.5.5 When the vacancy of side pile can not meet the pressing condition for middle-ship pile press machine, it is appropriate to use border pile press machine or forward type hydraulic pressure pile press machine to press the pile, but the influence caused by the reduction of maximal pile press capability should be estimated at this time.

7.5.6 When the leading hole method is adopted for pile pressing because of the design requirement or construction demand, it shall equip with auger drilling machine or equip the pile press machine with special spiral drill. And when supporting course at pile tip need entering relatively hard rock formation, it shall equip with drilling or punching pile press machine.

7.5.7 The maximal pile pressure shall be no less than the designed normal value of vertical ultimate bearing pressure for individual pile; and it can be determined by in-situ test if necessary.

7.5.8 The quality control of static pile pressing execution shall be in accordance with the following requirements:

- 1 The verticality deviation shall not be larger than 0.5% when the pike of first section

is depressed;

2 It is appropriate to depress each pile to the bottom continuously at one time, and the effective pile length of the last section shall be no less than 5m;

3 The enfolding pressure shall not be larger than 1.1 times of the permissible lateral pressure of the pile body.

7.5.9 Final pressure condition shall be in accordance with the following requirements:

1 It shall determine final pressure standard according to the test result of in-situ pile pressing test;

2 The continuous repress operation times of the final pressing shall be determined according to the pile length and geological conditions. As for the pile with buried depth greater than or equal to greater than or equal to greater than or equal to 8m, the repress operation times may be two to three; as for less than 8m, the repress operation times may be three to five;

3 Stabilized pile pressure shall not be less than the final pressure, and the stable pile pressing time is five to ten seconds appropriately.

7.5.10 The pile pressing sequence shall be determined according to the engineering geological conditions of the field, and it should be in accordance with the following requirements:

1 When there are sands or gravels partially in the layer of the field, it is appropriate to have pile pressing for this region firstly.

2 When there is large difference among the buried depths in the supporting course or the buried depth of the piles, it is appropriate to pressing long pile first and short pile latter.

7.5.11 Measure the verticality of the pile body at the process of pile pressing, When the deviation of the pile body verticality is larger than 1%, it should find out the reason and manage to rectify it; After the pile toe entering the relatively hard layer, it is forbidden to correct an error forcibly with method of moving the framework or other methods.

7.5.12 When appearing any following cases, it shall suspend the pile pressing operation, and analyze reasons to adopt corresponding measures:

1 The reading display of the pressure gauge does not conform to the soil layer property given in the reconnaissance report apparently;

2 The pile is difficult to pass through the hard interlining layer that has weak subsoil

layer;

- 3 There is large discrepancy between practical pile length and designing pile length;
- 4 There is abnormal noise; pile press machine has abnormal operation mode;
- 5 There appears longitudinal crack in the pile body and the concrete at the pile head has the abnormal phenomenon such as flaking off;
- 6 Clamping devices have skidding;
- 7 Pile press machine sinks.

7.5.13 The quality control of static pile delivering shall be in accordance with the following requirements:

1 Measure the pile verticality and check the quality of the pile head, and it may have pile delivery only after the check, and the pressing and deliver operation shall be proceeded continuously.

2 The pile delivery shall adopt special steel pile follower, and the engineering pile can not be used as pile follower;

3 When length L of most piles in the field is less than or equal to 15m or the supporting course at the pile tip is weathering soft rock, the pile delivering depth shall not be larger than 1.5m if there needs to have repress operation;

4 Besides satisfying the above three items of this article, when the pile verticality is 1%, and the effective pile length is larger than 15m, the static pile delivering depth shall not be larger than 8m;

5 The maximal pile pressure when delivery the pile shall not be 1.1 times larger than permissible enfolding pile pressure of the pile body.

7.5.14 The quality control of leading hole pipe pressing method shall meet the following requirements:

1 The leading hole is appropriate to adopt dry spiral drilling operation method; the verticality deviation of the leading hole shall not be larger than 0.5%;

2 Leading hole operation and the pile pressing operation shall be proceeded continuously, and the interval time shall not be longer than 12h; and not be longer than 3h when at soft oil foundations;

3 When there is water in the leading hole, it shall adopt opening pile tip.

7.5.15 When the piles are distributed densely, or the foundation are saturate silt, mucky soil and cohesive soil, it shall set plastic drain board and pack drain to curtail reduce the hole pressure or adopt measures such as leading hole, and it also can implement with the 7.4.8 article of this code. At the construction process of pile pressing, it shall set observing point of upwelling and horizontal deviation on 10% of the total piles, and test the pile upwelling amount and horizontal deviation value of the pile top with certain interval, adopt measures such as repress operation if the upwelling and deviation are large.

7.5.16 As for the pile entering position deviation of the pre-casted concrete square pile, prestressed concrete hollow pile, and steel pile, it shall conform to the provisions in Table 7.4.5 of this code.

7.6 Steel pile (steel pipe pile, pile of H type and other special steel piles) construction

I Steel pile manufacturing

7.6.1 The materials for manufacturing steel pile shall adherence to specification, and they shall with the ex-factory conformity certificate and test report.

7.6.2 It is required smooth field and protection measures against weather for the in-situ steel pile manufacturing.

7.6.3 The permissible variation of steel pile manufacturing shall conform to the provision given in Table 7.6.3, the segmenting length of the steel pile shall this the provision given in Article 7.1.5 of this code, and it shall not be larger than 15m.

Table 7.6.3 Permissible variation for the steel pile manufacturing

Items		Permissible variation (mm)
Outside diameter cross dimensions	Pile tip	$\pm 0.5\%$ outside diameter or side length
	Pile body	$\pm 0.1\%$ outside diameter or side length
Length		> 0
Vector height		$\leq 1\%$ pile length
End smoothness		≤ 2 (pile of H type ≤ 1)
End smoothness and slant value of pile body centerline		≤ 2

7.6.4 Steel pile adopted at the region where groundwater is aggressive or at aggressive soil layer shall have antiseptic treatment according to design requirement.

II Steel pile weld

7.6.5 The weld of the steel pile shall be in accordance with the following requirements:

1 It is required to clean the smudge on the pile tip such as float rust and oil sludge to keep it dry; the distortional part being stamped at the pile top shall be resected;

2 It shall rectify the verticality when weld the up and down pile nodes, the aboral gap shall be two to three 2~3mm;

3 The welding wire (automatic welding) or welding rod shall be dried;

4 The weld shall be carried out symmetrically;

5 It shall adopt multi-layer welding, the welding seam joints at each layer on the steel pipe pile shall be staggered, and welding slag shall be cleaned;

6 When the air temperature is under 0°C or at sleety days that there is no reliable measures to ensure the welding quality, it is not allowed to weld;

7 After finishing the welding of each joint, it is required cooling for 1 min before stamping it;

8 The welding quality shall conform to the provisions given in the national current standard "Code for acceptance of construction quality of steel structures" GB 50205 and "Code for acceptance of construction quality of steel structures" JGJ 81, besides the appearance inspection for each joint according to provisions in Table 7.6.6 of this code, there also shall have ultrasonic check according to 5% of the total joint number or X-ray filming check according to 2% of the total joint number, and as for one project, the sampling inspection of fault detection shall be no 3 joints.

Table 7.6.6 Permissible variation for weld appearance of pile extension

Items	Permissible Variation (mm)
Mismatch between up and down pile nodes:	
① Outside diameter of steel pipe pile ≥ 700 mm	3
② Outside diameter of steel pipe pile < 700 mm	2
H-steel pile	1
Undercut depth (welding seam)	0.5
Height of reinforcing ply (welding seam)	0~2
Width of reinforcing ply (welding seam)	0~3

7.6.6 H As for section steel pile or other heterotypic steel pile with thin wall, add joint plate at the joint section, and it may be set according to constant strength.

III Transportation and storage for steel pile

7.6.7 The transportation and storage of the steel pile shall be in accordance with the following requirements:

1 The storage place shall be level, solid and with good drainage facilities;

2 There shall have proper protective measures at both end of the pile, and there shall set guard circle for the steel pipe pile;

3 Prevent spoilage or bent of the pile tip pile body and pile body caused by stricken of the pile body when portaging;

4 The steel pile shall be separately piled up by specifications and materials, the pile up layers: for steel pile of $\varnothing 900\text{mm}$, it shall be no larger than three layers; steel pile of $\varnothing 600\text{mm}$ no larger than four layers; the one of $\varnothing 400\text{mm}$ no larger than five layers; And H-steel pile shall be no larger than six layers. The setting of the pivot shall be reasonable, and both sides of the steel pile shall be stopped up with chock.

VI Steel pile sinking

7.6.8 When adopting hammering pile-sinking for the steel pile, it may be implemented according to relevant provisions given in Section 7.4 of this code; when adopting static pressure pile-sinking, it may be implemented according to relevant provisions given in Section 7.5 of this code.

7.6.9 As for open-end steel pipe pile, when there is difficulty at hammering pile-sinking, it may borrow soil from the pipe to help sinking.

7.6.10 When hammering H-steel pile, the hammer weight shall be no larger than grade of 4.5t (diesel fuel hammer), and there should have lateral holding equipment in front of the pile rack in the process of hammering.

7.6.11 When supporting course is relatively hard, H-steel pile is not appropriate to delivered.

7.6.12 When there are backfilled materials such as big rock and concrete block, there should have feeler inspection before inserting H-steel pile, and clean the impediment at the pile position.

8 Pile cap Construction

8.1 Pit Excavation and Backfilling

8.1.1 The sequence for pile cap construction at pile foundation is appropriate to from deep to shallow position.

8.1.2 When pile cap is imbedded deeply, there should have necessary protective measures for adjacency buildings and urban facilities, and have monitoring during construction period.

8.1.3 Before pit excavation, there shall edit the construction scheme for the supporting model of side slope, precipitation measures, earth excavation plan, earthmoving route and mounding position, if the pile foundation construction causes excess pore pressure, it is appropriate to start the excavation after most excess pore pressure has dissipated.

8.1.4 When the underground water table is so high that needs precipitation, it may adopt inner precipitation or outer precipitation measures according to the surrounding environment.

8.1.5 Earth excavation shall be proceeded with balanced layers, and as for the pit excavation of plastic soft soil, the height difference shall be not larger than 1m.

8.1.6 The excavated earthwork shall not be stacked near to the pit.

8.1.7 Must ensure that the pile body in the pit is free from spoilage when earth excavating by machine.

8.1.8 After pit excavation, make weeper drains and collecting well at the bottom of the pit, and the precipitation facilities if there have should be keep on the go.

8.1.9 Before backfilling the earth to gap between the external wall of the pile cap and basement and the sidewall of the pit, drain the water, clean the loose earth and building rubbish, the backfilling earth shall be selected according to design requirement, tamp in layers, and the backfilling is proceeded symmetrically.

8.2 Steel Bar and Concrete Construction

8.2.1 Remove the laitance part at the head of the filling pile and the fracture part at the hammer face in the top of the premolded pile before assemble the steel bar, the embedding length in the pile cap of the pile body and the main steel bar shall be in accordance with the design requirement, weld the junction piece at the pile top of the steel pipe pile, and have waterproof measurement of the pile head and the underlayer according to design.

8.2.2 Concrete casting on the pile cap shall be finished at one time, and the concrete is proper to be put into the slot flatly. As for construction of concrete with large volume, it shall take effective measure to prevent the rupture caused by temperature stress.

9 Quality Inspection and Acceptance of the Pile Foundation

Construction

9.1 General Requirements

9.1.1 As for pile foundation construction, there shall have inspection for pile position, pile length, quality of pile body and bearing capacity of single pile.

9.1.2 The inspection of pile foundation construction can be divided into three stages with chronological order: inspection before, during, and after the construction.

9.1.3 The inspection item and method for the raw material of pile body such as sand, gravel, cement, and steels shall conform to the provisions of the relevant current national standard,

9.2 Inspection before Construction

9.2.1 Have strict inspection for the pile position before construction.

9.2.2 The premolded pile (concrete premolded pile and steel pile) shall have the following inspections before construction:

1 The production pile should be manufactured according to the selected standard drawing or design drawing, and there should have in-situ inspection for its appearance quality and concrete strength of the pile body;

2 Inspect the materials and equipments such as the welding rod for pile extension and the pressure gauge for pile pressing.

9.2.3 Filling pile shall have the following inspections before construction:

1 When mixing concrete, inspect the quality and measurement of the raw material, the proportioning, slump constant and strength level of the concrete;

2 When manufacturing reinforcing cage, inspect the specification of the steel bar, specification and variety of the welding rod, weld bond specification, weld length, weld appearance and quality, and the manufacturing deviation of the main steel bar and the stirrup, and the permissible manufacturing variation of the reinforcing cage should conform to the requirement given in Table 6.2.5 of this code.

9.3 Construction Inspection

9.3.1 The premolded pile (concrete premolded pile and steel pile) shall have the following inspections during the construction:

1 Inspection for the pressing (static pressure) depth, the hammer stopping standard, terminal static pressure value and verticality of the pile body (rack);

2 The quality and pause time of pile extension, and intact condition of the pile top;

3 The hammering times of each meter and the last 1.0m, the total hammering times, penetration of the last three arrays and the elevation of the pile tip, etc..

9.3.2 Filling pile shall have the following inspections during the construction:

1 Before casting the concrete, inspect the center position, the depth, diameter, and verticality of the formed hole, the settled materials thickness at the bottom of the hole according to the relevant requirement for construction quality in Chapter Six of this code.

2 Inspect the actual settlement position of the reinforcing cage, and fill in the corresponding quality detection and record of inspection;

3 After the hole formed under dry operational condition, inspect supporting course at the pile tip of the pile with major diameter.

9.3.3 As for the quality inspection for the construction procedure of sinking pipe filling pile, it is appropriate to be carried out according to the relevant items in Article 9.1.1~9.3.2 of this code.

9.3.4 As for soil compacting premolded pile and filling pile, have systematic observation for the vertical and horizontal displacement horizontal displacement of the pile top and surface soil during the construction; Adopt the measures such as retapping, repress operation, leading hole, setting drainage measures and pile-sinking velocity adjustment, and so on.

9.4 Inspection after Construction

9.4.1 Inspect the position deviation of the formed pile of different types according to the provisions given in Tables 6.2.4 and 7.4.5 of this code.

9.4.2 **Inspect the bearing capacity and pile body quality for the engineering pile.**

9.4.3 The foundation pile project with any one of the following conditions should have the inspection for the vertical bearing capacity of the engineering single pile with static load test, the inspection times shall be determined according to the design grade of the pile foundation, the reliability factor of the test data obtained before the construction, and the current professional standard "Technical code for testing of building foundation piles" JGJ 106:

1 When there has had the single pile static test before construction, but the technological parameter is changed or there appears abnormal in the construction quality during the

construction;

2 Project that has no single pile static test according to the provisions given in Article 5.3.1 of this code before the construction;

3 The geological conditions are complicated and the reliability of the construction quality is low;

4 Adopt new pile types or new technology.

9.4.4 Pile foundation projects with any one of the following conditions shall inspect the vertical bearing capacity of the engineering single pile with high-strain dynamic test:

1 Except the pile foundations that are out of the provision conditions given in Article 9.4.3 of this code;

2 Design auxiliary test of degrees a and b for the static test of the building pile foundation.

9.4.5 The pile body quality not only needs the inspection for obligated concrete sample, but also needs in-situ inspection. The inspection method can be reliable dynamic test, and the pile with large diameter can also adopt auger core method and sound wave transmission method; the inspection times can be determined according to the current professional standard "Technical code for testing of building foundation piles" JGJ 106.

9.4.6 As for the special uplift pile and the pile foundation project with special requirement for the horizontal bearing capacity, there should have withdrawal resisting static test and horizontal static test for the single pile.

9.5 Acceptance Materials of Foundation Pile and Pile Cap Project

9.5.1 When the design elevation of pile top is close to the elevation at the construction yard, the acceptance check of the foundation pile shall be carried out after the its construction finished; when it is lower, carry out the acceptance check after it excavates to the design elevation.

9.5.2 Acceptance check of the foundation pile shall include the following materials:

1 Reconnaissance report of geotechnical engineering, constructional drawing of pile foundation, drawing joint examination summary, design alteration list, material substitution notification, etc..

2 Prescribed construction management plan, construction scheme, and alteration list under execution;

- 3 Layout drawing of pile position measurement, including authentication certificate of the verification for project pile position line;
- 4 Quality acceptance and expertise report of the raw materials;
- 5 Conformity certificate of semi-finished products such as premolded pile and steel pile;
- 6 Construction note and acceptance documents of concealed work;
- 7 Quality examination report of the formed pile;
- 8 Examination report for the bearing capacity of single pile;
- 9 Final completion plan of foundation pile and the hypsography of the pile top when the foundation pit is dug to the design elevation;
- 10 Other documents and records that must be supplied.

9.5.3 Engineering acceptance of the pile cap should include the following materials:

- 1 Construction and inspection record of the steel bar and the concrete at the pile cap;
- 2 Record for the anchor bar at the pile head and pile cap, the distance from side pile to the edge of pile cap, and the reinforcement cover of the pile cap;
- 3 Waterproof structure and construction quality of pile head and pile cap;
- 4 The measurement record of the thickness length and width of the pile cap, and the description for the appearance, etc..

9.5.4 The engineering acceptance of the pile cap shall not only conform to the provisions given in this section, but also conform to the provisions in the current national standard "Code for acceptance of constructional quality of concrete structures" GB 50204.

Appendix A Selection for Pile Types and Pile Forming Technology

A.0.1 Selection for pile types and pile forming technology made be made according to architectural types, load property, functions of pile usage, traversing soil layer, pile tip supporting course, ground water table, construction equipment, construction environment, construction experience, supply condition of pile material, etc. and according to Table A.0.1.

Table A.0.1 Selection for Pile Types and Pile Forming Technology

Pile types	Pile diameter		Maximal pile length (mm)	Traversing soil layer										Pile tip ingress supporting course		Ground water table		Impact for environment		Hole toe is compaction with or without			
	Pile shaft (mm)	Expansive head (mm)		General cohesive soil and its filling	Silt and mucky soil	Silty soil	Sandy soil	Soil aggregate	Seasonal frozen ground and swelling soil	Non-self weight collapse loess	Loess	Self weight collapse loess	With hard interlining in the middle	With skerry in the middle	With gravel interlining in the middle	Hard cohesive soil	Dense sandy soil	Soil aggregate	Soft rock and weathered rock		More than	Less than	Vibration and noise
Non-squeezing soil pile forming	300-800	—	28	○	×	○	○	○	○	○	○	○	○	○	○	○	○	△	○	×	○	Without	Without
				○	×	○	○	○	○	○	○	○	○	○	○	○	○	○	○	△	○	×	○
Dry operation method	300-800	—	20	○	×	○	○	○	○	○	○	○	○	○	○	○	○	△	○	×	○	Without	Without
				○	×	○	○	○	○	○	○	○	○	○	○	○	○	○	○	△	○	×	○

Table A.0.1 (continued)

Pile types	Pile diameter		Maximal pile length (mm)	Traversing soil layer										Pile tip ingress supporting course		Ground water table		Impact for environment		Hole toe is compaction with or without				
	Pile shaft (mm)	Expansive head (mm)		General cohesive soil and its filling	Silt and mucky soil	Silty soil	Sandy soil	Soil aggregate	Seasonal frozen ground and swelling soil	Non-self weight collapse loess	Loess	Self weight collapse loess	With hard interlining in the middle	With skerry in the middle	With gravel interlining in the middle	Hard cohesive soil	Dense sandy soil	Soil aggregate	Soft rock and weathered rock		More than	Less than	Vibration and noise	Draining
Non-squeezing soil pile forming	300-600	800-1200	30	○	×	○	×	○	○	△	×	△	×	△	○	○	△	△	○	×	○	×	Without	Without
	300-500	—	20	○	×	○	×	○	○	△	×	△	×	△	○	○	×	×	○	×	○	Without	Without	
	800-2000	1600-3000	30	○	×	△	△	○	○	△	×	△	○	△	○	○	△	△	○	△	○	△	Without	Without
Method with mud with protecting wall	500-800	—	50	○	○	○	×	△	△	×	△	△	△	△	△	△	△	△	△	○	○	Without	With	Without

Appendix B Basic parameters of prestressed concrete hollow pile

B.0.1 Basic parameters of pretensioned concrete pipe pile with centrifugal forming may be adopted according to Table B.0.1.

Table B.0.1 Reinforcing Bars and Mechanical Property of Prestressed Concrete Pipe Pile

Varieties	Outside diameter d (mm)	Wall thickness t (mm)	Single sectional pile length (m)	Concrete strength level	Type	Prestressed reinforcement	Spiral bar specification	Effective compressive pre-stress of concrete (MPa)	Control value M_{cr} of fracture-resistant bending moment (kN · m)	Control value M_u of ultimate bearing moment (kN · m)	Design value R_p of vertical bearing capacity of pile shaft (kN)	Theoretical weight (kg/m)
High strength prestressed concrete pipe pile (PHC)	300	70	≤11	C60	A	6Φ7.1	Φ ^b 4	3.8	23	34	1410	131
					AB	6Φ9.0		5.3	28	45		
					B	8Φ9.0		7.2	33	59		
					C	8Φ10.7		9.3	38	76		
	400	95	≤12	C80	A	10Φ7.1	Φ ^b 4	3.6	52	77	2550	249
					AB	10Φ9.0		4.9	63	704		
					B	12Φ9.0		6.6	75	135		
					C	12Φ10.7		8.5	87	174		
	500	100	≤15	C80	A	10Φ9.0	Φ ^b 5	3.9	99	148	3570	327
					AB	10Φ10.7		5.3	121	200		
					B	13Φ10.7		7.2	144	258		
					C	13Φ12.6		9.5	166	332		

Table B.0.1 (continued)

Varieties	Outside diameter d (mm)	Wall thickness t (mm)	Single sectional pile length (m)	Concrete strength level	Type	Prestressed reinforcement	Spiral bar specification	Effective compressive pre-stress of concrete (MPa)	Control value M_{cr} of fracture-resistant bending moment (kN · m)	Control value M_u of ultimate bearing moment (kN · m)	Design value R_p of vertical bearing capacity of pile shaft (kN)	Theoretical weight (kg/m)
High strength prestressed concrete pipe pile (PHC)	500	125	≤15	C80	A	10Φ9.0	Φ ⁵	3.5	99	148	4190	368
					AB	10Φ10.7		4.7	121	200		
					B	13Φ10.7		6.2	144	258		
					C	13Φ12.6		8.2	166	332		
	550	100	≤15	C80	A	11Φ9.0	Φ ⁵	3.9	125	188	4020	368
					AB	11Φ10.7		5.3	154	254		
					B	15Φ10.7		6.9	182	328		
					C	15Φ12.6		9.2	211	422		
	550	125	≤15	C80	A	11Φ9.0	Φ ⁵	3.4	125	188	4700	434
					AB	11Φ10.7		4.7	154	254		
					B	15Φ10.7		6.1	182	328		
					C	15Φ12.6		7.9	211	422		
	600	110	≤15	C80	A	13Φ9.0	Φ ⁵	3.9	164	246	4810	440
					AB	13Φ10.7		5.5	201	332		
					B	17Φ10.7		7	239	430		
					C	17Φ12.6		9.1	276	552		
	600	130	≤15	C80	A	13Φ9.0	Φ ⁵	3.5	164	246	5440	499
					AB	13Φ10.7		4.8	201	332		
					B	17Φ10.7		6.2	239	430		
					C	17Φ12.6		8.2	276	552		

Table B.0.1 (continued)

Varieties	Outside diameter d (mm)	Wall thickness t (mm)	Single sectional pile length (m)	Concrete strength level	Type	Prestressed reinforcement	Spiral bar specification	Effective compressive pre-stress of concrete (MPa)	Control value M_{cr} of fracture-resistant bending moment (kN · m)	Control value M_u of ultimate bearing moment (kN · m)	Design value R_p of vertical bearing capacity of pile shaft (kN)	Theoretical weight (kg/m)
High strength prestressed concrete pipe pile (PHC)	800	110	≤15	C80	A	15Φ10.7	Φ ^b 6	4.4	367	550	6800	620
					AB	15Φ12.6		6.1	451	743		
					B	22Φ12.6		8.2	535	962		
					C	27Φ12.6		11	619	1238		
	1000	130	≤15	C80	A	22Φ10.7	Φ ^b 6	4.4	689	1030	10080	924
					AB	22Φ12.6		6	845	1394		
					B	30Φ12.6		8.3	1003	1805		
					C	40Φ12.6		10.9	1161	2322		
	300	70	≤11	C60	A	6Φ7.1	Φ ^b 4	3.8	23	34	1070	131
					AB	6Φ9.0		5.2	28	45		
					B	8Φ9.0		7.1	33	59		
					C	8Φ10.7		9.3	38	76		
Prestressed concrete pipe pile (PC)	400	95	≤12	C60	A	10Φ7.1	Φ ^b 4	3.7	52	77	1980	249
					AB	10Φ9.0		5.0	63	104		
					B	13Φ9.0		6.7	75	135		
					C	13Φ10.7		9.0	87	174		
	500	100	≤15	C60	A	10Φ9.0	Φ ^b 5	3.9	99	148	2720	327
					AB	10Φ10.7		5.4	121	200		
					B	14Φ10.7		7.2	144	258		
					C	14Φ12.6		9.8	166	332		

Table B.0.1 (continued)

Varieties	Outside diameter d (mm)	Wall thickness t (mm)	Single sectional pile length (m)	Concrete strength level	Type	Prestressed reinforcement	Spiral bar specification	Effective compressive pre-stress of concrete (MPa)	Control value M_G of fracture-resistant bending moment (kN · m)	Control value M_u of ultimate bearing moment (kN · m)	Design value R_p of vertical bearing capacity of pile shaft (kN)	Theoretical weight (kg/m)
Prestressed concrete pipe pile (PC)	550	100	≤15	C60	A	11Φ9.0	Φ ^b 5	3.9	125	188	3060	368
					AB	11Φ10.7		5.4	154	254		
					B	15Φ10.7		7.2	182	328		
					C	15Φ12.6		9.7	211	422		
	600	110	≤15	C60	A	13Φ9.0	Φ ^b 5	3.9	164	246	3680	440
					AB	13Φ10.7		5.4	201	332		
					B	18Φ10.7		7.2	239	430		
					C	18Φ12.6		9.8	276	552		

B.0.2 Basic parameters for hollow square pile of prestressed concrete with centrifugal forming may be adopted according to Table B.0.2.

Table B.0.2 Reinforcing Bars and Mechanical Property for Hollow Square Pile of Prestressed Concrete Pipe Pile

Varieties	Length of side b (mm)	Internal diameter d_i (mm)	Single sectional pile length (m)	Concrete strength level	Prestressed reinforcement	Spiral bar specification	Effective compressive pre-stress of concrete (MPa)	Control value M_{Gr} of fracture-resistant bending moment (kN · m)	Control value M_u of ultimate bearing moment (kN · m)	Design value R_p of vertical bearing capacity of pile shaft (kN)	Theoretical weight (kg/m)
High strength Hollow Square Pile of Prestressed Concrete Pipe Pile (PHS)	300	160	≤12	C80	8Φ ^p 7.1	Φ ^b 4	3.7	37	48	1880	185
					8Φ ^p 9.0	Φ ^b 4	5.9	48	77		
	350	190	≤12	C80	8Φ ^p 9.0	Φ ^b 4	4.4	66	93	2535	245
					8Φ ^p 9.0	Φ ^b 4	3.8	88	110		
	400	250	≤14	C80	8Φ ^p 10.7	Φ ^b 4	5.3	102	155	2985	290
					12Φ ^p 9.0	Φ ^b 5	4.1	135	185		
	450	250	≤15	C80	12Φ ^p 10.7	Φ ^b 5	5.7	160	261	4130	400
					12Φ ^p 12.6	Φ ^b 5	7.9	190	352		
	500	300	≤15	C80	12Φ ^p 9.0	Φ ^b 5	3.5	170	210	4830	470
					12Φ ^p 10.7	Φ ^b 5	4.9	198	295		
	550	350	≤15	C80	12Φ ^p 12.6	Φ ^b 5	6.8	234	406	5550	535
					16Φ ^p 9.0	Φ ^b 5	4.1	237	310		
500	380	≤15	C80	16Φ ^p 10.7	Φ ^b 5	5.7	278	440	6640	645	
				16Φ ^p 12.6	Φ ^b 5	7.8	331	582			
500	380	≤15	C80	20Φ ^p 9.0	Φ ^b 5	4.2	315	430	782	782	
				20Φ ^p 10.7	Φ ^b 5	5.9	370	596			
					200Φ ^p 12.6	Φ ^b 5	8.1	440			

Table B.0.2 (continued)

Varieties	Length of side b (mm)	Internal diameter d_i (mm)	Single sectional pile length (m)	Concrete strength level	Prestressed reinforcement	Spiral bar specification	Effective compressive pre-stress of concrete (MPa)	Control value of fracture-resistant bending moment ($kN \cdot m$)	Control value M_u of bearing moment ($kN \cdot m$)	Design value R_p of vertical bearing capacity of pile shaft (kN)	Theoretical weight (kg/m)	
Hollow Square Pile of Prestressed Concrete Pipe Pile (PS)	300	160	≤ 12	C60	8 Φ^P 7.1	Φ^B 4	3.7	35	48	1440	185	
					8 Φ^P 9.0	Φ^B 4	5.9	46	77			
	350	190	≤ 12	C60	8 Φ^P 9.0	Φ^B 4	4.4	63	93	1940	245	
					8 Φ^P 10.7	Φ^B 4	3.8	85	110			
	400	250	≤ 14	C60	8 Φ^P 10.7	Φ^B 4	5.3	99	155	2285	290	
					12 Φ^P 9.0	Φ^B 5	4.1	129	185			
	450	250	≤ 15	C60	12 Φ^P 10.7	Φ^B 5	5.7	152	256	3160	400	
					12 Φ^P 12.6	Φ^B 5	7.8	182	331			
	500	300	≤ 15	C60	12 Φ^P 9.0	Φ^B 5	3.5	163	210	3700	470	
					12 Φ^P 10.7	Φ^B 5	4.9	189	295			
	550	350	≤ 15	C60	12 Φ^P 12.6	Φ^B 5	6.7	223	388	4250	535	
					16 Φ^P 9.0	Φ^B 5	4.1	225	310			
	500	380	≤ 15	C60	16 Φ^P 10.7	Φ^B 5	5.6	266	426	5085	645	
					16 Φ^P 12.6	Φ^B 5	7.7	317	558			
						200 Φ^P 9.0	Φ^B 5	4.2	300	430		
						200 Φ^P 10.7	Φ^B 5	5.9	355	576		
						200 Φ^P 12.6	Φ^B 5	8.0	425	735		

Appendix C Piled foundation considering pile cap (including underground walling), foundation pile teamwork and soil elastic resistance acting calculation are bearing horizontal load

C.0.1 Basic assumption:

1 Regard the soil mass as elastic deformation medium, its horizontal resisting force coefficient is increased in response to deep linearity (m method), and it is 0 in the ground.

For piled foundation with low pile cap, when calculating piled foundation, suppose horizontal resisting force coefficient at pile top elevation is 0, and it is increased in response to deep increase.

2 Contact stress (normal elastic resistance) of any point on the surface of foundation pile, pile cap and underground walling is proportional to normal displacement δ of that point under action of horizontal force sum vertical pressure.

3 It shall neglect action of adhesive force and frictional force of sides between pile shaft, pile cap and underground walling for resisting horizontal force.

4 When it is designed according to composite piled foundation, that is when it complies with article 5.2.5 of this code, it may consider vertical resisting force and horizontal resistance forces of pile cap subsoil.

5 Fixed joint (rigid coupling) of pile top and pile cap, pile cap rigidity is regarded as infinity. So, only when pile cap rigidity is larger, or pile cap rigidity reinforced by superstructure and pile cap synergistic action, it may be calculated by adopting this methods.

When considering soil elastic resistance in calculation, it shall pay attention to stability of soil mass.

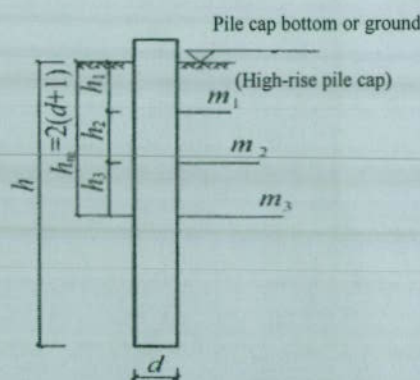


Figure C.0.2

C.0.2 Basic calculating parameter:

1 Proportionality coefficient m of horizontal resisting force coefficient for the foundation soil, it is taken according to article 5.7.5 of this code.

When foundation pile side is composed several kinds of soil layers, it shall calculate m in the equation of major influence depth $h_m=2(d+1)m$, and with m act as calculated value (figure C.0.2).

When there exist two layers of different soils within h_m depth:

$$m = \frac{m_1 + h_1^2 + m_2(2h_1 + h_2)h_2}{h_m^2} \quad (\text{C.0.2-1})$$

When there exist three layers of different soils within h_m depth:

$$m = \frac{m_1 h_1^2 + m_2(2h_1 + h_2)h_2 + m_3(2h_1 + 2h_2 + h_3)h_3}{h_m^2} \quad (\text{C.0.2-2})$$

2 Horizontal resisting force coefficient C_n at side of pile cap:

$$C_n = m \cdot h_n \quad (\text{C.0.2-3})$$

Where: m —Proportionality coefficient of horizontal resisting force coefficient of foundation soil within buried depth of pile cap (MN/m^4);

h_n —Buried depth of pile cap (m).

3 Vertical resisting force coefficient C_0 , C_b of foundation soil and proportionality coefficient m_0 of vertical resisting force coefficient of foundation soil:

1) Vertical resisting force coefficient C_0 of foundation soil on pile bottom surface

$$C_0 = m_0 h \quad (\text{C.0.2-4})$$

Where: m_0 —Proportionality coefficient of vertical resisting force coefficient of foundation soil on pile bottom surface (MN/m^4), it is approximately taken $m_0=m$;

h —Pile buried depth (m), when h is less than 10m, it is calculated as 10m.

2) Vertical resisting force coefficient C_b of foundation soil at pile cap bottom

$$C_b = m_0 h_n \eta_c \quad (\text{C.0.2-5})$$

Where: h_n —Buried depth of pile cap (m), when h_n is less than 1m, it is calculated as 1m;

η_c —Pile cap effect coefficient, it is determined according to article 5.2.5 of this code.

Vertical resisting force coefficient of rock foundation, it is not increased in response to terrane buried depth, and its value is adopted according to Table C.0.2;

Table C.0.2 Vertical Resisting Force Coefficient C_R of Rock Foundation

Saturated uniaxial compressive strength of rock f_{rk} (kPa)	C_R (MN/m ³)
1000	300
≥ 25000	15000

Note: f_{rk} is medium value among numerical value listed in the table, C_R is determined with interpolation.

4 Vertical Resisting Force Coefficient C_R of Rock Foundation

5 Flexural rigidity EI of the pile shaft: it is determined by calculation specified in article 5.7.2-6 of this code.

6 Axial pressure transfer coefficient ξ_N of pile shaft:

$$\xi_N = 0.5 \sim 1.0$$

Friction-type pile takes the smaller value and end support type pile takes the larger value.

7 Friction factor μ between foundation soil and pile cap panel is taking value according to Table 5.7.3-2 of this code.

C.0.3 Computing formula:

1 Single piled foundation or single-row pile foundation perpendicular to exogenous processing plane see Table C.0.3-1

2 Piled foundation with low pile cap of single-row (or multi-row) pile lying (or parallel to) exogenous processing plane sees Table C.0.3-2.

3 Piled foundation with high pile cap of single-row (or multi-row) pile lying (or parallel to) exogenous processing plane sees Table C.0.3-3.

C.0.4 Determine calculating parameter and several schematic problems for piled foundation under earthquake effect:

1 When soil layer above pile cap bottom surface is fluidized layer, it shall not consider elastic resistance of soil mass at side of pile cap and vertical elastic resistance and resistance forces of pile cap subsoil, at this time, make $C_n=C_b=0$, it may be calculated according to high pile cap equation in Table C.0.3-3.

2 When soil layer above pile cap bottom surface isn't fluidized layer, but soil mass on and under pile cap bottom surface may be broken away (when parts under pile cap bottom surface have underconsolidation, self-subsidence, seismic settlement and fluidized soil mass), it takes no account of vertical elastic resistance and resistance forces of foundation soil at pile cap bottom, it only consider elastic resistance of soil mass at sides of pile cap, and it should make calculation according to high pile cap schemata in Table C.0.3-3; but when calculating counter force of pile top, pile cap and underground walling causing by pile cap unit deflection, it shall consider influence of elastic resistance of soil mass at sides of pile cap and underground walling. It may be calculated according to equation of step 5 in Table C.0.3-2 ($C_b=0$).

3 When there are fluidized interlining within $2(d+1)$ meter depth under pile top, integrated computing value m of proportionality coefficient for its horizontal resisting force coefficient is determined according to equations (C.0.2-1) or (C.0.2-2) (by substituting value m in the fluidized layer) in Table 5.3.12 of this code.

Table C.0.3-1 Single Piled Foundation or Single-row Pile Foundation Perpendicular to Exogenous Process Plane

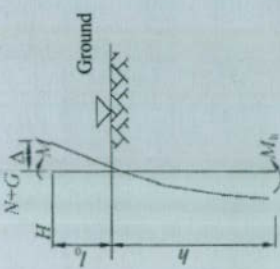
Computational procedure	Content	Notices
1	Determine load and calculate schemata 	Pile toe is supporting on non-rock soil or bedrock surface
2	Determine basic parameter $m, EI \text{ and } \alpha$	Details in appendix C.0.2
3	Calculate internal force for pile shaft on the ground $M_0 = \frac{M}{n} + \frac{H}{n} l_0 \quad H_0 = \frac{H}{n}$	n —Pile numbers of single-row piles; when it is low pile cap, makes $l_0=0$
4	Calculate deflection generate by pile shaft at the section when unit force is acting on pile shaft ground $\delta_{\text{rot}} = \frac{1}{\alpha^2 EI} \times \frac{(B_3 D_3 - B_1 D_3) + K_3 (B_3 D_3 - B_1 D_3)}{(A_3 B_3 - A_1 B_3) + K_3 (A_3 B_3 - A_1 B_3)}$ $\delta_{\text{rot}} = \frac{1}{\alpha^2 EI} \times \frac{(A_3 D_3 - A_1 D_3) + K_3 (A_3 D_3 - A_1 D_3)}{(A_3 B_3 - A_1 B_3) + K_3 (A_3 B_3 - A_1 B_3)}$ $\delta_{\text{rot}} = \delta_{\text{rot}}$ $\delta_{\text{rot}} = \frac{1}{\alpha^2 EI} \times \frac{(A_3 C_3 - A_1 C_3) + K_3 (A_3 C_3 - A_1 C_3)}{(A_3 B_3 - A_1 B_3) + K_3 (A_3 B_3 - A_1 B_3)}$	Pile toe is supporting in non-rock soil and when $h \geq 2.5/\alpha$, it may make $K_h=0$; Pile toe is supporting on the bedrock surface, and when $h \geq 3.5/\alpha$, it may make $K_h=0$. Calculation for K_h sees note 3 in this table Coefficients A_1, D_1, A_3, B_1 and C_1 check Table C.0.3-4 according to $\bar{h} = ah$

Table C.0.3-1 (continued)

Computational procedure		Content	Notices
5	Calculate deflection for pile shaft on the ground	Horizontal displacement (L) rotor angle (radian) $x_0 = H_0 \delta_{int} + M_0 \delta_{int}$ $\varphi_0 = -(H_0 \delta_{ext} + M_0 \delta_{ext})$	
6	Calculate internal force of pile shaft at any depth under the ground	Bending moment ($F \times L$) Horizontal force (F) $M_y = \alpha^2 EI \left(x_y A_y + \frac{\varphi_y B_y}{\alpha} + \frac{M_0}{\alpha^2 EI} C_y + \frac{H_0}{\alpha^2 EI} D_y \right)$ $H_y = \alpha^2 EI \left(x_y A_y + \frac{\varphi_y B_y}{\alpha} + \frac{M_0}{\alpha^2 EI} C_y + \frac{H_0}{\alpha^2 EI} D_y \right)$	
7	Calculate horizontal displacement on pile top	$\Delta = x_0 - \varphi_0 l_0 + \Delta_0$, where $\Delta_0 = \frac{Hl_0^3}{3nEI} + \frac{Ml_0^2}{2nEI}$	
8	Calculate turning position with maximal bending moment	Maximal bending moment position (L) $\frac{\alpha M_0}{H} = C_1$; getting corresponding αy and $y_{1max} = \frac{\alpha y}{\alpha}$ by checking table C.0.3-5	C_1 and D_0 see Table C.0.3-5
		Maximal bending moment ($F \times L$) $M_{max} = H_0 / D_{II}$	

Note: 1 Diagrammatic meanings of δ_{HH} , δ_{MH} , δ_{HM} and δ_{MM}

2 When pile toe is embedded in bedrock, δ_{HH} and δ_{MM} is calculated according to the following equations:

$$\delta_{HH} = \frac{1}{\alpha^3 EI} \times \frac{B_3 D_1 - B_1 D_3}{A_2 B_1 - A_1 B_2}; \quad \delta_{MM} = \frac{1}{\alpha^2 EI} \times \frac{A_3 D_1 - A_1 D_3}{A_2 B_1 - A_1 B_2}$$

$$\delta_{MH} = \delta_{HM}$$

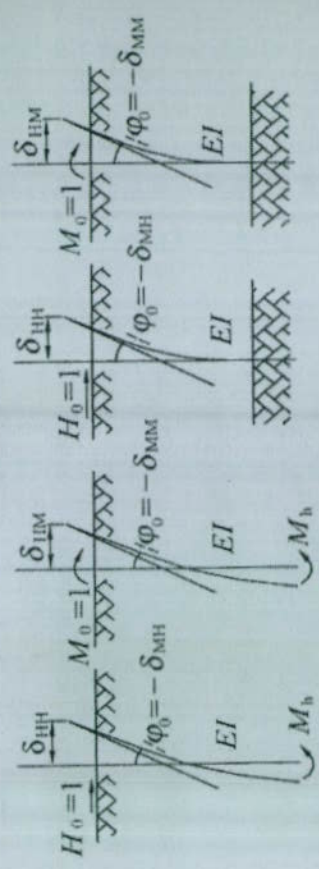
$$\delta_{MH} = \frac{1}{\alpha EI} \times \frac{A_3 C_1 - A_1 C_3}{A_2 B_1 - A_1 B_2};$$

3 Coefficient K_b
$$K_b = \frac{C_b I_b}{\alpha EI}$$

Where: C_b , α , E and I —Details see appendix C.0.2;

I_b —Inertia moment of pile toe section; for non-enlarged base, $I_b = I$.

4 F and L in the table denote dimension of force and length respectively.



(a) Pile tip is supporting on non-rock soil or bedrock surface
 (b) Pile tip is embedding in bedrock

Table C.0.3-2 Piled Foundation with Low Pile Cap of Single-row (or Multi-row) Pile Lying (or Parallel To) Exogenous Processing Plane

Computational procedure		Content	Notices
1	Determine load and calculate schemata		Origin of coordinate shall be on symmetry point or orthocenter of pile group
2	Determine basic calculating parameter	$M, m_0, EI, \alpha, \xi_N, C_0, C_3, \text{ and } \mu$ δ_{HH} δ_{MH} $\delta_{HM} = \delta_{MH}$ δ_{HH}	Details see appendix C.0.2
3	Deflection generated on pile top when calculating unit force acting on pile top	Horizontal displacement ($F-1 \times L$) Rotor angle ($F-1$)	Equation is same as step 4 in Table C.0.3-1 and $K_b = 0$; when pile toe is embedding in bedrock, it shall be calculated note 2 in Table C.0.3-1.
	Internal force generated on pile top when calculating pile cap occurring unit deflection	Horizontal displacement ($F-1$) Rotor angle ($F-1 \times L-1$) Axial force ($F \times L-1$)	
4	Internal force generated on pile top when calculating pile cap occurring unit deflection	When occurring unit vertical displacement	$\rho_{MH} = \frac{1}{\frac{\xi_N h}{EA} + \frac{1}{C_3 A_0}}$
		When occurring unit horizontal displacement	$\rho_{MH} = \frac{\delta_{MH}}{\delta_{MH} \delta_{MH} - \delta_{MH}^2}$
		When occurring unit rotor angle	$\rho_{MH} = \frac{\delta_{MH}}{\delta_{MH} \delta_{MH} - \delta_{MH}^2}$
			$\rho_{MH} = \frac{\delta_{MH}}{\delta_{MH} \delta_{MH} - \delta_{MH}^2}$

Table C.0.3-2 (continued)

Computational procedure		Content	Notices	
5	Counter force sum generated by all the pile top, pile cap and sidewall when calculating pile cap occurring unit deflection	Vertical counter force ($F \times L-1$)	<p>B_0—Pile cap width perpendicular to force acting surface direction;</p> <p>A_b, I_b, F^c, S^c, F—Details see note 3 and 4 in this table</p> <p>n—Foundation pile numbers</p> <p>x_r—Distance from origin of coordinate to all the piles</p> <p>K_r—Pile numbers of the r^{th} pile</p> <p>TOW</p>	
		When occurring unit vertical displacement		$\gamma_{vv} = n\rho_{ss} + C_s A_s$
		Horizontal counter force ($F \times L-1$)		$\gamma_{vh} = \mu C_s A_s$
		When occurring unit horizontal displacement		$\gamma_{hv} = n\rho_{ss} + B_0 F^c$
		Counter bending moment (F)		$\gamma_{ho} = -n\rho_{ss} + B_0 S^c$
6	Calculate pile cap deflection	Horizontal counter force ($F \times L-1$)	$\gamma_{vh} = \gamma_{hv}$	
		Counter bending moment ($F \times L$)	$\gamma_{ho} = n\rho_{ss} + \rho_{ss} \sum K_r x_r^2 + B_0 I^c + C_b I^c$	
		Vertical displacement (L)	$V = \frac{(N+G)}{\gamma_{vv}}$	
		Horizontal displacement (L)	$U = \frac{\gamma_{hv} H - \gamma_{vh} M}{\gamma_{vv} - \gamma_{vh}^2} - \frac{(N+G)\gamma_{vh} \gamma_{ho}}{\gamma_{vv}(\gamma_{vv} \gamma_{ho} - \gamma_{vh}^2)}$	
7	Calculate internal force of pile top of any foundation pile	Rotor angle (radian)	$\beta = \frac{\gamma_{vv} M - \gamma_{vh} H}{\gamma_{vv} \gamma_{ho} - \gamma_{vh}^2} - \frac{(N+G)\gamma_{vh} \gamma_{ho}}{\gamma_{vv}(\gamma_{vv} \gamma_{ho} - \gamma_{vh}^2)}$	
		Axial force (F)	$N_{si} = (V + \beta \cdot x_r) \rho_{ss}$	
		Horizontal force (F)	$H_{si} = U \rho_{mi} - \beta \rho_{mi}$	
		Bending moment ($F \times L$)	$M_{si} = \beta \rho_{mi} - U \rho_{mi}$	
			<p>x_r takes positive value on the right of the origin, and takes negative value on the left of the origin</p>	

Table C.0.3-2 (continued)

Computational procedure		Content	Notices	
8	Calculate bending moment of pile shaft at any depth	Bending moment($F \times L$)	$M_x = \alpha^2 EI \left(UA_x + \frac{\beta}{\alpha} B_x + \frac{M_0}{\alpha^2 EI} C_x + \frac{H_0}{\alpha^3 EI} D_x \right)$	
9	Calculate maximal bending moment and position of any foundation pile shaft	Position of maximum bending moment(L) Maximal bending moment($F \times L$)		y_{\max} M_{\max}
10	Calculate elastic resistance of pile cap and sidewall	Horizontal resisting force(F)	$H_x = UB_x F' - \rho B_x S'$	
		Counter bending moment($F \times L$)		$M_x = UB_x S' - \rho B_x S'$
11	Calculate elastic resistance and resistance forces of underlying soil in pile cap lowland	Vertical resisting force(F)	$N_x = VC_x A_x$	
		Horizontal resisting force(F)		$H_x = \mu N_x$
		Counter bending moment($F \times L$)		$M_x = \beta C_x I_x$
12	Check calculated result of horizontal force		$\sum H_x + H_x + H_x = H$	

Note: 1 Diagrammatical meanings of ρ_{NS} , ρ_{BS} , ρ_{MS} , ρ_{MB} and ρ_{MM} .

2 A_0 —Pressure distribution area of single pile bottom, for point bearing pile, A_0 is bottom surface of a single pile; for friction-type pile, it takes the smaller value between the values calculated by the two equations:

$$A_s = \pi \left(h \tan \frac{\varphi_m}{4} + \frac{d}{2} \right)^2$$

$$A_s = \frac{\pi}{4} S^2$$

Where: h —Pile penetration depth;

φ_m —Weighted average of internal friction angle of soil layers around piles;

d —Design diameter of piles;

s —Center distance of piles

3 F^c , S^c and I^c —Area, area moment for bottom surface and inertia moment of coefficient of lateral horizontal resisting force above pile cap bottom surface:

$$F^c = \frac{C_s h}{2}$$

$$S^c = \frac{C_s h^2}{6}$$

$$I^c = \frac{C_s h^3}{12}$$

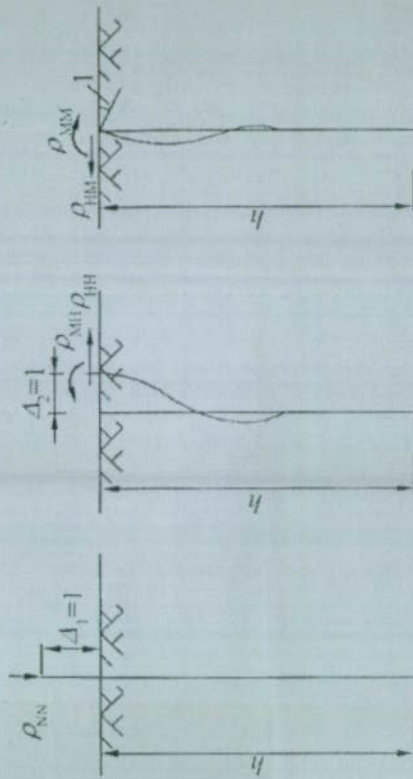
4 A_b and I_b —Contact area and inertia moment of pile cap bottom and foundation soil:

$$A_b = F - nA$$

$$I_b = I_c - \sum AK_i x_i^2$$

Where: F —Bottom area of pile cap;

nA —Cross-sectional areas' sum of pile top of all the foundation piles.



When pile top is generating unit vertical displacement

When pile top is generating unit horizontal displacement

Pile top is generating unit rotor angle

Table C.0.3-3 Piled foundation with high pile cap (or multi-row) pile lying (or parallel to) exogenous processing plane

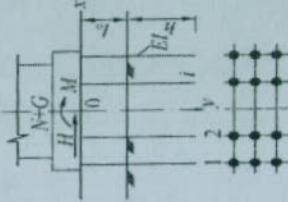
	Evaluation Procedures	Content	Remark
1	Identify Load and Calculation Scheme		The grid origin shall be located on the symmetry point or the gravity centre of pile group
2	Identify the basic calculating parameters	$m, m_0, EI, \alpha, \xi_N, C_0$ $\delta_{HB}, \delta_{MB}, \delta_{HM}, \delta_{MM}$	Detailed in Appendix C.0.2
3	Calculate the deflection on pile foundation, when the unit force acts on pile foundation ground		The formula is same to one specified in Table C.0.3-2
4	Calculate the deflection of the pile top, when the unit force acts on the pile top	Horizontal Displacement ($F-1 \times L$)	$\delta'_{mi} = \frac{l^3}{3EI} + \sigma_{m0} l^2 + 2\delta_{mi} l + \delta_{mi}$
	$H_i = 1$, acts on	Turn angle ($F-1$)	$\delta'_{mi} = \frac{l^3}{2EI} + \delta_{mi} l + \delta_{mi}$
	$M_i = 1$, acts on	Horizontal Displacement ($F-1$)	$\delta'_{mi} = \delta'_{mi}$
		Turn angle ($F-1 \times L-1$)	$\delta'_{mi} = \frac{l}{EI} + \delta_{mi}$

Table C.0.3-3 (continued)

	Evaluation Procedures	Content	Remark	
5	Unit vertical displacement	Axial-direction force ($F \times L-1$)		
	Unit horizontal displacement	Horizontal force ($F \times L-1$)		$\rho_{NS} = \frac{1}{I_0 + \zeta_n h + C_0 A_0}$
		Bending moment (F)		$\rho_{MH} = \frac{\delta'_{MH}}{\delta'_{MH,SO} - \delta'^2_{MH}}$
		Horizontal force (F)		$\rho_{MH} = \rho_{MH}$
	Unit rotation	Bending moment ($F \times L$)		$\rho_{MH} = \frac{\delta'_{MH}}{\delta'_{MH,SO} - \delta'^2_{MH}}$
6	Unit vertical displacement	Vertical counterforce ($F \times L-1$)	$\gamma_{VY} = n\rho_{NS}$	
		Horizontal counterforce ($F \times L-1$)	$\gamma_{LU} = n\rho_{MH}$	
	Unit horizontal displacement	Counter bending moment (F)	$\gamma_{R1} = -n\rho_{MH}$	
		Horizontal counterforce ($F \times L-1$)	$\gamma_{10} = \gamma_{R1}$	
	Unit rotation	Counter bending moment ($F \times L$)	$\gamma_{10} = n\rho_{NS} + \rho_{NS} \sum K_i x_i^2$	

n —Foundation pile number
 x_i —Distance from the grid origin to all piles
 K_i —The pipe number of i^{th} row

Table C.0.3-3 (continued)

Evaluation Procedures		Content	Remark
7	Calculate the cushion cap deflection	Vertical displacement (L)	$V = \frac{(N+G)}{\gamma_{sv}}$
		Horizontal Displacement (L)	$U = \frac{\gamma_{sh} H - \gamma_{sh} M}{\gamma_{sh} - \gamma_{sh}^2}$
		Turn angle (Radian)	$\beta = \frac{\gamma_{sh} M - \gamma_{sh} H}{\gamma_{sh} \gamma_{sh} - \gamma_{sh}^2}$
8	Calculate the internal force of any foundation pile top	Horizontal force (F)	$N_{oi} = (V + \beta \cdot x_i) \rho_{ps}$
		Horizontal force (F)	$H_{oi} = U \rho_{mi} - \beta \rho_{oin} = H_i$
		Bending moment ($F \times L$)	$M_{oi} = \beta \rho_{mi} - U \rho_{oin}$
9	Calculate the internal force of any foundation pile cross section on ground	Horizontal force (F)	$H_{oi} = H_i$
		Bending moment ($F \times L$)	$M_{oi} = M_i + H_i l_o$
10	Calculate the deflection of any foundation pile cross section on ground	Horizontal Displacement (L)	$H_{oi} = H_i \delta_{oin} + M_{oi} \delta_{oin}$
		Turn angle (Radian)	$\delta_{oi} = -(H_{oi} \delta_{oin} + M_{oi} \delta_{oin})$

x_i , Shall be adopted as positive value on the right of the origin point, and negative value on the left of the origin point

Table C.0.3-3 (continued)

		Evaluation Procedures	Content	Remark
11	Calculate the internal force of pile foundation cross section of any depth under the ground	Bending moment ($F \times L$)	$M_y = \alpha^2 EI \left(x_w A_3 + \frac{\varphi_w}{\alpha} B_3 + \frac{M_w}{\alpha^2 EI} C_3 + \frac{H_w}{\alpha^3 EI} D_3 \right)$	A_3, \dots, D_4 are detailed in Table C.0.3-4. This item of calculation is needed when the pile foundation variable cross-section is treated with reinforcement assembly
		Horizontal resisting force (F)	$H_y = \alpha^2 EI \left(x_w A_4 + \frac{\varphi_w}{\alpha} B_4 + \frac{M_w}{\alpha^2 EI} C_4 + \frac{H_w}{\alpha^3 EI} D_4 \right)$	
12	Max bending moment and position of any foundation pile	Position with max bending moment (L)	y_{max}	The formula is same to one specified in Table C.0.3-1
		Max bending moment ($F \times L$)	M_{max}	

Table C.0.3-4 Influence Function Values

Equivalent Depth $h = cy$	A_3	B_3	C_3	D_3	A_4	B_4	C_4	D_4	$B_3D_4 - B_4D_3$	$A_3B_4 - A_4B_3$	$B_2D_4 - B_4D_2$
0	0.00000	0.00000	1.00000	0.00000	0.00000	0.0000	0.00000	1.00000	0.00000	0.00000	1.00000
0.1	-0.00017	-0.00001	1.00000	0.10000	-0.00500	-0.00033	-0.00001	1.00000	0.00002	0.00000	1.00000
0.2	-0.00133	-0.00013	0.99999	0.20000	-0.02000	-0.00267	-0.00020	0.99999	0.00040	0.00000	1.00004
0.3	-0.00450	-0.00067	0.99994	0.30000	-0.04500	-0.00900	-0.00101	0.99992	0.00203	0.00001	1.00029
0.4	-0.01067	-0.00213	0.99974	0.39998	-0.08000	-0.02133	-0.00320	0.99966	0.00640	0.00006	1.00120
0.5	-0.02083	-0.00521	0.99922	0.49991	-0.12499	-0.04167	-0.00781	0.99896	0.01563	0.00022	1.00365
0.6	-0.03600	-0.01080	0.99806	0.59974	-0.17997	-0.07199	-0.01620	0.99741	0.03240	0.00065	1.00917
0.7	-0.05716	-0.02001	0.99580	0.69935	-0.24490	-0.11433	-0.03001	0.99440	0.06006	0.00163	1.01962
0.8	-0.08532	-0.03412	0.99181	0.79854	-0.31975	-0.17060	-0.05120	0.98908	0.10248	0.00365	1.03824
0.9	-0.12144	-0.05466	0.98524	0.89705	-0.40443	-0.24284	-0.08198	0.98032	0.16426	0.00738	1.06893
1.0	-0.16652	-0.08329	0.97501	0.99445	-0.49881	-0.33298	-0.12493	0.96667	0.25062	0.01390	1.11679
1.1	-0.22152	-0.12192	0.95975	1.09016	-0.60268	-0.44292	-0.18285	0.94634	0.36747	0.02464	1.18823
1.2	-0.28737	-0.17260	0.93783	1.18342	-0.71573	-0.57450	-0.25886	0.91712	0.52158	0.04156	1.29111
1.3	-0.36496	-0.23760	0.90727	1.27320	-0.83753	-0.72950	-0.35631	0.87638	0.72057	0.06724	1.43498
1.4	-0.45515	-0.31933	0.86575	1.35821	-0.96746	-0.90954	-0.47883	0.82102	0.97317	0.10504	1.63125
1.5	-0.55870	-0.42039	0.81054	1.43680	-1.10468	-1.11609	-0.63027	0.74745	1.28938	0.15916	1.89349
1.6	-0.67629	-0.54348	0.73859	1.50695	-1.24808	-1.35042	-0.81466	0.65156	1.68091	0.23497	2.23776
1.7	-0.80848	-0.69144	0.64637	1.56621	-1.39623	-1.61346	-1.03616	0.52871	2.16145	0.33904	2.68296
1.8	-0.95564	-0.86715	0.52997	1.61162	-1.54728	-1.90577	-1.29909	0.37368	2.74734	0.47951	3.25143
1.9	-1.11796	-1.07357	0.38503	1.63969	-1.69889	-2.22745	-1.60770	0.18071	3.45833	0.66632	3.96945
2.0	-1.29535	-1.31361	0.20676	1.64628	-1.84818	-2.57798	-1.96620	-0.05652	4.31831	0.91158	4.86824
2.2	-1.69334	-1.90567	-0.27087	1.57538	-2.12481	-3.35952	-2.84858	-0.69158	6.61044	1.63962	7.36356
2.4	-2.14117	-2.66329	-0.94885	1.35201	-2.33901	-4.22811	-3.97323	-1.59151	9.95510	2.82366	11.13130
2.6	-2.62126	-3.59987	-1.87734	0.91679	-2.43695	-5.14023	-5.35541	-2.82106	14.86800	4.70118	16.74660
2.8	-3.10341	-4.71748	-3.10791	0.19729	-2.34558	-6.02299	-6.99007	-4.44491	22.15710	7.62658	25.06510
3.0	-3.54058	-5.99979	-4.68788	-0.89126	-1.96928	-6.76460	-8.84029	-6.51972	33.08790	12.13530	37.38070
3.5	-3.91921	-9.54367	-10.34040	-5.85402	1.07408	-6.78895	-13.69240	-13.82610	92.20900	36.85800	101.36900
4.0	-1.61428	-11.7307	-17.91860	-15.07550	9.24368	-0.35762	-15.61050	-23.14040	266.06100	109.01200	279.99600

Note: In the table, y refers to the depth of pile foundation calculation cross-section; α refers to the horizontal deformation coefficient of pile.

Table C.0.3-4 (continued)

Equivalent Depth $\frac{h}{h} = \alpha$	A_2B_4 $-A_1B_2$	A_3D_4 $-A_1D_3$	A_2D_4 $-A_1D_2$	A_3C_4 $-A_1C_3$	A_2C_4 $-A_1C_2$	A_1F $\frac{B_2D_2 - B_1D_1}{A_1B_1 - A_1B_2}$	B_1F $\frac{A_1D_2 - A_1D_1}{A_1B_1 - A_1B_2}$	C_1F $\frac{A_1C_2 - A_1C_1}{A_1B_1 - A_1B_2}$	$\frac{B_2D_2 - B_1D_1}{A_1B_1 - A_1B_2}$	$\frac{A_1D_2 - A_1D_1}{A_1B_1 - A_1B_2}$	$\frac{A_1C_2 - A_1C_1}{A_1B_1 - A_1B_2}$
0	0.00000	0.00000	0.00000	0.00000	0.00000	∞	∞	∞	0.00000	0.00000	0.00000
0.1	0.00500	0.00033	0.00003	0.00500	0.00050	1800.00	24000.00	36000.00	0.00033	0.00500	0.10000
0.2	0.02000	0.00267	0.00033	0.02000	0.00400	450.00	3000.000	22500.10	0.00269	0.02000	0.20000
0.3	0.04500	0.00900	0.00169	0.04500	0.01350	200.00	888.898	4444.590	0.00900	0.04500	0.30000
0.4	0.07999	0.02133	0.00533	0.08001	0.03200	112.502	375.017	1406.444	0.02133	0.07999	0.39996
0.5	0.12504	0.04167	0.01302	0.12505	0.06251	72.102	192.214	576.825	0.04165	0.12495	0.49988
0.6	0.18013	0.07203	0.02701	0.18020	0.10804	50.012	111.179	278.134	0.07192	0.17893	0.59962
0.7	0.24535	0.11443	0.05004	0.24559	0.17161	36.740	70.001	150.236	0.11406	0.24448	0.69902
0.8	0.32091	0.17094	0.03539	0.32150	0.25632	28.108	46.884	88.179	0.16985	0.31867	0.79783
0.9	0.40709	0.24374	0.13685	0.40842	0.36533	22.245	33.009	55.312	0.24092	0.40199	0.89562
1.0	0.50436	0.33507	0.20873	0.50714	0.50194	18.028	24.102	36.480	0.32855	0.49374	0.99179
1.1	0.61351	0.44739	0.30600	0.61893	0.66965	14.915	18.160	25.122	0.43351	0.59294	1.08560
1.2	0.73565	0.58346	0.43412	0.74562	0.87232	12.550	14.039	17.941	0.55589	0.69811	1.17605
1.3	0.87244	0.74650	0.59910	0.88991	1.11429	10.716	11.102	13.235	0.69488	0.80737	1.26199
1.4	1.02612	0.94032	0.80887	1.05550	1.40059	9.265	8.952	10.049	0.84855	0.91831	1.34213
1.5	1.19981	1.16960	1.07061	1.24752	1.73720	8.101	7.349	7.838	1.01382	1.02816	1.41516
1.6	1.39771	1.44015	1.39379	1.47277	2.13135	7.154	6.129	6.268	1.18632	1.13380	1.47990
1.7	1.62522	1.75934	1.78918	1.74019	2.59200	6.375	5.189	5.133	1.36088	1.23219	1.53540
1.8	1.88946	2.13653	2.26933	2.06147	3.13039	5.750	4.456	4.300	1.53179	1.32058	1.58115
1.9	2.19944	2.58362	2.84909	2.45147	3.76049	5.190	3.878	3.680	1.69343	1.39688	1.61718
2.0	2.56664	3.11583	3.54638	2.92905	4.49999	4.737	3.418	3.213	1.84091	1.43979	1.64405
2.2	3.53366	4.51846	5.38469	4.24806	6.40196	4.032	2.756	2.591	2.08041	1.54549	1.67490
2.4	4.95288	6.57004	8.02219	6.28800	9.09220	3.526	2.327	2.227	2.32974	1.58566	1.68520
2.6	7.07178	9.62890	11.82060	9.46294	12.97190	3.161	2.048	2.013	2.52965	1.59617	1.68665
2.8	10.26420	14.25710	17.33620	14.40320	18.66360	2.905	1.869	1.889	2.71119	1.59262	1.68717
3.0	15.09220	21.32850	25.42750	22.06800	27.12570	2.727	1.758	1.818	2.38547	1.58606	1.69051
3.5	41.01820	60.47600	67.49820	64.76960	72.04850	2.502	1.641	1.757	2.38891	1.58435	1.71100
4.0	114.7220	176.7060	185.9960	190.8340	200.0470	2.441	1.625	1.751	2.40074	1.59979	1.73218

Table C.0.3-5 Max bending moment section factor C_1 and max bending moment coefficient D_{II} of pile foundation

Equivalent Depth $\frac{y}{h} = \alpha y$	C_1					D_{II}						
	$\alpha h = 4.0$	$\alpha h = 3.5$	$\alpha h = 3.0$	$\alpha h = 2.8$	$\alpha h = 2.6$	$\alpha h = 2.4$	$\alpha h = 4.0$	$\alpha h = 3.5$	$\alpha h = 3.0$	$\alpha h = 2.8$	$\alpha h = 2.6$	$\alpha h = 2.4$
0.0	∞	∞	∞	∞	∞	∞	∞	∞	∞	∞	∞	∞
0.1	131.252	129.489	120.507	112.954	102.805	90.196	131.250	129.551	120.515	113.017	102.839	90.226
0.2	34.186	33.699	31.158	29.090	26.326	22.939	34.315	33.818	31.282	29.218	26.451	23.065
0.3	15.544	15.282	14.013	13.003	11.671	10.064	15.738	15.476	14.206	13.197	11.864	10.258
0.4	8.781	8.605	7.799	7.176	6.368	5.409	9.039	8.862	8.057	7.434	6.625	5.667
0.5	5.539	5.403	4.821	4.385	3.829	3.183	5.855	5.720	5.138	4.702	4.147	3.502
0.6	3.710	3.597	3.141	2.811	2.400	1.931	4.086	3.973	3.519	3.189	2.778	2.310
0.7	2.566	2.465	2.089	1.826	1.506	1.150	2.999	2.899	2.525	2.263	1.943	1.587
0.8	1.791	1.699	1.377	1.160	0.902	0.623	2.282	2.191	1.871	1.655	1.398	1.119
0.9	1.238	1.151	0.867	0.683	0.471	0.248	1.784	1.698	1.417	1.235	1.024	0.800
1.0	0.824	0.740	0.484	0.327	0.149	-0.032	1.425	1.342	1.091	0.934	0.758	0.577
1.1	0.503	0.420	0.187	0.049	-0.100	-0.247	1.157	1.077	0.848	0.713	0.564	0.416
1.2	0.246	0.163	-0.052	-0.172	-0.299	-0.418	0.952	0.873	0.664	0.546	0.420	0.299
1.3	0.034	-0.049	-0.249	-0.355	-0.465	-0.557	0.792	0.714	0.522	0.418	0.311	0.212
1.4	-0.145	-0.229	-0.416	-0.508	-0.597	-0.672	0.666	0.588	0.410	0.319	0.229	0.148
1.5	-0.299	-0.384	-0.559	-0.639	-0.712	-0.769	0.563	0.486	0.321	0.241	0.166	0.101
1.6	-0.434	-0.521	-0.634	-0.753	-0.812	-0.853	0.480	0.402	0.250	0.181	0.118	0.067
1.7	-0.555	-0.645	-0.796	-0.854	-0.898	-0.925	0.411	0.333	0.193	0.134	0.082	0.043
1.8	-0.665	-0.756	-0.896	-0.943	-0.975	-0.987	0.353	0.276	0.147	0.097	0.055	0.026
1.9	-0.768	-0.862	-0.988	-1.024	-1.043	-1.043	0.304	0.227	0.110	0.068	0.035	0.014
2.0	-0.865	-0.961	-1.073	-1.098	-1.105	-1.092	0.263	0.186	0.081	0.046	0.022	0.007
2.2	-1.048	-1.148	-1.225	-1.227	-1.210	-1.176	0.196	0.122	0.040	0.019	0.006	0.001
2.4	-1.230	-1.328	-1.360	-1.338	-1.299	0	0.145	0.075	0.016	0.005	0.001	0
2.6	-1.420	-1.507	-1.482	-1.434	0	0	0.106	0.043	0.005	0.001	0	0
2.8	-1.635	-1.692	-1.593	0	0	0	0.074	0.021	0.001	0	0	0
3.0	-1.893	-1.886	0	0	0	0	0.049	0.008	0.001	0	0	0
3.5	-2.994	0	0	0	0	0	0.010	0	0	0	0	0
4.0	0	0	0	0	0	0	0	0	0	0	0	0

Note: In the table, α refers to the horizontal coefficient of deformation; y refers to the depth of the pile foundation calculation cross-section; h refers to the pile length. When $\alpha h > 4.0$, αh is thought as 4.0.

Appendix D Subsidiary stress coefficient α and average subsidiary stress coefficient $\bar{\alpha}$ calculated through

Boussinesq

D.0.1 Subsidiary stress coefficient α and average subsidiary stress coefficient $\bar{\alpha}$ of angle point under evenly distributed load on rectangular area shall be identified in accordance with Table D.0.1-1, and Table D.0.1-2.

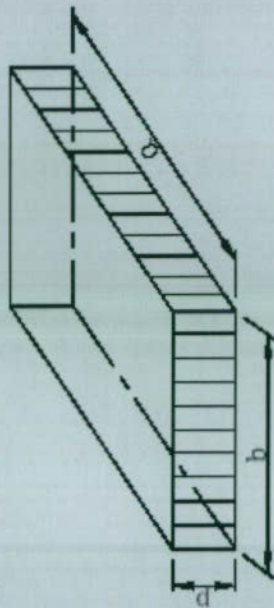


Table D.0.1-1 Subsidiary stress coefficient α of angle point under evenly distributed load on rectangular area

a/b z/b	1.0	1.2	1.4	1.6	1.8	2.0	3.0	4.0	5.0	6.0	10.0	条形
0.0	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250
0.2	0.249	0.249	0.249	0.249	0.249	0.249	0.249	0.249	0.249	0.249	0.249	0.249
0.4	0.240	0.242	0.243	0.243	0.244	0.244	0.244	0.244	0.244	0.244	0.244	0.244
0.6	0.223	0.228	0.230	0.232	0.232	0.233	0.234	0.234	0.234	0.234	0.234	0.234
0.8	0.200	0.207	0.212	0.215	0.216	0.218	0.220	0.220	0.220	0.220	0.220	0.220
1.0	0.175	0.185	0.191	0.195	0.198	0.200	0.203	0.204	0.204	0.204	0.205	0.205

Table D.0.1-1 (continued)

$\frac{a/b}{z/b}$	1.0	1.2	1.4	1.6	1.8	2.0	3.0	4.0	5.0	6.0	10.0	条形
1.2	0.152	0.163	0.171	0.176	0.179	0.182	0.187	0.188	0.189	0.189	0.189	0.189
1.4	0.131	0.142	0.151	0.157	0.161	0.164	0.171	0.173	0.174	0.174	0.174	0.174
1.6	0.112	0.124	0.133	0.140	0.145	0.148	0.157	0.159	0.160	0.160	0.160	0.160
1.8	0.097	0.108	0.117	0.124	0.129	0.133	0.143	0.146	0.147	0.148	0.148	0.148
2.0	0.084	0.095	0.103	0.110	0.116	0.120	0.131	0.135	0.136	0.137	0.137	0.137
2.2	0.073	0.083	0.092	0.098	0.104	0.108	0.121	0.125	0.126	0.127	0.128	0.128
2.4	0.064	0.073	0.081	0.088	0.093	0.098	0.111	0.116	0.118	0.118	0.119	0.119
2.6	0.057	0.065	0.072	0.079	0.084	0.089	0.102	0.107	0.110	0.111	0.112	0.112
2.8	0.050	0.058	0.065	0.071	0.076	0.080	0.094	0.100	0.102	0.104	0.105	0.105
3.0	0.045	0.052	0.058	0.064	0.069	0.073	0.087	0.093	0.096	0.097	0.099	0.099
3.2	0.040	0.047	0.053	0.058	0.063	0.067	0.081	0.087	0.090	0.092	0.093	0.094
3.4	0.036	0.042	0.048	0.053	0.057	0.061	0.075	0.081	0.085	0.086	0.088	0.089
3.6	0.033	0.038	0.043	0.048	0.052	0.056	0.069	0.076	0.080	0.082	0.084	0.084
3.8	0.030	0.035	0.040	0.044	0.048	0.052	0.065	0.072	0.075	0.077	0.080	0.080
4.0	0.027	0.032	0.036	0.040	0.044	0.048	0.060	0.067	0.071	0.073	0.076	0.076
4.2	0.025	0.029	0.033	0.037	0.041	0.044	0.056	0.063	0.067	0.070	0.072	0.073
4.4	0.023	0.027	0.031	0.034	0.038	0.041	0.053	0.060	0.064	0.066	0.069	0.070
4.6	0.021	0.025	0.028	0.032	0.035	0.038	0.049	0.056	0.061	0.063	0.066	0.067
4.8	0.019	0.023	0.026	0.029	0.032	0.035	0.046	0.053	0.058	0.060	0.064	0.064
5.0	0.018	0.021	0.024	0.027	0.030	0.033	0.043	0.050	0.055	0.057	0.061	0.062
6.0	0.013	0.015	0.017	0.020	0.022	0.024	0.033	0.039	0.043	0.046	0.051	0.052
7.0	0.009	0.011	0.013	0.015	0.016	0.018	0.025	0.031	0.035	0.038	0.043	0.045
8.0	0.007	0.009	0.010	0.011	0.013	0.014	0.020	0.025	0.028	0.031	0.037	0.039

Table D.0.1-1 (continued)

a/b z/b	1.0	1.2	1.4	1.6	1.8	2.0	3.0	4.0	5.0	6.0	10.0	条形
9.0	0.006	0.007	0.008	0.009	0.010	0.011	0.016	0.020	0.024	0.026	0.032	0.035
10.0	0.005	0.006	0.007	0.007	0.008	0.009	0.013	0.017	0.020	0.022	0.028	0.032
12.0	0.003	0.004	0.005	0.005	0.006	0.006	0.009	0.012	0.014	0.017	0.022	0.026
14.0	0.002	0.003	0.003	0.004	0.004	0.005	0.007	0.009	0.011	0.013	0.018	0.023
16.0	0.002	0.002	0.003	0.003	0.003	0.004	0.005	0.007	0.009	0.010	0.014	0.020
18.0	0.001	0.002	0.002	0.002	0.003	0.003	0.004	0.006	0.007	0.008	0.012	0.018
20.0	0.001	0.001	0.002	0.002	0.002	0.002	0.004	0.005	0.006	0.007	0.010	0.016
25.0	0.001	0.001	0.001	0.001	0.001	0.002	0.002	0.003	0.004	0.004	0.007	0.013
30.0	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.002	0.003	0.003	0.005	0.011
35.0	0.000	0.000	0.001	0.001	0.001	0.001	0.001	0.002	0.002	0.002	0.004	0.009
40.0	0.000	0.000	0.000	0.000	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.008

Note: a —Rectangle length under evenly distributed load (m); b —Rectangle width under evenly distributed load (m); z —Perpendicular distance from the calculation point to the pile tip plane (m).

Table D.0.1-2 Average subsidiary stress coefficient $\bar{\alpha}$ of angle point under evenly distributed load on rectangular area

$\frac{a/b}{z/b}$	1.0	1.2	1.4	1.6	1.8	2.0	2.4	2.8	3.0	3.6	4.0	5.0	10.0
0.0	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500
0.2	0.2496	0.2497	0.2497	0.2498	0.2498	0.2498	0.2498	0.2498	0.2498	0.2498	0.2498	0.2498	0.2498
0.4	0.2474	0.2479	0.2481	0.2483	0.2483	0.2484	0.2485	0.2485	0.2485	0.2485	0.2485	0.2485	0.2485
0.6	0.2423	0.2437	0.2444	0.2448	0.2451	0.2452	0.2454	0.2455	0.2455	0.2455	0.2455	0.2455	0.2456
0.8	0.2346	0.2372	0.2387	0.2395	0.2400	0.2403	0.2407	0.2408	0.2409	0.2409	0.2410	0.2410	0.2410
1.0	0.2252	0.2291	0.2313	0.2326	0.2335	0.2340	0.2346	0.2349	0.2351	0.2352	0.2352	0.2353	0.2353
1.2	0.2149	0.2199	0.2229	0.2248	0.2260	0.2268	0.2278	0.2282	0.2285	0.2286	0.2287	0.2288	0.2289
1.4	0.2043	0.2102	0.2140	0.2146	0.2180	0.2191	0.2204	0.2211	0.2215	0.2217	0.2218	0.2220	0.2221
1.6	0.1939	0.2006	0.2049	0.2079	0.2099	0.2113	0.2130	0.2138	0.2143	0.2146	0.2148	0.2150	0.2152
1.8	0.1840	0.1912	0.1960	0.1994	0.2018	0.2034	0.2055	0.2066	0.2073	0.2077	0.2079	0.2082	0.2084
2.0	0.1746	0.1822	0.1875	0.1912	0.1980	0.1958	0.1982	0.1996	0.2004	0.2009	0.2012	0.2015	0.2018
2.2	0.1659	0.1737	0.1793	0.1833	0.1862	0.1883	0.1911	0.1927	0.1937	0.1943	0.1947	0.1952	0.1955
2.4	0.1578	0.1657	0.1715	0.1757	0.1789	0.1812	0.1843	0.1862	0.1873	0.1880	0.1885	0.1890	0.1895
2.6	0.1503	0.1583	0.1642	0.1686	0.1719	0.1745	0.1779	0.1799	0.1812	0.1820	0.1825	0.1832	0.1838
2.8	0.1433	0.1514	0.1574	0.1619	0.1654	0.1680	0.1717	0.1739	0.1753	0.1763	0.1769	0.1777	0.1784
3.0	0.1369	0.1449	0.1510	0.1556	0.1592	0.1619	0.1658	0.1682	0.1698	0.1708	0.1715	0.1725	0.1733
3.2	0.1310	0.1390	0.1450	0.1497	0.1533	0.1562	0.1602	0.1628	0.1645	0.1657	0.1664	0.1675	0.1685
3.4	0.1256	0.1334	0.1394	0.1441	0.1478	0.1508	0.1550	0.1577	0.1595	0.1607	0.1616	0.1628	0.1639
3.6	0.1205	0.1282	0.1342	0.1389	0.1427	0.1456	0.1500	0.1528	0.1548	0.1561	0.1570	0.1583	0.1595
3.8	0.1158	0.1234	0.1293	0.1340	0.1378	0.1408	0.1452	0.1482	0.1502	0.1516	0.1526	0.1541	0.1554
4.0	0.1114	0.1189	0.1248	0.1294	0.1332	0.1362	0.1408	0.1438	0.1459	0.1474	0.1485	0.1500	0.1516
4.2	0.1073	0.1147	0.1205	0.1251	0.1289	0.1319	0.1365	0.1396	0.1418	0.1434	0.1445	0.1462	0.1479
4.4	0.1035	0.1107	0.1164	0.1210	0.1248	0.1279	0.1325	0.1357	0.1379	0.1396	0.1407	0.1425	0.1444

Table D.0.1-2 (continued)

$\frac{a/b}{z/b}$	1.0	1.2	1.4	1.6	1.8	2.0	2.4	2.8	3.0	3.6	4.0	5.0	10.0
4.6	0.1000	0.1070	0.1127	0.1172	0.1209	0.1240	0.1287	0.1319	0.1342	0.1359	0.1371	0.1390	0.1410
4.8	0.0967	0.1036	0.1091	0.1136	0.1173	0.1204	0.1250	0.1283	0.1307	0.1324	0.1337	0.1357	0.1379
5.0	0.0935	0.1003	0.1057	0.1102	0.1139	0.1169	0.1216	0.1249	0.1273	0.1291	0.1304	0.1325	0.1348
5.2	0.0906	0.0972	0.1026	0.1070	0.1106	0.1136	0.1183	0.1217	0.1241	0.1259	0.1273	0.1295	0.1320
5.4	0.0878	0.0943	0.0996	0.1039	0.1075	0.1105	0.1152	0.1186	0.1210	0.1229	0.1243	0.1265	0.1292
5.6	0.0852	0.0916	0.0968	0.1010	0.1046	0.1076	0.1122	0.1156	0.1181	0.1200	0.1215	0.1238	0.1266
5.8	0.0828	0.0890	0.0941	0.0983	0.1018	0.1047	0.1094	0.1128	0.1153	0.1172	0.1187	0.1211	0.1240
6.0	0.0805	0.0866	0.0916	0.0957	0.0991	0.1021	0.1067	0.1101	0.1126	0.1146	0.1161	0.1185	0.1216
6.2	0.0783	0.0842	0.0891	0.0932	0.0966	0.0995	0.1041	0.1075	0.1101	0.1120	0.1136	0.1161	0.1193
6.4	0.0762	0.0820	0.0869	0.0909	0.0942	0.0971	0.1016	0.1050	0.1076	0.1096	0.1111	0.1137	0.1171
6.6	0.0742	0.0799	0.0847	0.0886	0.0919	0.0948	0.0993	0.1027	0.1053	0.1073	0.1088	0.1114	0.1149
6.8	0.0723	0.0779	0.0826	0.0865	0.0898	0.0926	0.0970	0.1004	0.1030	0.1050	0.1066	0.1092	0.1129
7.0	0.0705	0.0761	0.0806	0.0844	0.0877	0.0904	0.0949	0.0982	0.1008	0.1028	0.1044	0.1071	0.1109
7.2	0.0688	0.0742	0.0787	0.0825	0.0857	0.0884	0.0928	0.0962	0.0987	0.1008	0.1023	0.1051	0.1090
7.4	0.0672	0.0725	0.0769	0.0806	0.0838	0.0865	0.0908	0.0942	0.0967	0.0988	0.1004	0.1031	0.1071
7.6	0.0656	0.0709	0.0752	0.0789	0.0820	0.0846	0.0889	0.0922	0.0948	0.0968	0.0984	0.1012	0.1054
7.8	0.0642	0.0693	0.0736	0.0771	0.0802	0.0828	0.0871	0.0904	0.0929	0.0950	0.0966	0.0994	0.1036
8.0	0.0627	0.0678	0.0720	0.0755	0.0785	0.0811	0.0853	0.0886	0.0912	0.0932	0.0948	0.0976	0.1020
8.2	0.0614	0.0663	0.0705	0.0739	0.0769	0.0795	0.0837	0.0869	0.0894	0.0914	0.0931	0.0959	0.1004
8.4	0.0601	0.0649	0.0690	0.0724	0.0754	0.0779	0.0820	0.0852	0.0878	0.0893	0.0914	0.0943	0.0938
8.6	0.0588	0.0636	0.0676	0.0710	0.0739	0.0764	0.0805	0.0836	0.0862	0.0882	0.0898	0.0927	0.0973
8.8	0.0576	0.0623	0.0663	0.0696	0.0724	0.0749	0.0790	0.0821	0.0846	0.0866	0.0882	0.0912	0.0959
9.2	0.0554	0.0599	0.0637	0.0670	0.0697	0.0721	0.0761	0.0792	0.0817	0.0837	0.0853	0.0882	0.0931

Table D.0.1-2 (continued)

$\frac{a/b}{z/b}$	1.0	1.2	1.4	1.6	1.8	2.0	2.4	2.8	3.0	3.6	4.0	5.0	10.0
9.6	0.0533	0.0577	0.0614	0.0645	0.0672	0.0696	0.0734	0.0765	0.0789	0.0809	0.0825	0.0855	0.0905
10.0	0.0514	0.0556	0.0592	0.0622	0.0649	0.0672	0.0710	0.0739	0.0763	0.0783	0.0799	0.0829	0.0880
10.4	0.0496	0.0537	0.0572	0.0601	0.0627	0.0649	0.0686	0.0716	0.0739	0.0759	0.0775	0.0804	0.0857
10.8	0.0479	0.0519	0.0553	0.0581	0.0606	0.0628	0.0664	0.0693	0.0717	0.0736	0.0751	0.0781	0.0834
11.2	0.0463	0.0502	0.0535	0.0563	0.0587	0.0609	0.0644	0.0672	0.0695	0.0714	0.0730	0.0759	0.0813
11.6	0.0448	0.0486	0.0518	0.0545	0.0569	0.0590	0.0625	0.0652	0.0675	0.0694	0.0709	0.0738	0.0793
12.0	0.0435	0.0471	0.0502	0.0529	0.0552	0.0573	0.0606	0.0634	0.0656	0.0674	0.0690	0.0719	0.0774
12.8	0.0409	0.0444	0.0474	0.0499	0.0521	0.0541	0.0573	0.0599	0.0621	0.0639	0.0654	0.0682	0.0739
13.6	0.0387	0.0420	0.0448	0.0472	0.0493	0.0512	0.0543	0.0568	0.0589	0.0607	0.0621	0.0649	0.0707
14.4	0.0367	0.0398	0.0425	0.0448	0.0468	0.0486	0.0516	0.0540	0.0561	0.0577	0.0592	0.0619	0.0677
15.2	0.0349	0.0379	0.0404	0.0426	0.0446	0.0463	0.0492	0.0515	0.0535	0.0551	0.0565	0.0592	0.0650
16.0	0.0332	0.0361	0.0385	0.0407	0.0425	0.0442	0.0469	0.0492	0.0511	0.0527	0.0540	0.0567	0.0625
18.0	0.0297	0.0323	0.0345	0.0364	0.0381	0.0396	0.0422	0.0442	0.0460	0.0475	0.0487	0.0512	0.0570
20.0	0.0269	0.0292	0.0312	0.0330	0.0345	0.0359	0.0383	0.0402	0.0418	0.0432	0.0444	0.0468	0.0524

D.0.2 Subsidiary stress coefficient α and average subsidiary stress coefficient $\bar{\alpha}$ of angle point under triangular load on rectangular area shall be identified in accordance with Table D.02.

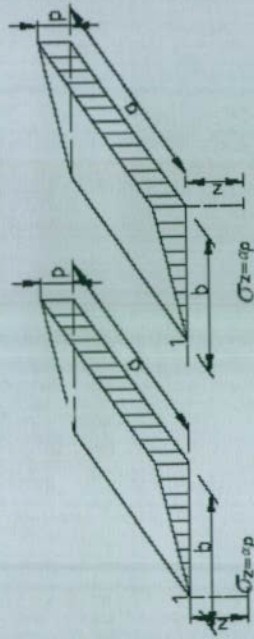


Table D.0.2 Subsidiary stress coefficient α and average subsidiary stress coefficient $\bar{\alpha}$ of angle point under triangular load on rectangular area

a/b Point Index z/b	0.2						0.4						0.6					
	1		2		2		1		2		2		1		2			
	α	$\bar{\alpha}$	α	$\bar{\alpha}$	α	$\bar{\alpha}$	α	$\bar{\alpha}$	α	$\bar{\alpha}$	α	$\bar{\alpha}$	α	$\bar{\alpha}$	α	$\bar{\alpha}$		
0.0	0.0000	0.0000	0.2500	0.2500	0.0000	0.0000	0.2500	0.2500	0.0000	0.0000	0.0000	0.0000	0.2500	0.2500	0.0000	0.0000		
0.2	0.0223	0.0112	0.1821	0.2161	0.0280	0.0140	0.2115	0.2308	0.0140	0.0140	0.2115	0.2308	0.0296	0.0148	0.0148	0.2333		
0.4	0.0269	0.0179	0.1094	0.1810	0.0420	0.0245	0.1604	0.2084	0.0245	0.0245	0.1604	0.2084	0.0487	0.0270	0.0270	0.2153		
0.6	0.0259	0.0207	0.0700	0.1505	0.0448	0.0308	0.1165	0.1851	0.0308	0.0308	0.1165	0.1851	0.0560	0.0355	0.0355	0.1966		
0.8	0.0232	0.0217	0.0480	0.1277	0.0421	0.0340	0.0853	0.1640	0.0340	0.0340	0.0853	0.1640	0.0553	0.0405	0.0405	0.1787		
1.0	0.0201	0.0217	0.0346	0.1104	0.0375	0.0351	0.0638	0.1461	0.0351	0.0351	0.0638	0.1461	0.0508	0.0430	0.0430	0.1624		
1.2	0.0171	0.0212	0.0260	0.0970	0.0324	0.0351	0.0491	0.1312	0.0351	0.0351	0.0491	0.1312	0.0450	0.0439	0.0439	0.1480		
1.4	0.0145	0.0204	0.0202	0.0865	0.0278	0.0344	0.0386	0.1187	0.0344	0.0344	0.0386	0.1187	0.0392	0.0436	0.0436	0.1356		
1.6	0.0123	0.0195	0.0160	0.0779	0.0238	0.0333	0.0310	0.1082	0.0333	0.0333	0.0310	0.1082	0.0339	0.0427	0.0427	0.1247		
1.8	0.0105	0.0186	0.0130	0.0709	0.0204	0.0321	0.0254	0.0993	0.0321	0.0321	0.0254	0.0993	0.0294	0.0415	0.0415	0.1153		
2.0	0.0090	0.0178	0.0108	0.0650	0.0176	0.0308	0.0211	0.0917	0.0308	0.0308	0.0211	0.0917	0.0255	0.0401	0.0401	0.1071		
2.5	0.0063	0.0157	0.0072	0.0538	0.0125	0.0276	0.0140	0.0769	0.0276	0.0276	0.0140	0.0769	0.0183	0.0365	0.0365	0.0908		
3.0	0.0046	0.0140	0.0051	0.0458	0.0092	0.0248	0.0100	0.0661	0.0248	0.0248	0.0100	0.0661	0.0135	0.0330	0.0330	0.0786		
5.0	0.0018	0.0097	0.0019	0.0289	0.0036	0.0175	0.0038	0.0424	0.0175	0.0175	0.0038	0.0424	0.0054	0.0236	0.0236	0.0476		
7.0	0.0009	0.0073	0.0010	0.0211	0.0019	0.0133	0.0019	0.0311	0.0133	0.0133	0.0019	0.0311	0.0028	0.0180	0.0180	0.0352		
10.0	0.0005	0.0053	0.0004	0.0150	0.0009	0.0097	0.0010	0.0222	0.0097	0.0097	0.0010	0.0222	0.0014	0.0133	0.0133	0.0253		

Table D.0.2 (continued)

z/b	0.8		1.0		1.2		a/b Point Index z/b
	2		1		2		
	α	$\bar{\alpha}$	α	$\bar{\alpha}$	α	$\bar{\alpha}$	
0.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2500
0.2	0.0301	0.0151	0.0304	0.0152	0.0305	0.0153	0.2342
0.4	0.0517	0.0280	0.0531	0.0285	0.0539	0.0288	0.2187
0.6	0.06210	0.0376	0.0654	0.0388	0.0673	0.0394	0.2039
0.8	0.0637	0.0440	0.0688	0.0459	0.0720	0.0470	0.1899
1.0	0.0602	0.0476	0.0666	0.0502	0.0708	0.0518	0.1769
1.2	0.0546	0.0492	0.0615	0.0525	0.0664	0.0546	0.1649
1.4	0.0483	0.0495	0.0554	0.0534	0.0606	0.0559	0.1541
1.6	0.0424	0.0490	0.0492	0.0533	0.0545	0.0561	0.1443
1.8	0.0371	0.0480	0.0435	0.0525	0.0487	0.0556	0.1354
2.0	0.0324	0.0467	0.0384	0.0513	0.0434	0.0547	0.1274
2.5	0.0236	0.0429	0.0284	0.0478	0.0326	0.0513	0.1107
3.0	0.0176	0.0392	0.0214	0.0439	0.0249	0.0476	0.0976
5.0	0.0071	0.0285	0.0088	0.0324	0.0104	0.0356	0.0661
7.0	0.0038	0.0219	0.0047	0.0251	0.0056	0.0277	0.0496
10.0	0.0019	0.0162	0.0023	0.0186	0.0028	0.0207	0.0359

Table D.0.2 (continued)

a/b Point Index z/b	1.4				1.6				1.8			
	1		2		1		2		1		2	
	α	$\bar{\alpha}$	α	$\bar{\alpha}$	α	$\bar{\alpha}$	α	$\bar{\alpha}$	α	$\bar{\alpha}$	α	$\bar{\alpha}$
0.0	0.0000	0.0000	0.2500	0.2500	0.0000	0.0000	0.2500	0.2500	0.0000	0.0000	0.2500	0.2500
0.2	0.0305	0.0153	0.2185	0.2343	0.0306	0.0153	0.2185	0.2343	0.0306	0.0153	0.2185	0.2343
0.4	0.0543	0.0289	0.1886	0.2189	0.0545	0.0290	0.1889	0.2190	0.0546	0.0290	0.1891	0.2190
0.6	0.0684	0.0397	0.1616	0.2043	0.0690	0.0399	0.1625	0.2046	0.0649	0.0400	0.1630	0.2047
0.8	0.0739	0.0476	0.1381	0.1907	0.0751	0.0480	0.1396	0.1912	0.0759	0.0482	0.1405	0.1915
1.0	0.0735	0.0528	0.1176	0.1781	0.0753	0.0534	0.1202	0.1789	0.0766	0.0538	0.1215	0.1794
1.2	0.0698	0.0560	0.1007	0.1666	0.0721	0.0568	0.1037	0.1678	0.0738	0.0574	0.1055	0.1684
1.4	0.0644	0.0575	0.0864	0.1562	0.0672	0.0586	0.0897	0.1576	0.0692	0.0594	0.0921	0.1585
1.6	0.0586	0.0580	0.0743	0.1467	0.0616	0.0594	0.0780	0.1484	0.0639	0.0603	0.0806	0.1494
1.8	0.0528	0.0578	0.0644	0.1381	0.0560	0.0593	0.0681	0.1400	0.0585	0.0604	0.0709	0.1413
2.0	0.0474	0.0570	0.0560	0.1303	0.0507	0.0587	0.0596	0.1324	0.0533	0.0599	0.0625	0.1338
2.5	0.0362	0.0540	0.0405	0.1139	0.0393	0.0560	0.0440	0.1163	0.0419	0.0575	0.0469	0.1180
3.0	0.0280	0.0503	0.0303	0.1008	0.0307	0.0525	0.0333	0.1033	0.0331	0.0541	0.0359	0.1052
5.0	0.0120	0.0382	0.0123	0.0690	0.0135	0.0403	0.0139	0.0714	0.0148	0.0421	0.0154	0.0734
7.0	0.0064	0.0299	0.0066	0.0520	0.0073	0.0318	0.0074	0.0541	0.0081	0.0333	0.0083	0.0558
10.0	0.0033	0.0224	0.0032	0.0379	0.0037	0.0239	0.0037	0.0395	0.0041	0.0252	0.0042	0.0409

Table D.0.2 (continued)

a/b Point Index z/b	2.0				3.0				4.0			
	1		2		1		2		1		2	
	α	$\bar{\alpha}$	α	$\bar{\alpha}$	α	$\bar{\alpha}$	α	$\bar{\alpha}$	α	$\bar{\alpha}$	α	$\bar{\alpha}$
0.0	0.0000	0.0000	0.2500	0.2500	0.0000	0.0000	0.2500	0.2500	0.0000	0.0000	0.2500	0.2500
0.2	0.0306	0.0153	0.2185	0.2343	0.0306	0.0153	0.2186	0.2343	0.0306	0.0153	0.2186	0.2343
0.4	0.0547	0.0290	0.1892	0.2191	0.0548	0.0290	0.1894	0.2192	0.0549	0.0291	0.1894	0.2192
0.6	0.0696	0.0401	0.1633	0.2048	0.0701	0.0402	0.1638	0.2050	0.0702	0.0402	0.1639	0.2050
0.8	0.0764	0.0483	0.1412	0.1917	0.0773	0.0486	0.1423	0.1920	0.0776	0.0487	0.1424	0.1920
1.0	0.0774	0.0540	0.1225	0.1797	0.0790	0.0545	0.1244	0.1803	0.0794	0.0546	0.1248	0.1803
1.2	0.0749	0.0577	0.1069	0.1689	0.0774	0.0584	0.1096	0.1697	0.0779	0.0586	0.1103	0.1699
1.4	0.0707	0.0599	0.0937	0.1591	0.0739	0.0609	0.0973	0.1603	0.0748	0.0612	0.0982	0.1605
1.6	0.0656	0.0609	0.0826	0.1502	0.0697	0.0623	0.0870	0.1517	0.0708	0.0626	0.0882	0.1521
1.8	0.0604	0.0611	0.0730	0.1422	0.0652	0.0628	0.0782	0.1441	0.0666	0.0633	0.0797	0.1445
2.0	0.0553	0.0608	0.0649	0.1348	0.0607	0.0629	0.0707	0.1371	0.0624	0.0634	0.0726	0.1377
2.5	0.0440	0.0586	0.0491	0.1193	0.0504	0.0614	0.0559	0.1223	0.0529	0.0623	0.0585	0.1233
3.0	0.0352	0.0554	0.0380	0.1067	0.0419	0.0589	0.0451	0.1104	0.0449	0.0600	0.0482	0.1116
5.0	0.0161	0.0435	0.0167	0.0749	0.0214	0.0480	0.0221	0.0797	0.0248	0.0500	0.0256	0.0817
7.0	0.0089	0.0347	0.0091	0.0572	0.0124	0.0391	0.0126	0.0619	0.0152	0.0414	0.0154	0.0642
10.0	0.0046	0.0263	0.0046	0.0403	0.0066	0.0302	0.0066	0.0462	0.0084	0.0325	0.0083	0.0485

Table D.0.2 (continued)

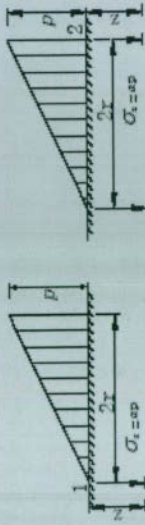
a/b Point Index z/b	6.0				8.0				10.0			
	1		2		1		2		1		2	
	α	$\bar{\alpha}$	α	$\bar{\alpha}$	α	$\bar{\alpha}$	α	$\bar{\alpha}$	α	$\bar{\alpha}$	α	$\bar{\alpha}$
0.0	0.0000	0.0000	0.2500	0.2500	0.0000	0.0000	0.2500	0.2500	0.0000	0.0000	0.2500	0.2500
0.2	0.0306	0.0153	0.2186	0.2343	0.0306	0.0153	0.2186	0.2343	0.0306	0.0153	0.2186	0.2343
0.4	0.0549	0.0291	0.1894	0.2192	0.0549	0.0291	0.1894	0.2192	0.0549	0.0291	0.1894	0.2192
0.6	0.0702	0.0402	0.1640	0.2050	0.0702	0.0402	0.1640	0.2050	0.0702	0.0402	0.1640	0.2050
0.8	0.0776	0.0487	0.1426	0.1921	0.0776	0.0487	0.1426	0.1921	0.0776	0.0487	0.1426	0.1921
1.0	0.0795	0.0546	0.1250	0.1804	0.0796	0.0546	0.1250	0.1804	0.0796	0.0546	0.1250	0.1804
1.2	0.0782	0.0587	0.1105	0.1700	0.0783	0.0587	0.1105	0.1700	0.0783	0.0587	0.1105	0.1700
1.4	0.0752	0.0613	0.0986	0.1606	0.0752	0.0613	0.0987	0.1606	0.0753	0.0613	0.0987	0.1606
1.6	0.0714	0.0628	0.0887	0.1523	0.0715	0.0628	0.0888	0.1523	0.0715	0.0628	0.0889	0.1523
1.8	0.0673	0.0635	0.0805	0.1447	0.0675	0.0635	0.0806	0.1448	0.0675	0.0635	0.0808	0.1448
2.0	0.0634	0.0637	0.0734	0.1380	0.0636	0.0638	0.0736	0.1380	0.0636	0.0638	0.0738	0.1380
2.5	0.0543	0.0627	0.0601	0.1237	0.0547	0.0628	0.0604	0.1238	0.0548	0.0628	0.0605	0.1239
3.0	0.0469	0.0607	0.0504	0.1123	0.0474	0.0609	0.0509	0.1124	0.0476	0.0609	0.0511	0.1125
5.0	0.0283	0.0515	0.0290	0.0833	0.0296	0.0519	0.0303	0.0837	0.0301	0.0521	0.0309	0.0839
7.0	0.0186	0.0435	0.0190	0.0663	0.0204	0.0442	0.0207	0.0671	0.0212	0.0445	0.0216	0.0674
10.0	0.0111	0.0349	0.0111	0.0509	0.0128	0.0359	0.0130	0.0520	0.0139	0.0364	0.0141	0.0526

D.0.3 Subsidiary stress coefficient Index α and average subsidiary stress coefficient Index $\bar{\alpha}$ of angle point under evenly distributed load on round area shall be identified in accordance with Table D.03.

Table D.0.3-1 (d) Subsidiary stress coefficient Index α and average subsidiary stress coefficient Index $\bar{\alpha}$ of angle point under evenly distributed load on round area

z/r	Round		z/r	Round	
	α	$\bar{\alpha}$		α	$\bar{\alpha}$
0.0	1.000	1.000	2.6	0.187	0.560
0.1	0.999	1.000	2.7	0.175	0.546
0.2	0.992	0.998	2.8	0.165	0.532
0.3	0.976	0.993	2.9	0.155	0.519
0.4	0.949	0.986	3.0	0.146	0.507
0.5	0.911	0.974	3.1	0.138	0.495
0.6	0.864	0.960	3.2	0.130	0.484
0.7	0.811	0.942	3.3	0.124	0.473
0.8	0.756	0.923	3.4	0.117	0.463
0.9	0.701	0.901	3.5	0.111	0.453
1.0	0.647	0.878	3.6	0.106	0.443
1.1	0.595	0.855	3.7	0.101	0.434
1.2	0.547	0.831	3.8	0.096	0.425
1.3	0.502	0.808	3.9	0.091	0.417
1.4	0.461	0.784	4.0	0.087	0.409
1.5	0.424	0.762	4.1	0.083	0.401
1.6	0.390	0.739	4.2	0.079	0.393
1.7	0.360	0.718	4.3	0.076	0.386
1.8	0.332	0.697	4.4	0.073	0.379
1.9	0.307	0.677	4.5	0.070	0.372
2.0	0.285	0.658	4.6	0.067	0.365
2.1	0.264	0.640	4.7	0.064	0.359
2.2	0.245	0.623	4.8	0.062	0.353
2.3	0.229	0.606	4.9	0.059	0.347
2.4	0.210	0.590	5.0	0.057	0.341
2.5	0.200	0.574			

D.0.4 Subsidiary stress coefficient α and average subsidiary stress coefficient index $\bar{\alpha}$ of angle point under triangular load on round area shall be identified in accordance with Table D.0.4.



r —Semi diameter of round area

Table D.0.4 Subsidiary stress coefficient index α and average subsidiary stress coefficient index $\bar{\alpha}$ of angle point under triangular load on round area

z/r	1		2	
	α	$\bar{\alpha}$	α	$\bar{\alpha}$
0.0	0.000	0.000	0.500	0.500
0.1	0.016	0.008	0.465	0.483
0.2	0.031	0.016	0.433	0.466
0.3	0.044	0.023	0.403	0.450
0.4	0.054	0.030	0.376	0.435
0.5	0.063	0.035	0.349	0.420
0.6	0.071	0.041	0.324	0.406
0.7	0.078	0.045	0.300	0.393
0.8	0.083	0.050	0.279	0.380
0.9	0.088	0.054	0.258	0.368
1.0	0.091	0.057	0.238	0.356
1.1	0.092	0.061	0.221	0.344
1.2	0.093	0.063	0.205	0.333

Table D.0.4 (continued)

Point Index	1		2	
	α	$\bar{\alpha}$	α	$\bar{\alpha}$
z/r				
1.3	0.092	0.065	0.190	0.323
1.4	0.091	0.067	0.177	0.313
1.5	0.089	0.069	0.165	0.303
1.6	0.087	0.070	0.154	0.294
1.7	0.085	0.071	0.144	0.286
1.8	0.083	0.072	0.134	0.278
1.9	0.080	0.072	0.126	0.270
2.0	0.078	0.073	0.117	0.263
2.1	0.075	0.073	0.110	0.255
2.2	0.072	0.073	0.104	0.249
2.3	0.070	0.073	0.097	0.242
2.4	0.067	0.073	0.091	0.236
2.5	0.064	0.072	0.086	0.230
2.6	0.062	0.072	0.081	0.225
2.7	0.059	0.071	0.078	0.219
2.8	0.057	0.071	0.074	0.214
2.9	0.055	0.070	0.070	0.209
3.0	0.052	0.070	0.067	0.204
3.1	0.050	0.069	0.064	0.200
3.2	0.048	0.069	0.061	0.196
3.3	0.046	0.068	0.059	0.192
3.4	0.045	0.067	0.055	0.188

Table D.0.4 (continued)

Point Index	1		2	
	α	$\bar{\alpha}$	α	$\bar{\alpha}$
3.5	0.043	0.067	0.053	0.184
0.041	0.066	0.051	0.180	0.041
0.040	0.065	0.048	0.177	0.040
0.038	0.065	0.046	0.173	0.038
0.037	0.064	0.043	0.170	0.037
0.036	0.063	0.041	0.167	0.036
0.033	0.062	0.038	0.161	0.033
0.031	0.061	0.034	0.155	0.031
0.029	0.059	0.031	0.150	0.029
0.027	0.058	0.029	0.145	0.027
0.025	0.057	0.027	0.140	0.025

Appendix E Calculation parameters of pile foundation equivalent settlement Index ψ_e

E.0.1 The pile foundation equivalent settlement Index ψ_e shall be selected from Table E.0.1-1~E.0.1-5, and calculated in accordance with Articles 5.5.9-1 or 5.5.9-2.

Table E.0.1-1 ($s_u/d = 2$)

l/d	L_u/B_e												
	C_0	C_1	C_2	1	2	3	4	5	6	7	8	9	10
5	C_0			0.203	0.282	0.329	0.363	0.389	0.410	0.428	0.443	0.456	0.468
	C_1			1.543	1.687	1.797	1.845	1.915	1.949	1.981	2.047	2.073	2.098
	C_2			5.563	5.356	5.086	5.020	4.878	4.843	4.817	4.704	4.690	4.681
10	C_0			0.125	0.188	0.228	0.258	0.282	0.301	0.318	0.333	0.346	0.357
	C_1			1.487	1.573	1.653	1.676	1.731	1.750	1.768	1.828	1.844	1.860
	C_2			7.000	6.260	5.737	5.535	5.292	5.191	5.114	4.949	4.903	4.865
15	C_0			0.093	0.146	0.180	0.207	0.228	0.246	0.262	0.275	0.287	0.298
	C_1			1.508	1.568	1.637	1.647	1.696	1.707	1.718	1.776	1.787	1.798
	C_2			8.413	7.252	6.520	6.208	5.878	5.722	5.604	5.393	5.320	5.259
20	C_0			0.075	0.120	0.151	0.175	0.194	0.211	0.225	0.238	0.249	0.260
	C_1			1.548	1.592	1.654	1.656	1.701	1.706	1.712	1.770	1.777	1.783
	C_2			9.783	8.236	7.310	6.897	6.486	6.280	6.123	5.870	5.771	5.689
25	C_0			0.063	0.103	0.131	0.152	0.170	0.186	0.199	0.211	0.221	0.231
	C_1			1.596	1.628	1.686	1.679	1.722	1.722	1.724	1.783	1.786	1.789
	C_2			11.118	9.205	8.094	7.583	7.095	6.841	6.647	6.353	6.230	6.128
30	C_0			0.055	0.090	0.116	0.135	0.152	0.166	0.179	0.190	0.200	0.209
	C_1			1.646	1.669	1.724	1.711	1.753	1.748	1.745	1.806	1.806	1.806
	C_2			12.426	10.159	8.868	8.264	7.700	7.400	7.170	6.836	6.689	6.568

Table E.0.1-1 (continued)

l/d	L_c/B_c	1									
		2	3	4	5	6	7	8	9	10	
40	C ₀	0.044	0.073	0.095	0.112	0.126	0.139	0.150	0.160	0.169	0.177
	C ₁	1.754	1.761	1.812	1.787	1.827	1.814	1.803	1.867	1.861	1.855
	C ₂	14.984	12.036	10.396	9.610	8.900	8.509	8.211	7.797	7.605	7.446
50	C ₀	0.036	0.062	0.081	0.096	0.108	0.120	0.129	0.138	0.147	0.154
	C ₁	1.865	1.860	1.909	1.873	1.911	1.889	1.872	1.939	1.927	1.916
	C ₂	17.492	13.885	11.905	10.945	10.090	9.613	9.247	8.755	8.519	8.323
60	C ₀	0.031	0.054	0.070	0.084	0.095	0.105	0.114	0.122	0.130	0.137
	C ₁	1.979	1.962	2.010	1.962	1.999	1.970	1.945	2.016	1.998	1.981
	C ₂	19.967	15.719	13.406	12.274	11.278	10.715	10.284	9.713	9.433	9.200
70	C ₀	0.028	0.048	0.063	0.075	0.085	0.094	0.102	0.110	0.117	0.123
	C ₁	2.095	2.067	2.114	2.055	2.091	2.054	2.021	2.097	2.072	2.049
	C ₂	22.423	17.546	14.901	13.602	12.465	11.818	11.322	10.672	10.349	10.080
80	C ₀	0.025	0.043	0.056	0.067	0.077	0.085	0.093	0.100	0.106	0.112
	C ₁	2.213	2.174	2.220	2.150	2.185	2.139	2.099	2.178	2.147	2.119
	C ₂	24.868	19.370	16.398	14.933	13.655	12.925	12.364	11.635	11.270	10.964
90	C ₀	0.022	0.039	0.051	0.061	0.070	0.078	0.085	0.091	0.097	0.103
	C ₁	2.333	2.283	2.328	2.245	2.280	2.225	2.177	2.261	2.223	2.189
	C ₂	27.307	21.195	17.897	16.267	14.849	14.036	13.411	12.603	12.194	11.853
100	C ₀	0.021	0.036	0.047	0.057	0.065	0.072	0.078	0.084	0.090	0.095
	C ₁	2.453	2.392	2.436	2.341	2.375	2.311	2.256	2.344	2.299	2.259
	C ₂	29.744	23.024	19.400	17.608	16.049	15.153	14.464	13.575	13.123	12.745

Note: L_c —Cushion cap length of clustered pile foundation; B_c —Cushion cap width of clustered pile foundation; l —Pile length; d —Pile diameter.

Table E.0.1-2 ($s_n/d = 3$)

l/d	L_j/B_c	1	2	3	4	5	6	7	8	9	10
		5	C ₀ 1.203 C ₁ 1.483 C ₂ 3.679	0.318 1.723 4.036	0.377 1.875 4.006	0.416 1.955 4.053	0.445 2.045 3.995	0.468 2.098 4.007	0.486 2.144 4.014	0.502 2.218 3.938	0.516 2.256 3.944
10	C ₀ 0.125 C ₁ 1.419 C ₂ 4.861	0.213 1.559 4.723	0.263 1.662 4.460	0.298 1.705 4.384	0.324 1.770 4.237	0.346 1.801 4.193	0.364 1.828 4.158	0.380 1.891 4.038	0.394 1.913 4.017	0.406 1.935 4.000	
15	C ₀ 0.093 C ₁ 1.430 C ₂ 5.900	0.166 1.533 5.435	0.209 1.619 5.010	0.240 1.646 4.855	0.265 1.703 4.641	0.285 1.723 4.559	0.302 1.741 4.496	0.317 1.801 4.340	0.330 1.817 4.300	0.342 1.832 4.267	
20	C ₀ 0.075 C ₁ 1.461 C ₂ 6.879	0.138 1.542 6.137	0.176 1.619 5.570	0.205 1.635 5.346	0.227 1.687 5.073	0.246 1.700 4.958	0.262 1.712 4.869	0.276 1.772 4.679	0.288 1.783 4.623	0.299 1.793 4.577	
25	C ₀ 0.063 C ₁ 1.500 C ₂ 7.822	0.118 1.565 6.826	0.153 1.637 6.127	0.179 1.644 5.839	0.200 1.693 5.511	0.218 1.699 5.364	0.233 1.706 5.252	0.246 1.767 5.030	0.258 1.774 4.958	0.268 1.780 4.899	
30	C ₀ 0.055 C ₁ 1.542 C ₂ 8.741	0.104 1.595 7.506	0.136 1.663 6.680	0.160 1.662 6.331	0.180 1.709 5.949	0.196 1.711 5.772	0.210 1.712 5.638	0.223 1.775 5.383	0.234 1.777 5.297	0.244 1.780 5.226	
40	C ₀ 0.044 C ₁ 1.632 C ₂ 10.535	0.085 1.667 8.845	0.112 1.729 7.774	0.133 1.715 7.309	0.150 1.759 6.822	0.165 1.750 6.588	0.178 1.743 6.410	0.189 1.808 6.093	0.199 1.804 5.978	0.208 1.799 5.883	

Table E.0.1-2 (continued)

l/d	L_c/B_c	1	2	3	4	5	6	7	8	9	10
		50	C_0 0.036 C_1 1.726 C_2 12.292	0.072 1.746 10.168	0.096 1.805 8.860	0.114 1.778 8.284	0.130 1.819 7.694	0.143 1.801 7.405	0.155 1.786 7.185	0.165 1.855 6.805	0.174 1.843 6.662
60	C_0 0.031 C_1 1.822 C_2 14.029	0.063 1.828 11.486	0.084 1.885 9.944	0.101 1.845 9.259	0.115 1.885 8.568	0.127 1.858 8.224	0.137 1.834 7.962	0.146 1.907 7.520	0.155 1.888 7.348	0.163 1.870 7.206	
70	C_0 0.028 C_1 1.920 C_2 15.756	0.056 1.913 12.801	0.075 1.968 11.029	0.090 1.916 10.237	0.103 1.954 9.444	0.114 1.918 9.047	0.123 1.885 8.742	0.132 1.962 8.238	0.140 1.936 8.038	0.147 1.911 7.871	
80	C_0 0.025 C_1 2.019 C_2 17.478	0.050 2.000 14.120	0.068 2.053 12.117	0.081 1.988 11.220	0.093 2.025 10.325	0.103 1.979 9.874	0.112 1.938 9.527	0.120 2.019 8.959	0.127 1.985 8.731	0.134 1.954 8.540	
90	C_0 0.022 C_1 2.118 C_2 19.200	0.045 2.087 15.442	0.062 2.139 13.210	0.074 2.060 12.208	0.085 2.096 11.211	0.095 2.041 10.705	0.103 1.991 10.316	0.110 2.076 9.684	0.117 2.036 9.427	0.123 1.998 9.211	
100	C_0 0.021 C_1 2.218 C_2 20.925	0.042 2.174 16.770	0.057 2.225 14.307	0.069 2.133 13.201	0.097 2.168 12.101	0.087 2.103 11.541	0.095 2.044 11.110	0.102 2.133 10.413	0.108 2.086 10.127	0.114 2.042 9.886	

Note: L_c —Cushion cap length of clustered pile foundation; B_c —Cushion cap width of clustered pile foundation; l —Pile length; d —Pile diameter.

Table E.0.1-3 ($s_n/d = 4$)

l/d	L_d/B_c	1	2	3	4	5	6	7	8	9	10
			0.203	0.354	0.422	0.464	0.495	0.519	0.538	0.555	0.568
5	C_0	1.445	1.786	1.986	2.101	2.213	2.286	2.349	2.434	2.484	2.530
	C_1	2.633	3.243	3.340	3.444	3.431	3.466	3.488	3.433	3.447	3.457
	C_2	0.125	0.237	0.294	0.332	0.361	0.384	0.403	0.419	0.433	0.445
10	C_0	1.378	1.570	1.695	1.756	1.830	1.870	1.906	1.972	2.000	2.027
	C_1	3.707	3.873	3.743	3.729	3.630	3.612	3.597	3.500	3.490	3.482
	C_2	0.093	0.185	0.234	0.269	0.296	0.317	0.335	0.351	0.364	0.376
15	C_0	1.384	1.524	1.626	1.666	1.729	1.757	1.781	1.843	1.863	1.881
	C_1	4.571	4.458	4.188	4.107	3.951	3.904	3.866	3.736	3.712	3.693
	C_2	0.075	0.153	0.198	0.230	0.254	0.275	0.291	0.306	0.319	0.331
20	C_0	1.408	1.521	1.611	1.638	1.695	1.713	1.730	1.791	1.805	1.818
	C_1	5.361	5.024	4.636	4.502	4.297	4.225	4.169	4.009	3.973	3.944
	C_2	0.063	0.132	0.173	0.202	0.225	0.244	0.260	0.274	0.286	0.297
25	C_0	1.441	1.534	1.616	1.633	1.686	1.698	1.708	1.770	1.779	1.786
	C_1	6.114	5.578	5.081	4.900	4.650	4.555	4.482	4.293	4.246	4.208
	C_2	0.055	0.117	0.154	0.181	0.203	0.221	0.236	0.249	0.261	0.271
30	C_0	1.477	1.555	1.633	1.640	1.691	1.696	1.701	1.764	1.768	1.771
	C_1	6.843	6.122	5.524	5.298	5.004	4.887	4.799	4.581	4.524	4.477
	C_2	0.044	0.095	0.127	0.151	0.170	0.186	0.200	0.212	0.223	0.233
40	C_0	1.555	1.611	1.681	1.673	1.720	1.714	1.708	1.774	1.770	1.765
	C_1	8.261	7.195	6.402	6.093	5.713	5.556	5.436	5.163	5.085	5.021
	C_2										

Table E.0.1-3 (continued)

l/d	L_c/B_c			1	2	3	4	5	6	7	8	9	10
	C_0	C_1	C_2										
50	C_0	0.036	0.081	0.109	0.130	0.148	0.162	0.175	0.186	0.196	0.205		
	C_1	1.636	1.674	1.740	1.718	1.762	1.745	1.730	1.800	1.787	1.775		
	C_2	9.648	8.258	7.277	6.887	6.424	6.227	6.077	5.749	5.650	5.569		
60	C_0	0.031	0.071	0.096	0.115	0.131	0.144	0.156	0.166	0.175	0.183		
	C_1	1.719	1.742	1.805	1.768	1.810	1.783	1.758	1.832	1.811	1.791		
	C_2	11.021	9.319	8.152	7.684	7.138	6.902	6.721	6.338	6.219	6.120		
70	C_0	0.028	0.063	0.086	0.103	0.117	0.130	0.140	0.150	0.158	0.166		
	C_1	1.803	1.811	1.872	1.821	1.861	1.824	1.789	1.867	1.839	1.812		
	C_2	12.387	10.381	9.029	8.485	7.856	7.580	7.369	6.929	6.789	6.672		
80	C_0	0.025	0.057	0.077	0.093	0.107	0.118	0.128	0.137	0.145	0.152		
	C_1	1.887	1.882	1.940	1.876	1.914	1.866	1.822	1.904	1.868	1.834		
	C_2	13.753	11.447	9.911	9.291	8.578	8.262	8.020	7.524	7.362	7.226		
90	C_0	0.022	0.051	0.071	0.085	0.098	0.108	0.117	0.126	0.133	0.140		
	C_1	1.972	1.953	2.009	1.931	1.967	1.909	1.857	1.943	1.899	1.858		
	C_2	15.119	12.518	10.799	10.102	9.305	8.949	8.674	8.122	7.938	7.782		
100	C_0	0.021	0.047	0.065	0.079	0.090	0.100	0.109	0.117	0.123	0.130		
	C_1	2.057	2.025	2.079	1.986	2.021	1.953	1.891	1.981	1.931	1.883		
	C_2	16.490	13.595	11.691	10.918	10.036	9.639	9.331	8.722	8.515	8.339		

Note: L_c —Cushion cap length of clustered pile foundation; B_c —Cushion cap width of clustered pile foundation; l —Pile length; d —Pile diameter.

Table E.0.1-4 ($s_x/d = 5$)

L_d/B_c	l/d	$s_x/d = 5$									
		1	2	3	4	5	6	7	8	9	10
5	C ₀	0.203	0.389	0.464	0.510	0.543	0.567	0.587	0.603	0.617	0.628
	C ₁	1.416	1.864	2.120	2.277	2.416	2.514	2.599	2.695	2.761	2.821
	C ₂	1.941	2.652	2.824	2.957	2.973	3.018	3.045	3.008	3.023	3.033
10	C ₀	0.125	0.260	0.323	0.364	0.394	0.417	0.437	0.453	0.467	0.480
	C ₁	1.349	1.593	1.740	1.818	1.902	1.952	1.996	2.065	2.099	2.131
	C ₂	2.959	3.301	3.255	3.278	3.208	3.206	3.201	3.120	3.116	3.112
15	C ₀	0.093	0.202	0.257	0.295	0.323	0.345	0.364	0.379	0.393	0.405
	C ₁	1.351	1.528	1.645	1.697	1.766	1.800	1.829	1.893	1.916	1.938
	C ₂	3.724	3.825	3.649	3.614	3.492	3.465	3.442	3.329	3.314	3.301
20	C ₀	0.075	0.168	0.218	0.252	0.278	0.299	0.317	0.332	0.345	0.357
	C ₁	1.372	1.513	1.615	1.651	1.712	1.735	1.755	1.818	1.834	1.849
	C ₂	4.407	4.316	4.036	3.957	3.792	3.745	3.708	3.566	3.542	3.522
25	C ₀	0.063	0.145	0.190	0.222	0.246	0.267	0.283	0.298	0.310	0.322
	C ₁	1.399	1.517	1.609	1.633	1.690	1.705	1.717	1.781	1.791	1.800
	C ₂	5.049	4.792	4.418	4.301	4.096	4.031	3.982	3.812	3.780	3.754
30	C ₀	0.055	0.128	0.170	0.199	0.222	0.241	0.257	0.271	0.283	0.294
	C ₁	1.431	1.531	1.617	1.630	1.684	1.692	1.697	1.762	1.767	1.770
	C ₂	5.668	5.258	4.796	4.644	4.401	4.320	4.259	4.063	4.022	3.990
40	C ₀	0.044	0.105	0.141	0.167	0.188	0.205	0.219	0.232	0.243	0.253
	C ₁	1.498	1.573	1.650	1.646	1.695	1.689	1.683	1.751	1.746	1.741
	C ₂	6.865	6.176	5.547	5.331	5.013	4.902	4.817	4.568	4.512	4.467

Table E.0.1-4 (continued)

l/d	L_c/B_c	1	2	3	4	5	6	7	8	9	10
		C_0	0.036	0.089	0.121	0.144	0.163	0.179	0.192	0.204	0.214
	C_1	1.569	1.623	1.695	1.675	1.720	1.703	1.868	1.758	1.743	1.730
50	C_2	8.034	7.085	6.296	6.018	5.628	5.486	5.379	5.078	5.006	4.948
	C_0	0.031	0.078	0.106	0.128	0.145	0.159	0.171	0.182	0.192	0.201
	C_1	1.642	1.678	1.745	1.710	1.753	1.724	1.697	1.772	1.749	1.727
60	C_2	9.192	7.994	7.046	6.709	6.246	6.074	5.943	5.590	5.502	5.429
	C_0	0.028	0.069	0.095	0.114	0.130	0.143	0.155	0.165	0.174	0.182
	C_1	1.715	1.735	1.799	1.748	1.789	1.749	1.712	1.791	1.760	1.730
70	C_2	10.345	8.905	7.800	7.403	6.868	6.664	6.509	6.104	5.999	5.911
	C_0	0.025	0.063	0.086	0.104	0.118	0.131	0.141	0.151	0.159	0.167
	C_1	1.788	1.793	1.854	1.788	1.827	1.776	1.730	1.812	1.773	1.737
80	C_2	11.498	9.820	8.558	8.102	7.493	7.258	7.077	6.620	6.497	6.393
	C_0	0.022	0.057	0.079	0.095	0.109	0.120	0.130	0.139	0.147	0.154
	C_1	1.861	1.851	1.909	1.830	1.866	1.805	1.749	1.835	1.789	1.745
90	C_2	12.653	10.741	9.321	8.805	8.123	7.854	7.647	7.138	6.996	6.876
	C_0	0.021	0.052	0.072	0.088	0.100	0.111	0.120	0.129	0.136	0.143
	C_1	1.934	1.909	1.966	1.871	1.905	1.834	1.769	1.859	1.805	1.755
100	C_2	13.812	11.667	10.089	9.512	8.755	8.453	8.218	7.657	7.495	7.358

Note: L_c —Cushion cap length of clustered pile foundation; B_c —Cushion cap width of clustered pile foundation; l —Pile length; d —Pile diameter.

Table E.0.1-5 ($s_w/d = 6$)

l/d	L_d/B_c	1									
		2	3	4	5	6	7	8	9	10	
5	C_0	0.203	0.423	0.506	0.555	0.588	0.613	0.633	0.649	0.663	0.674
	C_1	1.393	1.956	2.277	2.485	2.658	2.789	2.902	3.021	3.099	3.179
	C_2	1.438	2.152	2.365	2.503	2.538	2.581	2.603	2.586	2.596	2.599
10	C_0	0.125	0.281	0.350	0.393	0.424	0.449	0.468	0.485	0.499	0.511
	C_1	1.328	1.623	1.793	1.889	1.983	2.044	2.096	2.169	2.210	2.247
	C_2	2.421	2.870	2.881	2.927	2.879	2.886	2.887	2.818	2.817	2.815
15	C_0	0.093	0.219	0.279	0.318	0.348	0.371	0.390	0.406	0.419	0.423
	C_1	1.327	1.540	1.671	1.733	1.809	1.848	1.882	1.949	1.975	1.999
	C_2	3.126	3.366	3.256	3.250	3.153	3.139	3.126	3.024	3.015	3.007
20	C_0	0.075	0.182	0.236	0.272	0.300	0.322	0.340	0.355	0.369	0.380
	C_1	1.344	1.513	1.625	1.669	1.735	1.762	1.785	1.850	1.868	1.884
	C_2	3.740	3.815	3.607	3.565	3.428	3.398	3.374	3.243	3.227	3.214
25	C_0	0.063	0.157	0.207	0.024	0.266	0.287	0.304	0.319	0.332	0.343
	C_1	1.368	1.509	1.610	1.640	1.700	1.717	1.731	1.796	1.807	1.816
	C_2	4.311	4.242	3.950	3.877	3.703	3.659	3.625	3.468	3.445	3.427
30	C_0	0.055	0.139	0.184	0.216	0.240	0.260	0.276	0.291	0.303	0.314
	C_1	1.395	1.516	1.608	1.627	1.683	1.692	1.699	1.765	1.769	1.773
	C_2	4.858	4.659	4.288	4.187	3.977	3.921	3.879	3.694	3.666	3.643
40	C_0	0.044	0.114	0.153	0.181	0.203	0.221	0.236	0.249	0.261	0.271
	C_1	1.455	1.545	1.627	1.626	1.676	1.671	1.664	1.733	1.727	1.721
	C_2	5.912	5.477	4.957	4.804	4.528	4.447	4.386	4.151	4.111	4.078

Table E.0.1-5 (continued)

l/d	L_c/B_c										
		1	2	3	4	5	6	7	8	9	10
50	C_0	0.036	0.097	0.132	0.157	0.177	0.193	0.207	0.219	0.230	0.240
	C_1	1.517	1.584	1.659	1.640	1.687	1.669	1.650	1.723	1.707	1.691
	C_2	6.939	6.287	5.624	5.423	5.080	4.974	4.896	4.610	4.557	4.514
60	C_0	0.031	0.085	0.116	0.139	0.157	0.172	0.185	0.196	0.207	0.216
	C_1	1.581	1.627	1.698	1.662	1.706	1.675	1.645	1.722	1.697	1.672
	C_2	7.956	7.097	6.292	6.043	5.634	5.504	5.406	5.071	5.004	4.948
70	C_0	0.028	0.076	0.104	0.125	0.141	0.156	0.168	0.178	0.188	0.196
	C_1	1.645	1.673	1.740	1.688	1.728	1.686	1.646	1.726	1.692	1.660
	C_2	8.968	7.908	6.964	6.667	6.191	6.035	5.917	5.532	5.450	5.382
80	C_0	0.025	0.068	0.094	0.113	0.129	0.142	0.153	0.163	0.172	0.180
	C_1	1.708	1.720	1.783	1.716	1.754	1.700	1.650	1.734	1.692	1.652
	C_2	9.981	8.724	7.640	7.293	6.751	6.569	6.428	5.994	5.896	5.814
90	C_0	0.022	0.062	0.086	0.104	0.118	0.131	0.141	0.150	0.159	0.167
	C_1	1.772	1.768	1.827	1.745	1.780	1.716	1.657	1.744	1.694	1.648
	C_2	10.997	9.544	8.319	7.924	7.314	7.103	6.939	6.457	6.342	6.244
100	C_0	0.021	0.057	0.079	0.096	0.110	0.121	0.131	0.140	0.148	0.155
	C_1	1.835	1.815	1.872	1.775	1.808	1.733	1.665	1.755	1.698	1.646
	C_2	12.016	10.370	9.004	8.557	7.879	7.639	7.450	6.919	6.787	6.673

Note: L_c —Cushion cap length of clustered pile foundation; B_c —Cushion cap width of clustered pile foundation; l —Pile length; d —Pile diameter.

Appendix F Stress Effect Coefficient through Mindlin Stress

Formulas Considering Pile Diameter Effect

F.0.1 The subsidiary stress (specified in Article 5.5.14 of this standard) caused by the foundation pile shall be based on Mindlin Stress Formulas Considering Pile Diameter Effect, and shall be calculated according to following formula:

$$\sigma_z = \sigma_{zp} + \sigma_{zsr} + \sigma_{zst} \quad (\text{F.0.1-1})$$

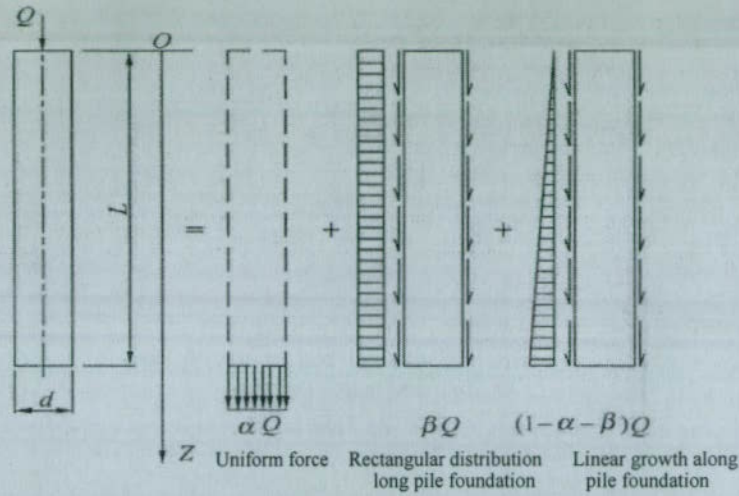
$$\sigma_{zp} = \frac{\alpha Q}{l^2} I_p \quad (\text{F.0.1-2})$$

$$\sigma_{zsr} = \frac{\beta Q}{l^2} I_{sr} \quad (\text{F.0.1-3})$$

$$\sigma_{zst} = \frac{(1 - \alpha - \beta) Q}{l^2} I_{st} \quad (\text{F.0.1-4})$$

- Where:
- σ_{zp} —Subsidiary stress caused by the end resistance on the stress calculation point;
 - σ_{zsr} —Subsidiary stress caused by the rectangular-distribution side-resistance on the stress calculation point;
 - σ_{zst} —Subsidiary stress caused by the rectangular-distribution side-resistance on the stress calculation point;
 - α —Tip resistance ratio;
 - β —Ratio of rectangular-distribution side resistance;
 - l —Pile length;
 - I_p, I_{sr}, I_{st} —Stress effect coefficient through Mindlin Stress Formulas Considering Pile Diameter Effect, identified according to Article F.0.2.

F.0.2 The Mindlin stress effect coefficient Considering Pile Diameter Effect simplifies the end resistance and the side resistance as forms of Figure F.0.2, and the Mindlin stress effect coefficient is calculated.



F.0.2 Individual Pile Load, Side Resistance and End Resistance Distributions

1 Analysis formula for vertical stress coefficient along pile foundation axial line, considering the pile diameter influence:

$$\begin{aligned}
 I_p = \frac{l^2}{\pi \cdot r^2} \cdot \frac{1}{4(1-\mu)} \left\{ 2(1-\mu) - \frac{(1-2\mu)(z-l)}{\sqrt{r^2+(z-l)^2}} - \frac{(1-2\mu)(z-l)}{z+l} + \frac{(1-2\mu)(z-l)}{\sqrt{r^2+(z-l)^2}} \right. \\
 - \frac{(1-2\mu)(z-l)}{z+l} + \frac{(1-2\mu)(z-l)}{\sqrt{r^2+(z+l)^2}} - \frac{(z-l)^3}{[r^2+(z-l)^2]^{3/2}} \\
 + \frac{(3-4\mu)z}{z+l} - \frac{(3-4\mu)z(z+l)^2}{[r^2+(z+l)^2]^{3/2}} - \frac{l(5z-l)}{(z+l)^2} \\
 \left. + \frac{l(z+l)(5z-l)}{[r^2+(z+l)^2]^{3/2}} + \frac{6lz}{(z+l)^2} - \frac{6zl(z+l)^3}{[r^2+(z+l)^2]^{5/2}} \right\} \quad (F.0.2-1)
 \end{aligned}$$

$$\begin{aligned}
 I_{sr} = \frac{l}{2\pi r} \cdot \frac{1}{4(1-\mu)} \left\{ \frac{2(2-\mu)r}{\sqrt{r^2+(z-l)^2}} \right. \\
 - \frac{2(2-\mu)r^2 + 2(1-2\mu)z(z+l)}{r\sqrt{r^2+(z+l)^2}} + \frac{2(1-2\mu)z^2}{r\sqrt{r^2+z^2}} \\
 - \frac{4z^2[r^2-(1+\mu)z^2]}{r(r^2+z^2)^{3/2}} - \frac{4(1+\mu)z(z+l)^3 - 4z^2r^2 - r^4}{r[r^2+(z+l)^2]^{3/2}} \\
 \left. - \frac{r^3}{[r^2+(z-l)^2]^{3/2}} - \frac{6z^2[z^4-r^4]}{r(r^2+z^2)^{5/2}} - \frac{6z[zr^4 - (z+l)^5]}{r[r^2+(z+l)^2]^{5/2}} \right\} \quad (F.0.2-2)
 \end{aligned}$$

$$I_{st} = \frac{l}{\pi r} \cdot \frac{1}{4(1-\mu)} \left\{ \frac{2(2-\mu)r}{\sqrt{r^2+(z-l)^2}} \right.$$

$$\begin{aligned}
& + \frac{2(1-2\mu)z^2(z+l) - 2(2-\mu)(4z+l)r^2}{lr\sqrt{r^2+(z+l)^2}} \\
& + \frac{8(2-\mu)zr^2 - 2(1-2\mu)z^3}{lr\sqrt{r^2+z^2}} + \frac{12z^7 + 6zr^4(r^2 - z^2)}{lr(r^2+z^2)^{5/2}} \\
& + \frac{15zr^4 + 2(5+2\mu)z^2(z+l)^3 - 4\mu zr^4 - 4z^3r^2 - r^2(z+l)^3}{lr[r^2+(z+l)^2]^{3/2}} \\
& - \frac{6zr^4(r^2 - z^2) + 12z^3(z+l)^5}{lr[r^2+(z+l)^2]^{5/2}} \\
& + \frac{6z^3r^2 - 2(5+2\mu)z^5 - 2(7-2\mu)zr^4}{lr[r^2+z^2]^{3/2}} \\
& - \frac{zr^3 + (z-l)^3r}{l[r^2+(z-l)^2]^{3/2}} + 2(2-\mu)\frac{r}{l} \\
& \ln \frac{(\sqrt{r^2+(z-l)^2} + z-l)(\sqrt{r^2+(z+l)^2} + z+l)}{[\sqrt{r^2+z^2} + z]^2} \quad (F.0.2-3)
\end{aligned}$$

Where: μ —Foundation soil poisons ratio;
 r —Pile foundation semidiameter;
 l —Pile length;
 z —Vertical distance from the calculated stress point to the pile top.

2 Mindlin vertical stress effect coefficient Table considering pile diameter influence, 1) the vertical stress effect coefficients of all points on pile foundation axis ($n=\rho/l=0$) below pile tip are calculated according to formulas (F.0.2-1)~(F.0.2-3), and the values are listed in Table F.0.2-1~Table F.0.2-3. 2) the vertical stress effect coefficients of piles with in horizontal effective influence, are calculated through the numerical integrating method, and the values are listed in Table F.0.2-1~F.0.2-3. In tables: $m = z/l$; $n = \rho/l$; ρ refers to the horizontal distance from adjacent pile to the calculation pile axis.

F.0.3 The pile-side resistance distribution may be adopted as following mode:

The foundation pile side resistance distribution may be simplified as the pile foundation rectangular-distribution mode, namely, $\beta=1-\alpha$ (where formula (F.0.1-1), $\sigma_{zst}=0$). With testing basis, in accordance with test result, it may be respectively adopted as equilateral triangle distribution of growth along deep line, ($\beta=0$, where formula (F.0.1-1), $\sigma_{zst}=0$), Regular trapezoid distribution (uniform+equilateral triangle distribution) or inverted trapezia distribution (uniform-equilateral triangle distribution).

F.0.4 The vertical stress effect coefficients of long and short pile shall be calculated according to following principles:

1 For the influence of long pile ($m_1=z/l_1=l_2/l_1$) to short pile, from the--of the long pile adopted as the initial calculation point downward, the vertical stress effect coefficients of different depth below the short pile pile-tip are calculated;

2 For the influence of short pile ($m_2=z/l_2=l_1/l_2$) to long pile, from the--of the short pile adopted as the initial calculation point downward, the vertical stress effect coefficients of different depth below the long pile pile-tip are calculated;

3 If the overlapping junctions of positive stresses under the calculation point are negative value, the zero value shall be adopted.

Table F.0.2-1 Vertical Stress Effect Coefficient (I_p) of Uniform-distribution Tip Resistance, Considering Pile Diameter Influence

l/d	10														
	m	n	0.000	0.020	0.040	0.060	0.080	0.100	0.120	0.160	0.200	0.300	0.400	0.500	0.600
0.500						-0.600	-0.581	-0.558	-0.531	-0.468	-0.400	-0.236	-0.113	-0.037	0.004
0.550						-0.779	-0.751	-0.716	-0.675	-0.585	-0.488	-0.270	-0.119	-0.034	0.010
0.600						-1.021	-0.976	-0.922	-0.860	-0.725	-0.587	-0.297	-0.119	-0.026	0.018
0.650						-1.357	-1.283	-1.196	-1.099	-0.893	-0.694	-0.314	-0.109	-0.013	0.027
0.700						-1.846	-1.717	-1.568	-1.408	-1.086	-0.797	-0.311	-0.088	0.003	0.038
0.750						-2.589	-2.349	-2.080	-1.805	-1.289	-0.873	-0.279	-0.057	0.022	0.049
0.800						-3.781	-3.289	-2.772	-2.276	-1.448	-0.875	-0.212	-0.018	0.041	0.059
0.850						-5.787	-4.666	-3.606	-2.701	-1.434	-0.737	-0.117	0.023	0.059	0.067
0.900						-9.175	-6.341	-4.137	-2.625	-1.047	-0.426	-0.015	0.057	0.072	0.072
0.950						-13.522	-6.132	-2.699	-1.262	-0.327	-0.078	0.059	0.079	0.080	0.075
1.004				62.378		1.756	0.367	0.208	0.157	0.123	0.111	0.100	0.093	0.085	0.078
1.008				60.784		4.584	0.705	0.325	0.214	0.144	0.121	0.102	0.093	0.086	0.078
1.012				58.836		7.572	1.159	0.468	0.280	0.166	0.131	0.105	0.094	0.086	0.078
1.016				56.509		9.951	1.729	0.643	0.356	0.190	0.142	0.108	0.095	0.086	0.078
1.020				53.863		11.637	2.379	0.853	0.446	0.217	0.154	0.110	0.096	0.087	0.078
1.024				51.008		12.763	3.063	1.094	0.549	0.248	0.167	0.113	0.097	0.087	0.078
1.028				48.054		13.474	3.737	1.360	0.666	0.282	0.181	0.116	0.098	0.087	0.078
1.040				39.423		14.106	5.432	2.227	1.084	0.406	0.230	0.126	0.101	0.089	0.079
1.060				27.845		13.000	6.839	3.469	1.849	0.677	0.342	0.148	0.108	0.091	0.080
1.080				19.955		11.179	6.992	4.152	2.467	0.980	0.481	0.176	0.117	0.094	0.081
1.100				14.702		9.386	6.552	4.348	2.834	1.254	0.631	0.211	0.127	0.098	0.083
1.120				11.153		7.831	5.896	4.240	2.977	1.465	0.773	0.250	0.140	0.103	0.085
1.140				8.692		7.795	5.208	3.977	2.960	1.601	0.893	0.292	0.154	0.109	0.087
1.160				6.937		6.349	4.565	3.650	2.845	1.669	0.985	0.334	0.170	0.115	0.090
1.180				5.651		5.254	3.996	3.310	2.678	1.684	1.048	0.374	0.187	0.122	0.094
1.200				4.686		4.410	3.996	2.986	2.489	1.659	1.083	0.411	0.204	0.130	0.097
1.300				2.230		2.167	2.067	1.788	1.627	1.302	1.010	0.513	0.277	0.170	0.119
1.400				1.312		1.284	1.250	1.149	1.087	0.949	0.807	0.506	0.312	0.201	0.140
1.500				0.866		0.854	0.839	0.820	0.767	0.701	0.629	0.451	0.311	0.215	0.154
1.600				0.619		0.613	0.606	0.596	0.583	0.534	0.494	0.387	0.290	0.215	0.160

Table F.0.2-1 (continued)

l/d	15														
	m	0.000	0.020	0.040	0.060	0.080	0.100	0.120	0.160	0.200	0.300	0.400	0.500	0.600	
0.500				-0.619	-0.605	-0.585	-0.562	-0.534	-0.471	-0.402	-0.236	-0.113	-0.037	0.004	
0.550			-0.808	-0.786	-0.757	-0.721	-0.680	-0.680	-0.588	-0.490	-0.269	-0.119	-0.033	0.010	
0.600			-1.067	-1.032	-0.986	-0.930	-0.867	-0.867	-0.729	-0.589	-0.297	-0.118	-0.025	0.018	
0.650			-1.433	-1.375	-1.299	-1.208	-1.108	-1.108	-0.898	-0.695	-0.312	-0.108	-0.013	0.028	
0.700			-1.981	-1.876	-1.742	-1.587	-1.422	-1.422	-1.091	-0.797	-0.308	-0.087	0.004	0.038	
0.750			-2.850	-2.645	-2.389	-2.108	-1.820	-1.820	-1.290	-0.868	-0.275	-0.056	0.023	0.049	
0.800			-4.342	-3.889	-3.355	-2.805	-2.286	-2.286	-1.437	-0.862	-0.207	-0.016	0.042	0.059	
0.850			-7.174	-5.996	-4.747	-3.609	-2.668	-2.668	-1.395	-0.713	-0.112	0.024	0.059	0.067	
0.900			-13.179	-9.428	-6.231	-3.949	-2.469	-2.469	-0.980	-0.401	-0.012	0.057	0.072	0.072	
0.950			-25.874	-11.676	-4.925	-2.196	-1.061	-1.061	-0.288	-0.067	0.060	0.079	0.080	0.076	
1.004	139.202	137.028	6.771	6.657	6.288	0.189	0.151	0.151	0.122	0.111	0.100	0.093	0.085	0.078	
1.008	134.212	127.885	16.907	1.416	0.502	0.283	0.201	0.201	0.141	0.120	0.102	0.093	0.086	0.078	
1.012	127.849	116.582	24.338	2.473	0.771	0.392	0.256	0.256	0.161	0.130	0.105	0.094	0.086	0.078	
1.016	120.095	104.985	28.589	3.784	1.109	0.522	0.320	0.320	0.184	0.140	0.107	0.095	0.086	0.078	
1.020	111.316	94.178	30.723	5.224	1.516	0.677	0.394	0.394	0.209	0.152	0.110	0.096	0.087	0.078	
1.024	102.035	84.503	31.544	6.655	1.981	0.858	0.478	0.478	0.236	0.164	0.113	0.097	0.087	0.078	
1.028	92.751	75.959	31.545	7.976	2.487	1.062	0.575	0.575	0.267	0.177	0.116	0.098	0.087	0.078	
1.040	67.984	55.962	29.127	10.814	4.040	1.776	0.927	0.927	0.379	0.223	0.126	0.101	0.089	0.079	
1.060	40.837	35.291	22.966	12.108	5.919	2.983	1.625	1.625	0.627	0.328	0.147	0.108	0.091	0.080	
1.080	26.159	23.586	17.507	11.187	6.586	3.808	2.255	2.255	0.914	0.460	0.174	0.116	0.094	0.081	
1.100	17.897	16.610	13.391	9.640	6.442	4.160	2.679	2.679	1.187	0.605	0.208	0.127	0.098	0.083	
1.120	12.923	12.226	10.406	8.106	5.921	4.162	2.881	2.881	1.406	0.746	0.246	0.139	0.103	0.085	
1.140	9.737	9.332	8.241	6.781	5.281	3.962	2.911	2.911	1.555	0.868	0.288	0.153	0.108	0.087	
1.160	7.588	7.339	6.652	5.693	4.648	3.666	2.827	2.827	1.637	0.963	0.329	0.169	0.115	0.090	
1.180	6.075	5.915	5.463	4.813	4.073	3.340	2.678	2.678	1.663	1.030	0.369	0.185	0.122	0.093	
1.200	4.973	4.866	4.558	4.104	3.570	3.019	2.499	2.499	1.647	1.070	0.406	0.202	0.130	0.097	
1.300	2.291	2.269	2.202	2.097	1.962	1.807	1.640	1.640	1.307	1.010	0.511	0.276	0.170	0.118	
1.400	1.325	1.318	1.296	1.261	1.214	1.157	1.094	1.094	0.953	0.809	0.505	0.311	0.201	0.139	
1.500	0.871	0.868	0.859	0.844	0.824	0.799	0.770	0.770	0.704	0.630	0.451	0.310	0.215	0.154	
1.600	0.621	0.620	0.615	0.608	0.598	0.586	0.571	0.571	0.536	0.496	0.388	0.290	0.215	0.160	

Table F.0.2-1 (continued)

		20												
l/d	n	0.000	0.020	0.040	0.060	0.080	0.100	0.120	0.160	0.200	0.300	0.400	0.500	0.600
0.500				-0.621	-0.606	-0.587	-0.563	-0.535	-0.472	-0.402	-0.236	-0.113	-0.037	0.004
0.550				-0.811	-0.789	-0.759	-0.723	-0.682	-0.589	-0.491	-0.269	-0.118	-0.033	0.010
0.600				-1.071	-1.036	-0.989	-0.933	-0.869	-0.731	-0.590	-0.296	-0.117	-0.025	0.018
0.650				-1.440	-1.381	-1.304	-1.213	-1.112	-0.899	-0.696	-0.312	-0.107	-0.013	0.028
0.700				-1.993	-1.887	-1.751	-1.594	-1.426	-1.092	-0.797	-0.307	-0.086	0.004	0.038
0.750				-2.875	-2.665	-2.404	-2.117	-1.826	-1.290	-0.867	-0.273	-0.055	0.023	0.049
0.800				-4.396	-3.927	-3.378	-2.816	-2.288	-1.432	-0.857	-0.205	-0.016	0.042	0.059
0.850				-7.309	-6.069	-4.773	-3.608	-2.656	-1.382	-0.705	-0.110	0.024	0.059	0.067
0.900				-13.547	-9.494	-6.176	-3.877	-2.414	-0.957	-0.392	-0.011	0.058	0.072	0.072
0.950				-25.714	-10.848	-4.530	-2.043	-1.000	-0.275	-0.064	0.060	0.079	0.080	0.076
1.004	244.665	222.298	2.507	6.607	0.549	0.270	0.184	0.149	0.121	0.111	0.100	0.093	0.085	0.078
1.008	231.267	181.758	6.607	1.118	0.459	0.271	0.271	0.196	0.140	0.120	0.102	0.093	0.086	0.078
1.012	213.422	152.271	11.947	1.893	0.691	0.459	0.372	0.249	0.160	0.130	0.105	0.094	0.086	0.078
1.016	192.367	130.925	17.172	2.882	0.981	0.691	0.491	0.309	0.182	0.140	0.107	0.095	0.086	0.078
1.020	170.266	114.368	21.429	4.037	1.330	0.981	0.632	0.379	0.206	0.151	0.110	0.096	0.087	0.078
1.024	148.975	100.844	24.487	5.275	1.735	1.735	0.796	0.458	0.232	0.163	0.113	0.097	0.087	0.078
1.028	129.596	89.450	26.439	6.511	2.184	2.184	0.983	0.549	0.262	0.175	0.116	0.098	0.087	0.078
1.040	85.457	63.853	27.680	9.582	3.636	3.636	1.647	0.881	0.370	0.221	0.126	0.101	0.089	0.079
1.060	46.430	38.661	23.310	11.634	5.588	5.588	2.825	1.554	0.611	0.323	0.146	0.108	0.091	0.080
1.080	28.320	25.133	17.998	11.118	6.418	6.418	3.685	2.183	0.893	0.453	0.174	0.116	0.094	0.081
1.100	18.875	17.385	13.759	9.705	6.387	6.387	4.088	2.623	1.164	0.597	0.207	0.126	0.098	0.083
1.120	13.422	12.647	10.654	8.197	5.921	5.921	4.130	2.846	1.386	0.737	0.245	0.139	0.103	0.085
1.140	10.016	9.577	8.407	6.863	5.303	5.303	3.953	2.892	1.539	0.859	0.286	0.153	0.108	0.087
1.160	7.755	7.490	6.763	5.758	4.676	4.676	3.670	2.819	1.626	0.955	0.327	0.169	0.115	0.090
1.180	6.181	6.013	5.540	4.863	4.099	4.099	3.349	2.677	1.656	1.024	0.367	0.185	0.122	0.093
1.200	5.044	4.931	4.612	4.142	3.593	3.593	3.030	2.502	1.643	1.065	0.404	0.202	0.129	0.097
1.300	2.306	2.283	2.215	2.108	1.971	1.971	1.813	1.645	1.308	1.010	0.510	0.275	0.170	0.118
1.400	1.330	1.323	1.301	1.265	1.218	1.218	1.160	1.096	0.954	0.810	0.505	0.311	0.201	0.139
1.500	0.873	0.870	0.861	0.846	0.826	0.826	0.801	0.772	0.705	0.631	0.451	0.310	0.215	0.154
1.600	0.622	0.621	0.616	0.609	0.599	0.599	0.586	0.572	0.536	0.496	0.388	0.290	0.214	0.160

Table F.0.2-1 (continued)

		30													
l/d	n/m	0.000	0.020	0.040	0.060	0.080	0.100	0.120	0.160	0.200	0.300	0.400	0.500	0.600	
0.500			-0.631	-0.622	-0.608	-0.588	-0.564	-0.536	-0.472	-0.403	-0.236	-0.112	-0.037	0.004	
0.550			-0.827	-0.813	-0.791	-0.761	-0.725	-0.683	-0.590	-0.491	-0.269	-0.118	-0.033	0.010	
0.600			-1.096	-1.074	-1.038	-0.991	-0.935	-0.871	-0.732	-0.590	-0.296	-0.117	-0.025	0.018	
0.650			-1.483	-1.445	-1.386	-1.308	-1.216	-1.114	-0.900	-0.696	-0.311	-0.107	-0.012	0.028	
0.700			-2.071	-2.002	-1.895	-1.757	-1.598	-1.429	-1.093	-0.796	-0.306	-0.086	0.004	0.038	
0.750			-3.032	-2.892	-2.679	-2.414	-2.124	-1.829	-1.290	-0.865	-0.272	-0.054	0.023	0.049	
0.800			-4.764	-4.436	-3.955	-3.395	-2.824	-2.290	-1.429	-0.854	-0.204	-0.015	0.042	0.059	
0.850			-8.367	-7.408	-6.122	-4.791	-3.606	-2.646	-1.372	-0.699	-0.109	0.025	0.059	0.067	
0.900			-17.766	-13.813	-9.532	-6.130	-3.824	-2.374	-0.941	-0.386	-0.010	0.058	0.072	0.072	
0.950			-53.070	-25.276	-10.224	-4.262	-1.940	-0.959	-0.267	-0.062	0.060	0.079	0.080	0.076	
1.004	536.535		67.314	1.695	0.493	0.259	0.181	0.148	0.121	0.111	0.100	0.093	0.085	0.078	
1.008	480.071		114.047	4.129	0.973	0.433	0.264	0.194	0.140	0.120	0.102	0.093	0.086	0.078	
1.012	407.830		125.866	7.619	1.610	0.644	0.359	0.245	0.159	0.129	0.105	0.094	0.086	0.078	
1.016	335.065		123.804	11.742	2.429	0.905	0.471	0.302	0.180	0.139	0.107	0.095	0.086	0.078	
1.020	271.631		116.207	15.857	3.410	1.220	0.603	0.369	0.204	0.150	0.110	0.096	0.087	0.078	
1.024	220.202		106.561	19.459	4.502	1.587	0.757	0.445	0.230	0.162	0.113	0.097	0.087	0.078	
1.028	179.778		96.493	22.283	5.641	1.999	0.932	0.531	0.259	0.174	0.116	0.098	0.087	0.078	
1.040	104.344		69.738	26.055	8.735	3.375	1.563	0.850	0.364	0.219	0.125	0.101	0.089	0.079	
1.060	51.415		41.346	23.409	11.251	5.354	2.717	1.505	0.599	0.320	0.146	0.108	0.091	0.080	
1.080	30.085		26.343	18.329	11.045	6.290	3.597	2.133	0.878	0.448	0.173	0.116	0.094	0.081	
1.100	19.639		17.978	14.025	9.744	6.342	4.035	2.584	1.148	0.591	0.206	0.126	0.098	0.083	
1.120	13.802		12.964	10.836	8.259	5.919	4.105	2.820	1.371	0.730	0.244	0.139	0.103	0.085	
1.140	10.224		9.760	8.528	6.921	5.318	3.946	2.878	1.528	0.853	0.285	0.153	0.108	0.087	
1.160	7.879		7.602	6.845	5.805	4.695	3.672	2.813	1.618	0.950	0.326	0.168	0.115	0.090	
1.180	6.259		6.084	5.596	4.900	4.118	3.356	2.676	1.651	1.019	0.366	0.185	0.122	0.093	
1.200	5.095		4.980	4.651	4.170	3.610	3.038	2.503	1.640	1.062	0.403	0.202	0.129	0.097	
1.300	2.316		2.293	2.224	2.116	1.977	1.818	1.648	1.310	1.010	0.509	0.275	0.169	0.118	
1.400	1.333		1.326	1.304	1.268	1.220	1.163	1.098	0.955	0.811	0.505	0.310	0.200	0.139	
1.500	0.874		0.872	0.862	0.847	0.827	0.802	0.773	0.705	0.631	0.451	0.310	0.215	0.154	
1.600	0.623		0.621	0.617	0.610	0.599	0.587	0.572	0.537	0.496	0.388	0.290	0.214	0.160	

Table F.0.2-1 (continued)

l/d		40													
m	n	0.000	0.020	0.040	0.060	0.080	0.100	0.120	0.160	0.200	0.300	0.400	0.500	0.600	
0.500			-0.631	-0.622	-0.608	-0.588	-0.564	-0.536	-0.472	-0.403	-0.236	-0.112	-0.036	0.004	
0.550			-0.827	-0.814	-0.791	-0.762	-0.725	-0.684	-0.590	-0.491	-0.269	-0.118	-0.033	0.010	
0.600			-1.097	-1.075	-1.039	-0.992	-0.936	-0.872	-0.732	-0.591	-0.296	-0.117	-0.025	0.018	
0.650			-1.485	-1.447	-1.387	-1.309	-1.217	-1.115	-0.901	-0.696	-0.311	-0.107	-0.012	0.028	
0.700			-2.074	-2.006	-1.898	-1.759	-1.600	-1.431	-1.094	-0.796	-0.306	-0.086	0.004	0.038	
0.750			-3.039	-2.899	-2.684	-2.418	-2.126	-1.831	-1.290	-0.865	-0.272	-0.054	0.023	0.049	
0.800			-4.781	-4.449	-3.965	-3.401	-2.826	-2.291	-1.428	-0.853	-0.204	-0.015	0.042	0.059	
0.850			-8.418	-7.443	-6.140	-4.797	-3.606	-2.643	-1.368	-0.696	-0.108	0.025	0.059	0.067	
0.900			-17.982	-13.906	-9.543	-6.114	-3.805	-2.360	-0.935	-0.384	-0.010	0.058	0.072	0.072	
0.950			-54.543	-25.054	-10.003	-4.171	-1.905	-0.945	-0.264	-0.061	0.060	0.079	0.080	0.076	
1.004	924.755		26.114	1.523	0.477	0.255	0.180	0.147	0.121	0.111	0.100	0.093	0.085	0.078	
1.008	769.156		68.377	3.614	0.931	0.425	0.262	0.193	0.139	0.120	0.102	0.093	0.086	0.078	
1.012	595.591		97.641	6.633	1.529	0.630	0.355	0.243	0.159	0.129	0.105	0.094	0.086	0.078	
1.016	449.984		109.641	10.343	2.298	0.881	0.465	0.300	0.180	0.139	0.107	0.095	0.086	0.078	
1.020	341.526		110.416	14.244	3.224	1.185	0.594	0.366	0.203	0.150	0.110	0.096	0.087	0.078	
1.024	263.543		105.215	17.851	4.267	1.541	0.744	0.441	0.229	0.162	0.113	0.097	0.087	0.078	
1.028	207.450		97.302	20.843	5.369	1.940	0.916	0.526	0.258	0.174	0.116	0.098	0.087	0.079	
1.040	112.989		71.701	25.382	8.448	3.288	1.535	0.839	0.362	0.219	0.125	0.101	0.089	0.079	
1.060	53.411		42.340	23.410	11.109	5.272	2.680	1.488	0.596	0.319	0.146	0.108	0.091	0.080	
1.080	30.754		26.788	18.440	11.014	6.245	3.566	2.116	0.872	0.447	0.173	0.116	0.094	0.081	
1.100	19.920		18.194	14.119	9.755	6.325	4.016	2.570	1.143	0.589	0.206	0.126	0.098	0.083	
1.120	13.939		13.078	10.900	8.281	5.917	4.096	2.811	1.366	0.728	0.244	0.139	0.103	0.085	
1.140	10.300		9.825	8.571	6.941	5.323	3.944	2.873	1.524	0.850	0.284	0.153	0.108	0.087	
1.160	7.923		7.642	6.874	5.822	4.702	3.673	2.811	1.615	0.948	0.326	0.168	0.115	0.090	
1.180	6.287		6.110	5.616	4.912	4.125	3.358	2.676	1.649	1.018	0.366	0.185	0.122	0.093	
1.200	5.113		4.997	4.665	4.180	3.615	3.040	2.504	1.639	1.061	0.402	0.201	0.129	0.097	
1.300	2.320		2.297	2.227	2.119	1.980	1.820	1.649	1.310	1.009	0.509	0.275	0.169	0.118	
1.400	1.334		1.327	1.305	1.269	1.221	1.163	1.098	0.956	0.811	0.505	0.310	0.200	0.139	
1.500	0.875		0.872	0.863	0.848	0.827	0.802	0.773	0.706	0.632	0.451	0.310	0.215	0.154	
1.600	0.623		0.622	0.617	0.610	0.600	0.587	0.572	0.537	0.496	0.388	0.290	0.214	0.160	

Table F.0.2-1 (continued)

		50													
l/d	m	0.000	0.020	0.040	0.060	0.080	0.100	0.120	0.160	0.200	0.300	0.400	0.500	0.600	
0.500	n														
0.550															
0.600															
0.650															
0.700															
0.750															
0.800															
0.850															
0.900															
0.950															
1.004															
1.008															
1.012															
1.016															
1.020															
1.024															
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1.100															
1.120															
1.140															
1.160															
1.180															
1.200															
1.300															
1.400															
1.500															
1.600															

Table F.0.2-1 (continued)

l/d		60													
m	n	0.000	0.020	0.040	0.060	0.080	0.100	0.120	0.160	0.200	0.300	0.400	0.500	0.600	
0.500			-0.632	-0.623	-0.608	-0.589	-0.565	-0.537	-0.473	-0.403	-0.236	-0.112	-0.036	0.004	
0.550			-0.828	-0.814	-0.792	-0.762	-0.726	-0.684	-0.590	-0.491	-0.269	-0.118	-0.033	0.010	
0.600			-1.098	-1.076	-1.040	-0.993	-0.936	-0.872	-0.732	-0.591	-0.296	-0.117	-0.025	0.018	
0.650			-1.486	-1.448	-1.389	-1.310	-1.218	-1.116	-0.901	-0.696	-0.311	-0.107	-0.012	0.028	
0.700			-2.077	-2.008	-1.900	-1.761	-1.601	-1.431	-1.094	-0.796	-0.306	-0.086	0.004	0.038	
0.750			-3.044	-2.903	-2.688	-2.421	-2.128	-1.832	-1.290	-0.864	-0.272	-0.054	0.023	0.049	
0.800			-4.793	-4.459	-3.972	-3.405	-2.828	-2.291	-1.427	-0.852	-0.203	-0.015	0.042	0.059	
0.850			-8.454	-7.469	-6.153	-4.802	-3.605	-2.640	-1.366	-0.695	-0.108	0.025	0.059	0.067	
0.900			-18.139	-13.973	-9.551	-6.101	-3.792	-2.350	-0.931	-0.382	-0.010	0.058	0.072	0.072	
0.950			-55.606	-24.874	-9.844	-4.106	-1.881	-0.935	-0.262	-0.060	0.060	0.079	0.080	0.076	
1.004	1919.968		16.202	1.420	0.466	0.253	0.179	0.147	0.121	0.111	0.100	0.093	0.085	0.078	
1.008	1339.951		46.658	3.312	0.904	0.419	0.260	0.192	0.139	0.120	0.102	0.093	0.086	0.078	
1.012	880.499		77.527	6.043	1.476	0.620	0.352	0.242	0.159	0.129	0.105	0.094	0.086	0.078	
1.016	592.844		96.782	9.474	2.211	0.865	0.460	0.299	0.180	0.139	0.107	0.095	0.086	0.078	
1.020	417.074		103.916	13.198	3.101	1.162	0.587	0.363	0.203	0.150	0.110	0.096	0.087	0.078	
1.024	306.046		102.769	16.767	4.110	1.509	0.735	0.437	0.228	0.161	0.113	0.097	0.087	0.078	
1.028	232.784		97.065	19.836	5.184	1.900	0.904	0.521	0.257	0.174	0.116	0.098	0.087	0.079	
1.040	120.052		73.026	24.874	8.247	3.228	1.515	0.832	0.361	0.218	0.125	0.101	0.089	0.079	
1.060	54.929		43.067	23.399	11.006	5.214	2.654	1.477	0.593	0.318	0.146	0.108	0.091	0.080	
1.080	31.250		27.114	18.517	10.990	6.212	3.544	2.103	0.869	0.445	0.173	0.116	0.094	0.081	
1.100	20.126		18.351	14.185	9.763	6.312	4.002	2.560	1.139	0.587	0.206	0.126	0.098	0.083	
1.120	14.040		13.161	10.947	8.296	5.916	4.090	2.804	1.363	0.726	0.243	0.138	0.103	0.085	
1.140	10.354		9.873	8.602	6.956	5.326	3.942	2.869	1.521	0.849	0.284	0.153	0.108	0.087	
1.160	7.955		7.670	6.895	5.833	4.707	3.673	2.809	1.613	0.947	0.325	0.168	0.115	0.090	
1.180	6.307		6.128	5.630	4.922	4.130	3.359	2.676	1.647	1.017	0.365	0.184	0.122	0.093	
1.200	5.127		5.009	4.675	4.187	3.620	3.042	2.505	1.638	1.060	0.402	0.201	0.129	0.097	
1.300	2.322		2.299	2.230	2.121	1.981	1.821	1.650	1.310	1.009	0.509	0.275	0.169	0.118	
1.400	1.335		1.328	1.306	1.270	1.222	1.164	1.099	0.956	0.811	0.505	0.310	0.200	0.139	
1.500	0.875		0.872	0.863	0.848	0.828	0.802	0.773	0.706	0.632	0.451	0.310	0.215	0.154	
1.600	0.623		0.622	0.617	0.610	0.600	0.587	0.572	0.537	0.497	0.388	0.290	0.214	0.160	

Table F.0.2-1 (continued)

		70													
<i>l/d</i>	<i>m</i>	0.000	0.020	0.040	0.060	0.080	0.100	0.120	0.160	0.200	0.300	0.400	0.500	0.600	
0.500			-0.632	-0.623	-0.608	-0.589	-0.565	-0.537	-0.473	-0.403	-0.236	-0.112	-0.036	0.004	
0.550			-0.828	-0.814	-0.792	-0.762	-0.726	-0.684	-0.590	-0.492	-0.269	-0.118	-0.033	0.010	
0.600			-1.098	-1.076	-1.040	-0.993	-0.936	-0.872	-0.732	-0.591	-0.296	-0.117	-0.025	0.018	
0.650			-1.486	-1.449	-1.389	-1.310	-1.218	-1.116	-0.901	-0.696	-0.311	-0.107	-0.012	0.028	
0.700			-2.078	-2.008	-1.900	-1.761	-1.601	-1.432	-1.094	-0.796	-0.306	-0.086	0.004	0.038	
0.750			-3.045	-2.904	-2.688	-2.421	-2.128	-1.832	-1.290	-0.864	-0.272	-0.054	0.023	0.049	
0.800			-4.795	-4.462	-3.973	-3.406	-2.829	-2.292	-1.427	-0.852	-0.203	-0.015	0.042	0.059	
0.850			-8.462	-7.474	-6.156	-4.802	-3.605	-2.640	-1.365	-0.695	-0.108	0.025	0.060	0.067	
0.900			-18.172	-13.987	-9.553	-6.099	-3.789	-2.348	-0.930	-0.382	-0.010	0.058	0.072	0.072	
0.950			-55.833	-24.833	-9.810	-4.093	-1.876	-0.933	-0.261	-0.060	0.060	0.079	0.080	0.076	
1.004		2487.589	14.895	1.400	0.464	0.252	0.179	0.147	0.121	0.111	0.100	0.093	0.085	0.078	
1.008		1586.401	43.156	3.254	0.898	0.418	0.260	0.192	0.139	0.120	0.102	0.093	0.086	0.078	
1.012		978.338	73.579	5.929	1.465	0.617	0.351	0.242	0.159	0.129	0.105	0.094	0.086	0.078	
1.016		635.104	93.901	9.302	2.193	0.862	0.459	0.298	0.180	0.139	0.107	0.095	0.086	0.078	
1.020		437.410	102.308	12.987	3.075	1.157	0.586	0.363	0.203	0.150	0.110	0.096	0.087	0.078	
1.024		316.808	102.082	16.544	4.077	1.502	0.733	0.437	0.228	0.161	0.113	0.097	0.087	0.078	
1.028		238.940	96.915	19.626	5.146	1.891	0.902	0.521	0.257	0.174	0.116	0.098	0.087	0.079	
1.040		121.661	73.297	24.763	8.205	3.216	1.511	0.831	0.360	0.218	0.125	0.101	0.089	0.079	
1.060		55.262	43.223	23.396	10.984	5.202	2.648	1.474	0.592	0.318	0.146	0.108	0.091	0.080	
1.080		31.357	27.184	18.534	10.985	6.205	3.540	2.101	0.868	0.445	0.173	0.116	0.094	0.081	
1.100		20.170	18.385	14.200	9.764	6.310	3.999	2.558	1.138	0.587	0.206	0.126	0.098	0.083	
1.120		14.061	13.179	10.957	8.299	5.916	4.088	2.803	1.362	0.726	0.243	0.138	0.103	0.085	
1.140		10.365	9.883	8.608	6.959	5.327	3.941	2.868	1.520	0.849	0.284	0.153	0.108	0.087	
1.160		7.962	7.676	6.899	5.836	4.708	3.673	2.809	1.612	0.946	0.325	0.168	0.115	0.090	
1.180		6.311	6.132	5.633	4.924	4.131	3.360	2.676	1.647	1.016	0.365	0.184	0.122	0.093	
1.200		5.129	5.011	4.677	4.188	3.620	3.043	2.505	1.638	1.060	0.402	0.201	0.129	0.097	
1.300		2.323	2.300	2.230	2.121	1.982	1.821	1.650	1.310	1.009	0.508	0.275	0.169	0.118	
1.400		1.335	1.328	1.306	1.270	1.222	1.164	1.099	0.956	0.811	0.504	0.310	0.200	0.139	
1.500		0.875	0.872	0.863	0.848	0.828	0.802	0.773	0.706	0.632	0.451	0.310	0.215	0.154	
1.600		0.623	0.622	0.617	0.610	0.600	0.587	0.572	0.537	0.497	0.388	0.290	0.214	0.160	

Table F.0.2-1 (continued)

		80												
l/d	n	0.000	0.020	0.040	0.060	0.080	0.100	0.120	0.160	0.200	0.300	0.400	0.500	0.600
0.500	m		-0.632	-0.623	-0.608	-0.589	-0.565	-0.537	-0.473	-0.403	-0.236	-0.112	-0.036	0.004
0.550			-0.828	-0.814	-0.792	-0.762	-0.726	-0.684	-0.590	-0.492	-0.269	-0.118	-0.033	0.010
0.600			-1.098	-1.076	-1.040	-0.993	-0.936	-0.872	-0.732	-0.591	-0.296	-0.117	-0.025	0.018
0.650			-1.487	-1.449	-1.389	-1.310	-1.218	-1.116	-0.901	-0.696	-0.311	-0.107	-0.012	0.028
0.700			-2.078	-2.009	-1.900	-1.761	-1.602	-1.432	-1.094	-0.796	-0.306	-0.086	0.004	0.038
0.750			-3.046	-2.905	-2.689	-2.422	-2.129	-1.832	-1.290	-0.864	-0.272	-0.054	0.023	0.049
0.800			-4.797	-4.463	-3.974	-3.406	-2.829	-2.292	-1.427	-0.852	-0.203	-0.015	0.042	0.059
0.850			-8.467	-7.478	-6.158	-4.803	-3.605	-2.639	-1.365	-0.694	-0.108	0.025	0.060	0.067
0.900			-18.194	-13.997	-9.554	-6.097	-3.787	-2.347	-0.930	-0.382	-0.010	0.058	0.072	0.072
0.950			-55.980	-24.806	-9.788	-4.084	-1.872	-0.931	-0.261	-0.060	0.060	0.079	0.080	0.076
1.004		3076.311	14.141	1.388	0.462	0.252	0.179	0.147	0.121	0.111	0.100	0.093	0.085	0.078
1.008		1799.624	41.060	3.217	0.894	0.417	0.259	0.192	0.139	0.120	0.102	0.093	0.086	0.078
1.012		1053.864	71.096	5.856	1.458	0.616	0.351	0.242	0.159	0.129	0.105	0.094	0.086	0.078
1.016		665.764	92.018	9.193	2.182	0.860	0.459	0.298	0.180	0.139	0.107	0.095	0.086	0.078
1.020		451.655	101.227	12.853	3.059	1.154	0.585	0.362	0.203	0.150	0.110	0.096	0.087	0.078
1.024		324.188	101.604	16.401	4.056	1.498	0.732	0.436	0.228	0.161	0.113	0.097	0.087	0.078
1.028		243.104	96.798	19.490	5.122	1.886	0.900	0.520	0.257	0.174	0.116	0.098	0.087	0.079
1.040		122.727	73.470	24.691	8.177	3.208	1.508	0.830	0.360	0.218	0.125	0.101	0.089	0.079
1.060		55.480	43.325	23.393	10.969	5.194	2.645	1.473	0.592	0.318	0.146	0.108	0.091	0.080
1.080		31.427	27.230	18.544	10.982	6.200	3.537	2.099	0.868	0.445	0.173	0.116	0.094	0.081
1.100		20.199	18.407	14.209	9.765	6.308	3.997	2.556	1.137	0.587	0.206	0.126	0.098	0.083
1.120		14.075	13.190	10.963	8.301	5.915	4.087	2.802	1.361	0.726	0.243	0.138	0.103	0.085
1.140		10.373	9.889	8.613	6.961	5.327	3.941	2.868	1.520	0.848	0.284	0.153	0.108	0.087
1.160		7.966	7.680	6.902	5.837	4.708	3.673	2.809	1.612	0.946	0.325	0.168	0.115	0.090
1.180		6.314	6.135	5.635	4.925	4.131	3.360	2.676	1.647	1.016	0.365	0.184	0.122	0.093
1.200		5.131	5.013	4.679	4.189	3.621	3.043	2.505	1.638	1.060	0.402	0.201	0.129	0.097
1.300		2.323	2.300	2.231	2.122	1.982	1.821	1.650	1.310	1.009	0.508	0.275	0.169	0.118
1.400		1.335	1.328	1.306	1.270	1.222	1.164	1.099	0.956	0.811	0.504	0.310	0.200	0.139
1.500		0.875	0.872	0.863	0.848	0.828	0.802	0.773	0.706	0.632	0.451	0.310	0.215	0.154
1.600		0.623	0.622	0.617	0.610	0.600	0.587	0.572	0.537	0.497	0.388	0.290	0.214	0.160

Table F.0.2-1 (continued)

l/d		90													
m	n	0.000	0.020	0.040	0.060	0.080	0.100	0.120	0.160	0.200	0.300	0.400	0.500	0.600	
0.500			-0.632	-0.623	-0.608	-0.589	-0.565	-0.537	-0.473	-0.403	-0.236	-0.112	-0.036	0.004	
0.550			-0.828	-0.814	-0.792	-0.762	-0.726	-0.684	-0.590	-0.492	-0.269	-0.118	-0.033	0.010	
0.600			-1.098	-1.076	-1.040	-0.993	-0.936	-0.872	-0.732	-0.591	-0.296	-0.117	-0.025	0.018	
0.650			-1.487	-1.449	-1.389	-1.311	-1.218	-1.116	-0.901	-0.696	-0.311	-0.107	-0.012	0.028	
0.700			-2.078	-2.009	-1.900	-1.761	-1.602	-1.432	-1.094	-0.796	-0.306	-0.086	0.004	0.038	
0.750			-3.046	-2.905	-2.689	-2.422	-2.129	-1.832	-1.290	-0.864	-0.271	-0.054	0.023	0.049	
0.800			-4.798	-4.464	-3.975	-3.407	-2.829	-2.292	-1.427	-0.851	-0.203	-0.015	0.042	0.059	
0.850			-8.471	-7.480	-6.159	-4.803	-3.605	-2.639	-1.365	-0.694	-0.108	0.025	0.060	0.067	
0.900			-18.209	-14.003	-9.554	-6.096	-3.786	-2.346	-0.929	-0.382	-0.010	0.058	0.072	0.072	
0.950			-56.081	-24.787	-9.773	-4.078	-1.870	-0.930	-0.261	-0.060	0.060	0.079	0.080	0.076	
1.004	3669.635		13.662	1.379	0.461	0.252	0.179	0.147	0.121	0.111	0.100	0.093	0.085	0.078	
1.008	1980.993		39.699	3.192	0.892	0.417	0.259	0.192	0.139	0.120	0.102	0.093	0.086	0.078	
1.012	1112.459		69.431	5.807	1.454	0.615	0.351	0.242	0.158	0.129	0.105	0.094	0.086	0.078	
1.016	688.476		90.724	9.119	2.174	0.858	0.458	0.298	0.179	0.139	0.107	0.095	0.086	0.078	
1.020	461.944		100.469	12.761	3.048	1.151	0.584	0.362	0.203	0.150	0.110	0.096	0.087	0.078	
1.024	329.440		101.263	16.303	4.042	1.495	0.731	0.436	0.228	0.161	0.113	0.097	0.087	0.078	
1.028	246.040		96.709	19.397	5.105	1.882	0.899	0.520	0.256	0.174	0.116	0.098	0.087	0.079	
1.040	123.468		73.588	24.641	8.159	3.202	1.507	0.829	0.360	0.218	0.125	0.101	0.089	0.079	
1.060	55.631		43.395	23.391	10.959	5.189	2.642	1.472	0.592	0.318	0.146	0.108	0.091	0.080	
1.080	31.475		27.261	18.551	10.979	6.197	3.535	2.098	0.867	0.445	0.173	0.116	0.094	0.081	
1.100	20.219		18.422	14.215	9.766	6.307	3.996	2.555	1.137	0.586	0.206	0.126	0.098	0.083	
1.120	14.084		13.198	10.967	8.302	5.915	4.087	2.801	1.361	0.725	0.243	0.138	0.103	0.085	
1.140	10.378		9.894	8.616	6.962	5.328	3.941	2.867	1.520	0.848	0.284	0.153	0.108	0.087	
1.160	7.969		7.683	6.904	5.839	4.709	3.673	2.809	1.612	0.946	0.325	0.168	0.115	0.090	
1.180	6.316		6.137	5.636	4.926	4.132	3.360	2.676	1.647	1.016	0.365	0.184	0.122	0.093	
1.200	5.132		5.014	4.680	4.190	3.621	3.043	2.505	1.638	1.059	0.402	0.201	0.129	0.097	
1.300	2.323		2.300	2.231	2.122	1.982	1.822	1.651	1.310	1.009	0.508	0.275	0.169	0.118	
1.400	1.336		1.328	1.306	1.270	1.222	1.164	1.099	0.956	0.811	0.504	0.310	0.200	0.139	
1.500	0.875		0.872	0.863	0.848	0.828	0.802	0.773	0.706	0.632	0.451	0.310	0.215	0.154	
1.600	0.623		0.622	0.617	0.610	0.600	0.587	0.572	0.537	0.497	0.388	0.290	0.214	0.160	

Table F.0.2-1 (continued)

l/d		100													
m	n	0.000	0.020	0.040	0.060	0.080	0.100	0.120	0.160	0.200	0.300	0.400	0.500	0.600	
0.500			-0.632	-0.623	-0.608	-0.589	-0.565	-0.537	-0.473	-0.403	-0.236	-0.112	-0.036	0.004	
0.550			-0.828	-0.814	-0.792	-0.762	-0.726	-0.684	-0.590	-0.492	-0.269	-0.118	-0.033	0.010	
0.600			-1.098	-1.076	-1.040	-0.993	-0.936	-0.872	-0.732	-0.591	-0.296	-0.117	-0.025	0.018	
0.650			-1.487	-1.449	-1.389	-1.311	-1.218	-1.116	-0.901	-0.696	-0.311	-0.107	-0.012	0.028	
0.700			-2.078	-2.009	-1.901	-1.761	-1.602	-1.432	-1.094	-0.796	-0.306	-0.086	0.004	0.038	
0.750			-3.047	-2.906	-2.689	-2.422	-2.129	-1.832	-1.290	-0.864	-0.271	-0.054	0.023	0.049	
0.800			-4.799	-4.465	-3.975	-3.407	-2.829	-2.292	-1.427	-0.851	-0.203	-0.015	0.042	0.059	
0.850			-8.473	-7.482	-6.160	-4.804	-3.605	-2.639	-1.364	-0.694	-0.108	0.025	0.060	0.067	
0.900			-18.220	-14.007	-9.555	-6.095	-3.785	-2.345	-0.929	-0.381	-0.010	0.058	0.072	0.072	
0.950			-56.153	-24.774	-9.762	-4.074	-1.868	-0.930	-0.261	-0.060	0.060	0.079	0.080	0.076	
1.004	4254.172		13.337	1.373	0.461	0.252	0.179	0.147	0.121	0.111	0.100	0.093	0.085	0.078	
1.008	2133.993		38.762	3.174	0.890	0.416	0.259	0.192	0.139	0.120	0.102	0.093	0.086	0.078	
1.012	1158.357		68.260	5.773	1.450	0.615	0.351	0.241	0.158	0.129	0.105	0.094	0.086	0.078	
1.016	705.653		89.797	9.066	2.169	0.857	0.458	0.298	0.179	0.139	0.107	0.095	0.086	0.078	
1.020	469.584		99.919	12.696	3.040	1.150	0.584	0.362	0.203	0.150	0.110	0.096	0.087	0.078	
1.024	333.298		101.011	16.233	4.032	1.493	0.731	0.436	0.228	0.161	0.113	0.097	0.087	0.078	
1.028	248.182		96.640	19.330	5.093	1.880	0.898	0.519	0.256	0.174	0.116	0.098	0.087	0.079	
1.040	124.004		73.672	24.605	8.145	3.198	1.505	0.828	0.360	0.218	0.125	0.101	0.089	0.079	
1.060	55.739		43.445	23.390	10.952	5.185	2.640	1.471	0.592	0.318	0.146	0.108	0.091	0.080	
1.080	31.509		27.283	18.556	10.978	6.195	3.533	2.097	0.867	0.445	0.173	0.116	0.094	0.081	
1.100	20.233		18.432	14.220	9.766	6.306	3.995	2.555	1.137	0.586	0.206	0.126	0.098	0.083	
1.120	14.091		13.204	10.971	8.303	5.915	4.086	2.801	1.361	0.725	0.243	0.138	0.103	0.085	
1.140	10.382		9.897	8.618	6.963	5.328	3.941	2.867	1.519	0.848	0.284	0.153	0.108	0.087	
1.160	7.971		7.685	6.905	5.839	4.709	3.674	2.809	1.612	0.946	0.325	0.168	0.115	0.090	
1.180	6.317		6.138	5.637	4.926	4.132	3.360	2.675	1.647	1.016	0.365	0.184	0.122	0.093	
1.200	5.133		5.015	4.680	4.190	3.622	3.043	2.505	1.638	1.059	0.402	0.201	0.129	0.097	
1.300	2.324		2.300	2.231	2.122	1.982	1.822	1.651	1.310	1.009	0.508	0.275	0.169	0.118	
1.400	1.336		1.328	1.306	1.270	1.222	1.164	1.099	0.956	0.811	0.504	0.310	0.200	0.139	
1.500	0.875		0.872	0.863	0.848	0.828	0.802	0.773	0.706	0.632	0.451	0.310	0.215	0.154	
1.600	0.623		0.622	0.617	0.610	0.600	0.587	0.572	0.537	0.497	0.388	0.290	0.214	0.160	

Table F.0.2-2 (continued)

		15														
l/d	m	0.000	0.020	0.040	0.060	0.080	0.100	0.120	0.160	0.200	0.300	0.400	0.500	0.600		
0.500	n			0.508	0.502	0.494	0.484	0.472	0.444	0.411	0.323	0.241	0.175	0.125		
0.550				0.527	0.521	0.513	0.503	0.491	0.463	0.430	0.340	0.257	0.189	0.137		
0.600				0.561	0.555	0.546	0.534	0.521	0.490	0.454	0.359	0.271	0.201	0.147		
0.650				0.614	0.606	0.594	0.580	0.564	0.526	0.484	0.377	0.284	0.211	0.156		
0.700				0.691	0.679	0.663	0.644	0.622	0.572	0.520	0.396	0.296	0.220	0.163		
0.750				0.804	0.785	0.760	0.731	0.699	0.630	0.561	0.413	0.305	0.226	0.169		
0.800				0.973	0.940	0.898	0.850	0.799	0.697	0.605	0.428	0.311	0.231	0.173		
0.850				1.241	1.174	1.094	1.008	0.923	0.770	0.646	0.439	0.316	0.234	0.177		
0.900				1.703	1.544	1.370	1.204	1.059	0.834	0.676	0.444	0.318	0.236	0.179		
0.950				2.597	2.119	1.697	1.385	1.160	0.868	0.690	0.446	0.318	0.237	0.181		
1.004		4.206	4.682	4.571	2.553	1.830	1.435	1.181	0.873	0.689	0.444	0.317	0.238	0.182		
1.008		4.191	4.625	4.384	2.546	1.829	1.434	1.181	0.872	0.689	0.444	0.317	0.238	0.182		
1.012		4.158	4.511	4.135	2.534	1.825	1.433	1.180	0.872	0.689	0.444	0.317	0.238	0.183		
1.016		4.103	4.352	3.892	2.513	1.821	1.431	1.179	0.871	0.688	0.443	0.317	0.238	0.183		
1.020		4.024	4.172	3.672	2.484	1.814	1.428	1.177	0.870	0.688	0.443	0.317	0.238	0.183		
1.024		3.921	3.984	3.477	2.446	1.805	1.424	1.176	0.869	0.687	0.443	0.317	0.238	0.183		
1.028		3.800	3.798	3.302	2.402	1.793	1.420	1.173	0.869	0.687	0.443	0.317	0.238	0.183		
1.040		3.381	3.288	2.872	2.248	1.744	1.400	1.164	0.865	0.685	0.442	0.316	0.238	0.183		
1.060		2.715	2.622	2.349	1.976	1.624	1.346	1.136	0.855	0.680	0.440	0.316	0.238	0.183		
1.080		2.207	2.144	1.971	1.732	1.487	1.271	1.094	0.839	0.673	0.438	0.315	0.237	0.184		
1.100		1.838	1.797	1.684	1.525	1.352	1.187	1.042	0.818	0.662	0.435	0.314	0.237	0.184		
1.120		1.565	1.538	1.462	1.353	1.227	1.101	0.985	0.792	0.649	0.432	0.312	0.236	0.184		
1.140		1.358	1.339	1.287	1.209	1.117	1.020	0.926	0.762	0.633	0.427	0.311	0.236	0.184		
1.160		1.196	1.183	1.146	1.089	1.019	0.944	0.869	0.730	0.616	0.422	0.309	0.235	0.184		
1.180		1.067	1.057	1.030	0.987	0.934	0.875	0.814	0.697	0.596	0.416	0.306	0.234	0.183		
1.200		0.962	0.955	0.934	0.901	0.860	0.813	0.763	0.665	0.576	0.409	0.304	0.233	0.183		
1.300		0.636	0.634	0.627	0.616	0.601	0.584	0.564	0.520	0.473	0.367	0.286	0.225	0.180		
1.400		0.468	0.467	0.464	0.459	0.453	0.444	0.435	0.412	0.387	0.321	0.262	0.213	0.174		
1.500		0.366	0.366	0.364	0.361	0.358	0.353	0.348	0.336	0.321	0.279	0.236	0.198	0.165		
1.600		0.298	0.297	0.296	0.295	0.293	0.290	0.287	0.279	0.270	0.242	0.211	0.182	0.155		

Table F.0.2-2 (continued)

		20												
l/d	n	0.000	0.020	0.040	0.060	0.080	0.100	0.120	0.160	0.200	0.300	0.400	0.500	0.600
	m													
0.500				0.509	0.503	0.495	0.485	0.473	0.444	0.412	0.323	0.241	0.175	0.125
0.550				0.529	0.523	0.514	0.504	0.492	0.463	0.430	0.341	0.257	0.189	0.137
0.600				0.563	0.556	0.547	0.536	0.522	0.491	0.454	0.359	0.272	0.201	0.147
0.650				0.616	0.608	0.596	0.582	0.565	0.527	0.484	0.377	0.284	0.211	0.156
0.700				0.694	0.682	0.666	0.646	0.623	0.573	0.520	0.396	0.295	0.219	0.163
0.750				0.809	0.789	0.764	0.734	0.701	0.631	0.562	0.413	0.304	0.226	0.169
0.800				0.981	0.947	0.903	0.854	0.802	0.698	0.605	0.428	0.311	0.231	0.173
0.850				1.258	1.187	1.102	1.013	0.925	0.770	0.646	0.438	0.315	0.234	0.177
0.900				1.742	1.565	1.378	1.206	1.058	0.832	0.675	0.444	0.317	0.236	0.179
0.950				2.684	2.123	1.684	1.374	1.152	0.865	0.688	0.445	0.318	0.237	0.181
1.004				3.947	2.445	1.791	1.416	1.171	0.868	0.687	0.443	0.317	0.238	0.182
1.008			6.983	3.913	2.441	1.790	1.415	1.170	0.868	0.687	0.443	0.317	0.238	0.182
1.012				3.841	2.434	1.787	1.414	1.170	0.867	0.687	0.443	0.317	0.238	0.183
1.016				3.737	2.421	1.783	1.412	1.168	0.867	0.686	0.443	0.317	0.238	0.183
1.020				3.613	2.403	1.778	1.410	1.167	0.866	0.686	0.442	0.316	0.238	0.183
1.024				3.479	2.379	1.771	1.407	1.165	0.865	0.685	0.442	0.316	0.238	0.183
1.028				3.344	2.349	1.762	1.403	1.163	0.864	0.685	0.442	0.316	0.238	0.183
1.040				2.958	2.231	1.722	1.386	1.155	0.861	0.683	0.441	0.315	0.237	0.183
1.060				3.657	2.231	1.722	1.338	1.129	0.851	0.678	0.440	0.314	0.237	0.183
1.080				2.804	1.991	1.619	1.269	1.091	0.837	0.671	0.437	0.313	0.237	0.184
1.100				2.243	1.754	1.491	1.269	1.091	0.816	0.661	0.435	0.313	0.237	0.184
1.120				1.855	1.546	1.360	1.189	1.041	0.791	0.648	0.431	0.312	0.236	0.184
1.140				1.575	1.370	1.236	1.105	0.986	0.762	0.633	0.427	0.310	0.236	0.184
1.160				1.364	1.223	1.125	1.024	0.928	0.730	0.615	0.422	0.308	0.235	0.183
1.180				1.200	1.099	1.027	0.949	0.871	0.730	0.615	0.422	0.306	0.234	0.183
1.200				1.070	0.996	0.940	0.879	0.817	0.698	0.596	0.416	0.304	0.233	0.183
1.300				0.964	0.908	0.865	0.817	0.766	0.666	0.576	0.409	0.286	0.225	0.180
1.400				0.637	0.618	0.604	0.586	0.565	0.521	0.474	0.368	0.262	0.213	0.174
1.500				0.468	0.460	0.454	0.445	0.436	0.413	0.388	0.321	0.236	0.198	0.165
1.600				0.367	0.365	0.359	0.354	0.349	0.336	0.321	0.279	0.236	0.198	0.165
				0.298	0.295	0.293	0.290	0.287	0.279	0.270	0.242	0.211	0.182	0.155

Table F.0.2-2 (continued)

l/d		25												
		0.000	0.020	0.040	0.060	0.080	0.100	0.120	0.160	0.200	0.300	0.400	0.500	0.600
0.500	m			0.510	0.504	0.496	0.486	0.473	0.445	0.412	0.323	0.241	0.175	0.125
0.550				0.529	0.523	0.515	0.505	0.493	0.464	0.431	0.341	0.257	0.189	0.137
0.600				0.564	0.557	0.548	0.536	0.523	0.491	0.455	0.359	0.272	0.201	0.147
0.650				0.617	0.609	0.597	0.582	0.566	0.527	0.485	0.377	0.284	0.211	0.155
0.700				0.696	0.683	0.667	0.647	0.624	0.574	0.521	0.396	0.295	0.219	0.163
0.750				0.811	0.791	0.765	0.735	0.702	0.632	0.562	0.413	0.304	0.226	0.169
0.800				0.985	0.950	0.906	0.855	0.803	0.699	0.605	0.428	0.311	0.231	0.173
0.850				1.266	1.192	1.106	1.015	0.927	0.770	0.646	0.438	0.315	0.234	0.176
0.900				1.761	1.574	1.382	1.207	1.058	0.831	0.674	0.444	0.317	0.236	0.179
0.950				2.720	2.122	1.678	1.369	1.149	0.863	0.687	0.445	0.318	0.237	0.181
1.004		9.219	3.759	2.402	1.774	1.408	1.408	1.166	0.866	0.686	0.443	0.317	0.238	0.182
1.008		7.657	3.740	2.398	1.773	1.407	1.406	1.166	0.866	0.686	0.443	0.317	0.238	0.182
1.012		6.731	3.699	2.392	1.771	1.406	1.404	1.165	0.865	0.686	0.443	0.317	0.238	0.182
1.016		6.415	3.634	2.382	1.767	1.404	1.402	1.164	0.865	0.685	0.442	0.317	0.238	0.183
1.020		6.045	3.547	2.368	1.762	1.402	1.402	1.162	0.864	0.685	0.442	0.317	0.238	0.183
1.024		5.648	3.445	2.348	1.756	1.399	1.399	1.161	0.863	0.684	0.442	0.316	0.238	0.183
1.028		5.254	3.334	2.323	1.748	1.395	1.395	1.159	0.862	0.684	0.442	0.316	0.238	0.183
1.040		4.227	2.986	2.220	1.712	1.380	1.380	1.151	0.859	0.682	0.441	0.316	0.237	0.183
1.060		3.079	2.463	1.996	1.616	1.334	1.334	1.127	0.850	0.677	0.439	0.315	0.237	0.183
1.080		2.387	2.054	1.764	1.493	1.268	1.268	1.089	0.835	0.670	0.437	0.314	0.237	0.183
1.100		1.937	1.743	1.556	1.364	1.189	1.189	1.041	0.815	0.660	0.434	0.313	0.237	0.184
1.120		1.625	1.592	1.378	1.240	1.107	1.107	0.986	0.790	0.648	0.431	0.312	0.236	0.184
1.140		1.397	1.375	1.229	1.129	1.026	1.026	0.929	0.762	0.632	0.427	0.310	0.236	0.184
1.160		1.223	1.208	1.104	1.030	0.951	0.951	0.872	0.731	0.615	0.422	0.308	0.235	0.183
1.180		1.086	1.076	1.000	0.943	0.881	0.881	0.818	0.698	0.596	0.416	0.306	0.234	0.183
1.200		0.976	0.968	0.946	0.911	0.867	0.818	0.767	0.666	0.576	0.409	0.303	0.233	0.183
1.300		0.640	0.638	0.631	0.620	0.605	0.587	0.566	0.521	0.474	0.368	0.286	0.225	0.180
1.400		0.470	0.469	0.466	0.461	0.454	0.446	0.436	0.413	0.388	0.321	0.262	0.213	0.173
1.500		0.367	0.367	0.365	0.362	0.359	0.354	0.349	0.336	0.321	0.279	0.236	0.198	0.165
1.600		0.298	0.298	0.297	0.295	0.293	0.291	0.287	0.280	0.270	0.242	0.211	0.182	0.155

Table F.0.2-2 (continued)

		30												
l/d	n	0.000	0.020	0.040	0.060	0.080	0.100	0.120	0.160	0.200	0.300	0.400	0.500	0.600
m														
0.500			0.514	0.510	0.504	0.496	0.486	0.474	0.445	0.412	0.323	0.241	0.175	0.125
0.550			0.533	0.530	0.524	0.515	0.505	0.493	0.464	0.431	0.341	0.257	0.189	0.137
0.600			0.568	0.564	0.557	0.548	0.537	0.523	0.491	0.455	0.359	0.272	0.201	0.147
0.650			0.623	0.618	0.609	0.597	0.583	0.566	0.528	0.485	0.378	0.284	0.211	0.155
0.700			0.704	0.696	0.684	0.667	0.647	0.625	0.574	0.521	0.396	0.295	0.219	0.163
0.750			0.824	0.812	0.792	0.766	0.736	0.703	0.632	0.562	0.413	0.304	0.226	0.168
0.800			1.010	0.987	0.952	0.907	0.856	0.803	0.699	0.605	0.428	0.311	0.231	0.173
0.850			1.321	1.270	1.195	1.108	1.016	0.927	0.770	0.645	0.438	0.315	0.234	0.176
0.900			1.919	1.772	1.579	1.384	1.207	1.058	0.831	0.674	0.444	0.317	0.236	0.179
0.950			3.402	2.738	2.120	1.674	1.366	1.147	0.862	0.686	0.445	0.318	0.237	0.181
1.004	8.395		8.783	3.673	2.380	1.765	1.403	1.164	0.865	0.685	0.443	0.317	0.237	0.182
1.008	8.222		7.799	3.658	2.377	1.764	1.402	1.163	0.865	0.685	0.443	0.317	0.238	0.182
1.012	7.859		6.970	3.627	2.371	1.762	1.401	1.162	0.864	0.685	0.443	0.317	0.238	0.182
1.016	7.350		6.307	3.577	2.362	1.759	1.400	1.161	0.864	0.685	0.442	0.317	0.238	0.183
1.020	6.781		5.761	3.507	2.349	1.754	1.397	1.160	0.863	0.684	0.442	0.316	0.238	0.183
1.024	6.216		5.299	3.420	2.331	1.748	1.395	1.158	0.862	0.684	0.442	0.316	0.237	0.183
1.028	5.692		4.899	3.322	2.309	1.741	1.391	1.157	0.861	0.683	0.442	0.316	0.237	0.183
1.040	4.436		3.964	2.997	2.214	1.707	1.376	1.148	0.858	0.681	0.441	0.316	0.237	0.183
1.060	3.156		2.951	2.482	1.998	1.614	1.332	1.125	0.849	0.677	0.439	0.315	0.237	0.183
1.080	2.422		2.321	2.069	1.769	1.494	1.267	1.088	0.835	0.670	0.437	0.314	0.237	0.183
1.100	1.956		1.900	1.753	1.561	1.366	1.190	1.040	0.815	0.660	0.434	0.313	0.237	0.184
1.120	1.636		1.602	1.510	1.382	1.243	1.108	0.986	0.790	0.647	0.431	0.312	0.236	0.184
1.140	1.404		1.382	1.321	1.233	1.131	1.027	0.929	0.762	0.632	0.427	0.310	0.236	0.184
1.160	1.227		1.213	1.170	1.107	1.032	0.952	0.873	0.731	0.615	0.422	0.308	0.235	0.183
1.180	1.089		1.079	1.048	1.002	0.945	0.882	0.819	0.699	0.596	0.416	0.306	0.234	0.183
1.200	0.978		0.970	0.948	0.913	0.869	0.819	0.768	0.666	0.576	0.409	0.303	0.233	0.183
1.300	0.641		0.639	0.632	0.620	0.605	0.587	0.566	0.521	0.474	0.368	0.285	0.225	0.180
1.400	0.470		0.469	0.466	0.461	0.455	0.446	0.436	0.414	0.388	0.322	0.262	0.213	0.173
1.500	0.367		0.367	0.365	0.363	0.359	0.354	0.349	0.336	0.321	0.279	0.236	0.198	0.165
1.600	0.298		0.298	0.297	0.295	0.293	0.291	0.287	0.280	0.270	0.242	0.211	0.182	0.155

Table F.0.2-2 (continued)

l/d	50												
	0.000	0.020	0.040	0.060	0.080	0.100	0.120	0.160	0.200	0.300	0.400	0.500	0.600
m													
0.500		0.514	0.511	0.505	0.497	0.486	0.474	0.445	0.412	0.323	0.241	0.175	0.125
0.550		0.534	0.530	0.524	0.516	0.505	0.493	0.464	0.431	0.341	0.257	0.189	0.137
0.600		0.569	0.565	0.558	0.549	0.537	0.524	0.492	0.455	0.359	0.272	0.201	0.147
0.650		0.624	0.619	0.610	0.598	0.583	0.567	0.528	0.485	0.378	0.284	0.211	0.155
0.700		0.705	0.697	0.685	0.668	0.648	0.625	0.575	0.521	0.396	0.295	0.219	0.163
0.750		0.826	0.814	0.794	0.768	0.737	0.703	0.632	0.562	0.413	0.304	0.226	0.168
0.800		1.014	0.990	0.954	0.909	0.858	0.804	0.700	0.605	0.428	0.311	0.231	0.173
0.850		1.329	1.277	1.200	1.111	1.018	0.928	0.770	0.674	0.443	0.317	0.236	0.179
0.900		1.943	1.787	1.587	1.386	1.208	1.057	0.830	0.686	0.444	0.317	0.237	0.181
0.950		3.519	2.762	2.118	1.669	1.362	1.144	0.861	0.685	0.443	0.317	0.237	0.182
1.004	13.842	7.494	3.561	2.349	1.753	1.397	1.160	0.864	0.685	0.443	0.317	0.237	0.182
1.008	12.845	7.283	3.551	2.346	1.751	1.396	1.159	0.863	0.685	0.442	0.317	0.237	0.182
1.012	11.311	6.907	3.530	2.341	1.749	1.395	1.158	0.862	0.684	0.442	0.316	0.237	0.182
1.016	9.780	6.454	3.495	2.334	1.746	1.393	1.156	0.862	0.683	0.442	0.316	0.237	0.183
1.020	8.471	5.990	3.444	2.323	1.742	1.391	1.155	0.861	0.683	0.442	0.316	0.237	0.183
1.024	7.406	5.547	3.377	2.307	1.737	1.389	1.153	0.860	0.682	0.441	0.316	0.237	0.183
1.028	6.546	5.138	3.298	2.288	1.730	1.385	1.153	0.857	0.681	0.441	0.316	0.237	0.183
1.040	4.796	4.131	3.010	2.203	1.699	1.371	1.145	0.848	0.676	0.439	0.315	0.237	0.183
1.060	3.276	3.032	2.508	2.001	1.612	1.329	1.123	0.834	0.669	0.437	0.314	0.237	0.183
1.080	2.475	2.363	2.090	1.776	1.495	1.266	1.087	0.814	0.659	0.434	0.313	0.237	0.183
1.100	1.983	1.924	1.768	1.568	1.368	1.190	1.040	0.790	0.647	0.431	0.312	0.236	0.184
1.120	1.652	1.617	1.521	1.389	1.246	1.109	0.986	0.761	0.632	0.426	0.310	0.236	0.184
1.140	1.414	1.391	1.328	1.238	1.134	1.029	0.930	0.731	0.615	0.421	0.308	0.235	0.183
1.160	1.234	1.219	1.176	1.111	1.035	0.953	0.874	0.731	0.615	0.421	0.306	0.234	0.183
1.180	1.094	1.083	1.052	1.005	0.947	0.884	0.820	0.699	0.596	0.416	0.303	0.233	0.183
1.200	0.982	0.974	0.951	0.915	0.871	0.821	0.769	0.667	0.576	0.409	0.303	0.233	0.183
1.300	0.642	0.640	0.633	0.621	0.606	0.588	0.567	0.522	0.475	0.368	0.285	0.225	0.180
1.400	0.471	0.470	0.467	0.462	0.455	0.447	0.437	0.414	0.388	0.322	0.262	0.213	0.173
1.500	0.367	0.367	0.365	0.363	0.359	0.355	0.349	0.336	0.321	0.279	0.236	0.198	0.165
1.600	0.298	0.298	0.297	0.296	0.294	0.291	0.288	0.280	0.270	0.242	0.211	0.182	0.155

Table F.0.2-2 (continued)

		60												
l/d	n	0.000	0.020	0.040	0.060	0.080	0.100	0.120	0.160	0.200	0.300	0.400	0.500	0.600
m														
0.500			0.515	0.511	0.505	0.497	0.486	0.474	0.446	0.412	0.323	0.241	0.175	0.125
0.550			0.534	0.530	0.524	0.516	0.506	0.493	0.465	0.431	0.341	0.257	0.189	0.137
0.600			0.569	0.565	0.558	0.549	0.537	0.524	0.492	0.455	0.359	0.272	0.201	0.147
0.650			0.624	0.619	0.610	0.598	0.584	0.567	0.528	0.485	0.378	0.284	0.211	0.155
0.700			0.705	0.698	0.685	0.668	0.648	0.626	0.575	0.521	0.396	0.295	0.219	0.163
0.750			0.826	0.814	0.794	0.768	0.737	0.704	0.632	0.562	0.413	0.304	0.226	0.168
0.800			1.014	0.991	0.955	0.909	0.858	0.805	0.700	0.606	0.428	0.311	0.231	0.173
0.850			1.330	1.278	1.201	1.111	1.018	0.928	0.770	0.645	0.438	0.315	0.234	0.176
0.900			1.947	1.789	1.588	1.387	1.208	1.057	0.830	0.674	0.443	0.317	0.236	0.179
0.950			3.540	2.766	2.117	1.668	1.361	1.144	0.860	0.685	0.444	0.317	0.237	0.181
1.004		16.456	7.330	3.543	2.344	1.751	1.396	1.159	0.863	0.685	0.443	0.317	0.237	0.182
1.008		14.714	7.168	3.514	2.336	1.747	1.394	1.158	0.863	0.684	0.442	0.317	0.237	0.182
1.012		12.449	6.856	3.481	2.329	1.744	1.392	1.157	0.862	0.684	0.442	0.316	0.237	0.182
1.016		10.458	6.451	3.433	2.318	1.740	1.390	1.156	0.861	0.683	0.442	0.316	0.237	0.183
1.020		8.890	6.013	3.369	2.303	1.735	1.388	1.154	0.861	0.683	0.442	0.316	0.237	0.183
1.024		7.677	5.581	3.293	2.284	1.728	1.384	1.152	0.860	0.682	0.441	0.316	0.237	0.183
1.028		6.729	5.175	3.011	2.202	1.697	1.370	1.145	0.856	0.680	0.441	0.316	0.237	0.183
1.040		4.865	4.161	3.011	2.001	1.611	1.329	1.122	0.848	0.676	0.439	0.315	0.237	0.183
1.060		3.298	3.047	2.513	1.778	1.495	1.266	1.087	0.834	0.669	0.437	0.314	0.237	0.183
1.080		2.484	2.370	2.094	1.570	1.369	1.190	1.040	0.814	0.659	0.434	0.313	0.237	0.183
1.100		1.988	1.928	1.771	1.390	1.246	1.109	0.987	0.790	0.647	0.431	0.312	0.236	0.184
1.120		1.655	1.619	1.523	1.239	1.135	1.029	0.930	0.761	0.632	0.426	0.310	0.236	0.184
1.140		1.416	1.393	1.330	1.239	1.135	1.029	0.930	0.761	0.615	0.421	0.308	0.235	0.183
1.160		1.236	1.220	1.177	1.112	1.035	0.954	0.874	0.731	0.615	0.421	0.308	0.235	0.183
1.180		1.095	1.084	1.053	1.006	0.948	0.884	0.820	0.699	0.596	0.416	0.306	0.234	0.183
1.200		0.982	0.974	0.951	0.916	0.871	0.821	0.769	0.667	0.576	0.409	0.303	0.233	0.183
1.300		0.642	0.640	0.633	0.621	0.606	0.588	0.567	0.522	0.475	0.368	0.285	0.225	0.180
1.400		0.471	0.470	0.467	0.462	0.455	0.447	0.437	0.414	0.388	0.322	0.262	0.213	0.173
1.500		0.367	0.367	0.365	0.363	0.359	0.355	0.349	0.336	0.321	0.279	0.236	0.198	0.165
1.600		0.298	0.298	0.297	0.296	0.294	0.291	0.288	0.280	0.270	0.242	0.211	0.182	0.155

Table F.0.2-2 (continued)

		70												
l/d	π	0.000	0.020	0.040	0.060	0.080	0.100	0.120	0.160	0.200	0.300	0.400	0.500	0.600
	m													
0.500			0.515	0.511	0.505	0.497	0.486	0.474	0.446	0.413	0.323	0.241	0.175	0.125
0.550			0.534	0.530	0.524	0.516	0.506	0.493	0.465	0.431	0.341	0.257	0.189	0.137
0.600			0.569	0.565	0.558	0.549	0.537	0.524	0.492	0.455	0.359	0.272	0.201	0.147
0.650			0.624	0.619	0.610	0.598	0.584	0.567	0.528	0.485	0.378	0.284	0.211	0.155
0.700			0.705	0.698	0.685	0.669	0.648	0.626	0.575	0.521	0.396	0.295	0.219	0.163
0.750			0.827	0.814	0.794	0.768	0.737	0.704	0.632	0.562	0.413	0.304	0.226	0.168
0.800			1.015	0.991	0.955	0.909	0.858	0.805	0.700	0.606	0.428	0.311	0.231	0.173
0.850			1.331	1.278	1.201	1.111	1.018	0.928	0.770	0.645	0.438	0.315	0.234	0.176
0.900			1.949	1.791	1.589	1.387	1.208	1.057	0.830	0.674	0.443	0.317	0.236	0.179
0.950			3.552	2.768	2.117	1.668	1.361	1.143	0.860	0.685	0.444	0.317	0.237	0.181
1.004	18.968		7.238	3.533	2.341	1.749	1.395	1.159	0.863	0.685	0.443	0.317	0.237	0.182
1.008	16.288		7.100	3.523	2.338	1.748	1.394	1.158	0.862	0.684	0.443	0.317	0.237	0.182
1.012	13.303		6.822	3.504	2.334	1.746	1.393	1.158	0.862	0.684	0.442	0.316	0.237	0.182
1.016	10.933		6.445	3.473	2.326	1.743	1.392	1.157	0.862	0.683	0.442	0.316	0.237	0.183
1.020	9.170		6.024	3.426	2.316	1.739	1.390	1.155	0.861	0.683	0.442	0.316	0.237	0.183
1.024	7.853		5.601	3.365	2.301	1.734	1.387	1.154	0.860	0.682	0.441	0.316	0.237	0.183
1.028	6.845		5.197	3.290	2.282	1.727	1.384	1.152	0.860	0.680	0.441	0.316	0.237	0.183
1.040	4.909		4.178	3.012	2.200	1.697	1.370	1.144	0.856	0.680	0.441	0.316	0.237	0.183
1.060	3.311		3.055	2.515	2.001	1.611	1.328	1.122	0.847	0.676	0.439	0.315	0.237	0.183
1.080	2.490		2.375	2.096	1.778	1.495	1.266	1.086	0.833	0.669	0.437	0.314	0.237	0.183
1.100	1.991		1.930	1.772	1.570	1.369	1.190	1.040	0.814	0.659	0.434	0.313	0.237	0.183
1.120	1.657		1.621	1.524	1.391	1.247	1.109	0.987	0.790	0.647	0.431	0.312	0.236	0.183
1.140	1.417		1.394	1.330	1.239	1.135	1.029	0.930	0.761	0.632	0.426	0.310	0.236	0.183
1.160	1.236		1.221	1.177	1.112	1.035	0.954	0.874	0.731	0.615	0.421	0.308	0.235	0.183
1.180	1.095		1.085	1.053	1.006	0.948	0.884	0.820	0.699	0.596	0.415	0.306	0.234	0.183
1.200	0.983		0.975	0.952	0.916	0.871	0.821	0.769	0.667	0.576	0.409	0.303	0.233	0.183
1.300	0.642		0.640	0.633	0.621	0.606	0.588	0.567	0.522	0.475	0.368	0.285	0.225	0.180
1.400	0.471		0.470	0.467	0.462	0.455	0.447	0.437	0.414	0.388	0.322	0.262	0.213	0.173
1.500	0.367		0.367	0.365	0.363	0.359	0.355	0.349	0.337	0.321	0.279	0.236	0.198	0.165
1.600	0.298		0.298	0.297	0.296	0.294	0.291	0.288	0.280	0.270	0.242	0.211	0.182	0.155

Table F.0.2-2 (continued)

		80												
l/d	n	0.000	0.020	0.040	0.060	0.080	0.100	0.120	0.160	0.200	0.300	0.400	0.500	0.600
m														
0.500			0.515	0.511	0.505	0.497	0.486	0.474	0.446	0.413	0.323	0.241	0.175	0.125
0.550			0.534	0.530	0.524	0.516	0.506	0.493	0.465	0.431	0.341	0.257	0.189	0.137
0.600			0.569	0.565	0.558	0.549	0.537	0.524	0.492	0.455	0.359	0.272	0.201	0.147
0.650			0.624	0.619	0.610	0.598	0.584	0.567	0.528	0.485	0.378	0.284	0.211	0.155
0.700			0.706	0.698	0.685	0.669	0.648	0.626	0.575	0.521	0.396	0.295	0.219	0.163
0.750			0.827	0.814	0.794	0.768	0.737	0.704	0.632	0.562	0.413	0.304	0.226	0.168
0.800			1.015	0.991	0.955	0.910	0.858	0.805	0.700	0.606	0.428	0.311	0.231	0.173
0.850			1.332	1.279	1.202	1.112	1.018	0.928	0.770	0.645	0.438	0.315	0.234	0.176
0.900			1.951	1.792	1.589	1.387	1.208	1.057	0.830	0.674	0.443	0.317	0.236	0.179
0.950			3.560	2.770	2.117	1.667	1.360	1.143	0.860	0.685	0.444	0.317	0.237	0.181
1.004		21.355	7.180	3.526	2.339	1.749	1.395	1.159	0.863	0.685	0.443	0.317	0.237	0.182
1.008		17.597	7.056	3.517	2.336	1.747	1.394	1.158	0.863	0.684	0.442	0.317	0.237	0.182
1.012		13.949	6.799	3.498	2.332	1.745	1.393	1.157	0.862	0.684	0.442	0.317	0.237	0.182
1.016		11.273	6.440	3.467	2.324	1.742	1.391	1.156	0.862	0.684	0.442	0.316	0.237	0.182
1.020		9.365	6.031	3.422	2.314	1.738	1.389	1.155	0.861	0.683	0.442	0.316	0.237	0.183
1.024		7.973	5.613	3.361	2.299	1.733	1.387	1.154	0.860	0.683	0.442	0.316	0.237	0.183
1.028		6.924	5.211	3.288	2.281	1.726	1.384	1.152	0.860	0.682	0.441	0.316	0.237	0.183
1.040		4.937	4.190	3.012	2.200	1.696	1.369	1.144	0.856	0.680	0.441	0.316	0.237	0.183
1.060		3.320	3.061	2.517	2.002	1.611	1.328	1.122	0.847	0.676	0.439	0.315	0.237	0.183
1.080		2.494	2.377	2.098	1.779	1.495	1.266	1.086	0.833	0.669	0.437	0.314	0.237	0.183
1.100		1.993	1.932	1.773	1.571	1.369	1.190	1.040	0.814	0.659	0.434	0.313	0.237	0.183
1.120		1.658	1.622	1.524	1.391	1.247	1.110	0.987	0.790	0.647	0.431	0.312	0.236	0.184
1.140		1.418	1.395	1.331	1.239	1.135	1.030	0.930	0.761	0.632	0.426	0.310	0.236	0.183
1.160		1.237	1.221	1.178	1.113	1.035	0.954	0.874	0.731	0.615	0.421	0.308	0.235	0.183
1.180		1.096	1.085	1.054	1.006	0.948	0.884	0.820	0.699	0.596	0.415	0.306	0.234	0.183
1.200		0.983	0.975	0.952	0.916	0.871	0.821	0.769	0.667	0.576	0.409	0.303	0.233	0.183
1.300		0.642	0.640	0.633	0.621	0.606	0.588	0.567	0.522	0.475	0.368	0.285	0.225	0.180
1.400		0.471	0.470	0.467	0.462	0.455	0.447	0.437	0.414	0.388	0.322	0.262	0.213	0.173
1.500		0.368	0.367	0.365	0.363	0.359	0.355	0.349	0.337	0.321	0.279	0.236	0.198	0.165
1.600		0.298	0.298	0.297	0.296	0.294	0.291	0.288	0.280	0.270	0.242	0.211	0.182	0.155

Table F.0.2-2 (continued)

		90												
l/d	m	0.000	0.020	0.040	0.060	0.080	0.100	0.120	0.160	0.200	0.300	0.400	0.500	0.600
0.500			0.515	0.511	0.505	0.497	0.486	0.474	0.446	0.413	0.323	0.241	0.175	0.125
0.550			0.534	0.530	0.524	0.516	0.506	0.493	0.465	0.431	0.341	0.257	0.189	0.137
0.600			0.569	0.565	0.558	0.549	0.537	0.524	0.492	0.455	0.359	0.272	0.201	0.147
0.650			0.624	0.619	0.610	0.598	0.584	0.567	0.528	0.485	0.378	0.284	0.211	0.155
0.700			0.706	0.698	0.685	0.669	0.649	0.626	0.575	0.521	0.396	0.295	0.219	0.163
0.750			0.827	0.814	0.794	0.768	0.738	0.704	0.632	0.562	0.413	0.304	0.226	0.168
0.800			1.015	0.992	0.955	0.910	0.858	0.805	0.700	0.606	0.428	0.311	0.231	0.173
0.850			1.332	1.279	1.202	1.112	1.018	0.928	0.770	0.645	0.438	0.315	0.234	0.176
0.900			1.952	1.793	1.590	1.387	1.208	1.057	0.830	0.673	0.443	0.317	0.236	0.179
0.950			3.566	2.770	2.116	1.667	1.360	1.143	0.860	0.685	0.444	0.317	0.237	0.181
1.004			7.142	3.521	2.338	1.748	1.394	1.159	0.863	0.685	0.442	0.317	0.237	0.182
1.008		23.603	7.026	3.512	2.335	1.747	1.394	1.158	0.863	0.684	0.442	0.317	0.237	0.182
1.012		18.680	6.783	3.494	2.330	1.745	1.393	1.157	0.862	0.684	0.442	0.317	0.237	0.182
1.016		14.444	6.436	3.464	2.323	1.742	1.391	1.156	0.862	0.684	0.442	0.316	0.237	0.182
1.020		9.505	6.034	3.419	2.313	1.738	1.389	1.155	0.861	0.683	0.442	0.316	0.237	0.183
1.024		8.058	5.621	3.359	2.298	1.733	1.386	1.154	0.860	0.683	0.442	0.316	0.237	0.183
1.028		6.980	5.220	3.286	2.280	1.726	1.383	1.152	0.859	0.682	0.441	0.316	0.237	0.183
1.040		4.957	4.198	3.013	2.199	1.696	1.369	1.144	0.856	0.680	0.441	0.316	0.237	0.183
1.060		3.326	3.065	2.518	2.002	1.610	1.328	1.122	0.847	0.676	0.439	0.315	0.237	0.183
1.080		2.496	2.379	2.099	1.779	1.495	1.266	1.086	0.833	0.669	0.437	0.314	0.237	0.183
1.100		1.995	1.933	1.774	1.571	1.369	1.190	1.040	0.814	0.659	0.434	0.313	0.237	0.183
1.120		1.659	1.623	1.525	1.391	1.247	1.110	0.987	0.790	0.647	0.431	0.312	0.236	0.184
1.140		1.418	1.395	1.331	1.240	1.135	1.030	0.930	0.761	0.632	0.426	0.310	0.236	0.183
1.160		1.237	1.222	1.178	1.113	1.036	0.954	0.874	0.731	0.615	0.421	0.308	0.235	0.183
1.180		1.096	1.085	1.054	1.006	0.948	0.884	0.820	0.699	0.596	0.415	0.306	0.234	0.183
1.200		0.983	0.975	0.952	0.916	0.871	0.821	0.769	0.667	0.576	0.409	0.303	0.233	0.183
1.300		0.642	0.640	0.633	0.621	0.606	0.588	0.567	0.522	0.475	0.368	0.285	0.225	0.180
1.400		0.471	0.470	0.467	0.462	0.455	0.447	0.437	0.414	0.388	0.322	0.262	0.213	0.173
1.500		0.368	0.367	0.365	0.363	0.359	0.355	0.349	0.337	0.321	0.279	0.236	0.198	0.165
1.600		0.298	0.298	0.297	0.296	0.294	0.291	0.288	0.280	0.270	0.242	0.211	0.182	0.155

Table F.0.2-2 (continued)

l/d	100												
	0.000	0.020	0.040	0.060	0.080	0.100	0.120	0.160	0.200	0.300	0.400	0.500	0.600
$\frac{n}{m}$													
0.500		0.515	0.511	0.505	0.497	0.486	0.474	0.446	0.413	0.323	0.241	0.175	0.125
0.550		0.534	0.530	0.524	0.516	0.506	0.493	0.465	0.431	0.341	0.257	0.189	0.137
0.600		0.569	0.565	0.558	0.549	0.537	0.524	0.492	0.455	0.359	0.272	0.201	0.147
0.650		0.624	0.619	0.610	0.598	0.584	0.567	0.528	0.485	0.378	0.284	0.211	0.155
0.700		0.706	0.698	0.685	0.669	0.649	0.626	0.575	0.521	0.396	0.295	0.219	0.163
0.750		0.827	0.814	0.794	0.768	0.738	0.704	0.633	0.562	0.413	0.304	0.226	0.168
0.800		1.015	0.992	0.955	0.910	0.858	0.805	0.700	0.606	0.428	0.311	0.231	0.173
0.850		1.332	1.279	1.202	1.112	1.018	0.928	0.770	0.645	0.438	0.315	0.234	0.176
0.900		1.953	1.793	1.590	1.388	1.208	1.057	0.830	0.673	0.443	0.317	0.236	0.179
0.950		3.570	2.771	2.116	1.667	1.360	1.143	0.860	0.685	0.444	0.317	0.237	0.181
1.004	25.703	7.115	3.518	2.337	1.748	1.394	1.159	0.863	0.685	0.443	0.317	0.237	0.182
1.008	19.574	7.004	3.509	2.334	1.746	1.393	1.158	0.863	0.684	0.442	0.317	0.237	0.182
1.012	14.827	6.771	3.491	2.329	1.744	1.392	1.157	0.862	0.684	0.442	0.317	0.237	0.182
1.016	11.710	6.433	3.461	2.322	1.741	1.391	1.156	0.862	0.684	0.442	0.316	0.237	0.182
1.020	9.609	6.037	3.417	2.312	1.737	1.389	1.155	0.861	0.683	0.442	0.316	0.237	0.183
1.024	8.121	5.626	3.358	2.298	1.732	1.386	1.153	0.860	0.683	0.442	0.316	0.237	0.183
1.028	7.020	5.227	3.285	2.279	1.726	1.383	1.152	0.859	0.682	0.441	0.316	0.237	0.183
1.040	4.971	4.203	3.013	2.199	1.695	1.369	1.144	0.856	0.680	0.441	0.316	0.237	0.183
1.060	3.330	3.068	2.519	2.002	1.610	1.328	1.122	0.847	0.676	0.439	0.315	0.237	0.183
1.080	2.498	2.381	2.099	1.779	1.495	1.266	1.086	0.833	0.669	0.437	0.314	0.237	0.183
1.100	1.995	1.934	1.775	1.571	1.369	1.190	1.040	0.814	0.659	0.434	0.313	0.237	0.183
1.120	1.659	1.623	1.525	1.391	1.247	1.110	0.987	0.790	0.647	0.431	0.312	0.236	0.184
1.140	1.418	1.395	1.332	1.240	1.135	1.030	0.930	0.761	0.632	0.426	0.310	0.236	0.183
1.160	1.237	1.222	1.178	1.113	1.036	0.954	0.874	0.731	0.615	0.421	0.308	0.235	0.183
1.180	1.096	1.085	1.054	1.006	0.948	0.885	0.820	0.699	0.596	0.415	0.306	0.234	0.183
1.200	0.983	0.975	0.952	0.916	0.871	0.821	0.769	0.667	0.576	0.409	0.303	0.233	0.183
1.300	0.642	0.640	0.633	0.622	0.606	0.588	0.567	0.522	0.475	0.368	0.285	0.225	0.180
1.400	0.471	0.470	0.467	0.462	0.455	0.447	0.437	0.414	0.388	0.322	0.262	0.213	0.173
1.500	0.368	0.367	0.365	0.363	0.359	0.355	0.349	0.337	0.321	0.279	0.236	0.198	0.165
1.600	0.298	0.298	0.297	0.296	0.294	0.291	0.288	0.280	0.270	0.242	0.211	0.182	0.155

Table F.0.3-3 Vertical Stress Effect Coefficient (I_{σ}) of Side Resistance of growth along The Pile Foundation, Considering The Pile Diameter Influence

l/d	10												
	0.000	0.020	0.040	0.060	0.080	0.100	0.120	0.160	0.200	0.300	0.400	0.500	0.600
m													
0.500				-0.899	-0.681	-0.518	-0.391	-0.209	-0.089	0.061	0.105	0.107	0.092
0.550				-0.842	-0.625	-0.464	-0.340	-0.164	-0.049	0.088	0.123	0.119	0.102
0.600				-0.753	-0.539	-0.383	-0.263	-0.097	0.007	0.122	0.143	0.132	0.111
0.650				-0.626	-0.418	-0.268	-0.156	-0.006	0.081	0.163	0.165	0.144	0.118
0.700				-0.448	-0.250	-0.111	-0.012	0.111	0.173	0.208	0.186	0.155	0.125
0.750				-0.199	-0.019	0.099	0.177	0.257	0.281	0.256	0.208	0.166	0.132
0.800				0.154	0.301	0.383	0.423	0.433	0.403	0.302	0.227	0.175	0.137
0.850				0.671	0.751	0.761	0.733	0.632	0.527	0.344	0.243	0.183	0.142
0.900				1.463	1.390	1.251	1.096	0.828	0.637	0.377	0.257	0.190	0.146
0.950				2.781	2.278	1.797	1.433	0.974	0.714	0.404	0.269	0.196	0.150
1.004	4.437	4.686	5.938	5.035	2.956	2.096	1.604	1.059	0.768	0.427	0.281	0.203	0.154
1.008	4.450	4.694	5.836	4.953	2.963	2.104	1.610	1.064	0.771	0.429	0.282	0.204	0.155
1.012	4.454	4.689	5.635	4.790	2.964	2.110	1.616	1.068	0.774	0.430	0.283	0.204	0.155
1.016	4.449	4.665	5.390	4.592	2.956	2.114	1.622	1.072	0.778	0.432	0.284	0.205	0.155
1.020	4.431	4.622	5.138	4.388	2.938	2.116	1.626	1.076	0.781	0.433	0.285	0.205	0.156
1.024	4.398	4.559	4.897	4.194	2.911	2.115	1.629	1.080	0.783	0.435	0.286	0.206	0.156
1.028	4.351	4.478	4.673	4.014	2.876	2.111	1.631	1.083	0.786	0.436	0.287	0.206	0.156
1.040	4.128	4.161	4.096	3.552	2.734	2.080	1.629	1.091	0.794	0.441	0.289	0.208	0.157
1.060	3.600	3.557	3.373	2.976	2.457	1.975	1.595	1.095	0.803	0.448	0.293	0.210	0.159
1.080	3.060	3.007	2.836	2.547	2.190	1.836	1.530	1.086	0.807	0.454	0.297	0.213	0.161
1.100	2.599	2.554	2.420	2.210	1.954	1.690	1.447	1.064	0.804	0.458	0.301	0.215	0.162
1.120	2.226	2.192	2.092	1.937	1.749	1.548	1.356	1.031	0.795	0.461	0.304	0.217	0.164
1.140	1.927	1.902	1.827	1.713	1.571	1.418	1.264	0.992	0.780	0.463	0.306	0.219	0.165
1.160	1.687	1.668	1.613	1.527	1.419	1.299	1.176	0.948	0.761	0.462	0.308	0.221	0.167
1.180	1.493	1.478	1.436	1.370	1.286	1.192	1.093	0.902	0.738	0.460	0.310	0.223	0.168
1.200	1.332	1.321	1.289	1.238	1.172	1.097	1.017	0.857	0.713	0.457	0.311	0.224	0.170
1.300	0.838	0.834	0.823	0.806	0.783	0.755	0.723	0.653	0.580	0.419	0.304	0.226	0.174
1.400	0.591	0.590	0.585	0.577	0.567	0.554	0.539	0.505	0.466	0.368	0.284	0.220	0.173
1.500	0.447	0.446	0.444	0.440	0.434	0.428	0.420	0.401	0.379	0.318	0.259	0.209	0.168
1.600	0.354	0.353	0.352	0.350	0.347	0.343	0.338	0.327	0.313	0.274	0.232	0.194	0.161

Table F.0.2-3 (continued)

		25												
l/d	n	0.000	0.020	0.040	0.060	0.080	0.100	0.120	0.160	0.200	0.300	0.400	0.500	0.600
m														
0.500				-1.206	-0.889	-0.671	-0.508	-0.382	-0.202	-0.083	0.065	0.107	0.107	0.093
0.550				-1.146	-0.830	-0.614	-0.453	-0.330	-0.155	-0.042	0.092	0.125	0.120	0.102
0.600				-1.052	-0.739	-0.526	-0.370	-0.252	-0.087	0.015	0.126	0.145	0.132	0.111
0.650				-0.916	-0.607	-0.401	-0.252	-0.142	0.005	0.089	0.166	0.166	0.144	0.119
0.700				-0.722	-0.422	-0.226	-0.091	0.006	0.123	0.181	0.210	0.187	0.155	0.126
0.750				-0.443	-0.160	0.015	0.128	0.200	0.271	0.289	0.257	0.208	0.166	0.132
0.800				-0.031	0.219	0.353	0.422	0.450	0.446	0.408	0.302	0.226	0.175	0.137
0.850				0.617	0.786	0.829	0.809	0.760	0.638	0.526	0.342	0.242	0.182	0.141
0.900				1.734	1.663	1.482	1.281	1.098	0.816	0.627	0.374	0.256	0.189	0.146
0.950				3.849	2.920	2.206	1.712	1.369	0.943	0.698	0.399	0.268	0.196	0.150
1.004				6.271	3.709	2.565	1.919	1.508	1.021	0.749	0.422	0.280	0.202	0.154
1.008		12.508	16.972	6.261	3.720	2.575	1.927	1.514	1.026	0.752	0.424	0.280	0.203	0.154
1.012		12.381	13.914	6.208	3.725	2.583	1.934	1.520	1.030	0.756	0.425	0.281	0.203	0.155
1.016		12.039	12.117	6.105	3.722	2.588	1.940	1.526	1.034	0.759	0.427	0.282	0.204	0.155
1.020		11.487	10.831	5.959	3.710	2.592	1.946	1.531	1.038	0.762	0.428	0.283	0.204	0.155
1.024		10.795	9.822	5.781	3.688	2.592	1.950	1.535	1.042	0.765	0.430	0.284	0.205	0.156
1.028		10.046	8.988	5.584	3.655	2.588	1.952	1.539	1.046	0.768	0.431	0.285	0.205	0.156
1.040		9.301	8.278	4.959	3.500	2.553	1.949	1.546	1.055	0.775	0.436	0.287	0.207	0.157
1.060		7.355	6.630	4.015	3.129	2.420	1.905	1.535	1.063	0.786	0.443	0.291	0.209	0.159
1.080		5.196	4.846	3.279	2.733	2.228	1.817	1.497	1.060	0.791	0.449	0.295	0.212	0.160
1.100		3.912	3.732	2.724	2.375	2.019	1.702	1.436	1.046	0.791	0.453	0.299	0.214	0.162
1.120		3.091	2.990	2.302	2.071	1.818	1.576	1.360	1.021	0.785	0.457	0.302	0.216	0.163
1.140		2.530	2.469	1.977	1.818	1.635	1.450	1.277	0.987	0.773	0.459	0.305	0.219	0.165
1.160		2.127	2.087	1.721	1.608	1.474	1.332	1.193	0.948	0.756	0.459	0.307	0.220	0.166
1.180		1.824	1.797	1.517	1.434	1.333	1.223	1.112	0.906	0.736	0.457	0.308	0.222	0.168
1.200		1.590	1.571	1.350	1.288	1.211	1.124	1.035	0.862	0.713	0.454	0.309	0.223	0.169
1.400		1.404	1.390	1.085	0.824	0.798	0.768	0.734	0.659	0.583	0.419	0.303	0.226	0.173
1.300		0.859	0.855	0.843	0.824	0.798	0.768	0.734	0.659	0.583	0.419	0.303	0.226	0.173
1.400		0.600	0.598	0.593	0.585	0.574	0.561	0.545	0.509	0.469	0.369	0.284	0.220	0.173
1.500		0.451	0.450	0.448	0.444	0.438	0.431	0.423	0.404	0.381	0.319	0.259	0.209	0.168
1.600		0.356	0.356	0.354	0.352	0.349	0.345	0.340	0.329	0.315	0.274	0.232	0.194	0.161

Table F.0.2-3 (continued)

		30												
l/d	m	0.000	0.020	0.040	0.060	0.080	0.100	0.120	0.160	0.200	0.300	0.400	0.500	0.600
0.500			-1.759	-1.206	-0.888	-0.670	-0.508	-0.382	-0.201	-0.082	0.065	0.107	0.108	0.093
0.550			-1.698	-1.145	-0.829	-0.613	-0.453	-0.329	-0.155	-0.042	0.092	0.125	0.120	0.102
0.600			-1.603	-1.051	-0.738	-0.525	-0.369	-0.251	-0.087	0.015	0.126	0.145	0.132	0.111
0.650			-1.463	-0.915	-0.606	-0.400	-0.251	-0.141	0.005	0.089	0.166	0.166	0.144	0.119
0.700			-1.263	-0.720	-0.420	-0.225	-0.089	0.007	0.124	0.181	0.211	0.187	0.155	0.126
0.750			-0.973	-0.441	-0.157	0.017	0.129	0.201	0.272	0.289	0.257	0.208	0.166	0.132
0.800			-0.536	-0.026	0.223	0.356	0.424	0.452	0.447	0.408	0.302	0.226	0.175	0.137
0.850			0.177	0.627	0.793	0.833	0.812	0.761	0.638	0.526	0.342	0.242	0.182	0.141
0.900			1.507	1.756	1.675	1.486	1.282	1.098	0.816	0.627	0.374	0.256	0.189	0.146
0.950			4.706	3.888	2.919	2.199	1.707	1.366	0.941	0.697	0.399	0.268	0.196	0.150
1.004		15.226	16.081	6.097	3.664	2.547	1.910	1.503	1.019	0.748	0.422	0.279	0.202	0.154
1.008		14.944	14.179	6.096	3.676	2.557	1.918	1.509	1.024	0.751	0.423	0.280	0.203	0.154
1.012		14.281	12.577	6.062	3.682	2.565	1.925	1.515	1.028	0.755	0.425	0.281	0.203	0.155
1.016		13.323	11.303	5.988	3.681	2.571	1.932	1.521	1.032	0.758	0.426	0.282	0.204	0.155
1.020		12.240	10.258	5.874	3.672	2.575	1.937	1.526	1.036	0.761	0.428	0.283	0.204	0.155
1.024		11.162	9.376	5.728	3.654	2.575	1.941	1.530	1.040	0.764	0.429	0.284	0.205	0.156
1.028		10.159	8.616	5.557	3.626	2.573	1.944	1.534	1.043	0.766	0.431	0.285	0.205	0.156
1.040		7.763	6.846	4.979	3.486	2.541	1.942	1.541	1.053	0.774	0.435	0.287	0.207	0.157
1.060		5.344	4.949	4.050	3.132	2.416	1.901	1.532	1.061	0.785	0.442	0.291	0.209	0.159
1.080		3.978	3.786	3.307	2.741	2.229	1.815	1.495	1.059	0.790	0.448	0.295	0.212	0.160
1.100		3.126	3.020	2.743	2.384	2.022	1.702	1.435	1.045	0.790	0.453	0.299	0.214	0.162
1.120		2.551	2.488	2.316	2.079	1.822	1.577	1.360	1.020	0.784	0.457	0.302	0.216	0.163
1.140		2.140	2.099	1.986	1.824	1.639	1.452	1.278	0.987	0.773	0.458	0.304	0.218	0.165
1.160		1.833	1.806	1.728	1.613	1.477	1.334	1.194	0.948	0.756	0.459	0.307	0.220	0.166
1.180		1.596	1.577	1.522	1.438	1.336	1.224	1.113	0.906	0.736	0.457	0.308	0.222	0.168
1.200		1.408	1.394	1.354	1.291	1.213	1.126	1.036	0.862	0.713	0.454	0.309	0.223	0.169
1.300		0.860	0.856	0.844	0.825	0.799	0.769	0.734	0.660	0.584	0.419	0.303	0.226	0.173
1.400		0.600	0.599	0.594	0.586	0.575	0.561	0.545	0.509	0.469	0.369	0.284	0.220	0.173
1.500		0.451	0.451	0.448	0.444	0.439	0.432	0.423	0.404	0.381	0.319	0.259	0.209	0.168
1.600		0.356	0.356	0.354	0.352	0.349	0.345	0.340	0.329	0.315	0.275	0.232	0.194	0.161

Table F.0.2-3 (continued)

		40												
l/d	n	0.000	0.020	0.040	0.060	0.080	0.100	0.120	0.160	0.200	0.300	0.400	0.500	0.600
m														
0.500		-1.759	-1.205	-0.888	-0.670	-0.507	-0.381	-0.201	-0.082	0.066	0.108	0.108	0.108	0.093
0.550		-1.698	-1.145	-0.829	-0.612	-0.452	-0.329	-0.154	-0.042	0.092	0.125	0.125	0.120	0.102
0.600		-1.602	-1.050	-0.737	-0.524	-0.369	-0.250	-0.086	0.015	0.126	0.145	0.145	0.132	0.111
0.650		-1.462	-0.913	-0.605	-0.399	-0.250	-0.140	0.006	0.090	0.166	0.166	0.166	0.144	0.119
0.700		-1.261	-0.718	-0.419	-0.223	-0.088	0.008	0.125	0.182	0.211	0.187	0.187	0.155	0.126
0.750		-0.970	-0.438	-0.155	0.019	0.131	0.203	0.272	0.290	0.257	0.208	0.208	0.166	0.132
0.800		-0.531	-0.022	0.227	0.359	0.426	0.454	0.448	0.408	0.302	0.226	0.226	0.175	0.137
0.850		0.188	0.636	0.799	0.838	0.814	0.763	0.638	0.526	0.341	0.242	0.242	0.182	0.141
0.900		1.542	1.778	1.686	1.491	1.284	1.098	0.815	0.626	0.373	0.256	0.256	0.189	0.146
0.950		4.869	3.924	2.917	2.193	1.702	1.362	0.940	0.696	0.399	0.268	0.268	0.196	0.150
1.004	20.636	14.185	5.940	3.622	2.530	1.901	1.498	1.017	0.747	0.421	0.279	0.279	0.202	0.154
1.008	19.770	13.545	5.945	3.634	2.539	1.909	1.504	1.021	0.750	0.423	0.280	0.280	0.203	0.154
1.012	18.119	12.571	5.925	3.641	2.548	1.916	1.510	1.026	0.754	0.425	0.281	0.281	0.203	0.155
1.016	16.165	11.550	5.873	3.642	2.554	1.923	1.516	1.030	0.757	0.426	0.282	0.282	0.204	0.155
1.020	14.288	10.589	5.786	3.635	2.558	1.928	1.521	1.034	0.760	0.428	0.283	0.283	0.204	0.155
1.024	12.638	9.718	5.667	3.621	2.557	1.936	1.526	1.038	0.763	0.429	0.284	0.284	0.205	0.156
1.028	11.236	8.937	5.522	3.597	2.557	1.936	1.530	1.041	0.765	0.431	0.284	0.284	0.205	0.156
1.040	8.228	7.066	4.993	3.470	2.530	1.935	1.537	1.051	0.773	0.435	0.287	0.287	0.207	0.157
1.060	5.500	5.055	4.083	3.134	2.411	1.896	1.528	1.059	0.784	0.442	0.291	0.291	0.209	0.159
1.080	4.047	3.840	3.334	2.750	2.230	1.814	1.493	1.057	0.789	0.448	0.295	0.295	0.212	0.160
1.100	3.162	3.051	2.762	2.393	2.025	1.702	1.434	1.044	0.789	0.453	0.298	0.298	0.214	0.162
1.120	2.572	2.506	2.329	2.086	1.825	1.578	1.360	1.019	0.784	0.456	0.302	0.302	0.216	0.163
1.140	2.153	2.111	1.996	1.830	1.642	1.454	1.278	0.987	0.772	0.458	0.304	0.304	0.218	0.165
1.160	1.842	1.814	1.735	1.618	1.480	1.335	1.195	0.948	0.756	0.458	0.306	0.306	0.220	0.166
1.180	1.602	1.583	1.526	1.442	1.338	1.226	1.114	0.906	0.736	0.457	0.308	0.308	0.222	0.168
1.200	1.413	1.399	1.357	1.294	1.215	1.127	1.037	0.863	0.713	0.454	0.309	0.309	0.223	0.169
1.300	0.862	0.858	0.826	0.826	0.800	0.769	0.735	0.660	0.584	0.419	0.303	0.303	0.226	0.173
1.400	0.601	0.599	0.586	0.586	0.575	0.562	0.546	0.510	0.469	0.369	0.284	0.284	0.220	0.173
1.500	0.452	0.451	0.448	0.444	0.439	0.432	0.424	0.404	0.381	0.319	0.259	0.259	0.209	0.168
1.600	0.356	0.356	0.355	0.352	0.349	0.345	0.340	0.329	0.315	0.275	0.232	0.232	0.194	0.161

Table F.0.2-3 (continued)

		50												
l/d	n	0.000	0.020	0.040	0.060	0.080	0.100	0.120	0.160	0.200	0.300	0.400	0.500	0.600
m														
0.500			-1.758	-1.205	-0.887	-0.669	-0.507	-0.381	-0.200	-0.082	0.066	0.108	0.108	0.093
0.550			-1.697	-1.144	-0.828	-0.612	-0.452	-0.329	-0.154	-0.041	0.093	0.125	0.120	0.102
0.600			-1.601	-1.050	-0.737	-0.524	-0.368	-0.250	-0.086	0.016	0.126	0.145	0.132	0.111
0.650			-1.461	-0.913	-0.605	-0.398	-0.250	-0.140	0.006	0.090	0.166	0.166	0.144	0.119
0.700			-1.260	-0.718	-0.418	-0.223	-0.088	0.008	0.125	0.182	0.211	0.187	0.155	0.126
0.750			-0.969	-0.437	-0.154	0.020	0.132	0.203	0.273	0.290	0.257	0.208	0.166	0.132
0.800			-0.528	-0.020	0.229	0.360	0.427	0.454	0.448	0.409	0.302	0.226	0.175	0.137
0.850			0.193	0.641	0.803	0.840	0.816	0.763	0.638	0.526	0.341	0.242	0.182	0.141
0.900			1.558	1.789	1.691	1.493	1.284	1.098	0.815	0.626	0.373	0.256	0.189	0.146
0.950			4.947	3.940	2.916	2.190	1.699	1.360	0.939	0.696	0.398	0.268	0.196	0.150
1.004		25.958	13.491	5.873	3.603	2.522	1.897	1.495	1.016	0.747	0.421	0.279	0.202	0.154
1.008		24.069	13.126	5.879	3.615	2.532	1.905	1.502	1.020	0.750	0.423	0.280	0.203	0.154
1.012		21.098	12.429	5.864	3.622	2.540	1.912	1.508	1.025	0.753	0.424	0.281	0.203	0.155
1.016		18.118	11.575	5.820	3.624	2.546	1.919	1.513	1.029	0.756	0.426	0.282	0.204	0.155
1.020		15.572	10.695	5.745	3.619	2.551	1.924	1.519	1.033	0.759	0.427	0.283	0.204	0.155
1.024		13.503	9.854	5.638	3.605	2.552	1.929	1.523	1.037	0.762	0.429	0.284	0.205	0.156
1.028		11.836	9.077	5.503	3.583	2.551	1.932	1.527	1.040	0.765	0.431	0.284	0.205	0.156
1.040		8.466	7.170	4.998	3.463	2.524	1.931	1.535	1.050	0.773	0.435	0.287	0.207	0.157
1.060		5.577	5.105	4.098	3.135	2.409	1.894	1.527	1.058	0.783	0.442	0.291	0.209	0.159
1.080		4.080	3.866	3.347	2.754	2.230	1.813	1.492	1.057	0.789	0.448	0.295	0.212	0.160
1.100		3.179	3.065	2.771	2.397	2.027	1.702	1.434	1.043	0.789	0.453	0.298	0.214	0.162
1.120		2.581	2.515	2.335	2.090	1.827	1.579	1.360	1.019	0.783	0.456	0.302	0.216	0.163
1.140		2.159	2.117	2.000	1.833	1.644	1.455	1.279	0.987	0.772	0.458	0.304	0.218	0.165
1.160		1.846	1.818	1.738	1.620	1.481	1.336	1.195	0.948	0.756	0.458	0.306	0.220	0.166
1.180		1.605	1.585	1.529	1.443	1.340	1.227	1.114	0.906	0.736	0.457	0.308	0.222	0.168
1.200		1.415	1.401	1.359	1.296	1.216	1.128	1.037	0.863	0.713	0.454	0.309	0.223	0.169
1.300		0.862	0.858	0.846	0.826	0.801	0.770	0.735	0.660	0.584	0.419	0.303	0.226	0.173
1.400		0.601	0.599	0.594	0.586	0.575	0.562	0.546	0.510	0.469	0.369	0.284	0.220	0.173
1.500		0.452	0.451	0.449	0.444	0.439	0.432	0.424	0.404	0.381	0.319	0.259	0.209	0.168
1.600		0.356	0.356	0.355	0.352	0.349	0.345	0.340	0.329	0.315	0.275	0.233	0.194	0.161

Table F.0.2-3 (continued)

		60												
l/d	m	0.000	0.020	0.040	0.060	0.080	0.100	0.120	0.160	0.200	0.300	0.400	0.500	0.600
0.500			-1.758	-1.205	-0.887	-0.669	-0.507	-0.381	-0.200	-0.082	0.066	0.108	0.108	0.093
0.550			-1.697	-1.144	-0.828	-0.612	-0.452	-0.328	-0.154	-0.041	0.093	0.125	0.120	0.102
0.600			-1.601	-1.050	-0.737	-0.524	-0.368	-0.250	-0.086	0.016	0.126	0.145	0.132	0.111
0.650			-1.461	-0.913	-0.604	-0.398	-0.250	-0.140	0.006	0.090	0.166	0.166	0.144	0.119
0.700			-1.260	-0.717	-0.417	-0.222	-0.087	0.008	0.125	0.182	0.211	0.187	0.155	0.126
0.750			-0.968	-0.436	-0.153	0.021	0.132	0.203	0.273	0.290	0.257	0.208	0.166	0.132
0.800			-0.527	-0.018	0.230	0.361	0.428	0.455	0.448	0.409	0.302	0.226	0.175	0.137
0.850			0.196	0.643	0.804	0.841	0.816	0.764	0.638	0.526	0.341	0.242	0.182	0.141
0.900			1.566	1.794	1.694	1.494	1.284	1.098	0.814	0.626	0.373	0.256	0.189	0.146
0.950			4.990	3.948	2.915	2.188	1.698	1.360	0.938	0.695	0.398	0.267	0.196	0.150
1.004		31.136	13.161	5.837	3.593	2.518	1.895	1.494	1.015	0.746	0.421	0.279	0.202	0.154
1.008		27.775	12.894	5.845	3.604	2.527	1.903	1.500	1.020	0.750	0.423	0.280	0.203	0.154
1.012		23.351	12.325	5.832	3.612	2.536	1.910	1.507	1.024	0.753	0.424	0.281	0.203	0.155
1.016		19.460	11.565	5.792	3.614	2.542	1.917	1.512	1.028	0.756	0.426	0.282	0.204	0.155
1.020		16.399	10.738	5.722	3.610	2.547	1.922	1.517	1.032	0.759	0.427	0.283	0.204	0.155
1.024		14.037	9.920	5.621	3.597	2.548	1.927	1.522	1.036	0.762	0.429	0.284	0.205	0.156
1.028		12.197	9.149	5.493	3.576	2.547	1.930	1.526	1.040	0.765	0.430	0.284	0.205	0.156
1.040		8.602	7.226	5.000	3.459	2.522	1.930	1.533	1.049	0.773	0.435	0.287	0.207	0.157
1.060		5.619	5.133	4.106	3.135	2.408	1.893	1.526	1.058	0.783	0.442	0.291	0.209	0.159
1.080		4.098	3.880	3.354	2.756	2.230	1.812	1.492	1.056	0.789	0.448	0.295	0.212	0.160
1.100		3.188	3.073	2.776	2.400	2.028	1.702	1.434	1.043	0.789	0.453	0.298	0.214	0.162
1.120		2.587	2.520	2.339	2.092	1.828	1.579	1.360	1.019	0.783	0.456	0.302	0.216	0.163
1.140		2.162	2.120	2.003	1.835	1.645	1.455	1.279	0.987	0.772	0.458	0.304	0.218	0.165
1.160		1.848	1.820	1.740	1.622	1.482	1.337	1.196	0.948	0.756	0.458	0.306	0.220	0.166
1.180		1.606	1.587	1.530	1.444	1.340	1.227	1.114	0.906	0.736	0.457	0.308	0.222	0.168
1.200		1.416	1.402	1.360	1.296	1.217	1.129	1.037	0.863	0.713	0.454	0.309	0.223	0.169
1.300		0.862	0.858	0.846	0.827	0.801	0.770	0.735	0.660	0.584	0.419	0.303	0.226	0.173
1.400		0.601	0.600	0.595	0.586	0.575	0.562	0.546	0.510	0.470	0.369	0.284	0.220	0.173
1.500		0.452	0.451	0.449	0.445	0.439	0.432	0.424	0.404	0.381	0.319	0.259	0.209	0.168
1.600		0.356	0.356	0.355	0.352	0.349	0.345	0.340	0.329	0.315	0.275	0.233	0.194	0.161

Table F.0.2-3 (continued)

		70												
l/d	n	0.000	0.020	0.040	0.060	0.080	0.100	0.120	0.160	0.200	0.300	0.400	0.500	0.600
	m													
0.500			-1.758	-1.204	-0.887	-0.669	-0.507	-0.381	-0.200	-0.082	0.066	0.108	0.108	0.093
0.550			-1.697	-1.144	-0.828	-0.612	-0.452	-0.328	-0.154	-0.041	0.093	0.125	0.120	0.102
0.600			-1.601	-1.050	-0.736	-0.524	-0.368	-0.250	-0.086	0.016	0.126	0.145	0.132	0.111
0.650			-1.461	-0.912	-0.604	-0.398	-0.250	-0.140	0.006	0.090	0.166	0.166	0.144	0.119
0.700			-1.260	-0.717	-0.417	-0.222	-0.087	0.009	0.125	0.182	0.211	0.187	0.155	0.126
0.750			-0.968	-0.436	-0.153	0.021	0.133	0.204	0.273	0.290	0.257	0.208	0.166	0.132
0.800			-0.526	-0.018	0.230	0.362	0.428	0.455	0.448	0.409	0.302	0.226	0.175	0.137
0.850			0.198	0.645	0.805	0.842	0.817	0.764	0.638	0.526	0.341	0.242	0.182	0.141
0.900			1.572	1.798	1.696	1.495	1.285	1.098	0.814	0.626	0.373	0.256	0.189	0.146
0.950			5.016	3.953	2.915	2.187	1.697	1.359	0.938	0.695	0.398	0.267	0.196	0.150
1.004		36.118	12.976	5.816	3.587	2.515	1.894	1.493	1.015	0.746	0.421	0.279	0.202	0.154
1.008		30.900	12.756	5.824	3.598	2.525	1.902	1.500	1.020	0.749	0.423	0.280	0.203	0.154
1.012		25.046	12.255	5.813	3.606	2.533	1.909	1.506	1.024	0.753	0.424	0.281	0.203	0.155
1.016		20.400	11.552	5.775	3.608	2.540	1.915	1.511	1.028	0.756	0.426	0.282	0.204	0.155
1.020		16.954	10.759	5.708	3.604	2.544	1.921	1.517	1.032	0.759	0.427	0.283	0.204	0.155
1.024		14.385	9.957	5.611	3.592	2.546	1.925	1.521	1.036	0.762	0.429	0.284	0.205	0.156
1.028		12.427	9.191	5.486	3.571	2.545	1.929	1.525	1.040	0.764	0.430	0.284	0.205	0.156
1.040		8.687	7.261	5.002	3.457	2.520	1.929	1.533	1.049	0.772	0.435	0.287	0.207	0.157
1.060		5.645	5.150	4.111	3.135	2.407	1.892	1.525	1.058	0.783	0.442	0.291	0.209	0.159
1.080		4.109	3.888	3.358	2.757	2.230	1.812	1.491	1.056	0.789	0.448	0.295	0.212	0.160
1.100		3.194	3.078	2.779	2.401	2.028	1.702	1.434	1.043	0.789	0.453	0.298	0.214	0.162
1.120		2.590	2.523	2.341	2.093	1.829	1.579	1.360	1.019	0.783	0.456	0.302	0.216	0.163
1.140		2.164	2.122	2.004	1.836	1.645	1.455	1.279	0.987	0.772	0.458	0.304	0.218	0.165
1.160		1.849	1.821	1.741	1.622	1.483	1.337	1.196	0.948	0.756	0.458	0.306	0.220	0.166
1.180		1.607	1.588	1.531	1.445	1.341	1.228	1.114	0.906	0.736	0.457	0.308	0.222	0.168
1.200		1.417	1.402	1.361	1.297	1.217	1.129	1.037	0.863	0.713	0.454	0.309	0.223	0.169
1.300		0.863	0.859	0.846	0.827	0.801	0.770	0.736	0.660	0.584	0.419	0.303	0.226	0.173
1.400		0.601	0.600	0.595	0.586	0.575	0.562	0.546	0.510	0.470	0.369	0.284	0.220	0.173
1.500		0.452	0.451	0.449	0.445	0.439	0.432	0.424	0.404	0.381	0.319	0.259	0.209	0.168
1.600		0.356	0.356	0.355	0.352	0.349	0.345	0.340	0.329	0.315	0.275	0.233	0.194	0.161

Table F.0.2-3 (continued)

l/d		80													
		0.000	0.020	0.040	0.060	0.080	0.100	0.120	0.160	0.200	0.300	0.400	0.500	0.600	
0.500	$\frac{n}{m}$		-1.758	-1.204	-0.887	-0.669	-0.507	-0.381	-0.200	-0.082	0.066	0.108	0.108	0.093	
0.550			-1.697	-1.144	-0.828	-0.612	-0.452	-0.328	-0.154	-0.041	0.093	0.125	0.120	0.102	
0.600			-1.601	-1.050	-0.736	-0.524	-0.368	-0.250	-0.086	0.016	0.126	0.145	0.132	0.111	
0.650			-1.461	-0.912	-0.604	-0.398	-0.249	-0.139	0.006	0.090	0.166	0.166	0.144	0.119	
0.700			-1.259	-0.717	-0.417	-0.222	-0.087	0.009	0.125	0.182	0.211	0.187	0.155	0.126	
0.750			-0.968	-0.436	-0.153	0.021	0.133	0.204	0.273	0.290	0.257	0.208	0.166	0.132	
0.800			-0.526	-0.017	0.230	0.362	0.428	0.455	0.448	0.409	0.302	0.226	0.175	0.137	
0.850			0.199	0.646	0.806	0.842	0.817	0.764	0.638	0.526	0.341	0.242	0.182	0.141	
0.900			1.575	1.800	1.697	1.495	1.285	1.098	0.814	0.625	0.373	0.256	0.189	0.146	
0.950			5.032	3.956	2.914	2.186	1.697	1.359	0.938	0.695	0.398	0.267	0.196	0.150	
1.004		40.860	12.861	5.803	3.583	2.513	1.893	1.493	1.015	0.746	0.421	0.279	0.202	0.154	
1.008		33.500	12.667	5.811	3.594	2.523	1.901	1.499	1.019	0.749	0.423	0.280	0.203	0.154	
1.012		26.328	12.207	5.800	3.602	2.532	1.908	1.505	1.024	0.753	0.424	0.281	0.203	0.155	
1.016		21.074	11.541	5.765	3.605	2.538	1.915	1.511	1.028	0.756	0.426	0.282	0.204	0.155	
1.020		17.339	10.770	5.699	3.601	2.543	1.920	1.516	1.032	0.759	0.427	0.283	0.204	0.155	
1.024		14.622	9.979	5.604	3.589	2.544	1.925	1.521	1.036	0.762	0.429	0.284	0.205	0.156	
1.028		12.582	9.218	5.482	3.568	2.543	1.928	1.525	1.039	0.764	0.430	0.284	0.205	0.156	
1.040		8.743	7.283	5.002	3.455	2.519	1.928	1.532	1.049	0.772	0.435	0.287	0.207	0.157	
1.060		5.662	5.161	4.114	3.136	2.407	1.892	1.525	1.058	0.783	0.442	0.291	0.209	0.159	
1.080		4.116	3.894	3.360	2.758	2.230	1.812	1.491	1.056	0.788	0.448	0.295	0.212	0.160	
1.100		3.197	3.081	2.781	2.402	2.028	1.702	1.433	1.043	0.789	0.453	0.298	0.214	0.162	
1.120		2.592	2.524	2.342	2.094	1.829	1.580	1.360	1.019	0.783	0.456	0.301	0.216	0.163	
1.140		2.166	2.123	2.005	1.836	1.646	1.455	1.279	0.986	0.772	0.458	0.304	0.218	0.165	
1.160		1.850	1.822	1.741	1.623	1.483	1.337	1.196	0.948	0.756	0.458	0.306	0.220	0.166	
1.180		1.608	1.588	1.531	1.445	1.341	1.228	1.115	0.906	0.736	0.457	0.308	0.222	0.168	
1.200		1.417	1.403	1.361	1.297	1.217	1.129	1.038	0.863	0.713	0.454	0.309	0.223	0.169	
1.300		0.863	0.859	0.847	0.827	0.801	0.770	0.736	0.660	0.584	0.419	0.303	0.226	0.173	
1.400		0.601	0.600	0.595	0.587	0.575	0.562	0.546	0.510	0.470	0.369	0.284	0.220	0.173	
1.500		0.452	0.451	0.449	0.445	0.439	0.432	0.424	0.404	0.381	0.319	0.259	0.209	0.168	
1.600		0.356	0.356	0.355	0.352	0.349	0.345	0.340	0.329	0.315	0.275	0.233	0.194	0.161	

Table F.0.2-3 (continued)

		90												
l/d	n	0.000	0.020	0.040	0.060	0.080	0.100	0.120	0.160	0.200	0.300	0.400	0.500	0.600
m														
0.500			-1.758	-1.204	-0.887	-0.669	-0.507	-0.381	-0.200	-0.082	0.066	0.108	0.108	0.093
0.550			-1.697	-1.144	-0.828	-0.612	-0.452	-0.328	-0.154	-0.041	0.093	0.125	0.120	0.102
0.600			-1.601	-1.050	-0.736	-0.524	-0.368	-0.249	-0.086	0.016	0.126	0.145	0.132	0.111
0.650			-1.460	-0.912	-0.604	-0.398	-0.249	-0.139	0.006	0.090	0.166	0.166	0.144	0.119
0.700			-1.259	-0.717	-0.417	-0.222	-0.087	0.009	0.125	0.182	0.211	0.187	0.155	0.126
0.750			-0.967	-0.435	-0.152	0.022	0.133	0.204	0.273	0.290	0.257	0.208	0.166	0.132
0.800			-0.525	-0.017	0.231	0.362	0.428	0.455	0.448	0.409	0.302	0.226	0.175	0.137
0.850			0.200	0.646	0.807	0.842	0.817	0.764	0.639	0.526	0.341	0.242	0.182	0.141
0.900			1.578	1.801	1.697	1.495	1.285	1.098	0.814	0.625	0.373	0.256	0.189	0.146
0.950			5.044	3.958	2.914	2.186	1.696	1.358	0.938	0.695	0.398	0.267	0.196	0.150
1.004			12.784	5.793	3.580	2.512	1.892	1.492	1.015	0.746	0.421	0.279	0.202	0.154
1.008	45.330		12.606	5.802	3.592	2.522	1.900	1.499	1.019	0.749	0.423	0.280	0.203	0.154
1.012	35.651		12.174	5.792	3.600	2.530	1.908	1.505	1.024	0.752	0.424	0.281	0.203	0.155
1.016	27.309		11.532	5.757	3.602	2.537	1.914	1.511	1.028	0.756	0.426	0.282	0.204	0.155
1.020	21.569		10.777	5.693	3.598	2.541	1.920	1.516	1.032	0.759	0.427	0.283	0.204	0.155
1.024	17.616		9.994	5.600	3.587	2.543	1.924	1.521	1.036	0.761	0.429	0.283	0.205	0.156
1.028	14.790		9.236	5.479	3.566	2.542	1.927	1.525	1.039	0.764	0.430	0.284	0.205	0.156
1.040	12.691		8.782	5.003	3.454	2.518	1.927	1.532	1.049	0.772	0.435	0.287	0.207	0.157
1.060	8.782		7.298	4.116	3.136	2.406	1.891	1.525	1.057	0.783	0.442	0.291	0.209	0.159
1.080	5.674		5.168	3.362	2.759	2.230	1.812	1.491	1.056	0.788	0.448	0.295	0.212	0.160
1.100	4.121		3.898	2.783	2.402	2.029	1.702	1.433	1.043	0.789	0.453	0.298	0.214	0.162
1.120	3.200		3.083	2.343	2.094	1.829	1.580	1.360	1.019	0.783	0.456	0.301	0.216	0.163
1.140	2.594		2.526	2.006	1.837	1.646	1.456	1.279	0.986	0.772	0.458	0.304	0.218	0.165
1.160	2.166		2.124	1.742	1.623	1.483	1.337	1.196	0.948	0.756	0.458	0.306	0.220	0.166
1.180	1.851		1.822	1.532	1.446	1.341	1.228	1.115	0.906	0.736	0.457	0.308	0.222	0.168
1.200	1.608		1.589	1.361	1.297	1.218	1.129	1.038	0.863	0.713	0.454	0.309	0.223	0.169
1.300	1.417		1.403	1.197	1.087	0.801	0.770	0.736	0.660	0.584	0.419	0.303	0.226	0.173
1.400	0.863		0.859	0.847	0.827	0.801	0.562	0.546	0.510	0.470	0.369	0.284	0.220	0.173
1.400	0.601		0.600	0.595	0.587	0.576	0.432	0.424	0.404	0.381	0.319	0.259	0.209	0.168
1.500	0.452		0.451	0.449	0.445	0.439	0.432	0.424	0.404	0.381	0.319	0.259	0.209	0.168
1.600	0.356		0.356	0.355	0.352	0.349	0.345	0.340	0.329	0.315	0.275	0.233	0.194	0.161

Table F.0.2-3 (continued)

l/d		100												
		0.000	0.020	0.040	0.060	0.080	0.100	0.120	0.160	0.200	0.300	0.400	0.500	0.600
0.500	n	-1.758	-1.204	-0.887	-0.669	-0.507	-0.381	-0.200	-0.082	0.066	0.108	0.108	0.108	0.093
0.550	m	-1.697	-1.144	-0.828	-0.612	-0.452	-0.328	-0.154	-0.041	0.093	0.125	0.125	0.125	0.102
0.600		-1.601	-1.049	-0.736	-0.524	-0.368	-0.249	-0.085	0.016	0.127	0.145	0.145	0.145	0.111
0.650		-1.460	-0.912	-0.604	-0.397	-0.249	-0.139	0.007	0.090	0.166	0.166	0.166	0.166	0.119
0.700		-1.259	-0.717	-0.417	-0.222	-0.087	0.009	0.125	0.182	0.211	0.187	0.187	0.187	0.126
0.750		-0.967	-0.435	-0.152	0.022	0.133	0.204	0.273	0.290	0.257	0.208	0.208	0.208	0.132
0.800		-0.525	-0.017	0.231	0.362	0.428	0.455	0.448	0.409	0.302	0.226	0.226	0.226	0.137
0.850		0.201	0.647	0.807	0.843	0.817	0.764	0.639	0.526	0.341	0.242	0.242	0.242	0.141
0.900		1.579	1.803	1.698	1.495	1.285	1.098	0.814	0.625	0.373	0.256	0.256	0.256	0.146
0.950		5.052	3.960	2.914	2.186	1.696	1.358	0.938	0.695	0.398	0.267	0.267	0.267	0.150
1.004		12.730	5.787	3.578	2.511	1.892	1.499	1.015	0.746	0.421	0.279	0.279	0.279	0.154
1.008	49.507	12.563	5.795	3.590	2.521	1.900	1.492	1.019	0.749	0.423	0.280	0.280	0.280	0.154
1.012	37.430	12.149	5.786	3.598	2.530	1.907	1.505	1.024	0.752	0.424	0.281	0.281	0.281	0.155
1.016	28.070	11.524	5.752	3.600	2.536	1.914	1.510	1.028	0.755	0.426	0.282	0.282	0.282	0.155
1.020	17.820	10.782	5.689	3.596	2.541	1.919	1.516	1.032	0.759	0.427	0.283	0.283	0.283	0.155
1.024	21.941	10.005	5.596	3.585	2.543	1.924	1.520	1.036	0.761	0.429	0.283	0.283	0.283	0.156
1.028	14.913	9.249	5.477	3.565	2.541	1.927	1.524	1.039	0.764	0.430	0.284	0.284	0.284	0.156
1.040	12.771	7.309	5.003	3.453	2.517	1.927	1.532	1.048	0.772	0.435	0.287	0.287	0.287	0.157
1.060	8.810	5.174	4.118	3.136	2.406	1.891	1.525	1.057	0.783	0.442	0.291	0.291	0.291	0.159
1.080	5.682	3.900	3.364	2.759	2.230	1.812	1.491	1.056	0.788	0.448	0.295	0.295	0.295	0.160
1.100	4.125	3.085	2.783	2.403	2.029	1.702	1.433	1.043	0.789	0.453	0.298	0.298	0.298	0.162
1.120	3.202	2.527	2.344	2.095	1.829	1.580	1.360	1.019	0.783	0.456	0.301	0.301	0.301	0.163
1.140	2.595	2.124	2.006	1.837	1.646	1.456	1.279	0.986	0.772	0.458	0.304	0.304	0.304	0.165
1.160	2.167	1.823	1.742	1.623	1.483	1.337	1.196	0.948	0.756	0.458	0.306	0.306	0.306	0.166
1.180	1.851	1.589	1.532	1.446	1.341	1.228	1.115	0.906	0.736	0.457	0.308	0.308	0.308	0.168
1.200	1.609	1.403	1.361	1.297	1.218	1.129	1.038	0.863	0.713	0.454	0.309	0.309	0.309	0.169
1.300	1.417	0.859	0.847	0.827	0.801	0.770	0.736	0.660	0.584	0.419	0.303	0.303	0.303	0.173
1.400	0.863	0.600	0.595	0.587	0.576	0.562	0.546	0.510	0.470	0.369	0.284	0.284	0.284	0.173
1.500	0.601	0.451	0.449	0.445	0.439	0.432	0.424	0.404	0.381	0.319	0.259	0.259	0.259	0.168
1.600	0.356	0.356	0.355	0.352	0.349	0.345	0.340	0.329	0.315	0.275	0.233	0.233	0.233	0.161

Appendix G Calculation for strip pile foundation cushion cap beam under brick wall according to inversed beam on elastic foundation

G.0.1 In the calculation for strip pile foundation cushion cap beam under brick wall according to inversed beam on elastic foundation, the load under the beam shall be calculated firstly, and then the bending moment and the shearing force are calculated according to normal continuous beam. Computing formula for the bending moment and the shearing force may refer to Figure G.0.1, and the values may be selected in accordance with Table G.0.1.

Table G.0.1 Computing formula for the internal force of continuous cushion cap beam of strip pile foundation under the brick wall

Internal Force	Calculation Diagram Code	Computing formula for internal force
Support saddle bending moment	(a), (b), (c)	$M = P_0 \frac{a_0^2}{12} \left(2 - \frac{a_0}{L_0} \right)$ (G.0.1-1)
	(d)	$M = -q \frac{L_c^2}{12}$ (G.0.1-2)
Midspan Bending Moment	(a), (c)	$M = p_0 \frac{a_0^3}{12L_c}$ (G.0.1-3)
	(b)	$M = \frac{P_0}{12} \left[L_c \left(6a_0 - 3L_c + 0.5 \frac{L_c^2}{a_0} \right) - a_0^2 \left(4 - \frac{a_0}{L_0} \right) \right]$ (G.0.1-4)
	(d)	$M = \frac{qL_c^2}{24}$ (G.0.1-5)
Max Shearing Force	(a), (b), (c)	$Q = \frac{P_0 a_0}{2}$ (G.0.1-6)
	(d)	$Q = \frac{qL}{2}$ (G.0.1-7)

Note: When continuous cushion cap beams are less than 6, the support saddle and Midspan Bending Moments shall be supported with computing formulas according to practical span number and Figure G.0.1-1.

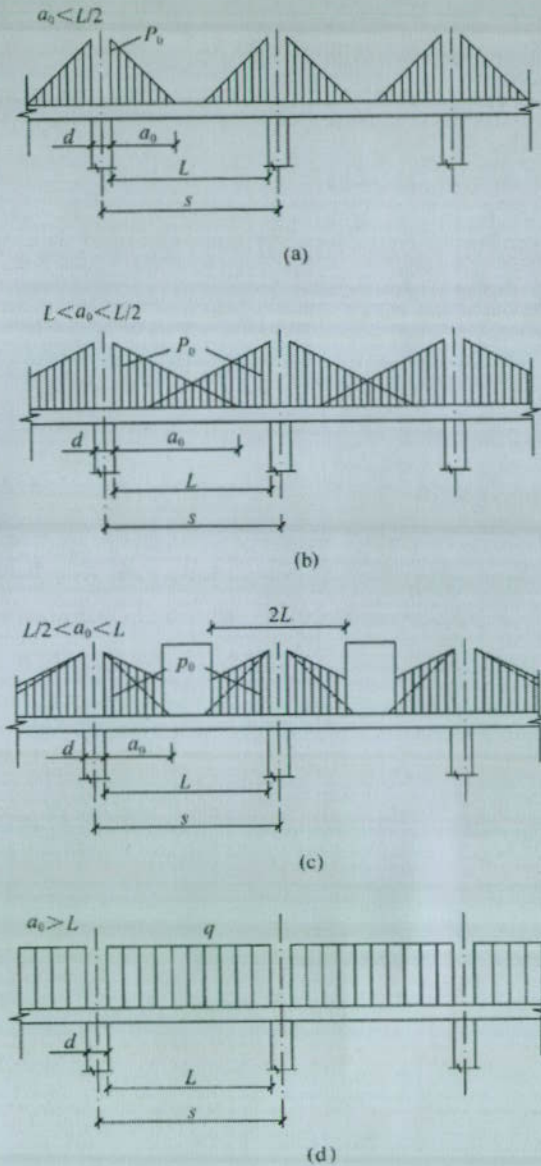


Figure G.0.1 Calculation diagram for continuous cushion cap beam of strip pile foundation under the brick wall

Where Formula G.0.1-1~G.0.1-7:

p_0 —Max value of line load (kN/m), identified according to following formula:

$$M = \frac{qL_c}{a_0} \quad (\text{G.0.1-8})$$

a_0 —Bottom side length of the triangular load figure, counted from the pile side, identified respectively according to following formula:

Intermediate Span
$$a_0 = 3.143 \sqrt{\frac{E_n I}{E_k b_k}} \quad (\text{G.0.1-9})$$

Side Span
$$a_0 = 2.43 \sqrt{\frac{E_n I}{E_k b_k}} \quad (\text{G.0.1-10})$$

Where: L_c —Theoretical span, $L_c=1.05L$;
 L —Clear distance of two adjacent piles;
 q —Evenly distributed load above the cushion cap beam bottom surface;
 $E_n I$ —Flexural rigidity of cushion cap beam;
 E_n —Elastic modulus of cushion cap beam concrete;
 I —Inertia moment of apron piece cross-section;
 E_k —Elastic modulus of wall body;
 b_k —Width of wall body.

When piles are arranged under doors and windows opens, and the height from the cushion cap beam top surface to doors and windows open brick masonry is less than the clear width of the door or window open, the bending moment of this beam shall be calculated according to inverted simply supported beam, namely, 1.05 times of door or window clear width is adopted as the calculation span, and the load of pile top under the door or window is adopted as the concentrated calculation load.

Appendix H Weight selection of hammer for stamping sinking pile

H.0.1 The weight selection of hammer for stamping sinking pile may be selected according to Table H.0.1.

Table H.0.1 Hammer Weight Selection

Hammer selection		Diesel hammer (t)						
		D25	D35	D45	D60	D72	D80	D100
Hammer dynamic performance	Impact part weight (t)	2.5	3.5	4.5	6.0	7.2	8.0	10.0
	Total weight (t)	6.5	7.2	6	15.0	18.0	17.0	20.0
	Impact Force (kN)	2000~2500	2500~4000	4000~5000	5000~7000	7000~10000	>10000	>12000
	Normal stroke (m)	1.8~2.3						
	Side length or diameter of premold square pile and prestressed pipe pile (mm)	350~400	400~450	450~500	500~550	550~600	600 or more	600 or more
	Steel-pipe pile diameter (mm)	400		600	900	900~1000	900 or more	900 or more
Supporting course	Cohesive soil, powdered soil	Normal entering depth (m)	1.5~2.5	2.0~3.0	2.5~3.5	3.0~4.0	3.0~5.0	
		Average value of static sounding specific penetration resistance P_s (MPa)	4	5	>5	>5	>5	

Table H.0.1 (continued)

Hammer selection			Diesel hammer (t)						
			D25	D35	D45	D60	D72	D80	D100
Supporting course	Sandy soil	Normal Entering Depth (m)	0.5~1.5	1.0~2.0	1.5~2.5	2.0~3.0	2.5~3.5	4.0~5.0	5.0~6.0
		Soil standard penetration compact number $N_{63.5}$ (Not revised)	20~30	30~40	40~45	45~50	50	>50	>50
Hammer Normal Controlled Penetrating Length (cm/10 compact)			2~3		3~5	4~8		5~10	7~12
Ultimate bearing pressure of design individual pile (kN)			800~1600	2500~4000	3000~5000	5000~7000	7000~10000	>10000	>10000

Note: 1 This table is only applicable for the selection of hammer;

2 This table is applicable to reinforced pre-cased concrete pile that the pile tip enters into the solid ground certain depth and the length is 20~60m, and the steel-pipe pile which the length is 40~60m.

Explanation of Wording in this code

1 Words used for different degrees of strictness are explained as follows in order to mark the differences in executing the requirements in this code.

1) Words denoting a very strict or mandatory requirement:

“Must” is used for affirmation; “must not” for negation.

2) Words denoting a strict requirement under normal conditions:

“Shall” is used for affirmation; “shall not” for negation.

3) Words denoting a permission of a slight choice or an indication of the most suitable choice when conditions permit:

“Should” is used for affirmation; “should not” for negation.

4) “May” is used to express the option available, sometimes with the conditional permit.

2 “Shall comply with...” or “shall meet the requirements of...” is used in this code to indicate that it is necessary to comply with the requirements stipulated in other relative standards and codes.

