TCXD CONSTRUCTION STANDARDS

TCXD 206: 1998

BORED PILES – REQUIRENMENTS FOR QUALITY OF CONSTRUCTION

(This translation is for reference only)

HA NOI – 1998

Bored piles – requirements for quality of construction

1. General principle

1.1. This standard specifies the main and minimum technical requirements on quality test of bored pile construction, used for the documents to test pile foundation.

This standard does not specify the specific test methods for quality control. But the contractor must specify in their bidding document on methods, equipment as well as test standard to meet common standards on quality specified by investors according to this standard. Depending on the importance of construction as well as the completeness of the equipment and experience of the construction company that investors may require higher than stated level in this standard.

Notes:

1) Analysis of the important level of the construction in accordance with the state current regulations (refer to Appendix A).

2) Assessment and processing of quality control results of piles should be taken in each period (refer to Appendix B).

1.2. The bidder should fully identify the technical basis prior to construction such as: construction drawings, special requirements (if any) of the design, the conditions of construction nature and hydrogeology are relation to the choice of construction technology, an allowable tolerance for the size and pile shape and piles stations, pile materials as well as the pile's bearing capacity.

Normally, before a series of construction should be proceed trying some piles to identify the technology and specific construction processes, to prepare for the next construction.

1.3 The problems related to the environment such as: noise level and vibration of equipment for humans and neighboring buildings as well as the handling of land taken from the pile, sludge of the bore mud should be adhered the environmental standards approved by state and local (standards relating to the environment refer to annex G)

1.4. All equipments, vehicles, power lines, safety equipment, tools, accessories, tools related to labour protection .vv, must be tested by inspection agencies with legal practicing functioning and regularly inspect to ensure safe use and reliability, regulatory compliance, "Safety in construction" mentioned in the bidding documents. Should be paid special attention on fire safety when drilling in the container of methane or other toxic gases.

1.5. Equipment, level, experience and skill of people working in bored pile quality control have meaningful decisions to the reliability of the test results ..., must have the technical management and periodic monitoring, selection of the specialized agencies authorized

1.6. The bored pile control quality assurance should clearly identify in text "programs and methods on quality management" and prepared by bidders in bid price after accepted bid they should be completed (if required) with the acceptance of investor and paid to state agencies as assigned.

Should have a consulting organization to help contractors ensuring quality and an independent consulting organization which help investors to check and confirm the quality of construction.

Note::

1) Equipment and technology as well as the capacity of different bored pile construction will lead to different quality. So, if a building has many equipments and difference technologies along with their construction should ensure the quality management for each type.

2) If that is the case referred to point 1 of this note, the total volume of construction required to test should increase compared with the regulations in this standards.

2. Pile hole

2.1. Pile hole can be created in the ground by difference drilling technologies should be defined specific drilling parameters to ensure pile holes with specified quality.

2.2. Locate the pile on the plan should rely on the landmarks and coordinate baselines are determined at the scene. Size of the pile hole (depth, diameter, the vertical or tilt) should comply with the requirements of the design.

2.3. Allowable tolerance of bored pile hole has been completed not exceed the regulation in Table 1.

Notes:

1) When construction on the water (sea, rivers, big lakes) consulting engineers on design can extend allowable tolerance specified in Table 1

2) For the constructions with 100% foreign fund, can refer to Appendix C to select the allowable tolerance of the pile hole.

2.4. Normally, should implement the experiments to keep the borehole before starting the construction in 3 boreholes outside the pile area, with the diameter and the depth as the most important piles, keep track in time of t not less than 4 hours that there is no indication of the hole, then boreholes need to be filled thoroughly with the excavated materials or cement mixer. In case there is no land then the user can use piles of construction to try (including concrete then) and regulated by design consultation.

2.5. Should be used appropriate methods (dredging by hand or machine, blow fire, pump ...) To clean the borehole before concreting, the thickness of loose soil or sediment that sinks the hole bottom (if any) must be written on hole diary and do not exceed the following regulations:

- Bearing pile ≤ 50mm;
- Skin friction pile = bearing ≤ 100mm
- Skin friction pile ≤ 200 mm

When designing not include resistance at pile tip (Pile extended each piece in itself), then do not to limit the thickness of loose soil and sediment at the hole bottom.

2.6. Before concreting, it is necessary to test the pile hole according to parameters specified in the table 2 and set a record as a basis for acceptance.

Table 1: Allowable tolerance on bored pile hole

Method for creating pile hole		**Allowable tolerance of pile diameter**	**Vertical allowable tolerance**		
				Single pile, Pile under band foundation on horizontal axis, inside edge pile	**Pile under band foundation on vertical axis, pile on pile group**
1. Bore pile uses solution for casing protection	D ≤ 1000mm	-0.1 D and ≤ -50	1	D/6 but not more than 100	D/4 but not more than 150
	D>1000mm	-50		10 + 0.01H	150+0.01 H
Making hole by pipe closing or vibration	D ≤ 500mm	-20	1	70	150
	D>500mm			100	150
Auger boring with extended pile bottom		-20	1	70	150

Note:

1. Negative values of allowable tolerance on pile diameter is particular section, when the pile bottom expanded then allowable tolerance of extended bottom is ± 100mm

2. Tilt error of the tilt pile is not greater than 15% tilt angle of the pile

3. Allowable tolerance of bore hole depth ± 100mm

4. H is distance between ground high reinforcement at the construction and pile cap high reinforcement specified in design, D is diameter of pile design

3. Solution for pile hole casing protection

3.1. Unless the soil can form a clay solution, or create holes by the other methods mentioned in the note of it, must use ready making solution for casing protection. Solution manufacturing must be mix designed according to equipments, construction technologies, borehole methods and construction geotechnical conditions and hydrogeology of the construction site. The initial target features of clay solution presented in table 3, if other chemicals are used to making the solution for casing protection then should be experimented in advance

Notes:

1) When casing protection with steel pile hole, dropping into the ground by drilling speed, the drill is not extended so certain limits to easy taking pipe to the ground (especially the hard soil), because the hole diameter was extended causing ground subsidence, causing problems when the pipe casing is drawn.

2) When the holes are created by the closing method or pipe vibration, casing protection of main pile through the connection pile.

Table 2 – Pipe hole 's parameters should be tested

Test parameters	Test method
Status of pile hole	-Visual inspection with headlight - Use of ultrasound or camera recording taken pile hole casing
The vertical and the depth	- Compare land mass taken up with the volume of the pile geometry. - By the amount of used liquid for casing protection - By the length of the drilling winch. - Plumb - Tilt meter, ultrasonic methods.
Hole size	- Sample, gauge, rules open and record the diameter size -By the diameter, rulers and record the diameter size. - By the diameter of casing protection pipe - By the opening of the bore wing when the bottom is extended
Status of hole bottom and the depth of pile tip on soil and rock	- Sampling and compare to rocks and soil when drilling, measuring the depth before and after the period t specified in Article 2.4 . - Purity of washing blowing water. - Method of dropping dumbbell or - Method of power (resistive, capacitive ...)

Table 3 – Original feature target of clay solution (if used)

Category	Feature targets	Test method
Density	1.05 – 1.15	Hydrometer of clay solution or Bomeke
Viscosity	18-45 seconds	Funnel method 500/700 $_{cc}$
Sand content	<6%	
Colloid ratio	>95%	Method of cup measuring
The amount of filtration	<30ml/30 minutes	Instruments of the amount of filtration
The thickness of clay jacket	1-3mm/30 minutes	Instruments of the amount of filtration
Static cutting force	1 minute: 20-30mg/cm ^{2} 10 minutes: 50-100mg/cm ^{2}	Static cutting dynamometer
Stability	< 0.03g/cm ^{2}	
Value of PH	7-9	PH test paper

3.2. The solution for casing protection must comply with the following regulations:

- Density and viscosity of the solution should be selected appropriately according to geotechnical conditions and solution using methods (Appendix D);
- During construction, solution surface in pile hole must be higher than groundwater levels from 1.0 m or more, when be influenced by the groundwater, then the solution surface must be higher than the highest groundwater level 1.5 m;
- Before concreting, density of the solution in about 500mm from the hole bottom must be less than 1.25, sand content ≤ 8%, viscosity ≤ 28s to easily push up the ground.
- Solution quality should be managed reasonably for each depth of different soil and to maintain the stability of the hole casing until the end of the concrete, it is necessary to have appropriate measures

4. Reinforcement

4.1. Reinforcement cage in addition to compliance with the design requirements as reinforcement, the type and grade of welding rod, welding specifications, weld length, bonded and weld quality... must comply with the following regulations.

4.1.1. For fabricating the reinforcement cage, allowable tolerance according to Table 4.

Table 4. Allowable tolerance when fabricating the reinforcement cage

Category	Allowable Tolerance (mm)
1. Distance between principal reinforcement	± 10
2. Distance of stirrup and hooped reinforcement	± 20
3. Diameter of reinforcement cage	± 10
4. Length of reinforcement cage	± 50

4.1.2 Reinforcement cage is fabricated into sections, joint should be used welded joints (tensile or pulling) or forced (compression) and the requirements of the current design standard for reinforced concrete structures.

Note:

1) Do not use welding to join reinforcement. Allow the projection welding and spot welding by electric and determined by certificates of used reinforcement.

2) To ensure that the thickness of the protection concrete layer in accordance with design regulations, it is necessary to set the peaks on the principal reinforcement for each section and according to the depth is regulated in the design.

3) The reinforcement cage extrusion when concreting, it is necessary to test rigorously and must not exceed the prescribed value of design.

4.1.3. Edge distance - the edge between the principal reinforcements must be greater than three times the diameter of the steel aggregate particles of concrete.

4.1.4. Strengthen belts should be placed at outer edge of the principal reinforcements, the principal reinforcements without hook bending, hook according to construction technology requirements, not stuck inside cause affecting the operation of concrete pipe.

4.1.5. The inside diameter of the reinforcement cage must be greater than 100 mm outside diameter at connector of the concrete pipe.

4.2. Allowable tolerance of the principal reinforcements of reinforcement cage as follows:

- Piles that pour concrete underwater ± 20mm;
- Piles that do not pour concrete underwater ± 10 mm.

5. Pile concrete

5.1. Concrete construction for bored piles in soil with groundwater must comply with regulations on concreting under water and it is necessary to manage comprehensively the concrete quality when concreting.

Concrete quality management including material quality, proper mixing ratio, concrete slump, concrete strength ..., to make the pile can achieve specified quality level, fulfill enough work in design requirements.

When using commercial concrete, quality management should be implemented periodically and daily by concrete providing unit and test certificates submitted to the purchaser.

Normally, the amount of cement used is not less than 350kg/m^3 pile concrete.

5.2. Coarse aggregate may be gravel or crushed stone, the largest particle diameter should be no larger than 50 mm and not more than 1/3 of the smallest distance of edge-edge between the principal reinforcements, for unreinforced piles, not more than 1/4 pile diameter and should not be greater than 70mm. All the specifications of the lager aggregate are tested according to TCVN 1772: 1987 "Stone, gravel in building - test method".

5.3. Before concreting into the pile, it is necessary to sample, each pile must have a sample taken from the concrete sections will be located at the top, in the middle and at the pile tip, each of 3 samples.

5.4. Volume of concrete (form mixing station set in the field or from commercial concrete on the car) must have fully before concerting into a pile to ensure that concreting continuously. Finish dumping time of a whole pile should not exceed 0.5t (mentioned in the article 2.4) since the completion of drilling.

5.5. Shall be established for each pile of a concrete curves and must have at least 5 points distributed over the entire pile length. In the case, the volume of concrete with anormal variation versus calculations (less than or more than 30%), then special measures should be used.

5.6. Construction manager in bored pile is important, after completing then it is necessary to test the quality.

The number of test piles should be based on the situation stated in Article 1.1 and decided by design or consulting organizations but not less than the rate of % (compared to pile total) specified in Table 5. For the construction with a number of piles under pier is less with redundant structural and high load (piers, a tall frame house....) then should be tested more than specified (see Appendix E).

Note:

1) If the pile with slenderness ratio L / D> 30, mechanical pulse or tension wave inability to transmit to the pile array and core drilling have risk deviate from the side of the pile before reaching the pile tip. It is necessary to place gauge glass front of the piles to check the concrete quality by ultrasonic methods or radioactive isotopes (Appendix E).

2) The amount of gauge glasses are placed for a pile usually defined as follows:

- 2 pipes for piles with D ≤ 60 or 1 pipe in the middle of piles when the transmitter-receiver used on an axis;

-3 pipes for piles with 60 <D <120 cm;

- 4 pipes for piles with D> 120cm.

Table 5: Test volume of pile concrete quality

Test parameters	Test method	Minimum test ratio. %
The integrity of pile	-Compare concrete volume poured into the pile hole with geometric volume of the pile -Core drilling - Ultrasound, gamma scattering with the front tube - Small deformation method (PIT, MIM), defect is observed across core barrel by radio camera - Large deformation method PDA.	100 1-2% + other method 10-25% + other method ≥ 50 4% and not less than 5 piles
The expansion or restraint of the pile tip into rock	Small diameter drilling (36mm) at the bottom expansion or through the pile tip	2 -3 piles during testing or according to Appendix E
The concrete intensity of pile	- Samples experiment when concreting - The experiment on the concrete core when drilling. - According to the drilling speed (blow drill not take core) - Resilience Guns or ultrasound to concrete at pile cap	According to article 5.3 According to the requirements of this table
Note: *1)Normally, it is necessary to combine 2 or more different methods to compare a test parameter described in this table. When piles have L / D> 30, then test methods through available pile be mainly.* *2) Protection concrete layer, pile diameter and surface shape of the reinforcement can check at pile tip when removing the concrete upper reinforcement of the pile tip.*		

5.7. For the pile foundation of the building with significant on economic and social or history and the foundations in complex geological conditions, the reliability on slightly lower quality or disputes about quality then it is necessary to increase the volume of quality test (Appendix E), with re-inspection to check out the bond amount specified in the contract.

6 Load bearing capacity test of single pile

6.1. To ensure accuracy and reality on the standard value of the load bearing capacity limit of single pile must be based on the materiality and historical value of the constructions, construction geological

conditions, design requirements and the construction status to test static or dynamic is enough reliable for single pile.

Note:

1) When static compression of the single pile can not proceed to limit load then the design and consultant shall provide a minimum compressive load on the pile in accordance with the regulation of the standard on the pile static test

2) The selection of single pile static test method should be based on the criteria required by the design or consultant with the acceptance of the investor.

6.2. The pile foundation constructions have one of the cases referred to in Articles 6.2.1 and 6.2.2 must test single pile static compression by vertical method. The number of test piles are not usually less than 1% total of piles, but not less than 3 piles, for construction with a total of piles less than 50 piles then it is necessary to experiment 2 piles.

6.2.1. Pile foundation of important construction but the single pile static test is not implemented before executing.

6.2.2. Before executing the work piles, ingle pile static test is not implemented but involving one of the following cases:

- Complex geological conditions;
- The reliability of the low construction quality;
- Pile foundation of the less important construction but many piles

6.3. The pile foundation constructions that have one of the cases referred to in Articles from 6.3.1 to 6.3.4 can test the vertical bearing capacity of single pile by dynamic test methods with the reliability, ratio% of dynamic test is required by consultants or design but usually not less than 4% and not less than 5 piles.

6.3.1. Pile foundation of important construction then the single pile static test is implemented before executing

6.3.2. Pile foundation of the less important construction as stated in Article 6.2.2.

6.3.3. Pile foundation of normally works.

6.3.4. Additional check for pile test by static compression.

Note:

1) The dynamic test method is considered reliable if it is compared with the results of pile static compression test in similar construction geotechnical conditions and correlation coefficients are relatively tight, then using the dynamic method to test with large numbers of executed pile.

2) Dynamic test methods have gauge that can measure penetration resistance and elastic refusal as well as large deformation method (PDA) is often used in dynamic testing for the pile.

3) The dynamic test under modern methods must be implemented by the highly qualified and practical experience engineers.

6.4. The pile foundation works in the following cases need to implement pile static testing under the effect of uplift or horizontal compression in accordance with the construction standards TCXD 88 1982 "Pile-field test method":

- Pile that bearing large spit in the building types such as TV tower, microwave communication tower, high-voltage towers, offshore oil and gas drilling, water pumping station located deep etc. ..
- Pile that bearing large cross in the building types such as bridges, ports, works in the hilly, quake works bearing etc.

Pile cap ratio should be tested, decided by consultants or design based on the requirements stated in Article 1.2 and 6.2 of this standard.

7. Acceptance for bored piles and work pile

7.1. The quality of the pile foundation must be ensured and check serious in the pile processing , recorded in the standard report being uniform regulation of quality management programs have been agreed and accepted by investors when winning time, recorded in acceptance document in accordance with the state regulation.

7.2. Acceptance for foundation piles includes the following documents:

General:

- Name of construction, name of the investor and the construction company name;
- Job caption
- Day, month, year of construction, weather, temperature;
- The name or number of the works, school number, diameter and design length of the pile;
- Type of construction methods, construction equipment, specified diameter;
- Drawings of the construction geological hole.

Hole creating:

- Groundwater level or sea river water;
- Speed and construction processing for the hole;
- The size and location of the pile hole(and the eccentricity of vertical);
- Diameter and hole depth, diameter or length of the pipe or located pipe in the surface layer, the actual length of the pile, the pile vertical.
- Inspection records in table 1 and table 2.

Casing protection and reinforcement

- Solution type for casing protection and solution management method ;

- Construction time for each stage;
- Arrangement of reinforcement, the connection method and the height initial stage of the concrete;
- Inspection records in Table 3 and Table 4;
- The malfunctions and problems if any and approach;
- Type and number of workers involved in the construction.

The quality test of piles:

- Report on the quality test of piles in Table 5 and the load capacity of single pile;
- Completion drawing of the pile foundation when excavating to the design column and high reinforcement drawing of pile cap.

7.3 . Pile work acceptance includes the following documents:

- Construction report and test report for reinforced concrete of the pile work;
- Report on anchored reinforcement between the pile cap and pile work, edges distance of the pile at the edge of the pile work of protective layer of pile work reinforcement;
- Record on the thickness, the length and the width of the pile work and the bond status of the pile work

Appendix A

Decentralization of the pile foundation construction

A.1. Based on the severity of the damage consequences caused by the damaged foundation (for human life, economic loss affecting the social production) when designing the foundation should be selected appropriate safety level (table A.1).

Table A.1 – Safety level of the pile foundation

(Standard JGJ 94-94, China)

Safety level	Damage consequence	Building type
Level 1	Serious	Civil buildings and importance industry buildings; industrial buildings with special requirements about the foundation disappearing
Level 2	Very serious	Civil buildings and general industry buildings
Level 3	Not serious	Architecture buildings are not important

A.2. In the quality control of the volume calculation of the bored pile to determine density of test piles (% of pile numbers) should be based on a scale (Table A.2) to perform.

A.3. Using table A2 as follows:

Multiplying the risk (by the numbers 1,2 or 3 in a row) with weights (0.5 to 3) depending on the rank in column.

Summing from section 1 to 9 of the above results;

Then, multiplying above sum with section 10 depending on the stress level;

Multiplying above result with the risk (1,2 or 3) is ranked at section 11.

If:

> 60: Use maximum quality control plus maximum non-destructive testing methods (NDT) (including available pipes);

42-60: quality control plus NDT

<42: normal quality control, don’t need NDT

Table A.2 - Scale used to check the entire of bored pile block

(Federal Highway Administration, 1993)

Category	Number description	Risk assessment			Weight
		1	2	3	
1	Foundation contract value (10^6 USD)	0.25	Medium	1.0	1.0
2	Experience and equipment of contractors	Good	Medium	Weak	1.5
3	Levels of knowledge about soil conditions (the survey) and the experience level of technical inspection	High	Medium	Low	1.5
4	The difficulty and complexity of construction	Low	Medium	High	1.5
5	As predicted (homogeneity) of the soil conditions	High	Medium	Low	1.5
6	Design conditions (including the mechanism of resistance of the pile)	Friction	Mixture	Bearing pile	1.0
7	Construction method	Dry	There is casing (left) There is casing (pulled up)	Use the solution and temporary casing Use the solution but not use casing	1.0 0.5 1.5 2.5 3.0
8	Capacity type	Axial	Tilt axial	Horizontal	1.0
9	Charging length	Dynamic load affect on short time, shockless or low	Knock or move	Short time (load static)	1.0

					2.0
10	The stress in proportion compare with the maximum allowable stress	[0.33] x 1.2	[0.67] x 1.2	[1.0] x 1.2	
11	The risk for pipe existence or economic disaster if damage occurs within the structure service	Low	Medium	High	

Note:

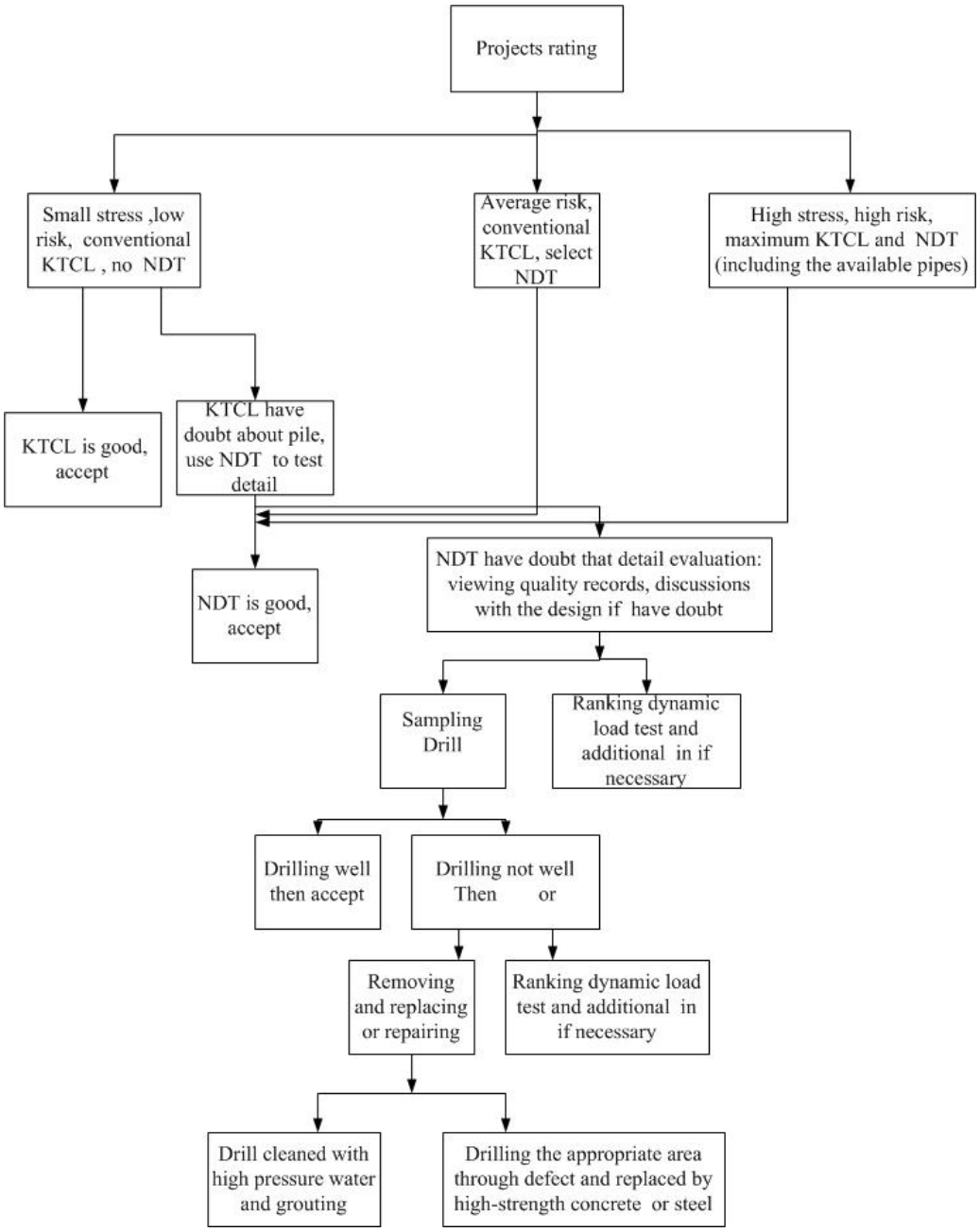
1) Instruction is only preliminary suggestions, finally decided by design engineers;

2) Multiply by 1,2 (in Section 10) if pipe casing don't leave (drawn up).

Annex B

Diagram for evaluation and treatment of bored piles

(Federal Highway Administration, 1993)



Note:

1) NDT: The non-destructive testing methods;
2) Dynamic load test: According to the method of small deformation dynamic test, (PIT, MIM) or large deformation (PDA):
3) QIA: Mean is the regular quality control as monitoring, drilling records, the solution, concrete ... usually specified by design.

Annex C

Allowable tolerance on pile hole

Standard	Vertical	Position
ADSC	2% on entire of pile length	7.5cm
FHWA (1998)	2% on entire of pile length	1/24 of pile diameter or 7.5cm
FHWA (1990)	1/48	7.5 cm
ACI	+ For the pile without reinforcement: 1,5% on entire of pile length + For the pile with reinforcement: 2% on entire of pile length	4% of pile diameter or 7.5 cm
ICE	1/75	7.5 cm
CGS	2% on entire of pile length	+ 7.5 cm + 15 cm for marine construction

Note:

ADSC: The International Association *of* Drilled *Shaft Contractors*

FHWA: Federal Highway Administration

ACI: American concrete institute

ICE: Institute of Civil engineering

CGS: Canadian Geotechnical Society

Annex D

Specification of Bentonite clay solution used (Japan experiment)

Drilling method	Stratum	Specification of clay solution					
		Density	Viscosity (Pa.S)	Sand content %	Colloidal material ratio %	Filtration (ml/30min)	PH
Favorable circulation , pressing drill	Clay	1.05÷1.20	16 ÷22	< 8 ÷4	> 90÷ 95	<25	8 ÷10
	Sandy soil Grit soil Pebble stone ballast	1.2 ÷1.45	19 ÷28	< 8÷4	>90 ÷95	<15	8 ÷10
Thrust drill, Bitter drill	Clay	1.1 ÷1.2	18 ÷24	<4	>95	<30	8÷ 11
	Sandy soil Gravel	1.2 ÷1.40	22 ÷30	<4	>95	<30	8÷11
Inverse circulation drill	Clay	1.02÷1.06	16÷20	<4	>95	<20	8÷10
	Sandy soil	1.0 ÷1.10	19÷28	<4	>95	<20	8÷10
	Grit soil	1.1 ÷1.15	20÷25	<4	>95	<20	8÷10

Annex E

Ratio regulation % of pile should be placed available pipe and checking for normal construction (DTU 13.2, P1 -212, 9-1992, French) (N- Total of construction piles, n- pile amount in a pier foundation)

Force receiving method of the pile	N	n≤ 4				n>4			
		A number of available pipes		A number of test piles		A number of available pipes		A number of test piles	
		Pipes 50/60	Pipes 102/114	Pile poll NDT	Trepan at the pile point	Pipes 50/60	Pipes 102/114	Pile poll NDT	Trepan at pile point
Only partial friction	≤50	100	0	100	0	100	0	50-100	0
	>50	100	0	100	1	50-100	0	50-100	0
Partial friction and pile point	≤50	100	≥ 50	100	≥30	100	≥ 30	50-100	≥ 20
	>50	100	≥ 30	50-100	≥20	50-100	≥ 20	50-100	≥ 10
Only pile point	≤50	100	100	100	50-100	100	50-100	50-100	≥ 30
	>50	100	50-100	50-100	≥ 30	50-100	≥ 30	50-100	≥ 20
See article 5.6: Determine the amount of available pile correspond to pile diameter									

Annex G

Related standards on environment

TCVN 5949:1995 Acoustics. Noise in public and residential areas. Maximum permitted noise level

BS 5228:1992 Noise control on construction and open sites. Part 4. Code of practice for noise and vibration control applicable to pilling operations

TCVN 5524:1995 Water quality. General requirements for protecting surface water against pollution

TCVN 5525:1995 Water quality. General requirements for protection of underground water