Foreword

According to the requirements of Document JIANBIAOHAN〔2021〕No. 11 issued by the Ministry of Housing and Urban-Rural Development(MOHURD)-"Notice on Printing and Distributing 'the Development and Revision Plan of National Engineering Construction Standards in 2021'", and after extensive investigation and research, summarization of practical experience, consultation of relevant international standards and foreign advanced standards, and wide solicitation of opinions, the drafting group has revised this standard.

The standard consists of 11 chapters and 9 appendixes, covering: general provisions, construction layout, construction survey, foundation construction, pump house construction, construction of inlet and outlet structures, construction of other types of pumping stations, construction under special weather conditions, installation of monitoring facilities and observation during construction period, installation and testing of steel structures, quality control and construction acceptance of pumping station, etc.

The main technical contents of the revision of this standard are:

1. The requirements for construction management of water pumping stations, structure removal of strengthening and retrofitting projects, and environmental restoration, safety production, occupational health, environmental protection and soil and water conservation are added.

2. The requirements of construction control network survey and construction setting out are modified, and the requirements of completion survey are added.

3. The requirements of foundation treatment and special foundation treatment are modified.

4. The general provisions for construction under special weather conditions, construction under catastrophic weather, and requirements for the construction of shaft pumping station and submersible pumping station are added.

5. The requirements of installation and commissioning of hoist and trash remover, construction acceptance of pumping station are modified.

6. In quality control, the general provisions and the requirements for concrete quality test and defect treatment are modified, and the requirements for construction safety, environmental protection and soil and water conservation during construction are not included.

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Contents

1 General provisions

1.0.1 This standard is prepared with a view to standardize the construction and acceptance of water pumping stations, unify the technical requirements, and achieve the objectives of safety, economy and convenient management.

1.0.2 This standard is applicable to the construction, extension and renovation of large and medium-sized irrigation and drainage pumping stations, and civil structures, installation of steel structures and acceptance small pumping stations in which medium-sized and above pump units are installed.

1.0.3 Construction planning shall be prepared by constructor prior to the commencement of the construction of the pumping station.

1.0.4 Any new technology, material, equipment and process to be used in pumping station construction shall be tested or validated.

1.0.5 For a renovation project, a special scheme for structure removal and environmental restoration should be prepared and the proceeding construction and acceptance activities shall be performed according to the scheme.

1.0.6 Work safety, occupational health and environmental protection involved in the construction of pumping stations shall comply with current professional standard SL 721 *Guidelines for Construction Safety Management of Water and Hydropower Projects*, and water and soil conservation involved shall be carried out in compliance with the provisions of current national standard GB 50433 *Technical Standard of Soil and Water Conservation for Production and Construction Projects*.

1.0.7 A complete set of technical archives shall be established for the construction and acceptance of pumping station projects. The technical archive shall comply with the provisions of current national standard GB/T 50328 *Code for Putting Construction Project Documents into Records*.

1.0.8 In addition to the requirements stipulated of this standard, the construction and acceptance of pumping stations shall also comply with requirements of the current relevant national standards.

2 Construction layout

2.1 General requirements

2.1.1 Construction layout shall be determined reasonably according to overall planning and local conditions based on the general layout of pumping station, structure type, construction conditions, and natural and social conditions of the project site.

2.1.2 For pumping station projects requiring river diversion during construction, the river diversion shall meet the requirements of current professional standard SL 303 *Specifications for Construction Planning of Water Resources and Hydropower Projects*.

2.1.3 The major construction plants and temporary facilities shall be located in such a way as to avoid or mitigate the impact of flood during the construction period, to meet the flood control requirements determined by the design, and to avoid area with adverse geologic conditions or area with potential hazards.

2.1.4 The construction layout shall meet the requirement of rational use of land, convenience of both production and living, minimizing soil erosion and least occupation of basic farmland and ecological red line controlled areas.

2.1.5 The temporary construction facilities should be arranged in combination with the permanent house buildings so as to minimize the removal and relocation of temporary facilities during construction and the construction site to be occupied. Permanent buildings and existing facilities may also be used as temporary facilities during construction.

2.1.6 If the site conditions allow construction layout alternatives differing greatly from each other, a careful comparison shall be made to select the optimum scheme. If necessary, special demonstration shall be carried out.

2.2 Methods and requirements of construction layout

2.2.1 Construction layout shall be formed in stages according to construction needs, and shall meet the construction requirements of each stage. The range of construction site to be leveled should be determined according to construction layout requirements.

2.2.2 In the construction layout design, the layout of construction diversion works and the construction zones of the main works should be first determined, and then the layout of temporary facilities, internal and external transportation. When arranging construction, factors such as the location and area of available site, the combination of temporary structures and permanent facilities and others shall be coordinated and considered. The boundary of production zone should be closed, and when the production zone is connected to the construction management zone and the living zone, measures such as fence or barricade shall be used to separate them.

2.2.3 The construction layout may be designed to include the following functional zones:

1 Main works construction area.

2 Construction plant areas.

3 Material processing area.

4 Warehouses and stockyards.

5 Assembly area for electromechanical equipment and steel structures.

6 Stockpiling or disposal area.

7 Construction management and living quarters.

2.2.4 The main construction zone should include the construction sites of main structures such as inlet structure, pump house and outlet structure. During the construction period, construction roads for earthwork excavation and backfilling, masonry works and concrete placing, as well as the assembly sites and transportation of steel structures, electromechanical equipment, shall be economically and reasonably considered.

2.2.5 The construction plant area should include working sites for aggregates production, steel bar fabrication, concrete production, water supply, power supply, wind supply, communications, mechanical repair and processing and others. The plants should be placed near the users and those to be served, occupy least arable land, avoid poor geological areas, and shall meet the requirements of flood control, firefighting, occupational health and environmental protection.

2.2.6 The material processing area shall be arranged in a wide and open place, with convenient transportation and good drainage.

2.2.7 Warehouses and stockyards shall possess good transportation conditions, and their layout shall conform to relevant national safety regulations on fire prevention and explosion prevention.

2.2.8 The assembly area for electromechanical equipment and steel structures should be arranged near the installation site. For large electromechanical equipment or steel structures, the assembly area should be planned for easy transportation and installation in advance. When the site nearby restrains, surrounding locations convenient for equipment transportation and installation may be selected. Reasonable connection between civil works construction and equipment installation shall be ensured, and the built structures and facilities from the construction of civil works shall be fully utilized to arrange the assembly area economically and reasonably.

2.2.9 The spoil shall be dumped to the nearby landfill or the gullies, sloping lands and wastelands that meet environmental and water protection requirements. It shall be piled up in an orderly manner and covered with soil for landfill to avoid occupying cultivated land and economic forest land. The side slope of stockyard for reserved soil shall be stable and safe with good drainage facilities. The temporary stockyard should be located near the site where the spoil is to be used and shall have good conditions for excavation, loading and unloading, and transportation.

2.2.10 The construction management and living quarters should be located near the construction site with convenient transportation and communications and good sunshine, ventilation, water supply, and drainage, and shall avoid the areas prone to flood, landslide or debris flow. The standard of buildings shall be determined according to local topography, meteorology and the service life of the building. A permanent structure or prefabricated mobile house should be used for the building with a design service life of more than 5 years.

2.2.11 The scheme for access and hauling roads shall be determined according to the construction layout and construction schedule. The scheme for access roads should be made to ensure the links from the construction site to highway stations, railway stations and ports, and the roads shall be able to meet the requirements of transportation, loading and unloading of materials

from outside during construction. The scheme for hauling roads shall be made to facilitate the transportation within the internal working area, to the material stockyard, disposal area, production area and living quarters of the construction site, and easy to connect with the external access road.

3 Construction survey

3.1 General requirements

3.1.1 Before construction surveying, the following work shall be done:

1 The data related to the horizontal and vertical control and the topographic survey of the construction area shall be collected.

2 Engineering design drawings shall be consulted to clarify construction needs.

3 Setting-out data shall be prepared.

4 Construction survey plans shall be prepared.

3.1.2 Construction survey shall cover the followings:

1 According to overall layout of construction and relevant data requirements, the control network for construction shall be set up.

2 According to construction requirements of each stage, topographic survey or setting-out and checking for structure construction, and installation of steel structures and electromechanical equipment shall be carried out.

3 The geometry of the structures after completion shall be measured.

3.1.3 The construction plane coordinate system should be consistent with the coordinate system of design drawings, or an independent construction coordinate system that has a conversion relationship with the coordinate system of design drawing may be established according to the construction needs. The construction elevation system shall be consistent with the elevation datum of design drawings, and shall be linked with the nearest national benchmark as required.

3.1.4 The main precision indices of outline setting-out for pumping station construction shall be in accordance with those specified in Table 3.1.4.

Table 3.1.4 Main precision indices of outline setting-out for pumping station construction

Construction item		Precision index (mm)		Remarks
Divisional works	Position	Allowable deviation of plane position	Allowable deviation of elevation	
Concrete	Pump house floor	±20	±20	The plane position is relative to the axis control point (the marking points on the central axis of the main pump house); The elevation is relative to the working base point
	Inlet and outlet channel and pump foundation pit	±10	±10	
	Abutment wall, wing wall	±25	±20	
	Stilling basin, blanket	±30	±30	
Mortar masonry	Abutment wall, wing wall	±30	±30	
	Bottom, apron, slope revetment	±40	±30	
Dry masonry	Bottom, apron, slope revetment	±40	±30	
Excavation works	Main engineering foundation	±50	±100	The allowable deviation is relative to the adjacent control point or measuring station and points on the axis
	Non-main engineering foundation	±100	±100	
	Soil, sand, and stone coverage	±200	±200	

3.1.5 Construction measuring instruments and tools shall be regularly certified or calibrated according to national relevant regulations, used within the validity period, and shall be maintained and checked in time.

3.1.6 Original records of the field book shall be true, legible, correct and complete, and shall not be altered, transcribed or made up afterwards.

3.2 Construction control network survey

3.2.1 The horizontal control network of construction may be established using Global Navigation Satellite System (GNSS) network, triangulation network, traverse or traverse network. The axis of the main pump house should be included as one side of the control network.

3.2.2 The points on the axis shall be set out according to the centerline mark of the pumping station, and the root mean square error (RMSE) shall be in accordance with those specified in Table 3.2.2.

Table 3.2.2 Limit of RMSE of main points on axis

Axis type	The RMSE relative to adjacent control points (mm)
Axis of civil works	≤10
Axis for installation	≤5

3.2.3 Regarding the order of the primary horizontal control network for construction, the second order may be adopted for the concrete structures of large pumping stations, the second or third order, for the earth-rock works of large pumping stations, the third order, for the concrete structures of medium-sized pumping stations, the third or fourth order for the earth-rock works of medium-sized pumping stations, the fourth order, for the concrete structures of small pumping stations, and the fourth or fifth order, for the earth-rock works of small pumping stations. Main technical requirements for the measurement using GNSS network, triangulation network, traverse or traverse network shall be determined according to those specified in Table 3.2.3-1, Table 3.2.3-2 and Table 3.2.3-3.

Table 3.2.3-1 Main technical requirements of GNSS network survey

Order		Average side length (km)	Fixed error (mm)	Coefficient of proportional error (mm/km)	Relative RMSE of side length between constraint points	Relative RMSE of the weakest side after constrained adjustment
Second order		9.0	≤10	≤2	≤1/250 000	≤1/120 000
Third order		4.5		≤5	≤1/150 000	≤1/70 000
Fourth order		2.0		≤10	≤1/100 000	≤1/40 000
Fifth order	Level 1	1.0		≤20	≤1/40 000	≤1/20 000
	Level 2	0.5		≤40	≤1/20 000	≤1/10 000

Table 3.2.3-2 Main technical requirements of triangulation network survey

Order		Relative RMSE		Number of observation set			RMSE of angular measurement (")	Maximum closure of triangulation network (mm)
		Starting side	Weakest side	1″ class instrument	2″ class instrument	6″ class instrument		
Second order		≤1/250 000	≤1/120 000	12	–	–	≤1.0	≤3.5
Third order		≤1/150 000	≤1/70 000	6	9	–	≤1.8	≤7
Fourth order		≤1/100 000	≤1/40 000	4	6	–	≤2.5	≤9
Fifth order	Level 1	≤1/40 000	≤1/20 000	–	2	4	≤5.0	≤15
	Level 2	≤1/20 000	≤1/10 000	–	1	2	≤10	≤30

Table 3.2.3-3 Main technical requirements of traverse or traverse network survey

Order		Traverse side length (km)	Average side length (km)	Relative RMSE of distance measurement	Relative closure of traverse side	Number of observation set			The RMSE of angular measurement (″)	Closure of azimuth angle measurement (″)
						1″ class instrument	2″ class instrument	6″ class instrument		
Third order		14	3	≤1/150 000	≤1/55 000	6	10	–	≤1.8	$\leqslant 3.6\sqrt{n}$
Forth order		9	1.5	≤1/80 000	≤1/35 000	4	6	–	≤2.5	$\leqslant 5\sqrt{n}$
Fifth order	Level 1	4	0.5	≤1/30 000	≤1/15 000	–	2	4	≤5	$\leqslant 10\sqrt{n}$
	Level 2	2.4	0.25	≤1/14 000	≤1/10 000	–	1	3	≤8	$\leqslant 16\sqrt{n}$
	Level 3	1.2	0.1	≤1/7 000	≤1/5 000	–	1	2	≤12	$\leqslant 24\sqrt{n}$

Note: n is the number of measuring stations.

3.2.4 After the primary horizontal control network for construction is established, repeating survey shall be conducted periodically according to network structure and accuracy as the network is set up. If any evidence of control point displacement is found, repeating survey shall be performed.

3.2.5 Leveling should be adopted to establish the vertical control network for construction. The trigonometric leveling by electromagnetic distance measurement may be adopted for the control network of the fourth order and below, and GPS fitting elevation survey may also be adopted for the fifth order.

3.2.6 Regarding the construction control network grade at the first-level elevation, the concrete buildings of large-sized pumping stations may be second-grade or third-grade, and the earth-rock buildings of large-scale pumping stations may adopt the third-grade. Concrete buildings of medium-sized pumping stations may be of the third grade, and earth-rock buildings of medium-sized pumping stations may adopt the fourth grade. Concrete buildings of small-sized pumping stations may be of fourth grade, and earth-rock buildings of small pumping stations may be of the fifth grade. Technical requirements for the level survey and the triangulation elevation survey of electromagnetic distance measurement shall be in accordance with those specified in Table 3.2.6-1 and Table 3.2.6-2.

Table 3.2.6-1 Main technical requirements for leveling survey

Order		Second order		Third order		Fourth order		Fifth order
Level type		DS05	DS1	DS1	DS3	DS1	DS3	DS3
Length of sighting line (m)	Optical	≤60	≤50	≤100	≤75	≤150	≤100	≤150
	Digital	≥3 and ≤60	≥3 and ≤50					
Difference between the forward and backward sighting distances (m)	Optical	≤1.0		≤2.0		≤3.0		Nearly equal
	Digital	≤1.5						
Accumulated difference between the forward and backward sighting distances (m)	Optical	≤3.0		≤6.0		≤10.0		–
	Digital	≤6.0						
Minimum height of sight above ground (m)	Optical	lower hair reading≥0.3		readings using upper, middle and lower hair		readings using upper, middle and lower hair		–
	Digital	≥0.55 and ≤2.8						
Number of repeated surveys on digital level		≥3		≥3		≥2		≥1

Table 3.2.6-1(continued)

Order		Second order		Third order		Fourth order		Fifth order
Level type		DS05	DS1	DS1	DS3	DS1	DS3	DS3
Difference between readings by basic and auxiliary divisions of the black and red side of the staff (mm)		≤0.5		≤1.0	≤2.0	≤3.0		–
Difference between the elevation readings by basic and auxiliary divisions of the black and red side of the staff (mm)		≤0.7		≤1.5	≤3.0	≤5.0		–
Discrepancy of height difference, closing error of connecting leveling and closed leveling for forward and backward observation (mm)	Plain area	$\leqslant 4\sqrt{L}$		$\leqslant 12\sqrt{L}$		$\leqslant 20\sqrt{L}$		$\leqslant 30\sqrt{L}$
	Mountainous area	–		$\leqslant 4\sqrt{n}$		$\leqslant 6\sqrt{n}$		–

Note: n is the number of leveling stations in one way. If there are more than 16 stations per km, the closure shall be calculated as in mountainous area. L is the length of leveling route (km). When the sighting image is noticeable, clear and steady, the length of sighting line specified in the table may be increased by 20%.

Table 3.2.6-2 Technical requirements for trigonometric leveling by electromagnetic distance measurement

Order	Zenith angle observation				Slope distance observation			Observation mode	Discrepancy of elevation difference with reciprocal observation (mm)	Closure of connecting or closed leveling line (mm)
	Instrument accuracy	Number of observation set	Difference of index error (″)	Difference of observation sets(″)	Instrument accuracy	Number of observation set	Maximum side length (km)			
Fourth order	2″level	3	≤7	≤7	10mm	2	≤1	reciprocal observation	$\leqslant 40\sqrt{D}$	$\leqslant 20\sqrt{L}$
Fifth order	2″level	2	≤10	≤10	10mm	2	≤1	reciprocal observation	$\leqslant 60\sqrt{D}$	$\leqslant 30\sqrt{L}$

Note: D is the distance side length (km), and L is the total length of leveling line (km).

3.2.7 At least one surface benchmark and one underground benchmark shall be set up for the construction leveling points. For the construction of large pumping station, two surface benchmarks and two underground benchmarks should be set up. The benchmark shall be located at a place free from construction influence, with solid foundation and easy to preserve. The burial depth shall be 0.5m below the frozen soil layer and the foundation shall be of concrete.

3.2.8 After the primary vertical control network is established, repeating survey shall be conducted periodically according to the network shape and accuracy as set up. If any elevation point is found to have evidence of displacement or settlement, re-survey shall be carried out.

3.2.9 After the control networks for construction are completed, maintenance and management shall be given close attention. Control points shall be equipped with conspicuous protective facilities. If the control point is destroyed, but still needed, it shall be restored with original order and accuracy. With the construction progress, the control network shall be gradually expanded and densified to ensure that the construction setting-out is directly established on the primary control points or the control points after densification.

3.3 Construction setting-out

3.3.1 Before construction setting-out, the data of existing control points, design documents and drawings, as well as geometric dimensions in the modification notice, shall be checked and confirmed

before being used as the basis for setting-out. The results of horizontal and vertical control points, points at axis and data of design drawings in the construction area shall be compiled for setting-out data according to design drawings and relevant data.

3.3.2 The construction setting-out method shall be reasonably selected according to the accuracy requirements of setting-out points, on-site conditions, and instruments and equipment. Polar coordinate method, intersection method, steel tape distance measurement method and GNSS RTK method. may be used for setting out the plane points. Leveling survey, trigonometric leveling by electromagnetic distance measurement, GNSS RTK elevation measurement method may be used for the elevation setting-out.

3.3.3 The control points for formwork on the bottom slab of pump house should be set out referring to the centerline of bottom slab in the direction perpendicular to the water flow direction and the centerline of inlet and outlet flow channel of the pumping station along the water flow direction set out the directly using the control points at axis with an allowable error of ±2mm.

3.3.4 The allowable deviation of measurement for installation of steel structures and electromechanical equipment of the pumping station shall be in accordance with those specified in Table 3.3.4.

Table 3.3.4 Allowable deviation for installation of steel structures and electromechanical equipment

Installation item		Allowable deviation (mm)		Remarks
		Plane	Elevation	
Penstock	Buttress plate	±3	±3	Relative to installation axis of steel pipe and vertical datum
	Center position of opening of the first erected pipe segment	±5	±5	
	Central position of opening of the pipe segments to be connected	±10	±10	
	Center position of openings of other pipes	±15	±15	
vertical lift gate	Lintel	±1	±2	Relative to centerline of the gate slot
	Bottom	±2	±2	
	Spacing between main and reverse rails and spacing between side rails	−1 to +4	-	
Pump	Embedded parts such as pump seat, motor seat and others	±2	±3	Relative to unit centerline and vertical datum
	Mounting center and orientation of stay ring	±(2 to 5)	Elevation±3 Levelness0.5	
	Inlet and outlet pipes	±2	±3	
Trash rack	Bottom gate	±3	±3	-
	Measuring point of main and reverse rail	±2	-	
Crane track	Gauge	±5	-	One track is relative to the other
	Relative elevation difference between parallel tracks	-	±10	
	Gradient	-	L/1 500	

Notes: 1 The upper and lower limits inside the table shall be determined by the installation company according to the accuracy requirements of specific equipment.

2 L is the length of crane track (mm).

3.3.5 The setting-out of elevation points for formwork, masonry or embankment shall be in accordance with the following requirements:

1 The elevation points used for concrete formwork, concrete plaster and installation of steel structures embedded parts shall be measured and checked by two benchmarks of known elevation.

2 When measuring the elevation of soft soil foundation, the soil settlement value shall be accounted for.

3 For measuring the installation elevation of main unit and the embedded parts of steel structures and the elevation of superstructure of pumping station, the initial observation reference marks shall be established on the bottom slab of pump house and the relative height difference control shall be adopted.

3.3.6 When setting out plane points and elevations using the GNSS RTK, the following requirements shall be in accordance with:

1 The coordinate conversion parameters of GNSS RTK may be obtained by homonymy points, the number of homonymy points shall be no less than 3, and shall be evenly distributed in or around the construction area.

2 Before the setting-out with GNSS RTK, the accuracy and reliability of coordinate conversion parameters shall be tested. The plane difference shall be no more than 50mm, and the elevation difference shall be no more than $30\sqrt{D}$mm (D is the distance from the reference station to the testing point, km).

3 The GNSS RTK reference station shall be relatively high in elevation, the alignment error shall be no greater than 2mm, and the antenna height shall be read to 1mm. The number of effective satellites operating at the rover should not be less than 5, and the fixed solution results shall be adopted.

4 Technical requirements for GNSS RTK plane setting-out shall be in accordance with those specified in Table 3.3.6-1.

Table 3.3.6-1 Technical requirements for GNSS RTK plane setting-out

Point RMSE (mm)	Relative RMSE of side length	Distance from reference station (km)	Number of observations	Order of starting point
≤±50	≤1/20 000	≤5	≥4	Fourth order or above
≤±50	≤1/10 000	≤5	≥3	Level 1 or above
≤±50	≤1/80 00	≤5	≥2	Level 2 or above

Note: The point RMSE is relative to the adjacent control point.

5 The technical requirements for GNSS RTK elevation setting-out shall be in accordance with those specified in Table 3.3.6-2.

Table 3.3.6-2 Technical requirements of GNSS RTK elevation setting-out

RMSE in elevation (mm)	Distance from reference station (km)	Number of observations	Order of starting point
≤±30	≤5	≥3	Fourth order or above

6 After setting-out points using GNSS RTK, a total station may be used to measure the side length and angles to check the plane position, leveling survey may be used to check the elevation, and the testing results shall meet the requirements.

3.4 Completion survey

3.4.1 On completion of the pumping station, the as-built plan drawings shall be made either by survey or by drawings compiled according to the needs. The coordinates and elevation system for the as-built plan shall be consistent with the original design drawing, and the scale should be 1:500.

3.4.2 The longitudinal and transverse cross-sections for the excavated foundation of main hydraulic structure shall be surveyed, and the scale of drawings should be 1:200 to 1:500.

3.4.3 The surveying and compilation of the as-built plan, and the surveying of the longitudinal and transverse cross-sections shall comply with the national current standards GB 50026 *Standard for Engineering Surveying* and SL 52 *Specification for Construction Survey of Water and Hydropower Projects*.

3.4.4 Completion survey and archiving data shall include the following:

1 Calculation results of the horizontal and vertical control network for construction.

2 Plans and profiles of major hydraulic structures and inlet and outlet channels.

3 Completion survey results such as table of coordinates, plans and profiles of the flow passing parts and other main parts of the structure.

4 Survey data of parts with special requirements.

5 Survey report.

4 Foundation construction

4.1 General requirements

4.1.1 Foundation construction shall comply with the following requirements:

1 The site shall be prepared, and temporary construction roads and water and electricity supply facilities shall be built.

2 Horizontal and vertical control points for construction shall be set up and set out.

3 Basic drainage facilities shall be arranged.

4 The foundation pit shall be excavated, and the soil and stone materials shall be stacked according to the design requirements.

5 Foundations of soft soil, expansive soil or collapsible loess shall be treated in accordance with the provisions and design requirements prescribed in Section 4.5 of this standard.

4.1.2 For foundation needing treatment, pre-construction field test on full scale should be performed in a selected representative area.

4.1.3 For treated foundations, the proceeding construction shall not be started until the foundation is qualified for acceptance.

4.1.4 For pumping stations with flood control requirements, the flood control works shall be determined in accordance with the construction planning design. If a specific construction flood control plan needs to be prepared, it should be submitted for approval or for record in accordance with relevant regulations.

4.1.5 If cultural relics and historic sites, fossils, as well as permanent marks and underground facilities set up by departments for administration of surveying and mapping, geology, earthquake, communications, municipal and others are found during construction, the construction shall be suspended accordingly and proper protective measures shall be taken, and report to relevant departments shall be made for proper action.

4.2 Foundation pit drainage

4.2.1 The planning and layout of foundation pit drainage system shall be coordinated and determined according to the topography, meteorology, hydrology, engineering geological conditions, discharge amount, off-site drainage system of the construction area. Before the completion of construction of the foundation structure, the foundation surface should be kept free of water.

4.2.2 Foundation pit drainage shall include initial drainage and regular drainage. The initial drainage discharge should be the summation of the amount of water accumulated within the foundation pit or area enclosed by the cofferdam, the seepage water from cofferdam and underground during pumping, and the possible amount of precipitation. Seepage flow, precipitation during drainage and construction abandoned water should be calculated separately for regular drainage, but construction abandoned water and precipitation should not be superimposed. The sum of the seepage flow and the larger value of either the construction disposal water or the precipitation shall be taken as the pumping intensity.

4.2.3 Methods of pumping from sumps, well points or deep wells (also called bored wells) shall be

used for draining or dewatering of the foundation pit according to the geology and hydrogeology. For soil foundation with no artesian aquifer, the sump method may be adopted. For foundation of sandy soil, sand and pebbles with artesian aquifer, the well point method may be adopted for dewatering.

4.2.4 The following requirements shall be in accordance with the use of sump methods:

1 Sumps and drainage ditches shall be set at an appropriate distance outside the pit perimeter of the foundation.

2 Sumps and drainage ditches shall be constructed at corresponding lower elevations along with the progressing of the foundation pit downward excavation. The bottom of the sump shall be 1.0m lower than the excavation surface of the foundation.

3 When the foundation pit is relatively deep, berms and drainage facilities shall be set in stages at different elevations.

4 The capacity of drainage equipment shall be compatible with the required amount of water pumping, and certain spare capacity shall be provided in reserve.

4.2.5 Well points or deep wells may be used for dewatering. The choice should be made by comparison in considerations of factors such as thickness, burial depth, permeability coefficient of the permeable layer, the required water level drop, and the foundation pit area.

4.2.6 For dewatering by well points or deep wells, the number, location, and the depth of well, as well as the amount of water pumped and the model of equipment used shall be determined via calculation according to the hydro geological data and the required groundwater level drop. If necessary, the calculation parameters may be determined according to the on-site pumping test.

4.2.7 In the use of well point, double-row well point or annular well point arrangement should be applied when the foundation pit width is greater than 6m, while second or third stage well point arrangement should be used if the water level drop is required to be more than 5m. The well to well distance is 0.8m to 1.6m, and should not exceed 3m.

4.2.8 Well point construction shall be in accordance with the following requirements:

1 The construction shall be carried out in such a sequence as: install the header water collection pipe, sink the well pipe, fill the filter material, connect the pipelines, and install the pumping equipment.

2 All the components shall be connected tightly without air leakage. The header water collection pipe and the well pipes should be connected with soft hoses, and the header water collection pipe and water collection tank should be arranged at an elevation close to the natural groundwater table.

3 The diameter of the flushed hole shall be no less than 300mm, and the hole bottom shall be more than 0.5m lower than the foot of the tube.

4 When sand filter material is filled in the space between the well pipe wall and the hole wall, such filling works can only be taken as acceptable on the conditions that mud comes out of the pipe opening, or water filled in the pipe quickly drops down.

5 Test pumping shall be performed in time after completion of the installation of the well point system, and the section in a range of 0.5m below the well opening shall be sealed with cohesive soil balls when the installation is qualified for completion.

4.2.9 The number of well points installed should be 1.2 times the calculated number, and the final water level dropped by the installed well points should be 0.5m lower than the required value.

4.2.10 The construction of deep wells shall be in accordance with the following requirements:

1 The well may be formed by drilling, and clear water should be used to stabilize the wall.

2 All sections of the well tube shall be firmly connected and shall only be put into use after cleaning, inspection and acceptance.

3 The filter mesh and filter fabric shall be fastened to the filter pipes, and filter material shall be backfilled around the pipe wall according to the design requirements.

4 On completion of the well, well flushing by pumping shall be executed in down-stage and alternate pump-and-stop manner.

5 During the pumping test, the pumped water volume shall be adjusted, and pumping shall not be stopped until the predetermined drawdown of water level is reached.

4.2.11 During the pumping period from the well, the water level and flow discharge shall be observed on time and recorded properly. The turbidity of discharge shall be monitored at all times, and if the water is found turbid, the cause shall be analyzed and dealt with in time. If necessary, an observation well may be added. For well points, the vacuum degree shall be observed.

4.2.12 On completion of dewatering by well, the plug shall be removed, or the well shall be sealed according to the design requirements, and record shall be made.

4.2.13 If the excavated part of the foundation pit and the underlying strata are strongly permeable, such as sand and gravel, the seepage interception treatment and drainage of the foundation pit shall be determined according to the construction planning. The soil replacement method, mixing pile method, high-pressure jet grouting method, concrete cut-off wall method, or the secant bored pile wall method may be chosen for the foundation pit seepage interception according to the engineering geological conditions.

4.2.14 If adjacent buildings or structures, underground pipe networks are likely to be adversely influenced by the drawdown of the groundwater level, observation points shall be set up for settlement monitoring. If necessary, protective measures shall be taken.

4.2.15 Reliable power supply and backup equipment shall be furnished for foundation drainage.

4.3 Foundation pit excavation

4.3.1 The excavation cross section of foundation pit shall meet the requirements of design, construction, and slope stability of the foundation pit.

4.3.2 Earthwork excavation shall be in accordance with the following requirements:

1 The construction plan shall be reasonably determined according to the requirements of engineering geology, hydrogeology, surrounding environment, and actual construction conditions.

2 The configuration of excavation cross section shall be determined according to the soil properties, groundwater table, permafrost depth of the construction site and the construction method.

3 The earth and rock excavation shall be carried out in layers from top to bottom, and the excavated materials shall be transported out in time and piled up in a place with a safe distance from the excavation groove. Cutting and filling earthworks should be balanced. For high-slope excavation, flood control and slope protection measures shall be taken during the flooding season. For the excavation of soil slopes or rock slopes prone to softening, drainage measures shall be taken. If excavated materials are disposed in a large amount at the top or middle of the slope, the incurred impact on slope stability shall be avoided, and the slope stability shall be ensured.

4 For sludge excavation, means such as manual excavation, dredging machine excavation, slurry pump dredging shall be chosen in accordance with the sludge category for the improvement of

construction efficiency and the assurance of construction safety. When the moisture content of the sludge is high and backflow occurs from the dumped pile, a barrier shall be set up around the dumping area for protection.

5 For excavation in frost heaving soil areas, the drainage of surface water and underground flow shall be ensured.

6 Measures shall be taken to prevent the collapse of excavation in winter due to thawing. The weather forecast information shall be well commanded during excavation in rainy season, and excavation shall be suspended in rainstorm or heavy rain. Drainage and other protective measures shall be taken during excavation in light rain.

4.3.3 The excavations by hydraulic breakers shall be in accordance with the following requirements:

1 Water source, power supply and disposal site shall meet the construction requirements.

2 Excavation shall be carried out in zones, sections and layers, with periphery area excavated first and the center area excavated later. The depth of each layer should be 2m to 3m.

3 The hydraulic machine units shall be evenly laid out, with an advisable spacing of 20m.

4 The enclosure dike for the dumped sludge shall be compacted in layers.

5 The wastewater discharge outlet of the sludge disposal area should be arranged in a relatively low-lying place, and the wastewater shall be treated to meet the standard before being discharged into the nearby river course, and the discharge outlet shall be protected with scouring facilities.

4.3.4 A protective layer shall be reserved at the foundation pit bottom according to soil properties, weather, and construction conditions, and shall be excavated block by block just prior to the construction of structures on the foundation.

4.3.5 The foundation pit base shall be neither under-excavated nor over-excavated, and local over-excavation shall be backfilled and compacted. When mechanical excavation is adopted, it is advisable to reserve a 0.2m protective layer for later manual excavation.

4.3.6 For the foundation of expansive soil, collapsible soil or soft soil that cannot be excavated with side slopes due to space constraint or the slopes incapable of maintaining stability on their own after excavation, foundation pit support shall be adopted before excavation according to the design requirements.

4.3.7 For the excavation of foundation pit in rock, shall comply with the current professional standard SL 47 *Technical Specification for Excavation Construction of Rock-Foundation of Hydraulic Structures*.

4.4 Foundation treatment

4.4.1 The soil replacement method should be applied for the treatment of foundations of mud, muddy soil, collapsible loess, plain fill, or miscellaneous fill and for the treatment of shallow foundations with hidden ditches or underground ponds. The construction technical requirements for the soil replacement method may be referred to Appendix A of this standard.

4.4.2 The mixing pile method should be applied for the treatment of foundations of normally consolidated mud, muddy soil, silt, saturated loose sand, saturated loess or plain fill with a bearing capacity of less than 70kPa. If the mixing pile method is used for the treatment of foundation with peat, clay with a plasticity index larger than 25 or with corrosive groundwater, the suitability of such method shall be determined by tests. The mixing pile method may be divided into the dry method and wet

method according to construction method. The dry method should not be used for the soft soil foundation with groundwater having a pH value of less than 4 or a sulfate content of more than 1%. The wet method shall go through solidification tests to ensure the suitability of using sulfate-resistant cement to reinforce the foundation soil. The technical requirements of construction for the mixing pile method may be referred to Appendix B of this standard.

4.4.3 The static pressure grouting method may be applied for the reinforcement of foundations of sand, silt, clay or ordinary fill. It may also be used as a treatment measure for foundation reinforcement or deviation rectification of pump houses and auxiliary structures. Its construction technical requirements may be referred to Appendix C of this standard.

4.4.4 The high-pressure jet grouting method should be applied for the reinforcement or seepage control of foundations of gravelly soil, silt, clay, muddy soil, collapsible loess or artificial fill. For foundations containing groundwater with corrosiveness or too large flow velocity and suffered from groundwater outburst and containing a large amount of boulders or block stones, and for foundations of mud and peat, the feasibility of the use of the high-pressure jet grouting method should be determined by tests. The high-pressure jet grouting method may also be used for the foundation reinforcement of existing pump house, the support for the sidewall of deep foundation pits and foundation seepage cut-off curtains. The construction technical requirements for the high-pressure jet grouting method may be referred to Appendix C of this standard.

4.4.5 For the reinforcement of the foundations of clayey soil, silty soil, sandy soil or strongly weathered rock lower than groundwater table, rotary bored cast-in-place piles and percussion bored cast-in-place piles may be used. Percussion bored piles may also be used for the reinforcement of gravelly soil foundation and the foundation containing underground obstacles such as old foundations and isolated large boulders, while in karst developed areas, the use feasibility of percussion bored piles shall be analyzed. Auger bored cast-in-place piles may only be used for the reinforcement of foundations of clayey soil, silty soil, sandy soil, or plain fill above groundwater table. For the reinforcement of foundations of clayey soil, silty soil, sandy soil, crushed gravelly soil, fully weathered bedrock, strongly weathered bedrock or artificial fill, rotary bored cast-in-place piles may be used. The construction technical requirements for bored cast-in-place piles may be referred to Appendix D of this standard.

4.4.6 Precast reinforced concrete piles may be used for the foundation treatment of buildings, and reinforced concrete secant bored piles may be used to build seepage cut-off walls for pumping station foundation pits. The construction technical requirements for precast reinforced concrete square piles and secant bored piles may be referred to Appendix D of this standard.

4.4.7 Foundations of gravelly soil, sandy soil, low saturation silt, collapsible loess, plain fill or miscellaneous fill may be reinforced by the dynamic tamping compaction method or by densification method. The construction technical requirements for the dynamic compaction method and densification method may be referred to Appendix E of this standard.

4.4.8 Caisson may be applied for the treatment of the following foundations, and the construction technical requirements for foundation treatment by the open caisson method may comply with Appendix F of this standard.

1 Silt and quicksand foundations difficult to excavate.

2 Foundations surrounded by important buildings or with limited excavation spaces due to other factors.

3 Soil foundations or soft, broken rock foundations where excavation with a certain side slope is not allowed.

4 Foundations with too many piles to be arranged reasonably.

4.5 Foundation treatment of special soil

4.5.1 The treatment of collapsible loess foundation shall be in accordance with the following requirements:

1 Treatment methods and construction procedures shall be selected according to the engineering conditions of the pumping station.

2 The self-weight collapsible loess strata in the foundation may be treated by the soil replacement method, dynamic tamping compaction method, densification method, pre-immersion method or combination method.

3 The dynamic tamping compaction method should be used to treat collapsible loess foundation above groundwater table, with a water content between 10% to 22% and an average water content lower than the shrinkage limit water content by 1% to 3%. The construction technical requirements for the dynamic compaction method may comply with Appendix E of this standard.

4 For the treatment of collapsible loess above groundwater table in partial or entire area of the foundation, the densification method may be used, and the pile depth may be between 5m to 15m. The construction technical requirements for the pile-driving compaction method may be referred to Appendix E of this standard.

5 The pre-immersion method should be used to treat foundations with a collapsible loess layer larger than 10m in thickness and a calculated value of self-weight collapsing deformation of no less than 500mm. Sufficient water source shall be ensured if the pre-immersion method is used, and immersion duration, water consumption and collapsibility should be determined through on-site pit immersion tests before construction. The foundation treatment by the pre-immersion method shall be in accordance with the following requirements:

1) The distance from the edge of immersion pit to the existing buildings should not be less than 50m, and the stability of nearby buildings and site slopes shall be protected from being affected by immersion;

2) The side length of immersion pit shall be no less than the thickness of the collapsible loess layer. When the area of immersion pit is relatively large, it may be immersed in sections;

3) The water depth in immersion pit should not be less than 300mm, and the immersion shall be maintained till the moment that collapse deformation is stable. The criterion of stable deformation is that the average collapse deformation rate in the last 5 days is less than 1mm/d.

6 After the completion of foundation pre-immersion, supplemented site investigation shall be carried out before construction on the foundation, and the collapsibility of foundation soil shall be reassessed. The upper collapsible loess layer shall be treated by the soil replacement method or others.

7 Collapsible loess or non-self-weight collapsible loess in a small area may be treated by the soil replacement method, pile foundation or other methods. The construction method may comply with Appendix A and Appendix D of this standard.

8 If the combination of the above methods is necessary, the optimal combination methods shall be selected according to the factors, such as the grade of foundation collapse, thickness of the soil layer to be treated, type of foundation, requirements of the superstructure on the deformation and bearing

capacity of the foundation, and environmental conditions.

4.5.2 The treatment of expansive soil foundation shall be in accordance with the following requirements:

1 The treatment construction of the expansive soil foundation should be arranged in winter or dry season. If the rainy season cannot be avoided during construction, measures shall be taken to prevent rainwater infiltration.

2 Before foundation pit excavation, the drainage facilities shall be well arranged on the construction site, and surface water as well as construction water shall not flow into the foundation pit.

3 Temporary living facilities and construction facilities such as water tanks, washing yards, concrete batching plants shall be arranged far from the foundation pit.

4 Rainwater shall be prevented from soaking into the slopes, and the moisture evaporation from slope soil shall be prevented as well. Meanwhile, the alternation of drying and wetting shall be avoided. Moreover, a protection layer of shot cement mortar may be put on the soil slope surface or geomembrane may be used to cover the ground surface.

5 When the foundation pit is excavated close to the design base elevation, a protective layer of 0.3m thick shall be reserved, and the layer shall only be removed just prior to the start of next construction process. As long as the foundation pit is excavated to the design base elevation, cement slurry shall be laid on the base surface of the pit in time to seal the surface, or plain concrete cushion may also be quickly placed to protect the foundation. Structure construction may only be started after the cushion concrete obtains a design strength of more than 50%.

6 The surrounding area of the structure shall be backfilled in layers in time. Non-expansive soil, weak expansive soil or expansive soil mixed with cement shall be used for backfilling. If weak expansive soil is selected for backfilling, its water content should be 1.1 times to 1.2 times the water content of plastic limit.

4.6 Foundation strengthening

4.6.1 The treatment of uneven foundation settlement shall be in accordance with the following requirements:

1 The strata formation and engineering geological conditions of the foundation shall be ascertained, and when the pump house foundation is subject to uneven settlement due to insufficient bearing capacity or other factors, the analysis shall be performed to make it clear whether the settlement is stabilized according to the subsidence observation data. before foundation treatment.

2 If the settlement tends to be stabilized, foundation treatment measures such as strengthening the bottom plate and fixing the cracks of side wall may be taken.

3 For foundations with unstable settlement, specific study shall be performed, and the mixing pile method, high-pressure jet grouting method, bore cast-in-place pile method or drive-in precast pile method may be selected for treatment.

4.6.2 The leaning correction to the pump house shall be carried out based on technical and economic comparison to decide whether a scheme of removal and reconstruction or a scheme of leaning correction shall be chosen for the risk elimination and strengthening of the pump house.

4.6.3 The following methods may be used for the leaning correction to pump house:

1 The foundation soil settlement promoting method.

2 The foundation soil strengthening method.

3 The structure jacking-up method.

4 The foundation basic stiffness enhancing method.

5 The foundation (ground) stress relieving method.

6 The comprehensive method.

4.6.4 When the foundation soil strengthening method is used to correct the leaning of the pump house, additional disturbance to the original foundation soil due to foundation reinforcement shall not cause additional settlement.

4.6.5 The application of foundation (ground) stress relieving method shall be in accordance with the following requirements:

1 The drilling hole position and hole spacing arrangement shall be determined according to the plane size, inclination direction and inclination rate of the structure, and geological characteristics of the foundation.

2 The drilling tool and hole opening shall be selected according to the requirement of effective stress relief. The opening should be ϕ400mm, and the hole depth and burial depth of casing pipes shall be determined according to the location where the soil is taken out.

3 Large twist drill or large pot cone may be used for soil excavation, and the number, quantity and time interval of soil excavation may be determined according to the measured settlement and leaning monitoring data. The amount of soil excavation should be roughly equal to the correction amount.

4 During the construction, the settlement and leaning of the structure shall be observed in real time. Once any settlement or inclination of the structure is found to exceed a defined criterion, the construction plan or scheme shall be adjusted in time. Submersible pumps may be used to drain the hole.

5 Pipe pulling shall be carried out sequentially, and backfilling and compaction with qualified soil material shall be carried out in time.

4.6.6 During the construction of the leaning correction to the pump house, the uniform deformation of foundation soil within the area with holes to be arranged shall be ensured, the deformation shall be controlled within an allowable range, and an emergency plan shall be prepared.

5 Pump house construction

5.1 General requirements

5.1.1 The construction of pump house shall be not started until the foundation treatment is completed and accepted. Before concrete placing, preparation work shall be inspected, and the placing shall only be started after the acceptance of the preparation work and the issue of the placing permission from the supervision agency.

5.1.2 Before pump house concreting, sufficient construction machinery and labor resources shall be made ready, and related technical preparation of concrete mix ratio tests shall be well performed according to the placing requirements specified in the construction plan. Concrete construction shall meet the requirements of the provisions of national current standards of GB 50666 *Code for Construction of Concrete Structures* and GB 50164 *Standard for Quality Control of Concrete* and current professional standard of SL 677 *Specifications for Hydraulic Concrete Construction*.

5.1.3 The formworks, steel rebar works, concrete production and transportation, and construction of cast-in-place concrete structure shall meet the requirements of the provisions of national current standard of GB 50666 *Code for Construction of Concrete Structures* and SL 677 *Specifications for Hydraulic Concrete Construction*.

5.1.4 If installed with large or medium-sized vertical units, the pump houses may be constructed in layers and from bottom to top according to the pump house structure and the integrity requirements of the water flow channels, and the layer surface shall be flat. For the construction of layers at different elevation, inclined transition sections should be set up for connection.

5.1.5 The pump house should not be concreted in blocks in plane. When the pump house with relatively large length needs to be concreted in stages and sections, the placing units shall be formed with the permanent expansion joints as boundaries. Vertical construction joints should not be set up on the enclosure structure such as retaining wall of the pump house. Structures such as support piers, partition walls, floors and columns inside the pump house, and the hoist platform and water guiding wall outside the exterior wall of the pump house, may be placed in stages.

5.1.6 The verticality of permanent settlement joints of the pump house as well as the type, size, embedded location of the water-stopping facilities of permanent expansion joints, and the varieties and specifications of the materials used shall meet the design requirements.

5.2 Pump house bottom plate

5.2.1 The thickness and strength of the plain concrete bedding on the foundation surface shall meet the design requirements. If there is no specific design requirement, the thickness may be between 80mm to 100mm, the concrete strength shall be no lower than C15, and the outline of bedding concrete shall be placed larger than that of bottom plate concrete.

5.2.2 Braces with sufficient strength and stability shall be used in the steel rebar skeleton network of the upper and lower layers of the bottom plate, and the braces may be of erection steel bars, steel columns or precast concrete columns. The embedded rebars connected to the superstructures shall be

set up firmly.

5.2.3 Precast concrete columns shall be in accordance with the following requirements:

1 The structure of columns shall be compatible with the reinforcement of the column.

2 The characteristic value of the concrete strength shall be consistent with that for the structure parts receiving the concrete.

3 The surface of column shall be roughened and washed.

4 If used on site, the columns shall be propped up stably.

5 The concrete around the perimeter and above the top surface of columns shall be properly treated.

5.2.4 Concrete shall be placed continuously in layers and shall not be placed in inclined layers. When placing area is relatively large, it may be placed by the multi-step advancing method, and the distance between upper and lower layers should not be less than 1.5m. The joint parts of the same concrete layer shall be fully vibrated without missing vibration.

5.2.5 For concrete placed on inclined foundation surface, the placement shall be started from the lowest location, raised layer by layer with each layer placed horizontally.

5.2.6 During concrete placing, the mortar adhering to formwork, steel bar, waterstop sheet and embedded parts shall be removed in time. When there is too much bleeding water on concrete surface, measures shall be taken in time to remove the water accumulated in the placing area, but mortar shall be remained in position.

5.2.7 The concrete surface shall be screeded, floated and troweled accordingly.

5.2.8 The second-stage concrete construction shall be in accordance with the following requirements:

1 Before the placement of the second-stage concrete, the surface of the first-stage concrete shall be roughened, cleaned and washed.

2 Fine aggregate concrete shall be used for the second-stage concrete, and the strength grade shall not be lower than that of the first-stage concrete in the same position.

3 Only after the second-stage concrete reaches its strength to more than 70% of the designed characteristic value, the loading installation on it shall be started.

5.3 Flow passage

5.3.1 The flow passage of reinforced concrete shall be seepage resistant, leakage proof, crack resistant and free of misalignment. The flow passage profile shall be smooth, the change of the cross- section area along the passage shall be even and acceptable, and the roughness of flow passage surface shall meet the design requirements.

5.3.2 The inlet and outlet passages shall be placed integrally and respectively in the specified placing unit, and each placing unit shall not be further divided into blocks or placed in stages.

5.3.3 The concrete of the enclosure structures such as retaining walls, gate piers and partition piers that are subject to water flow should be placed integrally with that of the flow passages, and the relative formwork shall be erected in one time accordingly.

5.3.4 The formwork, brackets and scaffolding used for placing flow passages shall be well designed as construction structures, and load applied and calculation method may be chosen in accordance with the provisions of current national standard GB 50666 *Code for Construction of Concrete Structures*.

5.3.5 Trusses and composite beams with long spans shall be used for the scaffolding of placing area.

When columns are relatively high, steel-pipe composite columns or pre-cast reinforced concrete columns may be used, and sufficient rods and diagonal braces shall be provided in between to connect the columns. The connecting rods crossing the concrete body may be gradually disassembled as the placed concrete rises.

5.3.6 The formwork for flow passage should be prepared and pre-assembled in the factory and transported to the construction site for erection after acceptance check. The allowable deviation of formwork fabrication and erection shall meet design requirements. If there is no specific design requirement, the requirements in Table 5.3.6 shall be met. Generally, the allowable deviation for formwork of reinforced concrete beams and columns shall comply with the requirements of current national standard GB 50204 *Code for Quality Acceptance of Concrete Structure Construction*.

Table 5.3.6 Allowable deviations for formwork fabrication and erection

Item			Allowable deviation (mm)
Wood formwork fabrication	Formwork length and width		±3
	Surface height difference between two adjacent plates		0 to 1
	Local unevenness of plane dressed formwork surface (checking with 2m ruler)		0 to 3
Steel formwork fabrication	Formwork length and width		±2
	Local unevenness of formwork surface (checking with 2m ruler)		0 to 2
	Hole position of connecting parts		±1
Formwork erection	Axis position		0 to 5
	Internal size of cross section	Bottom plate and foundation	0 to 10
		Walls and piers	±5
	Surface height difference between two adjacent plates		0 to 2
	Upper surface elevation of bottom formwork		±5
	Height from floor to floor	Full height no greater than 5m	0 to 6
		Full height greater than 5m	0 to 8
Elevation of supporting surface for assembled components			−5 to 2
Formwork fabrication and erection for gate slot, door sill, flow passage, shaft pump house and other special requirements			Determined according to design requirements

5.3.7 The concrete placing shall only be commenced after the formwork erection and the steel bars placement are completed and accepted. If suspended for a long time without concrete placing after acceptance, inspection and acceptance activities shall be performed again before the concrete placing starts.

5.3.8 Cement with low hydration heat and low shrinkability should be chosen for concrete.

5.3.9 Comprehensive measures including temperature control joints shall be taken during concrete placing. After placing, the top surface of the concrete shall be floated to finish, then the concrete shall be cured with spraying water and concrete surface shall be often kept wet. Curing records shall be made, and indoor and outdoor temperature changes shall be observed regularly.

5.3.10 Concrete placing shall be started from a lowest place and carried out sequentially layer by layer. Concrete placing inside the formworks shall rise in a balance way. Chutes shall be laid in the placing area, and the number of chutes shall meet the requirements of reaching the designated positions.

Vibrator shall not be allowed to spread the concrete to a long distance. Concrete at the bottom of inclined formwork shall be fully vibrated. When the formwork area is relatively large, a window shall be opened for feeding and tamping or consolidating. Specific personnel shall be assigned to take care the temporary construction holes, which shall be plugged in time.

5.3.11 During the process of concrete placing, a communication and command system shall be established.

5.3.12 Before concrete placing for the pump house installed with horizontal centrifugal pump unit, the embedded inlet and outlet pipes or casings shall be reinforced and fixed in position according to design requirements, and concrete surrounding the embedded pipes shall be evenly fed and vibrated during the construction process. After the completion of concrete placing, the elevation, axis, and levelness of the embedded pipes shall be rechecked by survey, and the deviation shall meet the requirements of current national standard GB 50666 *Code for Construction of Concrete Structures* and the current professional standard SL 317 *Specification for Equipment Installation and Acceptance of Pumping Stations*.

5.4 Structure of pump house

5.4.1 The construction joints of the floor concrete structure shall be set up in accordance with the following requirements:

1 The construction joints at the bottom end of piers, walls and columns should be set on the top surface of bottom plate or foundation concrete previously placed, while those at the upper end should be set up under the floor slab or girder. For piers, walls and columns, integrally connected with floor slab, beam or wall-attached staircase near the middle height, which need to be placed in stages, the location of construction joints, embedded reinforcement bars and grooves shall be decided in consultation with the designer.

2 For a large cross-sectional beam integrally connected with slab, it should be placed together with the slab in one time. If it is placed in stages, the construction joints should be set 20mm to 30mm below the bottom surface of the slab, and if corbels are provided under the slab, the construction joints shall be set just below the corbels.

3 For floor slabs with main beams and secondary beams, the construction joints of the slab should be located within the middle third of the secondary beam span.

4 The construction joints of one-way slab should be set in parallel with the long side of the slab.

5 For two-way slabs, multi-layer rigid frames and other complex structures, the construction joints shall be set according to design requirements.

5.4.2 The concrete construction joints shall be treated in accordance with the following requirements:

1 The upper concrete shall not be placed until the lower concrete placed previously attains a strength of 2.5MPa.

2 The laitance layer and loose layer on the hardened concrete surface shall be removed, and the surface shall be washed, cleaned and drained.

3 Prior to concrete placing, cement mortar layer with a thickness of 20mm to 30mm shall be laid onto the horizontal joints, and cement paste shall be brushed onto the vertical joints. Water-cement ratio of the mortar and paste should be 0.03 to 0.05 less than that of concrete.

5.4.3 Formwork, brackets and scaffolding shall have sufficient supporting area and reliable anti-slip measures. The member nodes shall be firmly connected.

5.4.4 The erection of formworks and brackets for upper concrete shall be in accordance with the following requirements:

1 The lower formwork shall have sufficient strength or supports, and its brackets shall bear all the loads both from upper and lower concrete.

2 When a truss is adopted to support the formwork, its supporting structure shall have sufficient strength and rigidity.

3 The columns for upper and lower brackets shall be aligned vertically, and the cushion plate shall be laid.

5.4.5 The formwork of piers, walls and columns should be fixed with split bolts, and bolts for the formwork of water partition walls, chest walls, flow passages and other parts with anti-seepage requirements should not be provided with casings. After formwork removal, the exposed sections and the sections deeply embedded into the concrete cover at both ends of the bolt shall be cut off, and shall be densely filled and smoothed with cement mortar with the same quality as that of the structure. If necessary, seepage interception steel plates may be welded to the bolt.

5.4.6 The mixing proportion and aggregates of concrete shall be selected according to concrete grade and design requirements and shall meet the requirements of national current standards GB 50666 *Code for Construction of Concrete Structures* and SL 677 *Specifications for Hydraulic Concrete Construction*.

5.4.7 Waterproof concrete shall be used for structures with the requirements of seepage resistant, such as water partition walls, chest walls, and water tanks when their thickness is less than 400mm. The cementitious material content of waterproof concrete should not be less than 300kg/m^3, the sand ratio should be increased, and waterproofing agent should be added. The mixing proportions shall be determined by tests.

5.4.8 For concrete placing of high piers, walls and columns, chutes and conduits and the likes shall be used to convey concrete. For thin walls, columns and other structures with narrow cross sections and densely distributed steel bars, flat windows that are convenient for feeding and vibrating concrete may be evenly arranged on the side of the formwork at the appropriate parts. As the placed concrete surface rises, the windows shall be well sealed in time.

5.4.9 The concrete placing for beams and slabs to be integrally jointed with piers, walls and columns shall not proceed until 0.5h to 1h after the completion of concrete placing for piers, walls and columns.

5.4.10 During concrete placing, specific personnel shall be assigned to inspect the formwork and brackets. Once any evidence of deformation is found, the placing shall be suspended to identify the deformation cause. Strengthening measures shall be taken under the premise of safe construction. Concrete placing shall be started again only after the strengthening is accepted as qualified.

5.4.11 For a pump house accommodating a horizontal centrifugal pump unit and with a closed reinforced concrete substructure and a bent masonry column superstructure, the concrete construction joints shall be arranged and treated in conformance with the provisions in Articles 5.4.1 and 5.4.2 of this standard, and the permanent expansion joints shall be arranged and treated in compliance with the provisions in Articles 5.1.5 and 5.1.6 of this standard.

5.4.12 The pipelines for oil, gas, water, measurement, and power cables, which are embedded in concrete structure, shall meet the design requirements, and shall be protected and temporarily plugged accordingly during concrete placing. The embedded parts of electro-mechanical equipment, steel structures, HVAC and fire-fighting facilities shall be positioned by survey and strengthened according to

design requirements. After the completion of placing, rechecking by survey shall be done for the embedded parts of important equipment and tolerances shall meet the requirements of national current standards GB 50666 *Code for Construction of Concrete Structures* and SL 317 *Specification for Equipment Installation and Acceptance of Pumping Stations*.

5.5 Architectural and decoration works of pump house

5.5.1 Architectural and decoration works of pump house shall be in accordance with the following requirements:

1 Architectural and decoration works shall be carried out under the premise of ensuring the safety of structures.

2 The construction of next process shall not be started until the previous process is inspected as qualified.

3 Components and materials shall be selected according to design requirements and meet the requirements of current national standards for the products.

4 Measures shall be taken to prevent any damage or deterioration to components and materials during transportation, storage and construction.

5.5.2 A sample works shall be made first in decoration construction, and the formal decoration construction shall not commence until the sample works is inspected and accepted as qualified.

5.5.3 Construction of exterior plastering and finishing works shall be carried out from top to bottom.

5.5.4 The construction of interior decoration works should be carried out after the completion of roof waterproofing construction and under the premise that it will not be damaged by subsequent works. Protective measures shall be taken if decoration construction starts before the completion of roof waterproofing construction.

5.5.5 Indoor works like suspended ceilings, cover panels for partition and decoration shall be carried out after the completion of wet work of the indoor floor.

5.5.6 Architectural and decoration works construction of pump house shall meet the requirements of the current national standards GB 50203 *Code for Acceptance of Constructional Quality of Masonry Structures*, GB 50207 *Code for Acceptance of Construction Quality of Roof*, GB 50209 *Code for Acceptance of Construction Quality of Building Ground* and GB 50210 *Standard for Construction Quality Acceptance of Building Decoration*.

5.6 Strengthening and retrofitting of pump house

5.6.1 The repair of damaged concrete surface layer of the pump house shall be in accordance with the following requirements:

1 In the removal of damaged concrete surface layer, it shall be ensured that intact concrete, steel bars, pipelines, monitoring devices and other embedded parts below or around the damaged layer are free from damage, and the safety of buildings and equipment near the damaged area shall also be ensured.

2 Methods such as handwork, air pickaxe chipping, mechanical cutting, small-scale static blasting, and manual wedging by drilling in rows shall be selected to remove the damaged concrete according to the damaged area and depth and the impact of construction on the surrounding areas.

3 Suitable materials and construction techniques shall be chosen for damaged concrete repair

based on the location and the cause of the damage and under the premise of meeting design requirements for impermeability, frost resistance, erosion resistance, and weathering resistance. The technical index for repairing concrete shall not be lower than that for the original concrete, and the cement grade shall be no lower than that for original concrete.

4 For carbonized concrete surface, anti-carbonization coating may be used to seal the surface. Before sealing, the surface layer shall be cleared off, and such defects as concrete bulking due to the steel bar rusting, exposed steel bars and damaged parts of surface concrete shall be repaired. If necessary, puttying may be applied once or twice on the concrete surface to make the surface flat.

5 For the repair of underwater concrete parts, temporary water-retaining measures shall be taken according to the location and construction conditions of the parts to form a dry construction environment, or special repairing materials shall be used for underwater repair by divers.

6 For important parts or parts with specific requirements, the repair materials and their mixing proportions shall be determined through tests.

5.6.2 Concrete crack treatment of the pump house shall be in accordance with the following requirements:

1 Repair should be carried out at low water head or low groundwater table and at temperatures or under dry conditions favorable for solidification of repairing materials. For underwater repair, corresponding materials and methods shall be selected. For cracks affected by temperature, repair should be performed in the low temperature season along with relatively large crack openings. For cracks not governed by temperature, repair should be performed after the cracks reach stable.

2 Methods such as plastering, patching, inlaying and spraying shall be chosen for crack surface treatment according to crack location, nature and treatment requirements.

3 When grouting is used to treat the internal part of the cracks, grouting pressure and grouting materials may be determined according to the nature, opening, depth and construction conditions of the cracks and in combination with the field tests. For treatment of a crack with an opening greater than 0.15mm to 0.30mm, cement grouting may be adopted. For treatment of a crack with an opening of 0.05mm to 0.15mm, chemical grouting treatment should be applied. Expansion joints affected by temperature variation should be treated with chemical grouting.

4 For stress-induced cracks, the cracked components shall be strengthened according to design requirements first, and then the cracks shall be treated.

5.6.3 Concrete leakage treatment of the pump house shall be in accordance with the following requirements:

1 Measures such as surface treatment, internal treatment, or combination of both shall be taken for crack leakage treatment according to the cause of cracks and degree of influence by the cracks on the structure, leakage amount and the distribution of leakage points or areas, either in a concentrated or scattered state.

2 For parts subject to scattered or concentrated leakage, treatment methods such as grouting, surface coating, adding impermeable layer or combination of all or several of the above methods shall be adopted according to location, degree and construction conditions of the leakage.

5.6.4 When the strengthening treatment of pump houses by means of foundation replacement and inclination rectification is likely to adversely affect the overall safety of pump houses, construction shall be carried out after the technical parameters are obtained through tests or studies and verified by technical evaluation.

5.6.5 If the foundation of pump house and its substructure are damaged by groundwater corrosion,

corrosion prevention measures shall be taken in the strengthening works.

5.6.6 The strengthening and retrofitting of beams, columns, slabs, and other components of pump houses shall meet the requirements of current national standard GB 50367 *Code for Design of Strengthening Concrete Structure*.

5.6.7 The anti-seismic strengthening of beams, columns, slabs, and other components of pump houses shall meet the requirements of current national standard GB 51247 *Standard for Seismic Design of Hydraulic Structures*.

5.6.8 In addition to meeting design requirements, the treatment or retrofitting of superstructure walls, doors and windows and roof leakage of pump houses shall also meet the requirements of relevant provisions in Section 5.5 of this standard.

6 Construction of inlet and outlet structures

6.1 General requirements

6.1.1 The construction layout and the establishment of survey control points and network of the inlet and outlet structures shall be determined according to the design and construction characteristics of the structures.

6.1.2 The construction plans for the works of earth-rock excavation and filling, stone masonry, and concrete shall be determined according to design and construction technical requirements.

6.1.3 The earth-rock excavation shall be carried out in accordance with the provisions of in Article 4.3.2 of this standard.

6.1.4 Earth-rock filling shall be in accordance with the following requirements:

1 Excavation materials should be used for filling based on the overall consideration of cut and fill balance in the works and under the premise of meeting the design requirements.

2 Construction machine shall be furnished according to the properties of filling materials and the design criterion for filling. The parameters of filling construction shall be determined by on-site technical tests before filling.

3 For general backfilling with no specific filling index in design requirements, the material for backfilling should be duly compacted to attain the same density as that in its natural state. If stone ballast is used for backfilling, the density of the ballast after compaction shall be close to the natural density of gravel.

6.1.5 Concrete construction shall meet the requirements of current national standards GB 50666 *Code for Construction of Concrete Structures* and GB 50164 *Standard for Quality Control of Concrete*.

6.2 Approach channel

6.2.1 Before construction, engineering characteristics and construction conditions shall be understood, and the design channel alignment shall be checked by survey. The plan and elevation of the channel alignment shall meet the design requirements.

6.2.2 Cohesive soil should be used for embanked channel while mud, cultivated soil, frozen soil, expansive soil and soil with organic matter content greater than 8% shall not be used. If the filling material contains rubbly soil, the particle size shall not be greater than 200mm. If the main component of the filling materials is rubbly soil prone to weathering, measures such as surface drainage and surface covering shall be taken. The measures for channel leakage prevention shall comply with the provisions and design requirements in the current national standard GB/T 50600 *Technique Standard for Seepage Control and Lining Engineering on Canal.*

6.2.3 Test on the quality of filling channel shall be carried out in layers and segments along with the construction process. One sample should be taken for dry density and moisture content testing within each filling area of 200m^2 to 500m^2.

6.2.4 The channel lining by masonry and precast blocks shall be constructed in accordance with the provisions in Appendix G of this standard. During construction, measures shall be taken to protect the

side slopes and bottom of the channel against damage.

6.2.5 Full-section channel concrete lining machinery should be used for the concrete lining of the approach channel, and expansion joints shall be set and treated according to the design requirements.

6.2.6 The channel shall be smoothly connected to the inlet structure, channel surface shall be flat, and the surface roughness shall meet the design requirements.

6.3 Forebay and inlet sump

6.3.1 The construction of forebay and inlet sump should take the inlet structure profile of the pump house as reference, and shall only be started after quality acceptance of the foundation in a sequence of constructing the part near the inlet structure first and then the farther, the deeper part first and then the shallower, the side wall first and then the bottom protection.

6.3.2 The construction of connection structure on both banks and the bottom protection shall meet the requirements of stability, strength, frost resistance and erosion resistance, respectively, and waterside surface shall be smoothly connected with the side pier of pump house.

6.3.3 The construction of filter layer of forebay and inlet sump shall be carried out after the foundation construction is inspected and accepted as qualified, and shall be in accordance with the following requirements as well:

1 The thickness of inverted filter layer and the particle size, gradation and clay content of the filter material shall meet the design requirements.

2 The filter materials should be in wet state during construction, particle separation shall be avoided, and impurities or materials of different specifications shall be prevented from mixing in.

3 Filter materials shall not be dumped downward along the slope.

4 The layer surfaces shall be flat and distinct, without mixing into each other. The thickness of each layer shall be no less than 85% of the design thickness, and the summation of thicknesses of all the layers shall be no less than 95% of the total design thickness.

5 If placed in sections, layers at the junction part shall be constructed into a stepped shape, while staggering, discontinuity and mixing between layers shall be avoided.

6 The geotextile for forebay and inlet sump shall be laid out in conformance with the following requirements:

1) The geotextile shall be placed flat, evenly tensed and firmly anchored at the ends.

2) The connection may be by overlapping, butting or others, and the lap length is determined according to the loading and foundation soil conditions.

3) The geotextile should not be exposed to the sunlight during placement or in storage, and the transition layer shall be covered in time later.

6.3.4 The filter layer shall be separated with the concrete or masonry bottom protection, and mortar shall be prevented from penetrating in. Before water filling into the forebay or inlet sump, the drainage hole shall be cleaned and tested with water filling. After the hole is cleared of blockage, it should be filled with small pebbles.

6.3.5 If the side wall of forebay and wing walls on both sides of the inlet sump are of stone masonry, their construction shall be carried out in accordance with the provisions in Appendix G of this standard.

6.3.6 If the side wall of the forebay and wing walls on both sides of the inlet sump are of concrete or reinforced concrete, comprehensive measures including material selection, mixing proportion design,

temperature control, construction arrangement and quality control shall be taken in accordance with the relevant provisions in Section 5.1 of this standard. If the wing walls on both sides are of reinforced concrete structure, the slump of the concrete for structure with narrow cross-section, densely placed rebars and difficult to vibrate, shall be 80mm to 100mm.

6.3.7 The construction of joints, seepage prevention and drainage for the side wall of forebay and the wing walls on both sides of inlet sump shall comply with the provisions and design requirements of current professional standard SL 379 *Design Specification for Hydraulic Retaining Wall*.

6.3.8 Earth backfilling shall be carried out according to design requirements and the types of structure, properties of the filling materials and the on-site construction conditions. Soil that is not ascertained by testing and that does not meet quality requirements shall not be used for backfilling.

6.3.9 The masonry and precast block lining on the bottom surface and slope of forebay and inlet sump shall be constructed in accordance with the provisions in Appendix G of this standard. Corresponding measures shall be taken during the construction to protect the slope and bottom floor against damage.

6.4 Outlet pipe foundation and structures

6.4.1 The construction of foundation trench for the outlet pipes shall be in accordance with the following requirements:

1 The excavation of pipe trench in soil foundation shall be carried out in accordance with relevant provisions in Section 4.3 of this standard. The excavated soil slope shall meet the design requirements, and drainage ditches shall be arranged on the bottom surface of trench. For the trench bottom surface not requiring backfilling, a permanent drainage system shall be set up in accordance with design requirements. The exiting groundwater from the slope surface shall be diverted.

2 If the pipe is laid on the foundation with filled earth, the fill shall be compacted in layers. Expansive soil should not be used as filling material, and if necessary, the provisions in Article 4.5.2 of this standard shall be followed.

3 The excavation of pipe trench in rock foundation may be carried out in accordance with the provisions of current professional standard SL 47 *Technical Specification for Excavation Construction of Rock-Foundation of Hydraulic Structures*.

6.4.2 The pipe foundation shall be made even and straight, and stagnant water shall be drained out. No under or over-excavation shall be allowed. Local over-excavation shall be backfilled and compacted to a density close to the natural one. In case of weak foundation, strengthening measures shall be taken.

6.4.3 The lining protected slope of the pipe trench shall meet the design requirements, and the slope surface shall be smooth, without obvious concave or convex. Stone masonry and precast block lining may be carried out in accordance with the provisions in Appendix G of this standard.

6.4.4 The foundation construction of anchor blocks and support piers shall be in accordance with the following requirements:

1 Foundation excavation shall be executed in accordance with relevant provisions in Section 4.3 of this standard.

2 For foundation with a weak interlayer, checking computation shall be performed together with the designer to verify the possibility of deep sliding inside the foundation. If deep sliding is possible, it shall be handled according to the design requirements.

3 The base of anchor blocks on soft foundations shall be seated below the permafrost layer.

6.4.5 The construction of anchor blocks and support piers shall be in accordance with the following requirements:

1 The grade of the concrete strength of the anchor blocks and support piers shall meet the design requirements. In the absence of specified strength grade, the grade shall not be lower than C20, and the frost resistance grade of concrete shall be guaranteed. The concrete for each anchor block and support pier shall be placed at one time, and its surface shall be flat, dense and smooth.

2 For stone masonry anchor blocks and supporting piers, the strength grade of cement mortar shall meet the design requirements, and shall not be lower than M7.5 if the grade is not specified. The mortar joints shall be fully filled and staggered with no through ones, the joint surface shall be flat and dense, and interface between undisturbed soil and pier shall be filled with cement mortar.

3 The supporting face of anchor block and supporting pier shall be in close contact with the exterior wall of pipeline.

4 After the construction of anchor blocks and support piers, the observation of displacement and settlement shall be intensified, and abnormalities shall be dealt with timely once found.

6.5 Discharge chamber and pressure tank

6.5.1 The construction of discharge chamber and pressure tank shall take the outlet structure profile of pump house as datum, and be carried out in a sequence of constructing the part near the outlet structure first and then the farther, the deeper part first and then the shallower, the side wall first and then the bottom protection.

6.5.2 If the foundation of discharge chamber and pressure tank is of filled earth, the following requirements shall be met:

1 Muddy soil, arable soil, frozen soil, expansive soil and soil with organic content greater than 8% shall not be used for filling. If the filling materials contains rubbly soil, the particle size shall not be greater than 200mm.

2 Earth fill shall be compacted in layers, with a layer thickness of 300mm to 500mm. Before filling, construction parameters shall be determined through field technique tests, based on the nature of filling materials, filling indicators and construction machinery properties.

3 The filling indicators shall meet the design requirements. If no design requirements are given, the compaction coefficient of cohesive soil should not be less than 0.95, and the relative density of non-cohesive soil should not be less than 0.70.

4 The engineering measures for leakage prevention shall meet the design requirements and provisions of current national standard GB/T 50600 *Technique Standard for Seepage Control and Lining Engineering on Canal*.

5 The quality test of filled earth shall comply with the provisions in Article 6.2.3 of this standard.

6.5.3 If the wing walls on both sides of discharge chamber are of stone masonry structure, construction of the walls shall be carried out in accordance with the provisions in Appendix G of this standard. If the wing walls on both sides are of concrete or reinforced concrete structure, construction of the walls shall be carried out in accordance with the provisions in Article 6.3.6 of this standard.

6.5.4 The construction of wing walls on both sides of discharge chamber shall meet requirements of stability, strength, impermeability, frost resistance, erosion resistance, abrasion resistance, and wear resistance, and the waterside surface shall be smoothly connected with the outlet pier of the flow

passage of pump house and downstream water conveyance structures.

6.5.5 The construction of joints, anti-seepage facilities and drainage of wing walls on both sides of the discharge chambers shall comply with the provisions in Article 6.3.7 of this standard.

6.5.6 Materials and the varieties and specifications of products for seepage control and permanent joints such as water-seal joints, expansion joints and seismic joints of the discharge chamber shall meet the design requirements.

6.5.7 If sheet piling, continuous walls formed by cement-soil mixing piles or concrete cutoff walls are used for seepage control, the relative construction shall be carried out in conformity with the provisions of current professional standard SL 27 *Specification for Sluice Construction*, and the construction of cutoff concrete wall may also be carried out in conformity with the provisions of current professional standard SL 174 *Technical Specification for Construction of Concrete Cut-off Wall for Water and Hydropower Projects*.

6.5.8 The construction of bottom protection concrete or reinforced concrete of the discharge chamber shall be carried out in conformity with relevant provisions in Section 5.2 of this standard. The bottom protection concrete should be placed in blocks and at time intervals as specified. For the adjacent parts with rather large load difference, the other concrete block at the junction shall be placed after the settlement of previously placed block is basically stable.

6.5.9 Heavy machinery driving and heavy objects stacking on concrete or reinforced concrete protection bottom shall be subject to the approval by designer.

6.5.10 The masonry and precast block linings on the bottom surface and slope of discharge chambers shall be carried out in accordance with the provisions in Article 6.3.9 of this standard.

6.5.11 The filling of clay blanket for the discharge chamber shall be performed with least construction joints. The quality of clay shall meet design requirements, the filling shall be densely compacted, the joints shall be reasonable, and suncracking and freezing shall be prevented. If the filling is carried out in sections, the slope of the junction part shall not be steeper than 1:3.

6.5.12 If geosynthetic materials such as geomembrane, composite geomembrane and geo-composite are used for seepage control blanket, the following requirements shall be met:

1 The construction plan and details for testing shall be formulated according to the material type, design requirements and actual engineering conditions before construction, following the provisions of current national standard GB/T 50290 *Technical Code for Application of Geosynthetics*.

2 Before laying, the site shall be cleaned up, and anchor ditches as well as exhaust and drainage systems shall be constructed. The laying should be carried out in dry and warm weather, and the blanket shall be laid flat with appropriate relaxation reserved. After laying, backfilling coverage shall be carried out in layers in time, and sun exposure or construction damage shall be avoided.

3 The materials shall be tightly and firmly connected, and appropriate splicing process shall be selected for on-site trial splicing according to material types. The lap width shall be determined according to material types, specifications and splicing process, and should not be less than 10cm.

4 Testing shall be performed on the materials at their arrival and during inspection, storage, different construction phases and acceptance. The laying shall not be started until materials are inspected as qualified. During the laying, the subsequent working process shall not proceed until the present process is finished and inspected as qualified.

6.5.13 The construction of outlet tower shall be in accordance with the following requirements:

1 Before construction of the outlet tower, a construction scheme corresponding to the construction characteristics of the tower shall be formulated according to design requirements.

2 The foundation construction of outlet tower shall be carried out in conformity with relevant provisions in Section 4.4 of this standard, and for special soil foundation, the construction shall be carried out in conformity with relevant provisions in Section 4.5 of this standard.

3 The construction of tower body shall match the installation progress of outlet pipelines. For pressure pipeline passing through the tower structure, the material, specification, location, connection method of the water-stop shall meet design requirements.

4 The construction of reinforced concrete shall be carried out in accordance with relevant provisions in Sections 5.2 and 5.4 of this standard, the quality of raw materials shall be ensured and the temperature stresses shall be well controlled during construction.

6.5.14 The construction of pressure tank shall be in accordance with the following requirements:

1 Before construction, a construction scheme corresponding to the construction characteristics of pressure tank shall be made according to design requirements.

2 The foundation strength of pressuretank shall meet design requirements. If it is not the case, strengthening works shall be carried out.

3 Before the excavation of the foundation pit, water on ground surface of the construction site shall be drained out, and the water shall be prevented from flowing into the pit.

4 If groundwater table is high, deep-well pumping measures should be taken.

5 The construction of reinforced concrete shall be carried out in accordance with relevant provisions in Section 5.3 of this standard, the quality of raw materials shall be ensured and the temperature stresses shall be well controlled during construction.

6.6 Strengthening and retrofitting of inlet and outlet structures

6.6.1 Before strengthening and retrofitting, original design data and as-built drawings of inlet and outlet structures shall be collected, the structural features shall be ascertained, and a reasonable construction scheme shall be formulated according to design requirements for strengthening and retrofitting.

6.6.2 Before implementation, reliability appraisal or analysis on the proposed construction scheme should be made.

6.6.3 If whole structures are demolished, engineering protection measures shall be taken so that the safety of adjacent structures shall not be jeopardized. The non-vibration static cutting method should be adopted for local concrete removal of inlet and outlet structures.

6.6.4 If part of the original structure is kept, quality testing shall be carried out on the remaining part.

6.6.5 The existing hydraulic structures should be used for construction diversion, and construction schedule shall be reasonably arranged according to the impact of hydraulic structures on flood control and the impact degree of utilizing original hydraulic structures on construction.

6.6.6 The construction of interface between new concrete and existing concrete shall be in accordance with the following requirements:

1 The existing concrete surface shall be chipped off till to the dense layer and the cleaned surface shall be roughened or slotted. The depth of slots should not be less than 6mm, the slot spacing should not be greater than stirrup spacing or 200mm, and scums and dust shall be cleared off at the same time.

2 Original and new load-carrying steel bars shall be de-rusted.

3 Before welding on load-carrying steel bars in old reinforced concrete, measures shall be taken to unload or support the top, and steel bars shall be welded one by one and by zoning in layers.

4 Before new concrete placement, the surface shall be flushed after the removal of damaged concrete and shall be treated with cement mortar or other interface treatment agents.

5 The erection of formwork, arrangement of steel bars as well as placing and curing of new concrete shall be carried out according to the construction characteristics of the strengthening and retrofitting for inlet and outlet structures of the pumping station, and comply with the provisions of current national standard GB 50204 *Code for Quality Acceptance of Concrete Structure Construction*.

6.6.7 The repair of damaged concrete surface, crack treatment and leakage treatment of inlet and outlet structures may be carried out in accordance with the provisions in Articles 5.6.1 to 5.6.3 of this standard, respectively.

6.6.8 Strengthening of water inlet and outlet structures shall be in accordance with the following requirements:

1 Rigid glues with high bonding strength, good durability and small temperature deformation shall be used for structural strengthening.

2 The safety performance index of anchoring agent for embedded bars shall comply with the provisions of current national standard GB 50728 *Technical Code for Safety Appraisal of Engineering Structural Strengthening Materials*, and filler should be added in the glue during production in factories.

3 For vertical and transverse reinforcement bars placed in fresh concrete, the net thickness of concrete cover shall not be less than 25mm.

4 Newly placed load-carrying steel bars shall be firmly welded to the embedded anchorage steel bars, and the anchorage length shall meet the requirements of the concrete structure. The anchorage length shall be determined by on-site pulling tests and according to the requirements of construction specifications and the characteristics of anchoring agent.

5 Hole drilling and anchorage steel bars shall be in accordance with the following requirements:

1) The distribution of steel bars in original concrete structure shall be ascertained based on the as-built drawings of the structure or the prospecting results with a steel detector.

2) The accurate position and diameter of the holes to be drilled on the construction surface shall be determined according to the requirements of construction drawings.

3) The holes should be drilled to the depth specified in the design at one time, and the subsequent work shall not proceed until the hole drilling is qualified.

4) The anchorage holes shall be cleaned before the bars are planted in the holes, and during the inserting, the bars shall be slowly rotated so as to be fully bonded with the holes.

5) Neither shall external forces be applied to the anchorage bars nor shall subsequent construction be started before the bonding agent consolidates.

6) Anchorage quality check and pulling test of anchorage bars shall be carried out in accordance with the provisions of current national standard GB 50367 *Code for Design of Strengthening Concrete Structure*.

6 Strengthening with carbon fiber cloth shall be in accordance with the following requirements:

1) The surface of existing concrete structure shall be treated and cleaned till a hard and fresh interface layer.

2)Construction shall be carried out when the moisture content of concrete surface, ambient humidity and temperature meet the working conditions for carbon fiber cloth.

3)Necessary drying and heating measures shall be taken to raise the curing temperature and thus speed up the solidification action.

7 The grouting resin material used shall meet design requirements, and be accompanied with quality certificate and test report. It shall be used in accordance with the product instruction manual.

6.6.9 The strengthening and retrofitting of the interior of the inlet and outlet flow passages and pressure culverts should adopt the self compaction, self-leveling and vibration-free concrete construction methods and shall be in accordance with the following requirements:

1 Before construction, concrete mix proportion shall be determined according to design requirements and tests. The concrete shall be of high fluidity, segregation resistance, gap permeability and fillibility, and shall autonomously fill the space enclosed by the formworks under its own weight to form a uniform and dense concrete layer without vibration.

2 Steel bars shall be bound and placed accurately in position at one time. The formwork shall have sufficient rigidity to keep the joints and surfaces smooth. Relevant dimensions shall be controlled during the erection of the formwork, and the formwork shall be positioned accurately. Connection between formworks shall be smooth, and the thickness of concrete protective cover for steel bars shall be well controlled. The formwork shall not be displaced during concrete placing.

3 Dense concrete placing shall meet the requirements of concrete compactness, surface flatness, and flow passage profile.

4 Concrete placing time and speed shall be controlled to make concrete layer rise evenly.

5 After placing, the concrete shall have no cracks due to plastic shrinkage, settlement and temperature variation, and it shall be ensured that the concrete is in its shape with smooth surface, compact interior and without voids and pits. The bonding strength of interface between new and old concretes shall meet design requirements.

7 Construction of other types of pumping stations

7.1 Shaft pumping station

7.1.1 The construction layout of shaft pumping station shall be in accordance with the following requirements:

1 The construction layout and excavation for shaft pumping station shall be executed based on the design requirements and construction conditions, the topographic and geomorphologic conditions of the site, the geological conditions, and the river hydrological and sediment characteristics, and the survey control network shall be set up.

2 For shaft pumping stations located on the river bank, the layout of cofferdam construction should minimize the occupation on the river cross section.

3 For shaft pumping stations located in river course, a cofferdam shall be set up in the river course during construction period, and a temporary traffic bridge leading to river bank shall be erected according to flood control standard for the construction period.

7.1.2 The construction of water-collecting well of pumping station shall be in accordance with the following requirements:

1 For separate pump house, the water-collecting well and the pump house shall be constructed separately. Before the excavation of water-collecting well foundation, potential water blockage and scouring shall be analyzed, and a scheme for construction cofferdam, foundation pit excavation and foundation treatment shall be formulated.

2 If a weak soil layer and unfavorable structural plane occur in the side wall of foundation pit, the support measures shall be intensified and the drainage capacity of the foundation pit shall be increased.

3 Foundation treatment shall meet design requirements, and the bottom plate construction shall be carried out only after the foundation treatment is accepted as qualified.

7.1.3 The construction of pump house shall be in accordance with the following requirements:

1 The pump house shall be seated on a solid and reliable foundation or on a foundation that meets design requirements after treatment, and the concrete construction of the pump house bottom plate shall be started only after the foundation treatment is accepted as qualified.

2 Before the plate concrete placing, a plain concrete bedding layer shall be placed first, and the thickness and strength of the bedding layer shall meet design requirements. The area covered by the bedding shall be greater than that of the plate.

3 The bottom plate and pump house shall be placed by continuous casting technique, the horizontal offset between the upper and lower layers should not be less than 1.5m, and the junction part of the same layer shall be fully vibrated and consolidated. During concrete placing, mortar adhered to formwork, steel bars, waterstop sheets and embedded parts shall be removed in time, and concrete surface shall be screeded, floated and troweled to prevent loose top and dry shrinkage cracks.

4 Before the second-stage concrete placing for gate slot and pipe-through parts, the surface of the first-stage concrete shall be roughened, washed and cleaned. The second-stage concrete shall be of fine aggregate concrete, and its strength grade shall not be lower than that of the first-stage concrete in the

same location. The subsequent installation shall not proceed until it is assured that the second-stage concrete reaches a strength of more than 70% of the design strength.

5 The architectural and decoration works of pump house shall meet design requirements and the provisions in Section 5.5 of this standard.

7.2 Cable car type pumping station

7.2.1 The construction of pump house shall be in accordance with the following requirements:

1 The steel structure construction of pump house shall meet design requirements and the provisions of current national standard GB 50205 *Standard for Acceptance of Construction Quality of Steel Structures*, and anti-corrosion works may be carried out in accordance with the provisions of current professional standard SL 105 *Specifications for Anticorrosion of Hydraulic Steel Structure*.

2 The installation of working mechanism in pump house may be carried out in accordance with the provisions in Article 10.5.2 of this standard.

3 The architectural and decoration works of pump house may be carried out in accordance with the provisions in Section 5.5 of this standard.

7.2.2 The construction of ramps and tracks for the cable car type pumping station shall be in accordance with the following requirements:

1 The axis of the tracks and water pipelines shall be set out during the ramp construction according to the design requirements.

2 The construction of foundation for the slope track shall be in accordance with the following requirements:

1) The foundation of the bank slope shall be stable and solid, or treated if otherwise. The construction of the structures on the foundation shall proceed only after the excavation of bank slope is accepted as qualified.

2) The natural river bank upstream and downstream of the ramp shall be made flat and satisfy the requirement that the ramp surface shall be 300mm to 400mm higher than the upstream and downstream bank slope surfaces.

3) If the slope track extends below the minimum water level, cofferdams shall be constructed for water pumping and sludge dredging.

4) The reinforced concrete construction of track foundation beams may be carried out in accordance with the provisions of current national standard GB 50666 *Code for Construction of Concrete Structures*.

3 The position deviation of slope track shall meet design requirements. In the absence of design requirements, the following requirements may be referred to:

1) The allowable deviation between the centerline of foundation beam of the slope track and the centerline of towing and lifting of the pump house is ±3mm;

2) The allowable deviation between track centerline and cable car towing centerline is ±2mm. The deviation of track gauge shall not exceed ±3mm.

4 Track construction shall be in accordance with the following requirements:

1) The concrete for embedded bolts on the track beam to fix the track should be placed in two stages or may be placed in one stage with an embedded transition plate with quality ensured;

2) The deviation between the center of track bolt and the centerline of track shall not exceed

±2mm.

7.2.3 The installation, commissioning and the foundation concrete construction of the hoist of cable car type pumping station should be started only after the completion of ramp and slope track construction and pump house assembly and installation, and shall also ensure the wire rope of hoist free from friction at the intersection between the track slope and the ground of the pump house. In addition to the provisions in Article 10.5.1 of this standard, the installation of hoist for pump house should comply with the provisions of current professional standard MT/T 953 *Low-speed Winch*.

7.2.4 The construction of water conveyance pipelines shall be in accordance with the following requirements:

1 The pipelines shall be laid according to design requirements, and the construction of foundation or anchor blocks and support piers of pipelines shall be carried out in accordance with the provisions in Section 6.4 of this standard.

2 The installation of water pipelines shall be carried out in accordance with the provisions of current professional standard SL 317 *Specification for Equipment Installation and Acceptance of Pumping Stations*.

7.3 Pontoon-type pumping station

7.3.1 Shipbuilding for a pontoon-type pumping station may be carried out in accordance with relevant provisions on the building of inland navigation vessels.

7.3.2 Anchoring facilities for pontoon shall meet design requirements, and shall be firm with no deformation or displacement while loaded.

7.3.3 The shore side rocker arm, pedestrian bridge, pipe bridge and anchor blocks connected to the pontoon shall be constructed according to design requirements, and the foundation shall be stable and solid, or reinforced if otherwise. Only after the excavation of bank slope is accepted as qualified, shall the construction of the structure on foundation be carried out, and embedded parts on structures shall meet the design requirements or satisfy the provisions of current professional standard SL 317 *Specification for Equipment Installation and Acceptance of Pumping Stations*, and the concrete for embedded bolts should be placed in two stages.

7.3.4 The construction of water pipelines shall be in accordance with the following requirements:

1 The onshore water conveyance pipeline shall be laid according to design requirements, and the construction of pipe foundation or anchor blocks and support blocks shall be carried out in accordance with the provisions in Section 6.4 of this standard.

2 The installation of pipelines shall be carried out in accordance with the provisions of current professional standard SL 317 *Specification for Equipment Installation and Acceptance of Pumping Stations*.

7.3.5 After the pontoon is launched, the anchoring facilities for the pontoon shall be connected to the pontoon in time, and the connection stability and reliability shall be tested. The pontoon shall not be put into operation until it is accepted as qualified.

7.3.6 The installation of facilities and equipment such as pedestrian bridges, pipe bridges, pipelines, cable bridges and others connected to the pontoon shall be carried out after the pontoon is launched and accepted as qualified. The installation should be carried out when water levels of rivers, lakes or reservoirs are low, and it shall be ensured that there is no friction between the facilities connected to the pontoon and bank slopes at low water level.

7.4 Submersible pumping station

7.4.1 The construction of fixed submersible pumping station and the movable submersible pumping station which is jointly used with sluices and pipelines shall meet design requirements.

7.4.2 For the construction of inlet and outlet water passages of submersible pumping station with fixed water passage, fixture shall be embedded at the conjunction between the water passage and submersible pump, and its centerline shall be aligned with the centerline of submersible pump installation. The connection between the inlet or outlet water passage and the inlet or outlet of submersible pump should be well sealed. After the installation of submersible pump, the second-stage concrete shall be placed around the embedded parts.

7.4.3 For the installation of submersible pump by bracket or caisson foundation, schemes for construction cofferdam, foundation excavation and foundation treatment shall be prepared and approved by the supervisor. The construction of the structures on the foundation shall be started only after the foundation treatment is accepted as qualified.

7.4.4 For movable submersible pumps installed in guide rails, the rail base parts shall be embedded in two-stage concrete construction, and the allowable deviation between centerlines of the track and embedded parts shall be ±2mm.

7.4.5 For the installation of large and medium-sized movable submersible pumps for temporary use, a stable foundation shall be set. For the installation of a small movable submersible pump for temporary use, the base seat shall be stout and firm.

7.4.6 The construction of water pipelines shall be in accordance with the following requirements:

1 The water pipelines shall be laid according to design requirements, and the construction of pipe foundation or anchor blocks and support piers shall be carried out in accordance with the provisions in Section 6.4 of this standard.

2 The installation of water pipelines shall be carried out in accordance with the provisions of current professional standard SL 317 *Specification for Equipment Installation and Acceptance of Pumping Stations*.

7.4.7 The architectural and decoration works of the pump house shall comply with design requirements and the provisions in Section 5.5 of this standard.

8 Construction under special weather conditions

8.1 General requirements

8.1.1 For construction in a temperature lower or higher than the stipulated temperature limit or during the rainy season, necessary measures for construction under special climatic conditions shall be taken.

8.1.2 The construction schemes under special climatic conditions shall be prepared and preparatory works shall be well done in advance all by the constructor.

8.1.3 If catastrophically severe weather possibly occurs during construction, a construction emergency plan shall be prepared.

8.2 Construction in cold weather

8.2.1 When the average daily outdoor temperature is forecasted to be below 5℃ for 5 consecutive days, measures for construction in cold weather shall be initiated.

8.2.2 Concrete aggregates screening and washing shall be completed before the coming of low temperatures.

8.2.3 Concrete placement should not be carried out in a cold wave period, but may be carried out during daytime when temperature is relatively high.

8.2.4 After the excavation of the foundation protective layer, thermal insulation measures shall be taken and concrete shall be placed in time. For concrete placed on the surface of old concrete or bedrock, measures such as heating to the surface shall be taken to treat the icing or frosting, and concrete shall be placed after the treatment is accepted as qualified.

8.2.5 The compressive strength of the concrete containing no freezing-resistance agent shall not be less than 10MPa before the concrete is subject to freezing.

8.2.6 Portland cement or ordinary Portland cement should be used for the concrete to be placed in low temperature season.

8.2.7 Air-entraining water-reducing agent should be used for concrete to be placed in low temperature season, and the air content should be 3%to 5%. Chloride shall not be added to reinforced concrete. Sodium sulfate early strength agent shall not be used in concrete in contact with galvanized steel or aluminum iron and adjacent to DC power sources and high-voltage power sources.

8.2.8 The temperature of concrete at the discharge of the mixer shall be reasonably defined, the temperature of the concrete at the time being discharged into the formworks should not be lower than 10℃, and the temperature of covering concrete should not be lower than 3℃.

8.2.9 In the process of concrete mixing, the aggregates shall not contain ice, snow or frozen mass, and mixing time should be extended as needed.

8.2.10 When the outdoor temperature is no lower than −15℃, the heat storage method or a method of heat storage plus usage of admixture shall be used in priority for the construction and curing of concrete for structures with a surface heat transfer coefficient of no more than 5. If the heat storage method or the method of heat storage plus usage of admixture still does not meet the requirements of strength development, steam heating, electric current heating or warm shed may be used for construction and

curing.

8.2.11 The curing by the heat storage method shall be in accordance with the following requirements:

1 Concrete shall be placed, vibrated and covered at intervals as short as possible.

2 The formworks or concrete surfaces shall be closely covered by thermal and moisture insulation materials. Wind blocking measures should be added to the windward side.

3 The protection to the angular part of thin structure shall be intensified.

4 The openings of water passages, galleries and pump wells, as well as holes in other structures shall be temporarily plugged.

8.2.12 The removal of formwork and insulation layer shall be in accordance with the following requirements:

1 The strength of concrete shall be greater than the critical strength with which the concrete is allowed to expose to freezing.

2 The concrete shall be cooled down to 5℃ before the removal.

3 Removal shall not be performed during a cold wave period or a sudden drop in temperature. When the temperature difference between concrete and the atmosphere is greater than 14 degrees Celsius, the concrete surface after formwork removal shall be covered so as to slow down the cooling.

8.2.13 The following observation records shall be made for construction in the low temperature season:

1 Outdoor temperature and temperature in warm shed shall be observed 4 times a day.

2 Water temperature and aggregate temperature shall be observed 8 times a day.

3 Temperature at the discharge of the mixer and the placement temperature shall be observed 8 times a day.

4 The observation on internal temperature of concrete shall be intensified in 3 days to 5 days after concrete placing. Observation shall be done 4 times a day for concrete cured by the heat storage method, once an hour for concrete cured by steam or the current heating method, and once every 2h during the constant temperature period for concrete cured by steam or the electric current heating method.

8.3 Construction in hot weather

8.3.1 If the maximum daily temperature is forecasted to be above 30℃, measures for construction in hot weather shall be initiated.

8.3.2 The temperature at the discharge of the mixer shall meet design requirements for temperature control and shall not exceed 30℃.

8.3.3 The following measures shall be adopted to reduce concrete placement temperature:

1 Raw materials should be pre-cooled. The aggregates should be stockpiled relatively high, and the storage time should be appropriately extended. Aggregates shall be taken from bottom of the pile when used, and groundwater spraying may be applied on the aggregates. The groundwater or low temperature water mixed with ice may be used to produce concrete.

2 Concrete placing should be arranged in the morning, evening or at night.

3 The concrete transport facilities shall be equipped with heat insulation and sun-shading measures, and the transport time shall be shortened.

4 Sun-shading measures shall be taken over the concrete placement area, and water mist should be sprayed to reduce surrounding temperature.

8.3.4 The fine-coarse aggregate ratio and slump should be increased and retarding and water reducing agent should be added during concrete construction.

8.3.5 After placing, the concrete shall be covered and cured as soon as possible.

8.4 Construction in rainy season

8.4.1 For the construction in rainy season, the following measures shall be taken:

1 Concrete shall not be placed in heavy rain or rainstorm or during a typhoon.

2 Free drainage shall be kept in aggregate stockyard.

3 Rainproof measures shall be taken on transportation facilities.

4 Necessary measures against typhoons and lightning strikes shall be taken.

5 The concrete placing area shall be provided with a rainproof shelter.

6 The water content test of aggregates shall be intensified.

7 The monitoring on the stability of excavated slope shall be enhanced, and slope support measures shall be taken if necessary.

8.4.2 Concrete placing in light rain with no rainproof shelter shall be in accordance with the following requirements:

1 The water consumption of concrete shall be reduced through tests.

2 The drainage inside and outside the concrete placing area shall be intensified, but mortar shall not be taken away.

3 The top surface shall be floated to finish and covered in time.

8.4.3 The concrete placing in an area without rainproof shelter shall be in accordance with the following requirements:

1 In case of heavy rain or rainstorm, concrete placing shall be suspended, and concrete already in placing area shall be sufficiently vibrated and timely covered.

2 After rain, soft layer on the surface shall be cleaned away in time.

3 Prior to resuming concrete placing, a layer of cement mortar shall be laid first on the old concrete surface.

4 If the specified time interval is exceeded, the old concrete surface shall be treated as construction joint.

8.5 Construction under catastrophic weather

8.5.1 During the construction period, if a catastrophically severe weather warning is issued, construction emergency plan corresponding to the warning level of catastrophic weather shall be activated in time, and the safety protection for construction site shall be carried out at the same time.

8.5.2 If sudden thunderstorm, strong wind, sand-dust, flood, and other catastrophic weather occur during construction, the construction shall be suspended, workers shall be evacuated, and construction site shall be well protected. In addition, according to the degree of impact of construction suspension on the quality of the works, safeguard measures shall be taken to ensure the quality of the works and the safety of facilities, equipment and workers who keep working.

9 Installation of monitoring facilities and observation during construction period

9.1 Installation of monitoring facilities

9.1.1 Monitoring facilities shall be calibrated and pass the on-site inspection as qualified before embedment.

9.1.2 The selection and embedment of observation base points shall be in accordance with the following requirements:

1 Base points shall be arranged on a bedrock or solid soil foundation at both banks of a structure, unaffected by subsidence or horizontal displacement and convenient to observation. The temporary observation base points shall be arranged in combination with the permanent ones.

2 The observation pier with a forced centering device should be used for the base point of horizontal displacement observation and for working base point.

3 For the base points of vertical displacement observation, bimetal or steel-pipe marks should be adopted. At least one group of such points shall be set up and each group shall consist of more than 3 fixed points.

9.1.3 The deformation monitoring points for a structure shall be firmly bonded with the structure, and a forced centering device with observation target or a reflector, or other fixed sighting device may be embedded.

9.1.4 For landslide deformation monitoring points, steel pipes with diameter matching the observation mark should be embedded at sites accessible, while steel pipes or wooden piles with a height of 1.2m above the ground may be embedded at dangerous sites not easily accessible, and a simple fixed observation mark shall be welded to or driven into the upper ends of the pipes.

9.1.5 Monitoring points for the stability of the high slope or expansive rock/soil slope may be arranged in cross-section form at different elevations on the slope surface depending on the height of the slope. The observation marks shall be readily visible so that the survey should be performed with no need of someone holding the rod.

9.1.6 Settlement monitoring points shall be made of copper, copper plated steel or stainless steel. During the construction period, the points may be embedded on the surface layer of the base slab first, and after the completion of the works and before water releasing, the underwater settlement points shall be transferred to the superstructure for continued observation. Monitoring points shall also be set up for important structures near the excavated foundation pits.

9.1.7 The form of crack monitoring point for structures should be specially designed and buried on both sides of the crack.

9.1.8 The monitoring of pressure, cracks, seepage and the embedment of such monitoring facilities may be carried out in accordance with the provisions of current professional standard SL 551 *Technical Specification for Earth-Rockfill Dam Safety Monitoring*.

9.1.9 The piezometer standpipe should be made of galvanized steel or rigid plastic, and the riser pipe section shall be straight, and outer hoop joint shall be adopted. The pipe opening shall be set higher than

the ground surface and protected with a cap. The piezometer standpipe may be embedded in the course of embankment construction, or embedded in a borehole after the completion of the works and before water releasing.

9.1.10 The location of water level observation facilities shall meet the design requirements. When there is no design requirement, they should be placed in the part of the structure where water flow is stable, with little impact from current fluctuation. Temporary staff gauge shall also be set up on the construction cofferdams.

9.1.11 For newly constructed pumping stations, temperature monitoring facilities shall be embedded inside the structure according to temperature control requirements. The number and locations of monitoring points shall meet the requirements of temperature control.

9.1.12 In addition to meeting design requirements, the layout of on-site automated observation facilities shall also meet the requirements of information transmission and remote monitoring. In the embedment of measurement cables and conducts, a certain number of cables and conducts should be reserved for the future informatization and intelligent development of pumping stations.

9.1.13 Records on the installation, calibration, inspection of observation facilities and other information shall be handed over to the management unit.

9.2 Observation during construction

9.2.1 Observation and monitoring items during the construction of a new pumping station and its appurtenant structures shall be determined according to factors such as construction environment, structure and layout, foundation conditions, topography and geomorphology, depth of foundation pit, excavation sections, construction methods. The observation and main monitoring items may be selected according to Table 9.2.1 on the basis that engineering needs and design requirements are met. For the strengthening and retrofitting of pumping station, they may be selected from Table 9.2.1 according to reinforcement and renovation conditions.

Table 9.2.1 Main monitoring items during construction

Category	Main monitoring item
High slope excavation	Horizontal displacement, vertical displacement, cracks, seepage, inclination and deflection
Pumping station structure	Horizontal displacement, vertical displacement, inclination, deflection, cracks, uplift and temperature
Foundation pit	Horizontal displacement, vertical displacement, groundwater table and seepage
Temporary cofferdam	Horizontal displacement, vertical displacement, seepage and deflection
Landslide near construction site	Horizontal displacement, vertical displacement, cracks and deep displacement
Atmosphere, water level and water quality	Air pollutants, river water level (water quality) and peripheral groundwater table (water quality)
Ice	Volume and pressure of ice

9.2.2 The accuracy of deformation observation during construction shall comply with the provisions in Table 9.2.2. The monitoring accuracy of large landslides and high slopes outside construction area may be determined according to design requirements. Leveling survey shall be used for vertical displacement observation, and trigonometric leveling using electromagnetic distance measurement may also be used when limited by practical conditions.

Table 9.2.2 Observation accuracy of deformation during construction

Category	Mean square error of measurement (mm)					Remarks
	Horizontal displacement	Vertical displacement	Deflection	Foundation inclination	Pump house inclination	
High slope excavation	≤3	≤3	–	–	–	Rock slopes
	≤5	≤5	–	–	–	Rock-soil slopes or soil slopes
Pumping station structure	≤1	≤1	≤0.3	≤1	≤6	The monitoring accuracy of horizontal displacement and vertical displacement of small and medium-sized pumping stations may be relaxed to 2 times the values specified hereby
Temporary cofferdam	≤5	≤10	–	–	–	–
Foundation pit subsidence	–	≤3	–	–	–	–
Landslide near pump house	≤3	≤3	–	–	–	Rock landslide masses
	≤6	≤5	–	–	–	Rock-soil landslide masses or soil landslide masses
Crack	≤1	–	–	–	–	Concrete structures and large metal members; The mean square error in the measurement of surface cracks of concrete structures shall not exceed 0.2mm
	≤3	–	–	–	–	Other structures
	≤0.5	–	–	–	–	Surface cracks of rock landslide
	≤5	–	–	–	–	Surface cracks of soil landslide

Note: The mean square error in temporary cofferdam displacement is relative to cofferdam axis, the mean square error in crack monitoring is relative to observation line, and others are relative to working base points.

9.2.3 The reference network for horizontal displacement observation may be established in the form of GNSS network, triangulation network, traverse network or by the collimation line method. The horizontal displacement observation should use the collimation line method, and technical requirements for the collimation line method shall comply with the provisions of Table 9.2.3.

Table 9.2.3 Technical requirements for the collimation line method

Required accuracy	Movable target method				Minor angle method			
	Length of collimation line (m)	Number of observation sets	Semi-observation reading difference (mm)	Observation set difference (mm)	Length of sight line (m)	Mean square error of angle observation (mm)	Semi-observation reading difference (mm)	Observation set difference (mm)
≤3mm	≤300	3	≤3.5	≤3.0	≤500	1.0	≤4.5	≤3.0
≤5mm	≤500	3	≤5.0	≤4.0	≤600	1.8	≤3.5	≤2.5

9.2.4 The reference network for vertical displacement observation shall be established with leveling survey, and vertical displacement observation should be based on national second order leveling.

9.2.5 The first time observation of deformation monitoring shall be done twice in a consecutive way, taking the average as the initial value. The observation frequency should be once every 15 days and may be increased in the early stage of construction. It shall be increased in special circumstances such as flood season, rainy season and earthquake.

9.2.6 The initial values shall be observed in time just after the settlement monitoring points are buried. During construction, observation shall be carried out regularly according to different loading conditions, and the interval between observations should not exceed 15 days. The settlement shall be observed once respectively before and after water releasing for the final acceptance of construction.

9.2.7 The deformation monitoring of important buildings (structures) around the foundation pit shall be done synchronously with the deformation monitoring of the foundation pit, observation shall begin before excavation or dewatering of the foundation pit, and observation may be ended after the foundation pit is backfilled. Before monitoring, a deformation monitoring scheme shall be formulated according to geological and hydrogeological conditions, variations of retained water level and supporting of foundation pit, and the layout of foundation drainage.

9.2.8 The water level in the piezometer standpipe and the upstream and downstream water levels shall be observed synchronously.

9.2.9 The time and frequency of uplift observation shall be determined according to variations of downstream and upstream water levels, groundwater table and foundation pit water level of the pumping station.

9.2.10 Instrument monitoring shall be combined with patrol inspection. Each patrol inspection shall be recorded on spot in accordance with regulations, and sketches or photos shall be attached if necessary.

9.2.11 In the strengthening or retrofitting of the structures, the observation of deformation, stress and seepage pressure of the original structures shall be intensified if loading or unloading may affect the original structures. Protective measures shall be taken in time in case any abnormality occurs.

9.2.12 During construction, observation shall be conducted on time, and the observation data shall be sorted out and analyzed in time. Records, analysis results shall be handed over to the management unit.

10 Installation and testing of steel structures

10.1 General requirements

10.1.1 Before the installation of the steel structures and equipment such as gates, flap gates, trash racks, hoists and trash removers, the following data shall be made available:

1 Construction drawings, including installation drawings, general drawings, assembly drawings, wearing parts drawings and electrical control schematic diagrams of steel structures and equipment such as gates, flap gates, trash racks, hoists and trash removers.

2 Documents on fabrication acceptance and quality certificates of gates, flap gates, trash racks, hoists and trash removers and quality certificates and installation and operation manuals for purchased parts.

3 Assembly inspection records of main components and product pre-assembly inspection reports.

4 Location diagram of control points for installation.

10.1.2 The measuring gauges and apparatus for the installation of gates, flap gates, trash racks, hoists, trash removers and embedded parts shall be verified or calibrated by the legal metrology department and shall be used within their validity period. The accuracy of main gauges and apparatus shall be in accordance with the following requirements:

1 The accuracy of the steel tape shall be no lower than Class One.

2 The accuracy of the theodolite shall be no lower than Class DJ_2.

3 The accuracy of the level gauge shall be no lower than Class DS_3.

4 The angular accuracy of the total station should not be less than 1", and the ranging measurement accuracy should not be less than $1\text{mm}+2\times D\times10^{-6}$ (D is the measured distance, in mm).

10.1.3 The reference points and installation control points for elevation measurement and installation axis shall be accurate, firm, visible and convenient for use.

10.1.4 The pressure gauge shall be calibrated before installation, with a full scale of 1.5 times to 2 times the test pressure, and the accuracy shall not be less than Class 1.5.

10.1.5 Welding materials such as welding rods, welding wires and flux used for installation shall be supplied with factory certificates of delivery and shall comply with relevant provisions of current national standard NB/T 35045 *Code for Manufacture Installation and Acceptance of Steel Gates in Hydropower Engineering*.

10.1.6 The appearance quality of welds and the detection of internal defects of Class Ⅰ and Class Ⅱ welds shall comply with the provisions of current professional standard SL 36 *General Technical Specifications for Welding of Steel Structures in Water Project*. When unacceptable defects are found in the weld, repair and treatment shall be carried out in accordance with the provisions of current professional standard SL 36 *General Technical Specifications for Welding of Steel Structures in Water Project*, and metal materials shall not be filled in the assembly gap of the welded parts.

10.1.7 When components such as gates, flap gates and trash racks are transported and hoisted, the center of gravity of the components shall be marked, and measures shall be taken to prevent damage and deformation of the components. Measures shall be taken to prevent collision damage to and rust on the

processed surface of gates, flap doors and embedded parts.

10.1.8 Measures shall be taken to prevent damage and rust during transportation and storage of hoists, trash removers, and automatic detachment beams. Measures shall be taken to prevent the deformation of oil cylinder and piston rod during the storage of hydraulic hoists. After equipment arrives at the construction site, it shall be properly stored in a temporary warehouse.

10.1.9 During transportation and installation, when the anti-corrosion coating of steel structure components and equipment is damaged or corroded, it shall be repaired and treated in accordance with the provisions of current professional standard SL 105 *Specifications for Anticorrosion of Hydraulic Steel Structure*.

10.2 Installation of embedded parts

10.2.1 The anchor bolts or anchor plates of embedded parts in the first stage concrete shall meet design requirements and be embedded by the constructor designated in the contract, and the embedded positions shall be checked and verified before concrete is placed.

10.2.2 Before the installation of embedded parts, formwork debris in the gate slot shall be cleaned up. The first stage concrete surface shall be chiseled, and the chiseling depth should be 5mm to 10mm. The cross-sectional dimensions of the second stage concrete shall meet the design requirements.

10.2.3 The allowable deviation for the installation of embedded parts of the vertical lift gate shall comply with the provisions in Appendix H of this standard. The components should have at least one testing point per meter for testing.

10.2.4 The allowable position deviation between the center of the base bolt and the design center of the flap gate hinge seat is 0 to 1.0mm.

10.2.5 The allowable installation deviation of flap gate hinge seats shall comply with the provisions in Table 10.2.5.

Table 10.2.5 Allowable installation deviation of flap gate hinge seats

Item	Allowable deviation
Distance between hinge seat center and hole center	±1.5mm
Mileage	±2.0mm
Elevation	±2.0mm
Inclination of hinge seat shaft hole (in any direction)	0 to 1/1 000
Coaxiality of axis of two hinged seats	±1.0mm

10.2.6 The flap gate frame should be installed with concrete placed in two stages. For embedded parts of inclined flap gate frame, the allowable deviation for the inclined angle should be ±10′.

10.2.7 After the embedded parts are installed and adjusted, the adjusting bolt shall be welded firmly to the anchor plate or anchor bolt.

10.2.8 After the installation of embedded parts is inspected as qualified, the second stage concrete shall be placed within 5 days to 7 days. The lift height of the second stage concrete should not exceed 5.0m, and an immersion vibrator in small diameter shall be selected for concrete vibration, and kept apart from the embedded parts, bars and formworks during vibration.

10.2.9 After the removal of formwork for the second stage concrete, the embedded parts shall be rechecked, with records kept properly. The dimensions of concrete surface shall be checked, and any remaining steel bars and debris shall be removed at the same time.

10.2.10 The offsets of butt joints on the working surface of embedded parts shall be treated by a gentle slope. The weld scars, extra height of weld seam and pits on the working surface shall be cleared off, welded and polished.

10.2.11 After the installation of the embedded parts and the installation inspection as qualified, a common gate shall be used to test each slot of all bulkhead gates before water retaining.

10.3 Installation of vertical lift gate and flap gate

10.3.1 Before installation, the main dimensions of the vertical lift gate shall be rechecked, and the dimensions shall comply with design requirements and the provisions of current national standard GB/T 14173 *Specification for Manufacture, Installation and Acceptance of Steel Gate in Hydraulic and Hydroelectric Engineering*.

10.3.2 The gate assembled with separate sections as a whole shall comply with the following requirements, in addition to the provisions of GB/T 14173 *Specification for Manufacture Installation and Acceptance of Steel Gate in Hydraulic and Hydroelectric Engineering*:

1 For the sections connected with screw bolts, the bolt nuts shall be uniformly tightened, and the compression amount of the sealing rubber between sections shall meet design requirements,

2 For the sections connected by welding, connection plates may be used without any forced combination. Measures shall be taken to control deformation during welding.

3 After assembly, the offsets at the connection shall be no greater than 2.0mm.

4 After the assembly is completed and checked as qualified, obvious signs and serial numbers shall be marked at the connections and reliable positioning devices shall be set up.

10.3.3 The position of screw bolt hole for sealing rubber of the vertical lift gate shall be consistent with the position of screw hole on the gate leaf or on water seal press plate. The hole diameter shall be 1.0mm smaller than the diameter of screw bolt hole, and hole pressing shall not be allowed.

10.3.4 After the sealing rubber of vertical lift gate is installed, the allowable deviation of the center distance of the water seals on both sides and of the distance from the top center of the water seal to the bottom edge of bottom water seal is ±3.0mm, and the unevenness of water seal surface should be 2.0mm. The compression amount of sealing rubber shall meet design requirements, with the allowable deviation of -1mm to 2mm.

10.3.5 The sealing rubber segments of vertical lift gate may be connected by hot pressing of raw rubber, and dislocation, dints, bulgings and loosening shall not be allowed at the bonded part.

10.3.6 Static balance test shall be carried out for the vertical lift gate, and the inclination shall not exceed 1/1 000 of the gate height and no more than 8.0mm. Otherwise, counterweights shall be allocated.

10.3.7 Protective measures shall be taken to prevent the deformation and collision of vertical lift gates during lifting and installing.

10.3.8 Before the flap gate is installed, its manufacturing weight shall be checked, and the deviation between the manufacturing weight and design weight shall not exceed ±5%. If control requirements for the gravity and float centers of the flap gate during rotation are given by the design, the gravity and float centers shall be remeasured, and lifting and installing of the gate shall not proceed until the requirements are met.

10.3.9 The installation of the seal rubber for flap gate shall comply with the provisions in Articles 10.3.3, 10.3.4 and 10.3.5 of this standard.

10.3.10 If metal water seal is used for the flap gate, the surface of the seal shall be processed mechanically, and the roughness *Ra* value shall be no greater than 3.2μm. The interface shall be well sealed during installation. If the design requires otherwise, the design requirements shall be met.

10.3.11 For counterweight type flap gate, the counterweight shall meet design requirements, with the allowable weight error of $\pm 2\%$. The operation of balancing mechanism shall be free from any disturbance.

10.3.12 After the installation of free flap gate, the opening angle deviation shall meet design requirements, and the deviation between its center and the flow passage center shall not be greater than 3.0mm.

10.3.13 For the flap gate controlled by a hoist, the center of lifting lug shall coincide with the centerline of the gate opening, and the allowable error shall be ± 1.5mm.

10.4 Installation of trash rack and trash remover

10.4.1 The installation of trash rack shall be in accordance with the following requirements:

1 The allowable deviation for the installation of embedded parts of movable trash rack shall comply with the provisions in Table 10.4.1. The allowable deviation for the inclined angle of embedded parts of trash rack is $\pm 10'$.

Table 10.4.1 Allowable deviation for installation of embedded parts of movable trash rack

Item	Allowable deviation (mm)		
	Bottom sill	Main rail	Reversal rail
Mileage	±5.0	–	–
Elevation	±5.0	–	–
Elevation of working face from one end to the other	0 to 3.0	–	–
Centerline of rack slot	–	−2.0 to 3.0	−2.0 to 5.0
Centerline of opening	±5.0	±5.0	±5.0

2 After the installation of the embedded parts for fixed trash rack, the difference between the highest and lowest points on the working surface of the beam shall not be greater than 3.0mm.

3 The installation accuracy for the trash rack with trash remover shall meet design requirements. The connection of rack bars in the segmented trash rack shall be smoothly connected, and plane and lateral offsets shall not be greater than 1.0mm.

10.4.2 The installation of rail type trash remover shall be in accordance with the following requirements:

1 The allowable deviation for rail installation shall be in accordance with the following requirements:

1) The deviation between actual centerline and design centerline of the rail shall not be greater than 2mm.

2) The deviation for space between the rails shall not exceed ± 3mm.

3) The longitudinal unevenness of the rails shall not exceed 1/1 500, and shall not exceed 2mm alongside the full length.

4) For the same cross section, the relative elevation difference between tops of two rails of both the upstream and downstream sides is no more than 5mm.

5) The offsets on left, right and upper sides of the connection of two rails is less than 1mm.

2 The allowable deviation for the installation of crane traveling mechanism shall be in accordance

with the following requirements:

1) The vertical installation deviation between traveling mechanism and lower cross beam is no greater than $H/2\,000$.

2) After the completion of the installation of crane traveling mechanism, wheels shall stand in contact with track surface at the same time, and no gap is allowed between the wheels and track.

3) The deviation for the actual rail centerline and the design rail centerline is no more than 2mm.

3 The allowable deviation for the gantry installation shall be in accordance with the following requirements:

1) The distance between the vertical centerlines of gantry legs in the span direction of trash remover is consistent with the span of trash remover, and the difference is no more than ±3mm.

2) After the installation of gantry leg, the inclination from the vertical centerline along the span direction of trash remover is not greater than 1/2 000 of the height of gantry leg itself, and the lower part of gantry leg should be inclined inward.

3) After the installation of gantry, points on four diagonal corners of the upper structure is measured, and the relative elevation difference is no greater than 5mm, and the absolute elevation difference of each point is no greater than 10mm. The difference between the diagonal lines of four diagonal corners is no greater than 5mm.

4) The upward midspan camber F of main beam remeasured is within (0.9 to 1.4)$L/1\,000$, and the maximum camber is controlled within $L/10$ of the midspan. The upward camber F_0 for effective cantilever is within (0.9 to 1.4)$L/350$.

4 The allowable deviation for main trolley installation shall be in accordance with the following requirements:

1) The trolley span deviation does not exceed ±3mm, and the relative difference of spans at both ends does not exceed ±3mm.

2) The difference between diagonal lines of the trolley frame is no greater than 5mm.

3) After the installation of the operating mechanism of trolley, the wheels shall contact the track surface at the same time, and gap between the wheels and the track is not allowed.

10.4.3 The installation of movable scraper type trash remover shall be in accordance with the following requirements:

1 Before installation, the shape and size of the steel rail shall be checked. If bending, twisting, and other deformations exceed design requirements, the corresponding rectification shall be performed.

2 Before lifting and installing track, installation reference line for the track shall be measured and calibrated. The horizontal position deviation between actual centerline of the track and installation precision line shall meet the following requirements:

1) For the span of no more than 10m, the deviation does not exceed 2mm;

2) For the span of more than 10m, the deviation does not exceed 3mm.

3 The longitudinal straightness error of the track shall not exceed 1/1 500, and the difference between highest point and lowest point along the whole travel shall not exceed 2mm.

10.4.4 The installation of rotary trash remover shall be in accordance with the following requirements:

1 The allowable deviation of embedded parts shall meet the requirements specified in Table 10.4.1 of this standard;

2 The allowable deviation of angle after installation is $\pm 10'$;

3 The allowable deviation of tooth width centerline of the driving sprocket and the traction sprocket is 0 to 1.5mm.

10.5 Hoist installation

10.5.1 The installation of fixed hoist shall meet the following requirements:

1 After a hoist arrives at the construction site, it shall be not installed until accepted by inspection as qualified according to the current professional standard SL/T 381 *Specification for Manufacture Installation and Acceptance of Hoist in Water and Hydropower Projects*.

2 The embedment conditions of hoist foundation bolts shall be checked whether the embedment position, embedment depth, and the length of projected part of the bolts meet the design requirements.

3 The elevation and levelness of the hoist platform shall be checked. The allowable deviation of elevation is ± 5.0mm, and the levelness deviation shall be less than 0.5/1 000.

4 The gate hoist installation shall be aligned with the gate hoisting center, and the allowable deviation of longitudinal and transverse centerlines is ± 3.0mm.

5 The steel wire rope left on the roller (drum) should not be less than the length of 4 laps when the lifting point is at the lower limit position, while the wire rope shall not be wound to the bare part of the drum when the lifting point is at the upper limit position.

6 The allowable error of hoisting height of hoist with double lifting points should be ± 3.0mm. After the steel wire rope is tensioned, the horizontal centerlines of two lifting shafts shall be at the same level, and the elevation difference shall not be greater than 5.0mm within the height of the gate slots.

7 The installation of electrical equipment of hoists shall comply with the provisions of current national standard GB 50171 *Code for Construction and Acceptance of Switchboard Outfit Complete Cubicle and Secondary Circuit Electric Equipment Installation Engineering*.

8 Before the power-on test of electrical equipment, all wiring shall be checked and meet design requirements. The insulation resistance shall be greater than 0.5MΩ before the power-on test. During the test, electrical equipment configured for the gate hoist shall be used for the test, and the temperature rise of various motors and electrical elements shall not exceed allowable value. If the contact or the likes are burnt during the test, the cause shall be ascertained and the damaged shall be replaced.

10.5.2 The installation of movable gate hoist shall be in accordance with the following requirements:

1 The allowable deviation for trolley track installation shall comply with the provisions in Appendix J of this standard.

2 The installation of crane track shall be in accordance with the following requirements:

1) Before laying, the track shall be checked. The track laying shall not be started until it is checked as qualified.

2) Before the track is lifted for installation, the installation reference line shall be determined. The allowable deviation for track installation shall comply with the provisions of Table 10.5.2.

3) The joints of two parallel tracks shall be staggered in a distance unequal to the distance between the front and rear wheels.

4) The tightness of bolts shall be checked thoroughly.

5) Before the bridge crane or gantry crane is lifted for installation, the vehicle stopper shall be

installed on the track. The two vehicle stoppers and the buffer on the same span shall be in contact, and shall be adjusted if there is any deviation.

6) The wheels of gantry crane shall be in contact with track surface, and there shall be no gap between the wheels and the track.

Table 10.5.2 Allowable deviation for track installation

Item	Basic dimension (m)	Allowable deviation (mm)
Deviation between actual centerline and reference line of crane track	$L \leqslant 10$	±2.0
	$L > 10$	±3.0
Crane gauge deviation	$L \leqslant 10$	±3.0
	$L > 10$	±5.0
Relative elevation difference of two parallel tracks with a same span	$L \leqslant 10$	0 to 5.0 at column
	$L > 10$	0 to 8.0 at column
Crane track joint	Offsets on left, right and upper sides	0 to 1.0
	Gap at joint	0 to 2.0
Longitudinal straightness error of track	–	0 to 1/1 500
Difference between the highest and lowest points of track along the full travel	–	0 to 2.0

Note: L represents the span.

3 The allowable deviation of bridge crane and gantry frame after assembly and that of the operating mechanism after installation shall comply with the provisions in Appendix J of this standard.

4 The installation of electrical equipment shall comply with the provisions of current national standard GB 50171 *Code for Construction and Acceptance of Switchboard Outfit Complete Cubicle and Secondary Circuit Electric Equipment Installation Engineering*.

5 The installation of automatic hanging beam shall be in accordance with the following requirements:

1) The static balance test shall be carried out before the delivery of automatic hanging beam, and hook device, hydraulic device and signal device shall be checked for their flexibility, accuracy and reliability with no jamming or leakage. Leakage from the cable junction box shall not be allowed.

2) The allowable deviations both for the distance between lifting-point centers and the distance between positioning centers on the automatic hanging beam is ± 2.0mm.

3) After the installation of the automatic hanging beam, test on gate hooking and unhooking in the dry is in a normal state.

6 When the movable gate hoist with automatic hanging beam is used to open and close the gates in multi-bays, the installation of gate hoist and automatic hanging beam shall be aligned according to the lifting center of gate slot at each bay. The allowable longitudinal and transverse errors for the centerline and lifting centerline of the bay after installation is ±5.0mm.

10.5.3 The installation of hydraulic hoist shall be in accordance with the following requirements:

1 The following inspections shall be carried out before installation:

1) All parts of hydraulic cylinder are free of bruise and damage, and the piston rod is free of deformation. When the piston rod is in vertical state, the allowable deviation of verticality is 0 to 0.5/1 000.

2) The piston rod is reliably locked with hydraulic cylinder after its retraction.

3) The hydraulic pump is in good condition, and the components and pipelines are free of damage and oil leakage.

4) The electrical control device is in good condition, and the components are free of damage.

2 During on-site installation, effective measures shall be taken to protect piston rod surface, cylinder side valve group and electrical equipment within the movement range of hydraulic cylinder.

3 When hydraulic cylinder is lifted, the number of supporting or lifting points shall be determined according to the diameter, length and weight of hydraulic cylinder.

4 The allowable error of distance between longitudinal and transverse centerlines of hydraulic hoist frame and actual lifting centerline is ±2.0mm. The allowable deviation of elevation is ±5.0mm. The allowable error for the elevation of bearing surface of the double lifting point hydraulic hoist is ±0.5mm.

5 The contact degree of the frame steel beam and thrust bearing shall be checked with a 0.05mm feeler gauge and the gauge shall not be able to pass through in between. If local gap is allowed, a 0.1mm feeler gauge may be used to check. In such a case, the insertion length shall not be greater than 1/3 of the gap width, and the cumulative depth shall not be greater than 20% of the circumference. The allowable horizontal deviation of the top surface of thrust bearing is 0 to 0.2/1 000.

6 A pipe bending machine should be used for on-site fabrication of bent pipes with cold bending technique. The bending of pipes shall comply with the provisions of current professional standard JB/T 5000.11 *Heavy Mechanical General Techniques and Standards-Part 11: Attached Piping.*

7 The upper and lower disconnection contacts and water filling contacts of height indicator and master switch shall be initially adjusted.

8 The hydraulic oil filtration accuracy of plunger pump shall not be less than 20μm. And that of vane pump shall not be less than 30μm.

9 When stainless steel pipes are installed, stainless steel gaskets or plastic and rubber gaskets with no chloride ions shall be used, and the pipes shall not be in direct contact with carbon steel pipe brackets.

10 Two straight sections on both sides of the pipe bend shall be fixed by pipe clamps. The pipe shall be firmly supported by pipe clamps at its end and along the length direction. The pipe clamps shall be spaced in compliance with the provisions of current professional standard SL 41 *Design Code for Gate Hoist in Water Resources and Hydropower Projects*.

11 An exclusive hydraulic pump shall be used for the overall circulation flushing of pipeline, and the hydraulic system and hydraulic cylinder circuit shall be cut off accordingly. During flushing, flow velocity in the pipeline shall be large enough to attain a turbulent flow, and the filtration accuracy of filter shall not be less than 10pm. The pipeline flushing shall comply with relevant provisions of JB/T 6996 *Common Technical Condition of Heavy Machinery Hydraulic System*. The flushing shall only be terminated at the time solid particle contamination level of flushing liquid meets the design requirements.

10.5.4 The installation of screw hoist shall be in accordance with the following requirements:

1 Before installation, the hoist shall be inspected according to design drawings and shall meet design requirements.

2 After cleaning and inspection, new oil shall be injected into the speed reducer, and oil level shall

be consistent with the graduates on the oil level gauge. The speed reducer shall rotate flexibly, and there shall be no oil leakage at oil seal and interfaces.

3 The length of anchor bolts shall be checked, nuts shall be tightened, and threads shall be checked for normality. If necessary, a die shall be used for thread restoring.

4 The location for foundation embedded parts shall meet design requirements, and the projected length of bolts shall meet design requirements.

5 The allowable deviation of the distance between longitudinal or transverse centerline of the screw hoist base and the lifting centerline measured at the actual position of the gate lifting lug shall be less than 2mm. The flatness deviation for upper plane on the foundation plate shall be no greater than 0.5mm/1 000mm, the allowable elevation deviation shall be ±5mm, and the relative elevation deviation of double lifting points shall not be greater than 5mm.

6 The base shall be in close contact with the base plate, and the local clearance shall not be greater than 0.5mm. The contact area between the base and the base plate shall be greater than 70% of the total area.

7 The verticality deviation of the screw before being connected to the gate shall not be greater than 0.2mm/1 000mm.

10.6 Testing on steel structures and equipment

10.6.1 The testing on sluice gate, flap gate and trash rack shall be in accordance with the following requirements:

1 After the installation of the sluice gate, opening and closing tests on the gate shall be carried out in the dry over the full range of travel. Before opening and closing, the sealing rubber shall be sprayed with water for lubrication. If conditions permit, the opening and closing of service gate and emergency gate shall be tested in flowing water.

2 During the opening and closing of sluice gate and flap gate, the operation behavior of the rotation parts including roller, flap hinge and others shall be checked. The lifting and closing of gates shall be operated without being stuck. The left and right lifting points of hoist shall move in synchronized way. The sealing rubber and the buffer block of quick gate and flap gate shall be free of damage.

3 After the installation of quick gate and flap gate, gate closing speed shall be tested, and the closing time shall meet the pump unit protection requirements.

4 After the trash rack is installed in the slot, lifting test shall be carried out to check whether there is any jamming in rack slot, whether rack system works properly, and whether the connection between each rack segment is reliable.

5 When a sluice gate is subject to the designed water head pressure, the allowable leakage of the water sealing shall comply with the provisions in Table 10.6.1.

Table 10.6.1 Allowable leakage of water sealing of sluice gate

Sealing material	Water leakage per meter of water sealing length (L/s)
Rubber	≤0.1
Metal	≤0.8

10.6.2 The test on fixed winch hoist shall be in accordance with the following requirements:

1 Before the no-load operation of the hoist, the electrical components, cable wiring, and travel

switch in the electrical control cabinet shall be checked. The electrical control shall meet design requirements. The electrical equipment used for the testing should be those specifically provided for the hoist, and 3 times gate raising and lowering operation over the full range of the travel shall be tested, with gate raising and lowering operation over the full range of the travel for 3 times. In addition to the necessary items, the following inspections shall also be carried out:

1) The steel wire rope shall not rub against other components at any part.

2) The lifting height and speed shall meet design requirements.

3) The steel wire rope shall be wound neatly on the drum, and overlapping or wrapping on the wrong drum groove shall not be allowed.

4) For the hoist with double lifting points and multi-layer winding rope, the layers of the steel wire ropes on different drums shall be changed synchronously.

5) The closing time of quick gate hoist shall not exceed the designed allowable value, preferably 2 minutes. During quick closing, the maximum speed at the location close to the bottom sill shall not exceed 5m/min.

6) The opening indication and limit switch device for water filling valve of the sluice gate shall be accurate and reliable. It is required to preset a water filling opening value so as to trigger the equipment to stop and fill water when the water filling valve opens. When the mechanism reaches the upper or lower limit position during operation, the main power supply is automatically disconnected and a signal is sent to stop the equipment.

7) Protection devices for electrical short circuit, overcurrent, voltage loss, zero position, phase loss, emergency stop, interlocking and others are reliable.

2 For load testing on the gate hoist, gate operated in the dry or in still water shall be tested first, and gate raising and lowering operation over the full range of the travel shall be carried out twice respectively in such test. After passing the above tests, the hoist for service gates such as the flap gate and the quick gate shall be tested with the gate opened or closed in flowing water according to the operation conditions of the gate, while the hoist for emergency gate should be tested with the gate closed in flowing water and opened in still water, with the gate raising and lowering operation over the full range of the travel twice. If there is an opportunity, the hoist for fast gate and emergency gate shall be tested with the gate closed in flowing water under the design pump lift condition, and with the gate quickly closed over the full range of travel under the load rejection condition at a maximum blade angle of the unit.

3 During the load test, the following inspections shall be conducted on the mechanical part:

1) The parts and components run smoothly without any abnormality.

2) The mechanism shall have no cracks, permanent deformations, and loose or damaged connections. The secondary contact spots and lateral clearances of open gear pairs shall meet the requirements. The brake shall be free of any skidding, without burnt smell or smoke emission. The quick-closing time for quick gate hoist shall not exceed the design allowable value. The maximum speed when the gate approaching the bottom sill during rapid closing shall not exceed 5m/min. The action function of centrifugal governor shall be normal, and the highest temperature of friction surface shall not exceed 200℃. When DC power is used to release the switch, the highest temperature of electromagnetic coil shall not exceed 100℃. The temperature of rolling bearing shall not exceed 85℃, and the temperature rise shall not exceed 35K. The temperature of sliding bearing shall not exceed 70℃, and the temperature rise shall not exceed 20K.

4 During the load test, the following inspections shall be conducted on the electrical part:

1) The motor runs smoothly, and the ratio between the unbalance deferential of three-phase current of motor and the rated current does not exceed 10%.

2) The electrical components are free from abnormal heating, and the contact of the controllers is free from burning.

3) The readings of opening indicator and load limiter accurately reflect the opening and closing forces of the gate at different openings. When the load reaches 90% of rated lifting load, the load limiter sends out a light alarm signal. When the limit position is reached or the load reaches 110% of rated lifting load, the motor power is automatically disconnected, the brake works for stop, and audible and visual alarm signals are sent out at the same time.

4) The protection function meets the design requirements and relevant regulations.

10.6.3 The testing on movable hoists shall be in accordance with the following requirements:

1 The inspection before the test shall be in accordance with the following requirements:

1) The oil filling conditions of all operating mechanism, hydraulic systems, speed reducers, and lubrication points shall be checked. The performance, type and quantity of lubricating oil meet the requirements of the accompanying technical documents.

2) Brake, load limiter, hydraulic safety overflow device, and the devices of overspeed limit protection, overvoltage and undervoltage protection, and overcurrent protection shall be tested and adjusted according to the requirements of the accompanying technical documents.

3) Electrical system, travel limit device, interlocking device and emergency power off device are sensitive, correct and reliable.

4) The wiring of each motor shall be checked to make sure the rotation direction of the motor, handwheel, handle, button, and controller operation indication direction are consistent with the actual direction requirements of the mechanism movement and action. For lifting or traveling mechanism driven by multiple motors, it shall be checked whether the rotation directions and speeds of the motors are consistent and synchronous, and whether the load currents of all motors are balanced.

5) The cable drum, central conductive device, sliding wire, electrical cabinet, interlock platform, transformer and motors shall be connected correctly without loosening, and the grounding shall be checked in a normal condition.

6) The fixing of wire rope ends and the wrapping of the rope on the drum and sheaves shall be correct and reliable. For the lifting mechanism with double lifting points, the steel wire ropes at the two lifting points shall be adjusted to the same length.

7) The brake wheel or disc of each mechanism shall be rotated by hand to make the last shaft rotate for one circle without being stuck.

8) The buffer, bumper, rail clamp, anchoring device and grounding device are installed correctly, quick in response, safe and reliable.

9) Before the test, the objects on both sides of the track hindering the operation shall be removed.

2 During the no-load test, the lifting and traveling mechanism shall run back and forth three times over the full range of travel, and shall be in accordance with the following requirements:

1) The mechanical parts shall run smoothly without any abnormality.

2) There shall be clearance between the brake pad and the brake wheel or disc during operation.

3)Bearings and gears shall be well lubricated.

4)In case of no interference from other noise sources, the noise generated by the mechanism shall be no greater than 85dB (A)when the cab window is closed.

5)When the crane and trolley run, the wheels shall be free of rail gnawing.

6)The motor shall run smoothly, and the ratio between the unbalance of three-phase stator current and the rated current of motor shall not exceed by 10%.

7)The electrical components shall be free from abnormal heating and the contact of controller shall be free from burning.

8)The travel limit device, safety device and interlocking device shall be quickly responsive and reliable. The operation handle and operation button shall act consistently with the actions of all mechanisms.

9)The cable reel for power-supply shall be easy to use, cable retraction and release shall be synchronized with the crane movement, and cable winding shall not be loose. The cable length shall meet the needs of crane movement, and the end switch of cable reel shall be accurate and reliable.

10)Devices for electrical short circuit, overcurrent, voltage loss, zero position, phase loss, emergency stop, overspeed, interlocking, wind speed, anchor, and rail clamp shall be reliable.

11)When crane and trolley run, the conductive device shall operate smoothly without jamming, jumping and serious sparkling.

3 The bearing capacity inspection on all parts of the hoist and steel structures by the static load test shall meet the following requirements:

1)The weight blocks meeting the requirements of static load test shall be available on the installation site.

2)The static load test shall be divided into three levels of 75%, 100% and 125% from the lowest level to the highest, and the operation condition of each part shall be observed and tested during the loading process. Higher-level test may be carried out only after the lower-level test is passed.

3)The trolley shall stop at the midspan of the main beam and the free cantilever end, respectively, and to set up the measuring reference point accordingly. The test load shall be increased gradually from 75%to 125%of the rated load, and the weight blocks shall be kept 100mm to 200mm above the ground for 10 minutes with no instability. After being unloaded, the gantry frame or bridge shall be checked for permanent deformation. Such check shall be repeated 3 times and there shall be no permanent deformation on the gantry frame or bridge.

4)The unloaded empty trolley shall be driven to the gantry leg or the span end of bridge to check the actual camber of main beam and the actual upward deflection of cantilever beam, which shall be no less than the value in Table 10.6.3.

Table 10.6.3 Minimum value of actual camber of main beam and actual upward deflection of cantilever

Category	Testing location	Minimum value
Main beam of two-way gantry crane or bridge crane	Within the middle $L/10$ of the main beam span	$0.7L/1\,000$
Gantry crane cantilever beam	Effective part of cantilever	$0.7L/350$
Main beam of one-way gantry crane or bridge crane	Within the middle $L/10$ of the main beam span	0

5)After static load test, make the trolley lift rated load to a height of 200 mm from the ground both at the midspan of the main beam and the effective part of cantilever. After the load is still, check the deflection value of main beam, which shall be no greater than $0.7L/1\ 000$ at the midspan and $0.7L/350$ at the free cantilever end. After the above static load test, check whether the steel structures of hoist are free of cracks, weld cracks, paint wrinkles, loose connections and damages that affect the performance and safety of the hoist.

4 The working performance inspection of each mechanism of the hoist and its brake by dynamic load test shall be in accordance with the following requirements:

1)The test run of each mechanism shall be conducted at dynamic load. If combined test run is required, test program shall be followed.

2)During dynamic load test at 110% rated load, short the output nodes of the load sensor, or make forcible shorting in the PLC program and return to the original setting state after the test.

3)At the rated load lifting point, 110% rated load shall be lifted, and the actions of raising, lowering, stopping, raising, and lowering shall be repeated for no less than 1h.

4)The crane and trolley shall lift 110% rated operating load and run back and forth twice over the normal range of travel. When the hoist is used as a crane, the crane and trolley shall run back and forth twice over the normal range of travel at 110% rated load.

5)Combined running test shall be conducted at 110% rated load according to design requirements. When there is no design requirement, a lifting mechanism and a traveling mechanism shall be started at the same time for test. The combined action of the revolving crane shall meet the design requirements. All kinds of actions shall be started, operated and braked repeatedly over the full range of travel, with the duration of no less than 1h.

6)In the tests of items 1 to 5 of this paragraph, the mechanisms shall act sensitively, work stably and reliably, the actions of limit switch and the devices of safety protection interlocking, anti-creeping shall be reliable, and the bearing temperature and temperature rise shall meet the requirements in Article 10.6.2, Item 3, 2 of this standard.

7)Check the hoist after unloading and the lifting mechanism and structure shall be free of damage, permanent deformation, loose connection, weld crack, coating wrinkling, and leakage of hydraulic system and seal.

5 If a type test before the installation of hoist is specified in the engineering design or bidding documents, it shall be conducted by the corresponding entrusted inspection and testing institution in accordance with the provisions of TSG Q7002 *Regulation for Type Test of Lifting Appliances*, and a type test report for the hoist shall be submitted.

10.6.4 The testing on screw type hoists shall be in accordance with the following requirements:

1 Before testing, electrical equipment shall be inspected as follows:

1)Electrical components in the electrical panel and cabinet shall be checked for their completeness and firm connection, and cable wiring from the electrical panel and cabinet to the equipment shall be correct.

2)The insulation resistance of the circuit shall be greater than 0.5MΩ.

3)The brush contact surface of the wound motor shall be checked, and the contact area shall not be less than 75% of single brush cross section.

4) The limit switch shall be checked to make sure the contact is intact, and connection and disconnection are correct.

5) The emergency stop protection function shall be reliable.

2 For no-load running testing, the hoist shall be made to run back and forth three times over the full range of travel at the designed speed and under the conditions of the hoist carrying no gate. The test results shall be in accordance with the following requirements:

1) The parts and components run smoothly without any abnormality.

2) The speed reducer is free of oil leakage.

3) The motor runs smoothly, and the ratio between the unbalanced differential of the three-phase stator current of motor and the rated current does not exceed 10%.

4) The electrical components are free from abnormal heating, and the contact of controller is free from burning.

5) The opening detector and travel switch device are accurate and reliable. When the mechanism runs to the limit position, the main power supply is automatically disconnected, and the signal is sent at the same time to stop the equipment.

3 For the load test on the hoist for gate opening and closing, the gate shall be raised and lowered twice over the full range of travel in the dry or in still water. For the service gate opened and closed in the flowing water, the gate shall be raised and lowered twice in flowing water under the design head condition. The tests shall be in accordance with the following requirements:

1) The parts and components run smoothly without any abnormality.

2) The hoist with double lifting points acts synchronous throughout the whole process, and there is no jamming or abnormality when opening and closing. The temperature and current of motor are not greater than the specified values.

3) The electrical components are free from abnormal heating, and the contact of controller is free from burning.

4) The opening detector and travel switch device are accurate and reliable. When the mechanism runs to the limit position, the main power supply is automatically disconnected, and the signal is sent at the same time to stop the equipment. The load limiter shall be accurate and reliable. When 90% of the rated lifting load reaches, a light alarm signal is sent out. When the load reaches 110% of rated lifting load, the power supply of motor is automatically disconnected, and audible and visual alarm signals are sent out at the same time. If the hoist is not equipped with a load sensor, the load mechanical travel switch acts when the lifting is overloaded.

10.7 Strengthening and retrofitting of steel structures

10.7.1 Before strengthening and retrofitting, the design drawings, as-built drawings, and test data of steel structures related shall be collected and analyzed. The construction plan for such purpose shall be formulated according to the design requirements and relevant provisions in the current national and professional standards. Strengthening and retrofitting shall be carried out according to the construction plan. When construction needs to be adjusted, the construction plan shall be revised timely.

10.7.2 In addition to the specified provisions in this standard, the strengthening of gate leaf, trash rack and others shall be in accordance with the following requirements:

1 For the welding of original components, the material of the components and welding

performance shall be verified. If impossible, the welding technology appraisal shall be carried out according to current national standard GB/T 19866 *Specification and Qualification of Welding Procedures for Metallic Materials-General Rules*.

2 The welding sequence shall be arranged reasonably according to structural characteristics of the original component, and welding deformation shall be controlled. In addition, the parts or fittings on the component that are planned to be retained shall be protected against damage by welding deformation.

3 Welding in any form shall not be performed on the gate proper if the gate is under the condition of water retaining.

4 Before welding, paint, oil stain, welding scar and other residues at the welding position of the original component shall be removed.

5 After strengthening and retrofitting of the component, static balance test shall be carried out to determine the gravity center of the component again.

6 After strengthening and retrofitting, anti-corrosion treatment shall meet design requirements. If there is no requirement in the design, it shall be implemented according to the current professional standard SL 105 *Specifications for Anticorrosion of Hydraulic Steel Structure*.

10.7.3 The replacement of embedded parts shall be in accordance with the following requirements:

1 During the removal of the original embedded parts, the reinforcement bars in the concrete should be retained. When the retained reinforcement bars do not meet the fixing strength requirements of the embedded parts, anchor bars should be increased by planting new reinforcement bars.

2 The chiseling scope of concrete shall meet design requirements. If there is no requirement in the design, the minimum space required for installation of new embedded parts shall be maintained.

3 During the concrete chiseling, measures shall be taken to minimize the damage to the original civil structures.

4 Survey and repeating survey shall be carried out on the newly embedded parts before and after the placement of the second stage concrete.

11 Quality control

11.1 General requirements

11.1.1 The constructor shall establish a quality assurance system in accordance with the relevant provisions of current national standards, such as GB/T 19000 *Quality Management Systems-Fundamentals and Vocabulary* and GB/T 19001 *Quality Management Systems-Requirements*. The constructors shall also formulate a set of systems for construction quality inspection and acceptance in consideration of the actual situation of the project thereof.

11.1.2 During the construction, the centerline, axis, elevation, dimensions and perpendicularity of the control parts shall be inspected and tested. The inspection and testing shall comply with design requirements and provisions in Section 3.4 of this standard, and it shall be corrected promptly when any non-conformity is found in the quality requirements.

11.1.3 The following records shall be well made during construction:

1 The description of geological conditions of pumping station.

2 Foundation treatment method, construction machinery and technical parameters.

3 Certificate of raw materials, certificate of intermediate product.

4 The reports of on-site inspection and sampling.

5 Monitoring data.

6 Problems and corresponding treatment measures during construction.

7 Quality testing, quality inspection opinions.

11.1.4 In addition to the records specified in Article 11.1.3 of this standard, the following original records shall be made during the strengthening and retrofitting construction:

1 Data of inspection or test on structures and components retained and strengthened.

2 Quality inspection and acceptance documents from the constructor, designer and supervisor on strengthening and retrofitting construction.

11.1.5 The concealed works after excavation or before the construction of the next works shall be checked for acceptance according to relevant regulations. The following data shall be available for such acceptance check:

1 Construction drawings and design modification documents.

2 As-built drawing of excavation, including plan, longitudinal and transverse cross sections.

3 Reports on geological logging, survey results, core test, soft foundation bearing capacity test, structural strength and others.

4 Image data.

5 Construction records.

6 Other necessary data.

11.1.6 The quality check and evaluation on structure construction and steel structure installation shall be in accordance with the following requirements:

1 The quality check and evaluation shall be executed according to the design requirements and the provisions in this standard.

2 If there is no requirement in design or no provision in this standard, the quality check and evaluation shall conform to the following requirements in addition to the provisions of the current national standard GB 50265 *Standard for Pumping Station Design*:

1) Earth-rock works shall be carried out in accordance with the provisions of current professional standard SL 631 *Inspection and Assessment Standard for Separated Item Project Construction Quality of Water Conservancy and Hydroelectric Engineering-Earth-Rock Works*;

2) The ground treatment and foundation works shall be carried out in accordance with the provisions of current professional standard SL 633 *Inspection and Assessment Standard for Separated Item Project Construction Quality of Water Conservancy and Hydroelectric Engineering-Ground Treatment & Foundation Works*;

3) Concrete works shall be carried out in accordance with the provisions of current national standards GB 50164 *Standard for Quality Control of Concrete*, GB 50204 *Code for Quality Acceptance of Concrete Structure Construction* and current professional standard SL 632 *Inspection and Assessment Standard for Separated Item Project Construction Quality of Water Conservancy and Hydroelectric Engineering-Concrete Works*;

4) The installation of hydraulic steel structures shall be carried out in accordance with the provisions of current professional standards SL 635 *Inspection and Assessment Standard for Separated Item Project Construction Quality of Water Conservancy and Hydroelectric Engineering-Installation of Metal Structures* and SL 582 *Directives for Quality Inspection of Manufacture and Installation of Hydro Steel Structure*;

5) The quality testing and inspection shall be carried out in accordance with the provisions of current professional standards SL 734 *Technical Code for Quality Detection of Water Projects*, SL 316 *Code for Safety Appraisal of Pumping Stations* and SL 548 *The Code of Practice of Field Testing of Performance and Safety for Pumping Station*.

3 Due attention shall be paid to check the construction process and procedures.

11.1.7 When the structure construction reaches the conditions for the installation of electromechanical equipment, steel structures and water outlet pipe, the constructor responsible for the structure construction shall timely hand over the datum line and benchmarks related to the installation work to the constructor undertaking the installation works on site.

11.1.8 Before being put into use, the civil and steel structures of the pumping station shall be inspected in accordance with the provisions of current national standard GB/T 30948 *Code of practice for Technical Management of Pumping station* and shall meet the management requirements.

11.2 Concrete quality test and defect treatment

11.2.1 Commercial concrete should be used for structure construction.

11.2.2 The quality test on materials for concrete produced on site shall be in accordance with the following requirements:

1 The aggregates shall be selected based on the principles of high quality, economy and use of local materials in priority, and shall be in accordance with the following requirements:

1) Natural aggregates, aggregates of crushed stone or both may be used.

2) For aggregates of crushed stone, limestone should be used in priority.

3) Every 600t to 1 200t of fine aggregates from the same source is taken as one package.

4)Every 2 000t of coarse aggregates from the same source and with the same specification shall be taken as one package, and every 1 000t of pebbles shall be taken as one package;

5)Alkali-active aggregates, and aggregates with yellow rust or calcareous agglomerates shall not be used without specific demonstration.

2 The branded cement, admixtures, additives, and other raw materials should be chosen for use or selected through tests. The manufacturers selected as the materials supplier shall be maintained relatively unchanged and the materials shall be in accordance with the following requirements:

1)The materials delivered to the site shall be provided with factory delivery certificate and quality test report, and shall be sampled for test after arrival at the construction site.

2)Every 200t to 400t of cement from the same factory with same brand, same strength grade and same production batch number is taken as one package. If the total cement quantity is less than 200t, it shall still be considered as one package.

3)For bagged cement with storage and transportation time of more than 3 months, and bulk cement with more than 6 months, retesting is required before use. Agglomerated cement is not used, and cement agglomerated due to damping may be used only after being treated and tested as qualified.

4)Continuously supplied admixture of the same variety to a quantity not exceeding 200t is taken as a package, and the admixture of less than 200t shall be taken as one package.

5)When the content of additives of the same variety and from the same manufacturer is not less than 1% of the concrete mixture, the additives of no more than 100t in total quantity shall be taken as one package. When the content is less than 1%, one package shall be in a quantity of no more than 50t. When the content is less than 0.05%, one package shall be in a quantity of no more than 2t.

3 All drinking water conforming to the provisions of current national standard GB 5749 *Standard for Drinking Water Quality* may be used for mixing concrete. When surface water, groundwater and other types of water are used for mixing concrete for the first time, they shall be tested as qualified before use. Retesting shall be conducted when water source changes.

11.2.3 The checking and testing on mixing and placing process of concrete produced on site shall be in accordance with the following requirements:

1 The gauge for concrete batching plant (station) shall be calibrated at least once a month, and sampling test shall be conducted at any time when necessary. The raw material proportion testing shall not be less than 3 times per shift, and the zero-point calibration of the weighing equipment shall be performed before the use of the weighing equipment by each shift.

2 Fineness modulus of sand, content of stone powder in crushed sand, and the silt content of natural sand shall be tested once a day. The moisture content of sand and gravel surface shall be tested once every 4h, and the testing shall be intensified in rainy and snowy weather and other special circumstances. The coarse aggregate shall be tested once every 8h for its oversize, undersize and silt content.

3 The concentration of additive solution shall be tested once or twice a day. The air content of concrete with air entraining agent shall be tested once every 4h, and the allowable deviation for air content of concrete shall be 1.0%.

4 During concrete mixing, batched raw material weighing, concrete mixture uniformity and

mixing time shall be checked and recorded, no less than twice every 8h.

5 The concrete slump shall be tested at the mixer discharge once or twice every 4h, and at the placement area once or twice every 8h. The testing shall be intensified in high temperature, rain and snow weather.

6 Before concrete placing, the treatment of foundation surface or construction joint surface, formwork, reinforcement, embedded parts shall be evaluated according to the provisions of current professional standard SL 632 *Inspection and Assesment Standard for Separated Item Project Construction Quality of Water Conservancy and Hydroelectric Engineering—Concrete Works*. Concrete shall not be placed until the above-mentioned works are qualified for acceptance and permission for commencement of concrete placement is obtained.

7 If steel structures, electromechanical equipment and instruments are to be concealed by concrete, the permission for commencement of concealing concrete placement shall not be started until the relative acceptance is conformed.

8 After the concrete mixture is deposited to the placing area, the uniformity and workability shall be observed, and any abnormality shall be handled in time.

9 When concrete is placed, a dedicated person shall be assigned in site to check and record the problems occurring in the placement and the relative treatment measures shall be taken.

10 After formworks are removed, the appearance quality shall be checked. If there are defects such as cracks, honeycombs, pitted surfaces, staggered platforms and formwork deviation, timely inspection, report and treatment shall be carried out.

11.2.4 The concrete quality testing shall be carried out mainly on compressive strength of 150mm cube specimens under standard curing conditions. If necessary, tensile strength, anti-freezing capacity and impermeability tests shall also be conducted. The concrete specimens of the same strength grade shall be reserved in a certain quantity according to the following provisions:

1 Specimens of concrete with different strength grades and different mix proportions shall be prepared separately.

2 The specimens for compressive strength shall meet the following requirements:

1) For thick and large-sized concrete components, 1 set of test specimens shall be prepared for every $100m^3$ to $200m^3$ of concrete.

2) For thin and small-sized concrete components, 1 set of test specimens shall be prepared for every $50m^3$ to $100m^3$ of concrete.

3) For each sub-part of works, no less than 1 set of test specimens shall be prepared;

4) For cast-in-place floors, no less than 1 set of test specimens shall be made for each floor;

5) No less than 1 set of test specimens shall be prepared in each work shift.

3 The specimens for tensile strength testing shall be in accordance with the following requirements:

1) For a 28-day strength, one set of test specimens shall be prepared for every $2\,000m^3$ of concrete produced;

2) For design age strength, one set of test specimens shall be made for every $3\,000m^3$ of concrete produced.

4 For specimens for testing of anti-freezing grade, permeability or other special index, sampling shall be conducted according to the provisions of current national standards GB 50108 *Technical Code*

for Waterproofing of Underground Works and GB 50204 *Code for Quality Acceptance of Concrete Structure Construction*.

11.2.5 Specimens with the same curing conditions as that for the on-site constructed structure shall be reserved during concrete construction. The reserved quantity of test specimens shall meet design requirements. If there is no design requirement, the provisions in Article 11.2.4 of this standard may be followed.

11.2.6 The cube compressive strength test of concrete specimens shall be carried out in accordance with the provisions of current national standard GB/T 50081 *Standard for Test Methods of Concrete Physical and Mechanical Properties*. The statistics of original evaluation data of concrete quality shall be in accordance with the following requirements:

1 A same package of concrete with same strength grade and mix proportion shall be taken as a statistical unit.

2 Any data shall not be discarded arbitrarily.

3 The average value of three test specimens in each set shall be taken as one statistical data. When the difference between the maximum and middle-value strength obtained from the three test specimens or between the minimum and middle-value strength obtained from the three test specimens exceeds 15% of the middle-value strength, the middle-value strength may be taken as one statistical data. When the difference between the maximum and the middle-value strength from the three test specimens and the difference between the minimum and the middle-value strength from the three test specimens exceed 15% of the middle-value strength, such set of test specimens shall not be used as the basis for strength evaluation.

11.2.7 When non-standard size test specimens are used, the compressive strength shall be multiplied by the size conversion factor and converted into the compressive strength of standard size test specimens with a side length of 150mm. The size conversion factor shall be adopted as follows:

1 For the concrete with strength grade lower than C60, a factor of 0.95 shall be taken for a cube test specimen with a side length of 100mm, while a factor of 1.05 shall be taken for a cube test specimen with a side length of 200mm.

2 For concrete with strength grade not lower than C60, standard size test specimens should be used. When non-standard size test specimens are used, the size conversion factor shall be determined by tests, and the number of test specimens shall not be less than 30 pairs.

11.2.8 Concrete strength assessment shall be in accordance with the following requirements:

1 Concrete strength shall be tested and accepted in package. The concrete tested and accepted in the same package shall have the same strength grade, and with basically the same production workmanship and mix proportions. Cast-in-place concrete structural components shall be divided into acceptance packages according to the acceptance items of unit works. The concrete strength of the same acceptance package shall be evaluated based on the representative strength value of all standard test specimens in the same package.

2 When the production conditions of concrete are unchanged for a long time and the strength variation performance of the same type of concrete is stable, three consecutive sets of test specimens shall represent one package to be accepted, and the strength shall meet the requirements of the following formulas at the same time:

$$m_{f_{cu}} \geqslant f_{cu,k} + 0.7\sigma_0 \qquad (11.2.8\text{-}1)$$

$$f_{cu,min} \geqslant f_{cu,k} - 0.7\sigma_0 \quad (11.2.8\text{-}2)$$

3 When the strength grade is not higher than C20, the strength shall also meet the requirements by the following formula in addition to the requirements of Formulas (11.2.8-1)and (11.2.8-2):

$$f_{cu,min} \geqslant 0.85 f_{cu,k} \quad (11.2.8\text{-}3)$$

4 When the strength grade is higher than C20, the minimum strength value shall meet the requirements by the following formula in addition to the requirements of Formulas (11.2.8-1) and (11.2.8-2):

$$f_{cu,min} \geqslant 0.90 f_{cu,k} \quad (11.2.8\text{-}4)$$

Where: $m_{f_{cu}}$—average value of concrete strength of the same acceptance package (N/mm^2);

$f_{cu,k}$— characteristic value of concrete specified in the design (N/mm^2);

σ_0— standard deviation of concrete strength of acceptance package (N/mm^2);

$f_{cu,min}$— minimum value of concrete strength of the same acceptance package (N/mm^2).

5 The standard deviation of concrete strength for an accepted package shall be determined by the formula below and based on the strength data of concrete specimens obtained during the previous test period with the same variety:

$$\sigma_0 = \frac{0.59}{m} \sum_{i-1}^{m} \Delta f_{cu,i} \quad (11.2.8\text{-}5)$$

Where: $\Delta f_{cu,i}$—difference between the maximum and minimum values of the strength of the ith accepted package of concrete specimens in the previous test period;

m— total number of acceptance packages in the previous test period.

6 Each test period shall not exceed 3 months, and the total number of acceptance packages within this period shall not be less than 15.

7 If the conditions for concrete production change, or if no sufficient strength data from the concrete of same variety during previous test period is available to determine the standard deviation of concrete strength for an acceptance package, no less than 10 sets of specimens shall be used to represent one acceptance package. The strength shall simultaneously meet the requirements of the following formulas:

$$m_{f_{cu}} - \lambda_1 S_{f_{cu}} \geqslant 0.9 f_{cu,k} \quad (11.2.8\text{-}6)$$

$$f_{cu,min} \geqslant \lambda_2 f_{cu,k} \quad (11.2.8\text{-}7)$$

Where: $S_{f_{cu}}$— standard deviation of concrete strength of acceptance package (N/mm^2). When the calculated value of $S_{f_{cu}}$ is less than $0.06 f_{cu.k}$, $S_{f_{cu}} = 0.06 f_{cu,k}$;

λ_1, λ_2— qualified judgment coefficient, which shall be selected according to Table 11.2.8.

Table 11.2.8 Judgment coefficient for qualification

Number of specimen set	10 to 14	15 to 24	⩾25
λ_1	1.70	1.65	1.60
λ_2	0.90	0.85	0.85

8 The standard deviation of concrete strength of one acceptancepackage shall be calculated according to the following formula:

$$S_{f_{cu}} = \sqrt{\frac{\sum_{i=1}^{n} f_{cu,i}^2 - n m_{f_{cu}}^2}{n-1}} \quad (11.2.8\text{-}8)$$

Where: $f_{cu,i}$—strength value of the ith set of concrete specimens in the acceptance package (N/mm^2);

n—total number of concrete test specimen sets in an acceptance package.

9 The strength for concrete for miscellaneous precast components or concrete produced on site in a small amount may be evaluated by the non-statistical method. The concrete strength of such an acceptance package shall meet requirements of the following formulas at the same time:

$$m_{f_{cu}} \geqslant 1.15 f_{cu,k} \tag{11.2.8-9}$$

$$f_{cu,min} \geqslant 0.95 f_{cu,k} \tag{11.2.8-10}$$

11.2.9 If the compressive strength test results of the concrete specimens do not meet the requirements of the qualification standard or there is doubt about the representativeness of concrete specimen strength, the specimen by concrete core sampling from the structure component or the non-destructive test method may be used to test the strength of the structure component according to current professional standard SL/T 352 *Test Code for Hydraulic Concrete*. If the requirements are still not met, the structural safety of completed structure shall be calculated according to actual conditions, and remedial measures or other treatment measures shall be taken.

11.2.10 For concrete surface defects that do not affect the service performance of structure, cement mortar with same type of cement as that for the parent structure shall be prepared to treat the defected surface by troweling after roughening and cleaning, and curing shall be intensified.

11.2.11 The concrete defects affecting the service performance of structure shall be studied jointly with the teams involved in the construction and treated accordingly. The following measures may be taken if the concrete defects do not constitute potential hazards or quality accidents:

1 After the loose concrete is removed and the surface is washed, the honeycombs or reinforcement bars exposed in depth and deep holes shall be brushed with cement paste or chemical binder and then filled and tamped with fine aggregate concrete. In such case, water-cement ratio should be less than 0.5, and an appropriate amount of expansion agent should be added.

2 For deep honeycombs and holes that are difficult to clean, pressure grouting shall be used to repair, and cement mortar with waterproof agent shall be pressed in, and water-cement ratio shall be 0.7 to 1.1.

3 The causes of cracks in reinforced concrete components shall be ascertained, and the treatment scheme shall be prepared and approved by the designer before treatment.

12 Construction acceptance of pumping station

12.0.1 The acceptance item division and quality assessment for structure construction and steel structures installation works shall be carried out in accordance with the provisions of current professional standard SL 176 *Inspection and Assessment Specification for Construction Quality of Hydraulic and Hydroelectric Engineering*.

12.0.2 The stage division, procedure and items for acceptance of structure construction and steel structures installation works shall follow the provisions of current professional standard SL 223 *Acceptance Code of Practice on Water Resources and Hydroelectric Engineering*.

12.0.3 Before the acceptance of each stage of structure construction and steel structures installation works by the owner, the constructor shall conduct a self-acceptance, and the acceptance by the owner shall be conducted according to relevant procedures only after the self-acceptance is qualified.

12.0.4 The acceptance of installation of steel structural works such as gate, flap gate, trash rack, gate hoist and trash remover may be carried out in the forms of the installation quality acceptance and trial-operation acceptance, respectively. The trial operation acceptance may be carried out in combination with the pump unit startup and commissioning, and shall comply with the provisions in Chapter 10 of this standard.

12.0.5 After the completion of structure construction, steel structural works installation and equipment installation, the acceptance for pump unit startup and commissioning shall be carried out according to the provisions of the current professional standard SL 317 *Specification for Equipment Installation and Acceptance of Pumping Stations*. The acceptance for taking-over of the pumping station shall be carried out only after the startup commissioning acceptance is qualified and certain operating conditions and relevant regulations are met. The taking-over acceptance shall be carried out in accordance with the provisions of the current professional standard SL 223 *Acceptance Code of Practice on Water Resources and Hydroelectric Engineering*.

12.0.6 During the acceptance of various stages of construction and installation works, the data and documents for acceptance shall be provided in accordance with the provisions of the current professional standard SL 223 *Acceptance Code of Practice on Water Resources and Hydroelectric Engineering*, and the data or documents for acceptance shall be modified and improved according to the acceptance comments. At the same time, such data or documents shall be transferred to the project legal representative for archiving.

Appendix A Soil replacement method

A.0.1 The method of replacing the fill layer may be applied to the treatment of the foundations of silt, sludge soil, collapsible loess, plain fill soil and miscellaneous soil, and of shallow layers, such as covered ditch, covered pond and so on.

A.0.2 Plain soil cushion composed of natural fine-grained soil may be used to replace the soft soil foundation of pumping station buildings. The plain soil cushion shall be in accordance with the following requirements:

1 The thickness of the plain soil cushion should not be less than 0.5m, nor should it be greater than 3m, and the bearing capacity characteristic value of the plain soil cushion should not exceed 180kPa in the absence of measured data.

2 The physical and mechanical properties and parameters of the plain soil cushion should be obtained through field tests.

3 The fine-grained soil used for the plain soil cushion shall not be mixed with cultivated (planted) soil, sludge soil and frozen soil blocks. Expansive soil, saline soil and soil with an organic matter content of more than 5% shall not be used. If gravels are contained, the particle size should not be greater than 50mm. The plain soil cushion used for collapsible loess foundation treatment shall not contain bricks, tiles, stones and other coarse-grained materials in the soil. Soil mixed with garbages and chemical corrosive substances shall not be used as plain soil.

4 The construction of plain soil cushion shall be in accordance with the following requirements:

1) When the backfill contains coarse particles with a particle size of no more than 50mm, it should be evenly distributed.

2) The water content of the backfill should be controlled within the range of the optimal water content Wop (100±2)% for the compaction tests.

3) The construction method of the plain soil cushion, the thickness of layered paving, and the number of compaction on each layer should be determined by tests. The layered laying thickness of the cushion may be 200mm to 300mm, the mechanical rolling speed should be controlled, and the compactionness should meet the design requirements.

4) Before the construction on the upper foundation start, the plain soil cushion should be protected from rain, frost and sun exposure.

5 After each layer is compacted, dry weight inspection and compactionness test shall be carried out, and the sampling depth shall be 2/3 layer thickness below the top surface of the layer, and the sampling part shall be representative.

6 After the construction of the plain soil cushion is completed, the cushion may be checked by in-situ test methods such as static load test.

A.0.3 The cemented soil cushion may be used for occasions such as uneven distribution of foundation soil layer on the plane of pumping station, required adjustment of settlement differences, eliminations or reduction of collapsibility, acting as a waterproof layer, and improving the stability of the foundation. The construction of cement soil cushion shall be in accordance with the following requirements:

1 The thickness of the cushion should not be less than 0.3m, nor should it be greater than 2m.

2 The ratio of cement to soil in the cushion may be controlled by the volume ratio, and 5% should be used. When the soil is wet, 8% to 12% may be used.

3 The soil used for cushion shall not be mixed with cultivated (plant) soil, sludge soil and frozen soil blocks, the organic matter content shall be no greater than 5%, and the water-soluble salt content shall be no greater than 3%. Expansive soil and saline soil shall not be used.

4 For soil used to make cement soil, the particle size of agglomeration shall not be too large. When mixed by manpower or small machinery, the soil should be screened before use. When special equipment for mixing and crushing is adopted, the particle size of the soil block may be relaxed to the one of no more than 50mm, and such soil shall be mixed evenly. The particle size of the soil block shall not be greater than 20mm when being crushed.

5 The time from the beginning of mixing to the end of rolling or compacting of cement soil should not exceed 24h. The mixed cement soil should not be left for more than 12h.

6 The filling thickness and compaction frequency of each cement soil layer should be determined by field tests according to the specific conditions of the soil and construction machinery. The water content of the backfill material for the cement soil cushion layer should be controlled within the range of the optimum water content Wop (100±4)% obtained from the compaction tests. The compactionness of the cement soil shall meet the design requirements.

7 The sampling and inspection requirements of the cushion should be the same as those of the plain soil cushion. The upper layer soil shall be filled on the cushion only after the compactness of each cushion layer meets the design requirements. If the compactness of the cushion is unqualified, compacting or ramming shall be replenished in time.

8 After the cushion is inspected as qualified, measures shall be taken to prevent rain, sun exposure and frost damage within 3 days to 5 days.

9 The physical and mechanical properties of the cushion shall be determined by on-site static load tests and indoor geotechnical tests.

Appendix B Mixing pile method

B.0.1 The mixing pile method may be applied to the treatment of foundations with normally consolidated silt, sludge soil, silt soil, saturated loose sand, saturated loess, and plain fill soil under the bearing capacity of less than 70kPa. For the treatment of foundations with peaty soil and clay with a plasticity index greater than 25 or with corrosive groundwater, the suitability of the mixing pile method shall be determined by tests. According to different construction methods, the mixing pile method may be divided into dry method or powder mixing method and wet method or slurry stirring method. Dry method should not be used to treat soft soil with groundwater pH value of less than 4 or sulfate content of more than 1%. The wet method shall go through the solidification test to determine its suitability in foundation soil reinforcement with sulfate-resistant cement. The mixing pile method shall be in accordance with the following requirements:

1 Before the determination of the reinforcement scheme, the geological conditions of the foundation soil layer, including the thickness and composition of the soil layer, the thickness and physical and mechanical properties of the soft soil layer, groundwater table, organic matter content, and the pH value and the corrosiveness of groundwater, shall be investigated.

2 The commonly used curing agent for the mixing pile method shall be ordinary Portland cement with a grade of P.O 42.5 or above, and fly ash may be used as admixture.

B.0.2 The construction of cement soil by the mixing pile method shall be in accordance with the following requirements:

1 Before construction, the site shall be leveled and obstacles on the ground and underground shall be removed. Ditches, ponds and depressions shall be drained or dredged, backfilled and compacted if any.

2 Before construction, trial construction shall be carried out according to the design requirements, and the number of trial piles shall not be less than 3. The cement mixing pile machine shall be equipped with measuring devices for depth and curing agent dosage. The number, length, height, tilting angle and rotation speed of the mixing head blades and the lifting speed shall be matched with each other to ensure that the soil at any point within the reinforcement depth range is effectively mixed 20 times by the mixing blades.

3 During construction, the slurry (powder) stopping surface shall be 300mm to 500mm higher than the bottom surface of the foundation. When the foundation pit is excavated, The pile section with poor construction quality at the top of the mixing pile shall be manually excavated.

4 It shall be ensured that the mixing pile machine is level and the guide frame is vertical. The vertical deviation of the mixing pile shall not exceed 1.0%, and the deviation of the pile position shall not be greater than 50mm. The diameter and length of the piling shall not be less than the design value.

B.0.3 The construction of cement soil by the mixing pile method shall follow the following steps:

1 The mixer is in place and leveled.

2 The mixer sinks to the design reinforcement depth for pre-mixing.

3 The mixer is lifted up to the predetermined slurry (powder) stopping surface along with mixing while slurry or powder is sprayed.

4 The mixer repeatedly sinks to the design reinforcement depth along with mixing.

5 The mixer is lifted up to the predetermined slurry (powder) stopping surface along with mixing while slurry or powder is sprayed or only with mixing.

6 The mixer is turned off.

B.0.4 The wet method construction shall be in accordance with the following requirements:

1 Before construction, the construction parameters such as the delivery volume of mortar pump, the time when the mortar reaches the mixer spray port through the slurry pipeline and the lifting speed of the lifting equipment shall be determined, and the construction process shall be determined through the technological pileing test according to the design requirements.

2 All cement used shall be sieved, and the prepared slurry shall not be separated and shall be continuously pumped. The number of slurry mixing tanks, the dosage of cement and admixtures, and the pumping time of the slurry shall be recorded by a dedicated person. The lifting speed and frequency of the spraying machine shall meet the requirements of the construction process, and shall be recorded by a dedicated person. When the slurry reaches the spray port, it shall be sprayed and mixed for 30s. The cement slurry shall be fully mixed with the soil at the end of the pile before the mixer head is lifted up.

3 When the mixer sinks for pre-mixing, it should not be flushed with water. If it encounters a hard soil layer and sinks slowly, water may be flushed, but the flushing shall not affect the strength of the piling.

4 If the slurry delivery stops due to unforeseen reasons during construction, the mixing head should be sunk to a position 0.5m below the stopping point, and the spraying, mixing and lifting of the mixer shall be resumed when the slurry spraying is restored. If the down time exceeds 3h, the pipeline should be dismantled and cleaned with water.

5 When wall reinforcement is adopted, the construction interval of adjacent piles should not be greater than 24h. The lap length should not be less than 200mm. If the time interval is too long to lap the adjacent piles, reinforcement measures such as partial re-piling or grouting shall be taken.

B.0.5 The dry method construction shall be in accordance with the following requirements:

1 Before construction, the tightness and reliability of mechanical equipment, gas (powder) supply pipelines and valves shall be checked.

2 The mixer shall be equipped with a powder measuring device with instantaneous detection function and an automatic mixing depth recorder accredited by the national metrology.

3 When the mixing head reaches 1.0m above the design piling bottom, the powder sprayer shall be turned on in time for powder spraying operation. The relationship between the lifting speed of the mixer and the speed of the mixing head shall be maintained at the circumstance the lifting height shall not exceed 15mm for each round of mixing. When the mixing head is lifted to 0.5m below the ground, the powder sprayer should stop spraying.

4 For piles above the groundwater table, water shall be added during construction or water shall be poured on the ground after construction to ensure that the cement is fully fused.

B.0.6 The quality inspection shall be in accordance with the following requirements:

1 The quality control of cement soil mixing piles shall be carried out throughout the entire construction process. During the construction process, construction records and measurement records shall be checked at any time, and the quality of the engineering piles shall be evaluated in accordance with the prescribed construction technology.

2 After cement soil mixing piling, quality tracking inspection shall be conducted. A shallow excavation of the pile head may be used for inspection, with a depth greater than 500mm. The uniformity of mixing shall be visually inspected and the diameter of the pile shall be measured. The piles for inspection count shall be 5% of the total piles.

3 Within 3 days after the mixing pile is formed, light dynamic penetration (N10) may be used to check the uniformity of each meter of pile body, and static penetration shall be used to test the strength of the pile body along the depth. Test piles should be 1% of the total piles, and shall not be less than 3.

4 For the bearing capacity test of vertical bearing cement soil mixing pile foundation, the multi-pile composite foundation load test and the single pile load test shall be adopted. The load test should be carried out in 28 days of piling, and the test points in each site should not be less than 3.

5 When the quality of the pile body is suspected after penetration and load tests, the core sampling shall be drilled by a double-tube single-action sampler for compressive strength test in 28 days of piling. Test piles should be 0.5% to 1% of the total piles, and should not be less than 3.

Appendix C Grouting method

C.0.1 Hydrostatic grouting may be applied to the reinforcement of foundations of sand, silt, clay and general fill layer, and may also be used as an engineering measure for foundation reinforcement or correction of pump houses and auxiliary buildings. The use of the hydrostatic grouting method for foundation treatment shall be in accordance with the following requirements:

1 Before hydrostatic grouting reinforcement, the distribution of the foundation soil layer and the engineering properties of the soil shall be collected, and the deformation of the foundation of the existing building and its influence on the superstructure shall be analyzed.

2 The grouting material may use cement-based suspension liquid or double liquid mixture of cement and sodium silicate (water glass). In the case of underground flowing water, double liquid slurry or a quick-setting formula with a short initial setting time shall be used.

3 When static pressure grouting is used to reinforce existing buildings, the grouting hole shall be arranged with different density based on the uneven settlement of the building. The grouting hole depth and different grouting volumes shall be determined based on the different properties of the strata and the reinforcement depth.

4 At least three rows of grouting holes shall be set for anti-seepage grouting, and the grouting hole spacing may be 1.0m to 1.5m. The grouting hole spacing for soil strength improvement may be 1.0m to 2.0m.

5 Static pressure grouting should be conducted in layers in the hole from top to bottom for many times, each grouting shall be carried out only after the previous slurry reaches the initial setting, and the thickness of the soil layer covered on the grouting point shall be greater than 2m.

6 Before grouting construction, trial construction shall be carried out, and the grouting pressure and each grouting volume shall be determined. The grouting flow rate may be set at 7L/min to 10L/min. For filling grouting, the flow rate should not exceed 20L/min. The grouting pressure for splitting grouting shall be able to overcome the initial stress and tensile strength of stratum. The grouting pressure in sandy soil should be 0.2MPa to 0.5MPa, and that in cohesive soil should be 0.2MPa to 0.3MPa. When cement mortar slurry is used for pressure grouting, the slump should be 25mm to 75mm, and the grouting pressure should be 1MPa to 7MPa. When the slump is small, the grouting pressures of the splitting grouting and pressure grouting may take the upper limit value. When cement-sodium silicate double liquid quick-setting slurry is used, the grouting pressure shall be less than 1MPa.

7 During winter construction, measures shall be taken to ensure that the slurry does not freeze. When the summer temperature exceeds 30℃, measures shall be taken to prevent the slurry from solidifying.

8 When static pressure grouting is used to reinforce existing buildings, deformation measurement monitoring and soil monitoring shall be carried out throughout the construction process, and excessive uplift and settlement shall be strictly controlled. After construction, the monitoring and tracking of grouting shall continue until the settlement rate reaches the permissible value specified in standards.

9 For grouting with impermeability requirements, the grouting effect shall be determined by in-

situ penetration tests.

10 The reinforcement effect shall be tested in 28 days of grouting. When the composite foundation load test is used to check the bearing capacity of the foundation, no less than three points should be adopted for each site.

C.0.2 High-pressure jet grouting may be used for the reinforcement or waterproofing of foundations of gravelly soil, silt, cohesive soil, sludge soil, collapsible loess and artificial fill. It may be used for the foundation reinforcement of existing pump house buildings, the side wall support of deep foundation pit, foundation waterproof curtain. High-pressure jet grouting used for foundation treatment shall be in accordance with the following requirements:

1 High-pressure jet grouting may be divided into three forms, i.e. rotary jet grouting, fixed jet grouting and swinging jet grouting. The grouting method may be divided into single-pipe method, double-pipe method and triple-pipe method according to the structure of the grouting pipe and grouting process. The grouting method shall be selected according to the different characteristics of the foundation and the design requirements.

2 For foundations with corrosive groundwater, excessive groundwater flow rate and water inrush, sludges, peat as well as strata containing more boulders and block stones in the foundation soil, the feasibility of high-pressure jet grouting shall be determined by testing.

3 Before the construction of high-pressure jet grouting construction, the site engineering geology, hydrogeology and existing building data shall be collected, and the construction technical requirements shall be understood. When high-pressure jet grouting is used to reinforce existing buildings, the effect of additional deformation of the foundation on the reinforced building and adjacent buildings during jet grouting shall be analyzed.

4 After the high-pressure jet grouting plan is determined, representative stratum shall be selected for the field tests of high-pressure jet grouting. The applicability of the high-pressure jet grouting method should be determined by testing with an enclosure consisting of single holes and clustered holes with different hole and row spacings.

5 The foundation to be reinforced with jet grouting piles should be designed as composite foundation. When jet grouting piles are used as a retaining structure, they may be designed to bear the load independently. When the jet grouting piles are arranged into a grid-like continuum, the piles and soil of the enclosure may be designed according to the gravity retaining wall structure.

6 The strength and diameter of the material of the jet grouting pile body shall be determined by the field test according to the layout form of the jet grouting pile, engineering geological conditions, construction parameters and other factors.

7 The pressure of the cement slurry for high-pressure jet grouting and the high-pressure water jet should be set at 20MPa to 40MPa. For the three-pipe method, the cement slurry pressure should be set at 0.5MPa to 2MPa, and the air pressure should be set at 0.6MPa to 0.8MPa. The lifting speed of the grouting pipe may be selected from 50mm/min to 250mm/min according to different soil layers or rocks, and shall be determined by on-site tests.

8 Clay, bentonite, fly ash, sand, and other materials may be added as appropriate to high-pressure jet grouting. The appropriate amounts of accelerators and antifreeze agents may also be added according to the project needs. The type and amount of admixture and additives shall be determined through experimentation.

9 The water-cement ratio of the cement slurry shall be determined through experimentation according to the needs of the project design and may be set at 1.5∶1 to 0.6∶1. The cement slurry shall be mixed uniformly and used promptly after mixing. The holding time of the excessive slurry should not exceed 4h, and should not exceed 3h when temperature is above 10℃.

10 During the grouting construction, the grouting holes shall be accurately positioned, and the grouting pipe shall be kept vertical. The depth of the holes shall meet the design requirements, and the deviation of the hole position shall not exceed 100mm. The diameter of the holes may be 30mm to 40mm greater than the grouting pipe diameter, and the hole inclination should be less than 1%.

11 Before the formal grouting construction, trial spraying shall be carried out on the ground. The operation of machinery and pipelines shall be checked, and the spraying direction and oscillation angle shall be adjusted. The formal construction shall only proceed after the trial spraying is tested as qualified. A detailed record of slurry consumption, mixing ratio, working pressure of water, air and slurry and equipment operation shall be made for each grouting shift, and the grouting process for each hole, including hole depth, underground obstacles, caves, water gushing and leakage shall be recorded, and grouting samples shall be collected.

12 When the nozzle reaches the design depth, in-situ injection shall be carried out first according to the determined parameters, and the nozzle shall be lifted up for grouting only after the slurry spills over the nozzle and the conditions are normal. High-pressure jet grouting should be continuously performed from the bottom to the top of the hole. If the injection pipe needs to be dismantled midway, the overlapped segment shall be re-injected, and the length of the overlapped segment shall not be less than 0.2m.

13 If the flow rate does not change while the pressure drops suddenly during the high-pressure jet grout process, the leakage of each part shall be checked. When there is no slurry spillover or intermittent slurry spillover, the cause shall be ascertained. If it is caused by cavities and channels, grouting shall be continued until slurry spillover. If there is still no spillover after a certain volume of slurry is grouted, the grouting pipe may be lifted out, and the grouting shall be resumed after the slurry solidifies.

14 After the jet grouting is completed, If there is a dilute slurry layer, grooves, and pits on the top of the consolidated body, the grouting pipe may be inserted 2m to 3m below the hole opening, the cement slurry with a density of 1.7kN/m^3 to 1.8kN/m^3 shall be grouted for the secondary time from bottom to top with a grouting pressure of 0.2MPa to 0.3MPa, and the dilute slurry shall be replaced and the grooves and pits filled up.

15 When the original building is reinforced by jet grouting piles, the settlement monitoring of the original building shall be carried out during the construction process, and the voids caused by the solidification bleeding of slurry between the foundation bottom and pile head shall be backfilled by grouting in time until the pile head and foundation bottom are in close contact.

16 The quality of grouting body may be inspected by the methods of excavation, compressive test with core drilling, static load test. The inspection shall be carried out in 28 days after grouting completion, and the impermeable body shall be tested with pressurized water or well pumping.

17 The quality inspection location shall be selected in the part with the largest load, the part with abnormal phenomena in construction, and the place where there are doubts about the quality of piling, and random sampling inspection shall be carried out.

Appendix D Pile foundation

D.0.1 Drilled cast-in-place piles may include rotary drilling cast-in-place pile, impact drilling cast-in-place pile, expanded-base cast-in-place drilling pile, helical drilling cast-in-place pile, and auger drilling cast-in-place pile. Rotary drilling cast-in-place piles may be divided into those of forward circulation and reverse circulation depending on the discharge mode of mud, and may be used for the reinforcement of foundation of cohesive soil, silty soil, sandy soil and heavily weathered rock below the groundwater table. In addition to the strengthening of the stratum of cohesive soil, silty soil, sandy soil and heavily weathered rock, impact drilling cast-in-place piles may also be used for the reinforcement of foundations of gravelly soil and foundations with underground obstacles penetrating through old foundations and with large block boulders, but shall be used with caution in karst regions. Helical drilling cast-in-place piles may be used for the reinforcement of foundations of cohesive soil, silty soil, sandy soil and artificial fill soil above the groundwater table. Auger drilling cast-in-place piles may be used for the reinforcement of foundations of cohesive soil, silty soil, sandy soil, gravel soil, completely weathered bedrock, heavily weathered bedrock and artificial fill soil. The foundation treatment with drilled cast-in-place piles shall be in accordance with the following requirements:

1 The diameter of drilled cast-in-place piles should not be less than 400mm, and that for the soft soil area should not be less than 550mm. For the placement of concrete above the groundwater table, the concrete strength of the pile body shall not be lower than C25, and the thickness of the protective layer shall not be less than 35mm. For the underwater placement of concrete, the concrete strength grade shall not be lower than C30, and the thickness of the protective layer shall not be less than 50mm.

2 A construction process conducive to the quality improvement of drilled cast-in-place piles shall be chosen. Holing should be tested before formal construction, and the appropriate piling process shall be selected.

3 If the drilling for drilled cast-in-place piles is protected by mud wall, the mud surface in the borehole shall always be kept above the groundwater table. In addition to self-pulping soil layers, slurry should be prepared with cohesive soil of a high plasticity index, and bentonite may also be used for slurry preparation. If necessary, additives that improve the performance of the slurry may be added. The performance indicators of prepared slurry shall meet the requirements of Table D.0.1-1.

Table D.0.1-1 Performance indicators of prepared slurry

Item	Performance indicator	Test method
Specific gravity	1.1 to 1.2	Mud hydrometer
Viscosity	10s to 25s	Funnel method
Sediment charge	<5%	–
Colloid fraction	>95%	Measuring glass method
Waterloss	<30mL/30min	Water loss meter
Mudcake thickness	1mm/30min–3mm/30min	Water loss meter
pH value	7 to 9	pH test paper

Note: When drilled cast-in-place piles pass through loose sandy soil layers, a higher value of slurry specific gravity may be used.

4 The deviation of hole forming construction of the drilled grouting pile shall meet the requirements of table D.0.1-2.

Table D.0.1-2 Construction deviation of drilled grouting pile

Item	Deviation
Deviation of hole center position	No greater than 100mm for single row piles and not greater than 150mm for clustered piles.
Hole diameter deviation	−50mm to +100mm
Hole deviation rate	<1%
Hole depth	No less than design hole depth

5 After the borehole reach the required depth for the drilled cast-in-situ piles, the first cleaning of the hole shall be done promptly. The second cleaning shall be done after the steel cage and guide pipes are installed and before the concrete placing. The hole cleaning shall be in accordance with the following requirements:

1) When the holes are cleaned with raw soil pulping, the mud density shall be 10.5kN/m^3 to 11kN/m^3. When the hole is cleaned with mud circulation, the mud density shall be 11.5kN/m^3 to 12.5kN/m^3.

2) The allowable thickness of sediment after the second cleaning shall be determined according to the deformation requirements of the superstructure and the performance of the pile. For friction end bearing piles and end bearing friction piles, the sediment thickness should not be greater than 50mm. For pure friction piles for support, the sediment thickness should be less than 100mm.

3) After the completion of the second cleaning of the hole, concrete shall be poured within 30 minutes. If the pouring starts after 30 minutes, the thickness of sediment at the bottom of the hole shall be remeasured. If the thickness of sediment exceeds the allowable one, a conduit shall be used to remove the sediment until the sediment thickness meets the requirement before the concrete placing.

6 The production of the steel reinforced cage for the drilled cast-in-place piles shall meet the design requirements. The net distance between the main reinforcement shall be greater than 3 times the size of the coarse aggregate in the concrete. The stirrup reinforcement should be set outside the main reinforcement, and the main reinforcement should not have a bend hook. The inner diameter of the steel reinforced cage shall be greater than the outer diameter of the conduit joints by more than 100mm. Protective concrete cushions or plates shall be installed on the top of the steel reinforced cage, with no less than 2 sets of 3 pieces for each segment of the steel cage. The top of the steel cage shall be secured. The installation of the steel reinforced cage shall be hoisted straightly and stably, aligned with the center of the pile hole, and slowly lowered. Two segments of steel reinforced cage shall be welded at the hole opening, and two welders should be used for opposite welding.

7 The welding lap length of the steel reinforced cage shall comply with the provisions of Table D.0.1-3, the width of the weld shall not be less than $0.7d$, the height shall not be less than $0.3d$, and the welding rod shall be reasonably selected according to the material of the steel bar.

Table D.0.1-3 Welding lap length of steel reinforced cage

Grade of reinforcing bar	Welding form	Lap length
Grade Ⅰ	Welding by one side	8*d*
	Welding by both sides	4*d*
Grade Ⅱ	Welding by one side	10*d*
	Welding by both sides	5*d*

Note: *d* is the diameter of steel bar.

8 The concrete used for drilled cast-in-place piles shall be in accordance with the following requirements:

1) The mixing ratio and strength grade of concrete are determined by the mixing ratio tests according to the strength grade of the pile design body, and the strength should leave a margin of 20%. Cement grade is not less than 32.5MPa for the part above water and not less than 42.5MPa for the underwater part, and the cement of the same brand and same grade is used for the same pile. The concrete slump should be 160mm to 220mm, and the workability of concrete shall be maintained;

2) Pebbles or crushed stones with a particle size of 5mm to 35mm and the maximum particle size of no more than 40mm should be selected as coarse aggregates, and continuous gradation is required. Pebbles or crushed stones shall have good quality and high strength, the content of needles and rods shall be less than 3%, the slightly weathered shall be less than 10%, the moderately weathered or strongly weathered stones shall not be used, and the mud content shall be less than 1%;

3) Fine aggregates should be medium and coarse sand mainly containing feldspar and quartz particles, and the organic matter content shall be less than 0.5%, mica content shall be less than 2%, and mud content shall be less than 3%;

4) The concrete used for the drilled cast-in-place piles may be mixed with fly ash, zeolite powder, volcanic ash and other admixtures. The amount of admixtures should be determined according to the mix ratio tests;

5) The concrete used for the drilled cast-in-place piles may be mixed with admixtures such as water reducers and retarders according to the engineering needs.

9 The concrete placing of drilled cast-in-place piles shall be in accordance with the following requirements:

1) A conduit is used for concrete placing after drilling. The inner diameter of the conduit should be 200mm to 300mm. The length of the middle section of the conduit should be 3m, that of the adjustable section should be 0.5m to 1.0m, and that of the bottom section should not be less than 4m with bottom end thickened. The conduit may be connected by screw threads or a flange. If the pile diameter *d* is less than 500mm, screw threads are used to connect the conduit. Before construction, the conduits shall be tested for assembly and pressure;

2) When a conduit is placed into the hole, its lower end should be kept 300mm to 500mm away from the hole bottom. The initial filling amount shall be appropriately increased, and the first placing of concrete shall make the conduit buried of no less than 0.8m in depth. During normal

concrete placing, the concrete surface rising in the hole shall be monitored at any time to keep the buried depth of the conduit, which should be 2m to 5m;

3) Concrete shall be placed continuously, the interruption time for any reason shall not exceed the initial setting time of concrete. The pouring time should not exceed 8h;

4) The filling coefficient of the pouring amount of concrete should be 1.0 to 1.3;

5) The actual pouring height of the concrete of the cast-in-place pile shall ensure that the poured concrete reaches the design elevation after the floating slurry on the top of the pile is chiseled;

6) During the pouring process of the pile body, no less than 1 group of test blocks composed of 3 pieces shall be taken from each pile for compressive test after being cured according to the standard;

7) When the strength of the concrete test block does not meet the design requirements, the inspection by coring the pile body may be carried out or other non-damage inspection methods may be adopted.

D.0.2 Prefabricated reinforced concrete square piles may be used for the foundation treatment of various types of buildings (structures) in pumping station engineering, and their construction shall be in accordance with the following requirements:

1 The concrete strength of prefabricated piles should not be lower than C30. When the static pressure method is used to sink the piles, the pile strength should not be lower than C25, and the thickness of the concrete protective layer of the longitudinal reinforcement of prefabricated piles should not be less than 30mm.

2 The cross-sectional size of the prefabricated pile should be 250mm to 550mm, and the pile length should be determined comprehensively according to the stratum conditions, the bearing capacity of a single pile, the pile sinking tool and other factors. When the pile needs to pass through a certain thickness of sandy stratum, the feasibility analysis of pile sinking shall be carried out in advance, and the appropriate pile hammer, pile pad, pile body structural strength and pile end depth into soil shall be selected, and on-site piling test shall be carried out for verification.

3 In addition to meeting the requirements of the current national standards GB 50202 *Standard for Acceptance of Construction Quality of Building Foundation* and GB 50204 *Code for Quality Acceptance of Concrete Structure Construction*, the fabrication quality of concrete square piles should also be in accordance with the following requirements:

1) Concrete shall be continuously poured from the top of the pile to the end of the pile without any interruption.

2) The position of the mesh on the top of the pile shall be correctly tied with reliable fixation, and the main reinforcement shall not protrude from the first layer of the mesh on the top of the pile, which shall be consistent with the thickness of the concrete protective layer.

3) When a concrete square pile is poured on site by the superposition method, the base formwork of the pile should be flat and solid, and cement floor or formwork should be used. A good isolation layer shall be placed between the adjacent piles or between the pile and base formwork. The pouring of upper or adjacent piles may be carried out when the concrete strength of the lower or adjacent piles reaches 30% or more of the design strength.

4 Concrete prefabricated square piles shall reach 70% or more of the design strength before they are lifted up. The strength of the pile shall reach the design strength at the time of delivery.

5 The both ends of the pile shall be protected intact and the pile body shall not be dragged directly on the site.

6 The stacking site of piles shall be flat and solid. Two skids shall be set on the ground perpendicular to the length of the pile for pile stacking, and the skids shall be located at 1/5 of the length of the pile from both ends.

7 The number of stacking layers of piles should not exceed 4, and the piles of different specifications shall be stacked separately.

8 The joints of the prefabricated concrete square pile should not exceed 2. When the end of the lower pile is about to enter or has entered hard plastic clay layer, medium dense sand layer or gravel soil layer which is difficult for insertion, it is not suitable to connect piles.

9 The connection of prefabricated concrete square piles should be welded with angle steel in any of the following circumstances:

1) The design value of the vertical bearing capacity of the monopile exceeds 1200kN.

2) The length of the pile is relatively large.

3) The piles are dens.

4) It is estimated the pile sinking is difficult.

5) Piles are subjected to upward pulling force.

10 When piles are connected by welding, the four corners of the piles shall be spot welded and fixed first, then symmetrical welding shall be conducted, and the weld quality and design size shall be ensured. When there is a gap between the two pile joints due to construction error, an iron sheet processed into a wedge of appropriated thickness shall be used to fill the gap and welded firmly. The surface of the embedded parts shall be cleaned up before welding.

11 Flange connection or mechanical quick connection shall comply with the provisions of the current professional standard JGJ 94 *Technical Code for Building Pile Foundations*.

12 The selection of pile hammer shall be determined according to the geological conditions of foundation engineering, pile type, pile body material strength, the vertical bearing capacity of a single pile, construction conditions, combined with the influence of hammering wave direction and other factors.

13 The verticality deviation of pile inserting shall be less than 0.5%. During pile driving, the verticality of the pile body may be monitored at an angle of 90° and the number of hammering per meter shall be recorded.

14 The piling sequence shall be in accordance with the following requirements:

1) According to the density of piles, piling may be carried out symmetrically from the middle to two opposite directions, from the middle to the surroundings, or from one side to the other side.

2) According to the design elevation of the foundation, piling should be deep first and then shallow.

3) According to the specifications of the piles, large piles should be driven first and then the small ones, and long piles should be driven first and then the short ones.

15 The pile driving stop standard shall be in accordance with the following requirements:

1) When the pile end is located in the general soil layer, the design elevation of the pile end shall be mainly controlled, and the penetration degree may be used as a reference.

2) When the pile end reaches hard clay soil, dense silt, sand, gravel soil and weathered rock, the penetration degree shall be the main requirement, and the pile end elevation may be used as a reference.

3) The penetration degree of pile driving control shall be determined by the prototype tests, taking that of the last 3 formations with hammering of 10 times for each formation as the final penetration degree.

16 The allowable deviation of the driven pile position shall comply with the requirements of Table D.0.2.

Table D.0.2 Allowable deviation of driven pile position

Item		Allowable deviation(mm)
Piles with foundation beam	Centerline perpendicular to foundation beam	0 to (100+0.01H)
	Centerline along foundation beam	0 to (150+0.01H)
Piles in foundation with 1 pile to 3 piles		0 to 100
Piles in foundation with 4 piles to 6 piles		0 to (1/2 pile diameter or 1/2 pile side length)
Piles in foundation with piles of more than 16	Outermost pile	0 to (1/3 pile diameter or 1/3 pile side length)
	Middle pile	0 to (1/2 pile diameter or 1/2 pile side length)

Note: H is the distance between the ground elevation of the construction site and the design elevation of the pile top.

17 For piles controlled according to elevation, the allowable deviation of the top elevation of the pile shall be −50mm to 100mm.

18 The deviation of the inclination angle of the batter pile shall not be greater than 15% of the tangent value of the angle between the longitudinal centerline of the pile and the plumb line.

19 For piling in large soft soil areas, drainage measures may be taken, and monitoring of pile head uplift and horizontal displacement shall be carried out.

D.0.3 Reinforced concrete secant piles may be used for foundation support structures and seepage interception of various types of buildings (structures) in pumping station engineering, and their construction shall be in accordance with the following requirements:

1 Secant piles may adopt a combi-wall structure of A and B piles. The A pile body shall be made of C30 ultra-retarded concrete, and the B pile body shall be made of C30 underwater concrete.

2 The length of the pile shall be determined comprehensively according to factors such as the geological conditions, load on the pile wall and piling equipment. If the pile needs to pass through a certain thickness of soft soil layer or sandy stratum, a feasibility analysis of piling shall be conducted in advance, and on-site testing shall be carried out to verify the feasibility of the piling process.

3 The construction parameters should be in accordance with the following requirements:

1) The positioning error of the opening is not more than 10mm.

2) The verticality deviation of the pile is not more than 2‰.

3) The thickness of the sediment is not more than 50mm.

4) If a crawler crane is used to lower the steel reinforcement cage, the allowable deviation for the main reinforcement is ±10mm, the allowable deviation for the spacing between the

stirrups is ±20mm, and the allowable deviation for the length of the steel reinforcement cage is ±100mm. The thickness of the protective layer is 50mm.

5) The wall thickness of the conduit is not less than 3mm, and the diameter of the conduit is 200mm to 250mm. Trial assembly and hydraulic pressure testing of the conduit shall be carried out before it is used.

4 The construction process shall conform to the following processes:

1) A pile (ultra-retarded plain concrete pile) for secant pile is constructed first, and then B pile (reinforced concrete pile).

2) The construction process is A1→A2→B1→A3→B2…A*n*→B*n*-1.

3) Monopile construction process is pile position lofting→ casing pile foundation in place→ casing hoisting→ rotary drilling of soil→ casing grinding in→ hole cleaning→ rebar cage (if any) lifting→ conduit putting in for concrete placing→ concrete placing→ drilling rig displacement.

5 The monopile construction shall be in accordance with the following requirements:

1) After the platform has sufficient strength, the base of the full-rotary drilling rig is hoisted to the platform for pile center positioning. The rig is then hoisted into place and leveled.

2) The first section of casing is pressed into first, and its verticality is corrected, The pile is ground down to press the casing, a grab is used to take soil from the casing when the casing is pressed into a depth of about 3.0m, and the bottom of the casing is kept at a depth of not less than 2.5m ahead of the excavation surface.

3) The verticality of each casing pressed into the soil needs to be inspected, and the subsequent casing is installed after the correction and adjustment are qualified. The casing is pressed down till the design hole bottom elevation for soil taking.

4) For the construction of B pile, the casing is ensured at the depth of no less than 0.5m ahead of the excavation surface when the drilling depth exceeds the bottom of A pile.

5) If the concrete is poured by the underwater concrete placing method, admixtures should be added, the concrete sand content is 40% to 50%, medium coarse sand is selected, and the maximum particle size of coarse aggregate is less than 40mm.

6) At the beginning of concrete placing, the bottom of the conduit is placed 0.3m to 0.5m away from the bottom of the hole. The conduit embedded below the concrete placement surface is not less than 0.8m at one time. The depth of the conduit buried in the concrete should be between 4m to 6m.

7) The hydraulic device of the pile driver is retracted and moved with the assistance of the crawler crane.

6 The quality standard shall be in accordance with the following requirements:

1) After the wall is formed for 28d or the strength of the pile body reaches 70% of the design strength, the impermeable wall is drilled and cored for testing, and no less than 4 groups of core samples are intercepted per hole. Coring samples are used for indoor tests of physical and mechanical performance indicators such as compressive strength and impermeability. Other requirements for drilling and coring shall be implemented in accordance with the provisions of the current professional standard JGJ 106 *Technical Code for Testing of Building Foundation Piles*.

2) For the newly built secant pile interception wall, 3 coring samples is taken and tested by the ultrasonic method for the integrity of the pile body.

Appendix E Dynamic compaction method and extrusion method

E.0.1 The construction by the dynamic compaction method shall be in accordance with the following requirements:

1 The weight of the tamper hammer may be 10t to 30t, and the hammer bottom should be round. The area of the hammer bottom should be determined according to the properties of the soil. The static pressure value of the hammer bottom may be 25kPa to 40kPa, and a small value should be taken for fine-grained soil. The bottom surface of the hammer should be symmetrically set with several exhaust holes through the top surface, and the aperture may be 250mm to 300mm.

2 Crawler cranes or other special equipment with automatic decoupling device should be used for dynamic compaction construction. If crawler cranes are used, auxiliary gantries may be set at the end of the cantilever or other safety measures may be taken to prevent the frame from overturning when the weight drops.

3 When the groundwater table is high and the accumulated water at the bottom of the rammed pit affects the construction, the groundwater table should be artificially lowered or loose materials should be laid. Water accumulation in the rammed pit or site shall be removed in time.

4 Before the dynamic compaction construction, the location and elevation of underground structures and various underground pipelines in the site area shall be ascertained, and measures shall be taken to avoid damage caused by dynamic compaction construction.

5 When the vibration generated by the dynamic compaction construction has a harmful effect on the adjacent buildings or equipment, anti-vibration or vibration isolation measures shall be taken.

6 The construction process of dynamic compaction may be as the following steps:

1) The construction site may be leveled and anti-seismic measures may be taken during construction. Construction machinery and dynamic compaction hammers may be selected according to construction requirements.

2) The line is laid to locate the ramming point. After ramming, the orientation of the ramming pit is checked, and the ramming missing and errors are corrected in time.

3) If the groundwater table is too high or the surface soil is soft, and if the construction is affected by water accumulation at the bottom of the ramming pit, a loose material cushion made of coarse particles shall be laid on the pit, or the groundwater table should be artificially lowered. The bottom of the pit may be at least 2m above the groundwater table. The accumulated water within the construction site and pit may be drained in time.

4) The pore water pressure is observed before ramming, and the pore water pressure is observed again according to the specified frequency and time after the ramming completion to accurately understand the change of excess pore water pressure loss.

5) The crane is in place, and the tamper hammer is aligned with the tamper point position;

6) The height of the hammer top is measured before ramming.

7) The hammer drops smoothly during the ramming process with accurate ramming position. If the pit bottom is over-tilted and misaligned, the pit bottom is filled with continuously graded

crushed stone and flakes in time, and the amount of filler is recorded.

8) The ramming of a compaction point is completed according to the design specified number of strikes and control standards in design. Step 5) to Step 8) are repeated to complete the first round of ramming of all compaction points.

9) In the process of dynamic compaction construction, the amount of each ramming subsidence, the number of ramming and the energy of all ramming points are recorded in detail.

10) The level gauge is used to measure the ramming depth (zero height and cumulative difference) and a record is made.

11) In the process of dynamic compaction construction, measure the uniform subsidence amount of the site is measured for each round of ramming.

12) The on-site measurement control network, control pile and test ramming distribution point are arranged in the process of dynamic compaction construction.

7 During the construction of dynamic compaction, a special person shall be designated for the following monitoring work:

1) The weight and drop distance of the tamper hammer are checked before ramming, and the energy of one ramming meets the design requirements.

2) Before each round of ramming, the line for ramming point positioning is reviewed. The position of the rammer pit is checked after ramming, and the deviation and ramming missing are corrected in time if they are found out.

3) The number and subsidence amount of ramming at each ramming point is checked according to the design requirements.

8 During the construction process, the construction situation and parameters shall be recorded in detail.

E.0.2 The construction by the extrusion method shall be in accordance with the following requirements:

1 The extrusion method of hole forming may include casing sinking, impacting, drilling and ramming expansion, bursting expansion. Hole forming shall be carried out in batches at intervals. Local treatment shall be conducted from the outside to the inside.

2 Compaction piles should be used to treat the foundations of collapsible loess, miscellaneous fill soil, soft silt soil and clay soil above the groundwater table, and the treatment thickness should be 3m to 15m.

3 After holes are formed by squeezing, they should be quickly backfilled and compacted, and the following requirements shall be met:

1) The bottom of the hole is tamped before filling. The filling material in the hole should be plain soil or lime soil, sand and gravel. If necessary, cement soil with high strength may be used. Plain soil should be filled for waterproof (water separation). Lime soil, sand and gravel, cement soil should be filled for the improvement of bearing capacity or reduction of treatment width. Backfilling should be made and compacted in layers, and the compaction coefficient should not be less than 0.97.

2) The mixing ratio of the backfilling materials meets the design requirements, with uniform mixing. The backfilling materials enter the holes in time after mixing, and they shall not be used in the next day.

3) The compacting height of the squeezed hole should exceed the design elevation of the foundation base by 0.2m to 0.3m, and the upper part of the foundation may be rammed to the ground with other soil materials to keep a 0.5m thick cushion under the foundation base.

4 The effect test of the extrusion method shall be in accordance with the following requirements:

1) The filling materials in the hole are sampled in time check the tamping quality, the number of the sampling is not less than 2% of the total number of holes, with no less than 1 hole sampling per shift. Along the depth of all holes, soil samples should be taken every 1m to determine soil dry density, and the sampling point shall be located at 2/3 of the hole radius from the hole core. The compaction quality of the filling materials in the hole may be determined by field tests.

2) For important or large-scale projects, layer-by-layer sampling shall be carried out within the treatment depth range to determine the collapsibility and compressibility of the squeezed soil and the filling materials in holes in addition to the method described in the above clause. Static load tests or other in-situ tests may also be conducted.

Appendix F Caisson foundation

F.0.1 Caisson may be used for foundation treatment in case of one of the following conditions:

1 It is difficult to excavate silt or quicksand foundation.

2 It is not allowed to excavate the soil foundation or soft and broken rock foundation according to a certain slope due to the restraint of important buildings around or other factors.

3 Foundation cannot be reasonably arranged due to the large number of piles.

F.0.2 The construction of caisson foundation shall be in accordance with the following requirements:

1 Before construction, the construction organization design of caisson foundation shall be made.

2 The surface of the area where the caisson is to be constructed shall be leveled and equipped with a good drainage system. The groundwater table shall be kept at least 0.5m below the bottom of the foundation pit.

3 The thickness of the sand cushion and the number and size of the underlayment timbers shall be analyzed and calculated according to the gravity of the caisson and the bearing capacity of the foundation soil when caisson is made by the underlayment timber method.

4 For caisson manufacture on relatively homogeneous soil layers, the method of no underlayment timbers may be adopted. In this case, a proper thickness of plain concrete or sand cushion layer shall be laid.

5 When the caisson is made in sections, the height of each section shell be reasonable, and the stability and smooth sinking of the caisson shall be ensured.

6 The manufacture of concrete caissons shall be in accordance with the following requirements:

1) Pouring shall be uniform and symmetrical, and the caisson exterior wall shall be smooth.

2) The blade foot formwork may be removed after the concrete reaches 70% of the design strength.

3) When a caisson is made in sections, the concrete of the upper section is poured after the concrete the first section reaches 70% of the design strength.

7 When the caisson sinks, the concrete of the first section of the caisson shall reach the design strength, and the remaining sections shall reach 70% of the design strength. Before sinking, the caisson with anti-seepage requirements shall be chiseled at the joint of bottom sealing or bottom plate and caisson wall, and the holes and bolts in the caisson wall shall be treated for seepage proof.

8 Underlayment timbers shall be extracted in groups, sequentially, symmetrically and synchronously, and the underlayment shall be filled with sand after the extraction of each group of timbers. The positioning underlayment timbers are extract synchronously at the end. The timbers shall be monitored during extraction, and the tilt shall be corrected in time if found.

9 The subsidence of soil digging shall be in accordance with the following requirements:

1) Soil is dug in layers uniformly and symmetrically, The excavation depth of each layer should not be greater than 0.5m. The soil surface height difference between the grids for caisson sinking should not be greater than 0.5 m.

2) Abandoned soil and building materials shall not be piled around the open caisson to avoid

unsymmetrical pressure.

3) For the excavation with drainage, the groundwater table shall be lowered to 0.5m below the excavation face. For the excavation without drainage, the water level difference inside and outside the caisson shall be controlled to prevent sand from flowing into the caisson, and equipment shall be supplied to replenish water into the caisson.

4) When the caisson sinks to a depth of about 2m below the design elevation, the sinking rate shall be slowed down to prevent excessive sinking.

5) Sinking observation shall be strengthened, and timely correction shall be made if any tilt and displacement is found out.

10 The caissons excavated by blasting shall be carried out in accordance with the current national standards for controlled blasting.

11 The caissons in parallel groups should sink simultaneously. If limited by conditions, the caissons may sink symmetrically and evenly in groups at intervals.

12 The caisson sinks to the design elevation, and its bottom shall be sealed after the caisson body is stabe.

13 The dry sealing of caisson bottom shall be in accordance with the following requirements:

1) Mud scum at the bottom is removed, the accumulated water in the bottom is drained out, and concrete is poured for bottom sealing;

2) Concrete is poured in grids symmetrically;

3) When the bottom concrete and base plate concrete do not reach the design strength, the groundwater table is controlled.

14 Underwater concrete bottom sealing by the tremie method shall be in accordance with the following requirements:

1) The bottom surface, perimetrical joints and waterstops are cleaned.

2) The bottom of the trimie should be 0.1 m away from the base surface for continuous pouring.

3) The number and spacing of trimies are determined according to the principle that concrete may cover each other.

4) Only after the concrete reaches the design strength, water may be pumped from the caisson.

15 Fillers in bottomless caisson shall be compacted in layers according to design requirements.

16 The connection and joint treatment between group caissons shall be carried out after all the caissons are sealed or backfilled.

17 The allowable deviation after caisson sinking shall be in accordance with the following requirements:

1) The allowable deviation between the average elevation of the blade foot and the design elevation is ±100 mm.

2) The height difference of the bottom surface of the blade foot in any two corners of the caisson four corners does not exceed 0.5% of the horizontal distance between the two corners, and the height difference does not exceed 150 mm. The horizontal distance and height difference between caissons is less than 10m and 50mm, respectively.

3) The horizontal displacement of the center of the caisson top surface does not exceed 1% of the total sinking depth, When the total sinking depth is less than 10m, it should not exceed 100mm.

18 The following main data shall be provided for the completion acceptance of caisson:

1)Record of open caisson construction process.

2)Inspection report of caisson crossing soil (rock)layer and foundation base.

3)Survey records after the completion of open caisson.

4)Test report of concrete block specimens.

5)Engineering quality accidents and their treatment.

Appendix G Masonry works

G.0.1 Masonry works shall be in accordance with the following requirements:

1 The masonry works shall be constructed after the foundation acceptance and the joint surface treatment inspection are qualified.

2 Lofting and marking shall be made and the line shall be pulled tight for masonry works.

3 Masonry shall be flat, stable, dense and staggered.

G.0.2 The materials used in masonry works shall be in accordance with the following requirements:

1 The stone shall be firm in texture, free of weathering spalling and cracks.

2 The particle size of the stone used for concrete placing block stone should not be greater than 20mm.

3 The cement strength grade shall be compatible with the design strength grade of the cemented material, and the cement strength grade of masonry mortar above M15 should not be lower than 42.5MPa.

4 The use of admixtures and additives shall be determined by testing. Fly ash should be preferred for admixtures, the quality indicators of which shall be determined in accordance with the relevant provisions of the current national standards.

5 Cement mortar and fine aggregate concrete for masonry shall be increased by 15% according to the design strength grade. The mix ratio shall be determined by tests for appropriate workability. The consistency of cement mortar may be expressed by standard cone submergence degree, which should be 50mm to 70mm. The slump of fine aggregate concrete should be 70mm to 90mm.

6 Mortar and concrete shall be used with mixing and used up within the initial setting time. If water bleeding is found during use, they shall be mixed again before placement.

G.0.3 Masonry stone construction shall be in accordance with the following requirements:

1 Before masonry placement, the stones shall be brushed clean and kept wet. Masonry stones shall be bonded and filled with cemented materials.

2 Masonry should be laid with mortar, which shall be full. The large gaps between the stones inside the slope revetment, bottom protection and wing walls shall be filled with mortar or fine aggregate concrete and pounded, and then compacted by tamping and inserting crushed stones. It shall not be allowed to use the method of filling the crushed stones first and then stuffing the mortar.

3 The thickness of mortar should be between 30mm and 50mm, and the mortar shall be applied along with the masonry. The joints shall be fully filled with mortar. Masonry shall not be directly attached without mortar. The mortar inside the masonry joints shall be compacted and tamped.

4 When the masonry works are interrupted for some reason and the mortar exceeds its initial setting time, construction shall continue only after the mortar strength reaches 2.5MPa. Before the construction is continued, the surface scum of the original masonry shall be removed, and it shall be avoided to affect the masonry of the lower layer during the construction.

G.0.4 The construction of masonry stone shall be in accordance with the following requirements:

1 The number of layers shall be calculated according to the design masonry height and stones

shall be selected before masonry construction. The masonry height of the stones and the horizontal and vertical masonry joints shall be controlled during masonry construction.

2 A staggered masonry pattern with alternate headers and stretchers should be adopted. When the thickness of the masonry is greater than or equal to the width of two pieces of stone, a running bond may also be used, but a bonder course shall be added for every two layers of masonry.

3 When the thickness of the masonry is large and block stones are used to fill the middle part, the length of the bonder stones in the block stone section shall not be less than 200mm.

4 The stones shall be laid on a bed of mortar in a leveled manner. The mortar seams between the stones shall be fully filled. The horizontal seams in the masonry shall be straight and even, and the vertical ones shall be of uniform width.

5 The same layer of masonry shall be overlapped both inside and outside with staggered placement. Stones shall be placed steadily in a one-header-one-stretcher or two-header-one-stretcher pattern. The mortar seams shall be horizontally and vertically straight, and the vertical seams between the upper and lower layers shall not be greater than 100mm. The bonder stones must not have vertical joints above or below them. The number of bonder stones shall be no less than 1/5 of the total amount of masonry and shall not be less than 1/3 of the total amount of masonry for important parts.

G.0.5 The construction of prefabricated blocks of masonry concrete shall be in accordance with the following requirements:

1 The size and strength of the concrete prefabricated blocks shall meet the design requirements and the relevant provisions of the current professional standard SL 677 *Specifications for Hydraulic Concrete Construction*, and the strength should not be less than 70% of the design strength during construction.

2 The number of prefabricated block layers shall be calculated according to the design masonry height and a reasonable seam width shall be selected before construction.

3 The prefabricated blocks shall be watered and moistened before use, their surface shall be cleaned up, and they shall be cured in time after the masonry is completed.

4 The concrete prefabricated blocks shall be laid on a bed of mortar in a leveled manner. The blocks of each masonry layer shall be placed firmly, and the mortar shall be fully filled between the blocks, with firm bonding. The masonry of the adjacent sections shall rise in a balanced manner.

5 Each layer shall be positioned in rows and columns with the outer layer built first and the inner layer built later, the outer masonry blocks shall be staggered and connected with the inner blocks, and the exposed surface of the masonry shall be jointed.

6 The laying of the upper layer blocks shall avoid the vibration to the lower layer blocks. If the laying is interrupted for any reason, loose debris on the surface of the original masonry shall be cleared and the surface of the original masonry shall be moistened with water before masonry resumes.

7 During construction, the blocks shall be laid in a one-header-one-stretcher order. The mortar seams shall be horizontally and vertically straight, and the vertical joints between the upper and lower layers shall not be less than 100mm. There shall be no vertical seams above or below the bonder blocks.

G.0.6 Wing wall and partition pier masonry shall be in accordance with the following requirements:

1 The surface layer of the foundation concrete shall be chiseled or roughened and thoroughly cleaned by washing before masonry.

2 Masonry shall be carried out layer by layer from the bottom up, with each layer started with the

corner stones, followed by the face stones and then the web stones. A bed of mortar shall be evenly applied, and the stones shall be laid and fixed promptly after being set in place.

3 The upper and lower layers of block stones shall be staggered at the time of masonry, The inner and outer block stones shall overlapped, and flat and large stones shall be chosen for the face stones. When masonry is performed with rubble stones, the rubbles shall be arranged in a one-header-one-stretcher or two-header-one-stretcher pattern, and shall be placed stably. Mortar seams shall be horizontally or vertically straight. The vertical seams between the upper and lower layers shall not be greater than 100mm, and there shall be no vertical joints above or below the header stones.

4 The seam widths of block stone masonry, rubble stone masonry and concrete prefabricated block masonry should be 20mm to 30mm, 15mm to 20mm, and 10mm to 15mm, respectively.

5 The seam surface between the masonry layers shall be scrubbed clean and kept moist.

6 The masonry body should rise in a balanced manner, and the height of the daily masonry and the height difference between adjacent sections both should not exceed 1.2m.

7 The masonry seams of the concealed masonry surface may be scraped flat with the masonry, and the seams of the exposed surface of the masonry shall be within the seam grooves with a depth of 20mm reserved when masonry is built.

8 The surfaces of the settlement joint and expansion joint shall be levelled or vertical.

G.0.7 During the masonry process, the mortar adhered to the surface of the masonry shall be cleaned day by day, and the exposed surface should be cured in time within 12h to 18h after masonry, and the exposed surface shall be kept moist frequently. The curing time of cement mortar masonry and concrete masonry should be 14 days and 21 days, respectively. It is not suitable for backfilling or retaining soil during the curing period.

G.0.8 Masonry jointing shall be in accordance with the following requirements:

1 The masonry surface shall be jointed, and flush joints should be used.

2 Clean the seam groove shall be cleaned and rinsed before jointing. The mortar embedment depth shall not be less than 20mm.

3 Sieved fine sand should be adopted for jointing, with a mix proportion of 1: 1.5 for cement mortar.

4 The jointing shall be carried out from top to bottom, the mortar adhered to the surface of the masonry shall be cleaned after the jointing is completed. The jointing mortar shall be cured with watering in time after its coagulation, and the curing time should not be less than 14 days.

5 The jointing should be uniform in width and depth. There shall not be false seams, through seams, missing seams, fractures and weak bonding.

G.0.9 The dragging of heavy objects or hammering vibrations shall not be allowed on the new masonry before it reaches the design strength.

G.0.10 In the event of moderate or heavy rain during masonry, the masonry shall be stopped, and the voids in the masonry shall be filled with mortar or fine stone concrete and then covered. After rain, stagnant water shall be removed before masonry continues.

G.0.11 Embedded parts, reserved holes, drainage holes, reverse filter layers, waterproof facilities on masonry shall be retained according to design requirements.

G.0.12 Dry masonry should be used for slope protection and bottom protection, and shall be in accordance with the following regulations:

1 The masonry seams shall be tight, and the masonry bottom shall be padded stably and filled, and shall not be overhead.

2 The chiseled or flying wedge-shaped stones shall not be used in masonry construction.

3 The rowlock method should be used, and bonding and floating insertion shall not be used. The minimum edge thickness of the stones should not be less than 150mm.

4 For dry masonry works with frames, the frames should be built first, and then masonry.

5 When a sand and gravel cushion is laid on a large slope, it shall be laid from bottom to top in layers, and rise in sections with the increase of the masonry surface.

G.0.13 The quality inspection of masonry shall be in accordance with the following provisions:

1 The quality of materials and masonry shall meet the design requirements.

2 The seam mortar shall be dense, and the width and distance of the seam shall meet the requirements.

3 The mixing ratio of mortar and fine aggregate concrete shall be correct, and the strength of the specimens shall be no lower than the design strength.

4 The allowable deviations of the masonry size and position shall comply with the provisions of Table G.0.13.

Table G.0.13 Allowable deviations of masonry size and location

Item	Allowable deviation(mm)			
	Pier and wall		Slope protection and bottom protection	
	Mortared rubble	Mortar stone (prefabricated block)	Mortared rubble	Dry placed rockfill
Axis position	±15	±10	-	-
Wall verticality(full height)	±0.5%H	±0.5%H	-	-
Wall masonry layer edge position	±20	±10	-	-
Wall slope	No steeper than design requirements	No steeper than design requirements	-	-
Section size or thickness	−20 to +30	0 to +20(±15)	±15% of masonry thickness and ±30	±15% of masonry thickness and ±30
Top surface elevation	±15	±15	-	-
Bottom protection elevation	-	-	−50 to +30	−50 to +30

Notes: 1 H refers to the full height of pier and wall.

2 Each (segment of)pier and wall or every 10m long is taken as a test unit, and 2 to 4 points on each test unit are tested.

G.0.14 When the salt-doped mortar method is used for construction in the low temperature season, the following requirements shall be in accordance with:

1 Masonry equipped with reinforcement bars, embedded iron parts and pipes shall not be built with salt-doped mortar.

2 Sodium chloride should be chosen for the salts used in the salt-doped mortar. The amount of sodium chloride shall be determined by tests according to different negative temperature limits and shall

comply with the provisions of Table G.0.14.

Table G.0.14 Salt content in water consumption

Salt name	Daily minimum temperature	
	>−10℃	−15℃ to −11℃
Sodium chloride(%)	4	7

3 When the salt solution is prepared, the concentration of the solution shall be measured at any time, and the salt content in the solution shall be controlled.

4 Temperature at which mortar is mixed should not exceed 35℃, the lowest temperature at which the mortar is used should not be less than 5℃.

Appendix H Allowable installation deviation of plane gate embedded parts

Table H Allowable deviation of plane gate embedment parts installation (mm)

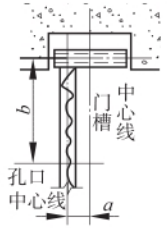
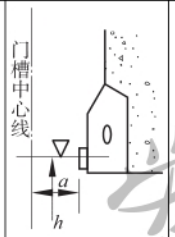
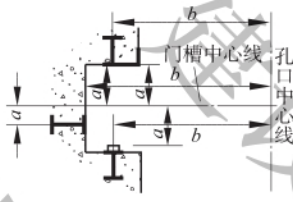
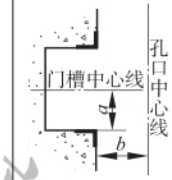
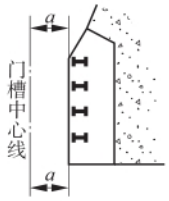
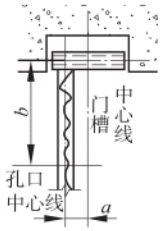
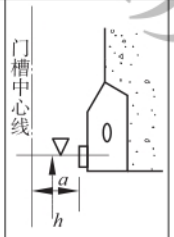
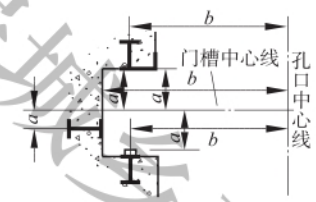
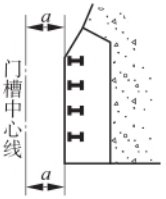
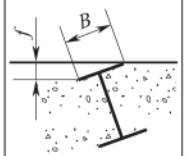
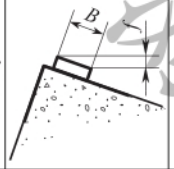
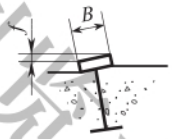
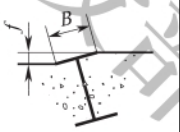
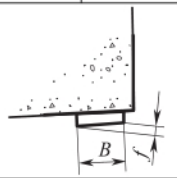
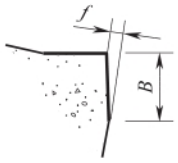
Serial number	Embedment part name		Bottom sill	The lintel	Main rail		Siding rail	Reversal rail	Side waterstop plate	Angle expansion as side rail	Breast wall			
											As waterstop		Not as waterstop	
					Processing	No processing					Upper part	Lower part	Upper part	Lower part
	Schematic diagram													
1	Centerline of door slot *a*	Within working scope	±5	−1 to 2	−1 to 2	−1 to 3	±5	−1 to 3	−1 to 2	±5	0 to 5	−1 to 2	0 to 8	−1 to 2
		Outsideworking scope	–	–	−1 to 3	−2 to 5	±5	−2 to 5	–	±5	–	–	–	–
2	Centerline of orifice *b*	Within working scope	±5	–	±3	±3	±5	±3	±3	±5	–	–	–	–
		Outside working scope	–	–	±4	±4	±5	±5	–	±5	–	–	–	–
3	Elevation	▽	±5	–	–	–	–	–	–	–	–	–	–	–
4	Distance from lintel center to bottom sill surface *h*		–	±3	–	–	–	–	–	–	–	–	–	–
5	Height difference between both ends of working surface	*L*≥10 000	0 to 3	–	–	–	–	–	–	–	–	–	–	–
		L<10 000	0 to 2	–	–	–	–	–	–	–	–	–	–	–
6	Working surface flatness	Within working scope	0 to 2	0 to 2	–	–	–	–	0 to 2	0 to 2	0 to 2	0 to 2	0 to 4	0 to 4
		Outside working scope	–	–	–	–	–	–	–	–	–	–	–	–

Table H（continued）

Serial number	Embedment part name		Bottom sill	The lintel	Main rail		Siding rail	Reversal rail	Side waterstop plate	Angle expansion as side rail	Breast wall			
					Processing	No processing					As waterstop		Not as waterstop	
											Upper part	Lower part	Upper part	Lower part
	Schematic diagram												
7	Dislocation of working surface combination	Within working scope	0 to 1	0 to 0.5	0 to 0.5	0 to 1	0 to 1	0 to 1	0 to 0.5	0 to 1	0 to 1	0 to 1	0 to 1	0 to 1
		Outside working scope	–	–	0 to 1	0 to 2	0 to 2	0 to 2	–	0 to 2	–	–	–	–
8	Surface twist f	Schematic diagram												
		Surface width within working scope $B<100$	1	1	0 to 0.5		0 to 1	0 to 2		0 to 2	0 to 1		0 to 2	
		Surface width within working scope $B=100$ to 200	1.5	1.5	0 to 1		0 to 2	0 to 2.5		0 to 2.5	0 to 1.5		0 to 2.5	
		Surface width within working scope $B>200$	2	–	0 to 1		0 to 2	0 to 3		0 to 3	–		0 to 3	
		Surface width within working scope All widths	–	–	–		–	–		–	–		–	
		Allowable value added outside working scope	–	–	0 to 2		0 to 2	0 to 2		0 to 2	–		0 to 2	

Notes：1 L refers to the gate width.

2 Components shall be measured at least one point per meter.

3 The lower part of the breast wall refers to the location combined with the gate lintel.

4 The working scope height of the gate groove refers to the height of the orifice for gate opening and closing in static water and the height of the main pressure rail for closing gate opening and closing in dynamic water.

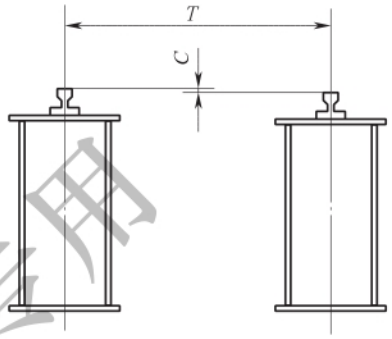
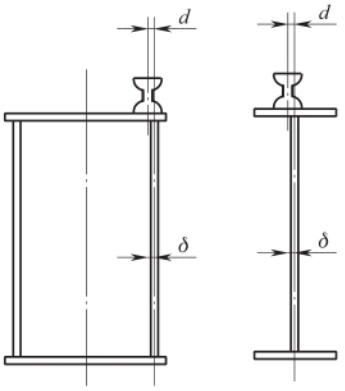
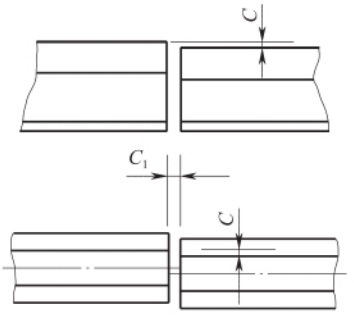
5 When the side wheel is a pre-stressed elastic device，the deviation of the side rail follows the specifications shown in the design drawings.

6 The offset of the connection shall be ground into a gradual slope.

Appendix J Allowable installation deviation of mobile hoist

J.0.1 The allowable deviation of trolley track installation of mobile hoist shall conform to the provisions of Table J.0.1. The trolley track shall be closely attached to the upper wing plate of the main beam of the crane. When the local gap is greater than 0.5mm and the gap length is more than 200mm, the pad should be added.

Table J.0.1 Allowable deviation of trolley track installation of mobile hoist

Serial number	Item	Basic size(m)	Allowable deviation(mm)	Schematic diagram
1	Trolley track distance difference	$T \leqslant 2.5$	±2.0	
		$T > 2.5$	±3.0	
2	Relative difference between span T_1 and span T_2 of trolley	$T \leqslant 2.5$	0 to 2.0	
		$T > 2.5$	0 to 3.0	
3	Height difference of the same section track C	$T \leqslant 2.5$	0 to 3.0	
		$T > 2.5$	0 to 5.0	
4	Position Difference between two centerlines of trolley track and rail beam web d	Bias-rail box girder	$\delta < 12$, 0 to 6.0 $\delta \geqslant 12$, 0 to 0.5δ	
		Single web beam and truss beam	0 to 0.5δ	
5	Straightness of centerline of trolley track with symmetrical box girder between tracks	–	0 to 3.0	
6	Joint of trolley rail	Left, right and upper side dislocation C	0 to 1.0	
		Joint gap C_1	0 to 2.0	
7	Local lateral bending of trolley track	Any 2.0m range	0 to 1.0	

J.0.2 The allowable deviations for the assembly of the crane span structure and gantry of a mobile hoist (Figure J.0.2)shall conform to the provisions in Table J.0.2.

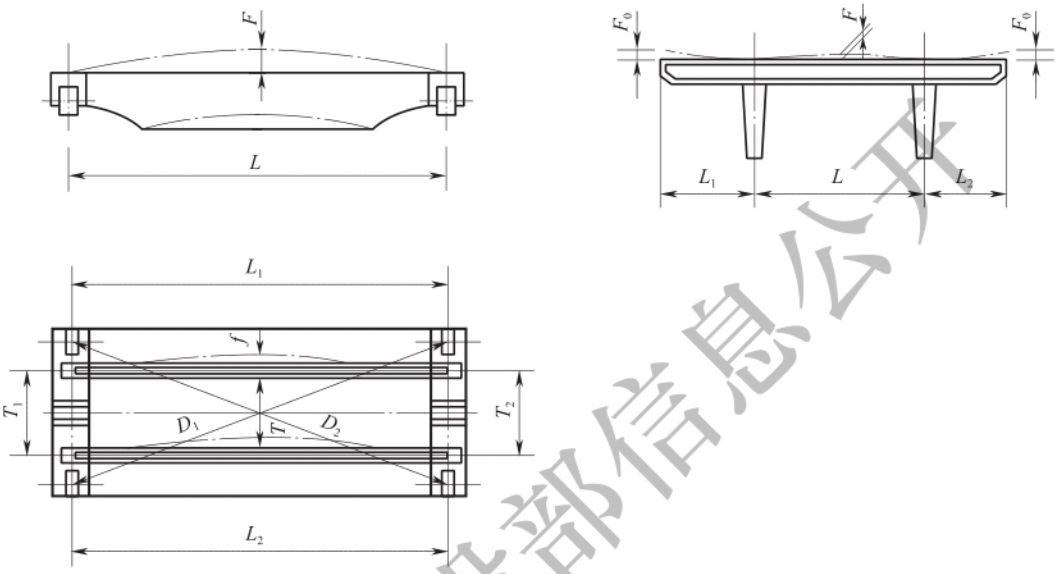


Figure J.0.2 Diagram of crane span structure and gantry of mobile hoist

Table J.0.2 Allowable deviation of assembly of crane span structure and gantry of mobile hoist (mm)

Serial number	Item	Allowable deviation
1	Mid-span camber of main beam F	0 to [(0.9 to 1.4)L/1000] and the maximum camber shall be within L/10 of the middle span
2	Upwarp degree of cantilever end F_0	0 to [(0.9 to 1.4)L_1/350] or 0 to [(0.9 to 1.4)L_2/350]
3	Horizontal bending of main beam f	0 to (L/2000) and the maximum value shall not exceed 20.0
4	D_1-D_2 diagonal difference of crane span structure	±5.0
5	Relative height difference between two legs from wheel face to flange plane on the legs	0 to 8.0

J.0.3 The allowable deviation for the installation of the operating mechanism of the mobile hoist (as shown in Figure J.0.3)should comply with the provisions specified in Table J.0.3.

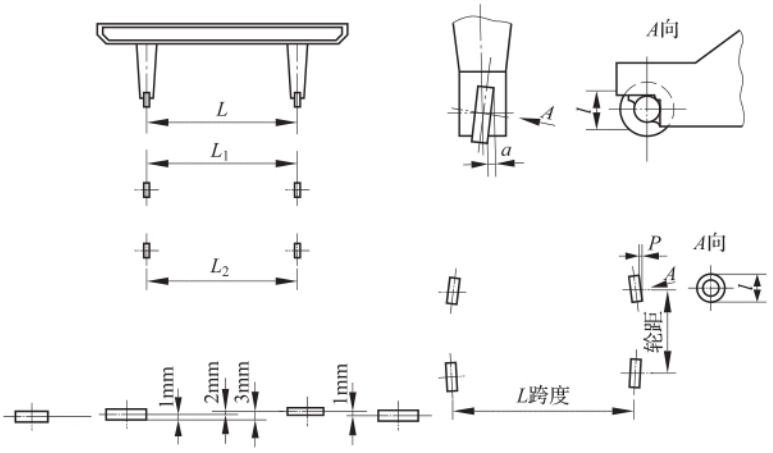


Figure J.0.3 Diagram of operating mechanism of mobile hoist

Table J.0.3 Allowable installation deviation of mobile hoist operating mechanism

Serial number	Item	Basic dimension (m)	Allowable deviation (mm)
1	Allowable span deviation of crane span structure	$L \leqslant 10$	±3.0, and the relative difference of the spans on both sides is 0 to 3.0
		$L > 10$	±5.0, and the relative difference of the spans on both sides is 0 to 5.0
2	Allowable span deviation of gantry crane	$L \leqslant 10$	±5.0, and the relative difference of the spans on both sides is 0 to 5.0
		$L > 10$	±8.0, and the relative difference of the spans on both sides is 0 to 8.0
3	Wheel vertical deflection	–	a is $\pm(l/400)$; l is the measurement length, measured in the wheel overhead state
4	Wheel horizontal deflection	–	p is $\pm(l/1\,000)$; l is the measured length and the deflection direction of a pair of wheels on the same axis shall be opposite
5	Coordinate difference of wheels under the same end beam	2 wheels	0 to 2.0
		3 wheels or more wheels	0 to 3.0
		Wheel under the same balance beam	0 to 1.0

Explanation of wording in this standard

1 Words used for different degrees of strictness are explained as follows in order to mark the differences in implementing the requirements of this standard:

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 standard to indicate that it is necessary to comply with the requirements stipulated in other relevant standards or codes.

List of quoted standards

GB 50026 *Standard for Engineering Surveying*

GB/T 50081 *Standard for Test Methods of Concrete Physical and Mechanical Properties*

GB 50108 *Technical Code for Waterproofing of Underground Works*

GB 50164 *Standard for Quality Control of Concrete*

GB 50171 *Code for Construction and Acceptance of Switchboard Outfit Complete Cubicle and Secondary Circuit Electric Equipment Installation Engineering*

GB 50202 *Standard for Acceptance of Construction Quality of Building Foundation*

GB 50203 *Code for Acceptance of Constructional Quality of Masonry Structures*

GB 50204 *Code for Quality Acceptance of Concrete Structure Construction*

GB 50205 *Standard for Acceptance of Construction Quality of Steel Structures*

GB 50207 *Code for Acceptance of Construction Quality of Roof*

GB 50209 *Code for Acceptance of Construction Quality of Building Ground*

GB 50210 *Standard for Construction Quality Acceptance of Building Decoration*

GB 50265 *Standard for Pumping Station Design*

GB/T 50290 *Technical Code for Application of Geosynthetics*

GB/T 50328 *Code for Putting Construction Project Documents into Records*

GB 50367 *Code for Design of Strengthening Concrete Structure*

GB 50433 *Technical Standard of Soil and Water Conservation for Production and Construction Projects*

GB/T 50600 *Technique Standard for Seepage Control and Lining Engineering on Canal*

GB 50666 *Code for Construction of Concrete Structures*

GB 50728 *Technical Code for Safety Appraisal of Engineering Structural Strengthening Materials*

GB 51247 *Standard for Seismic Design of Hydraulic Structures*

GB 5749 *Standard for Drinking Water Quality*

GB/T 14173 *Specification for Manufacture, Installation and Acceptance of Steel Gate in Hydraulic and Hydroelectric Engineering*

GB/T 19000 *Quality Management Systems-Fundamentals and Vocabulary*

GB/T 19001 *Quality Management Systems-Requirements*

GB/T 19866 *Specification and Qualification of Welding Procedures for Metallic Materials—General Rules*

GB/T 30948 *Code of Practice for Technical Management of Pumping Station*

JB/T 5000.11 *Heavy Mechanical General Techniques and Standards-Part 11:Attached Piping*

JB/T 6996 *Common Technical Condition of Heavy Machinery Hydraulic System*

JGJ 94 *Technical Code for Building Pile Foundations*

JGJ 106 *Technical Code for Testing of Building Foundation Piles*

MT/T 953 *Low-speed Winch*

NB/T 35045 *Code for Manufacture Installation and Acceptance of Steel Gates in Hydropower*

Engineering

SL 27 *Specification for Sluice Construction*

SL 36 *General Technical Specifications for Welding of Steel Structures in Water Project*

SL 41 *Design Code for Gate Hoist in Water Resources and Hydropower Projects*

SL 47 *Technical Specification for Excavation Construction of Rock-Foundation of Hydraulic Structures*

SL 52 *Specification for Construction Survey of Water and Hydropower Projects*

SL 105 *Specifications for Anticorrosion of Hydraulic Steel Structure*

SL 174 *Technical Specification for Construction of Concrete Cut-off Wall for Water and Hydropower Projects*

SL 176 *Inspection and Assessment Specification for Construction Quality of Hydraulic and Hydroelectric Engineering*

SL 223 *Acceptance Code of Practice on Water Resources and Hydroelectric Engineering*

SL 303 *Specifications for Construction Planning of Water Resources and Hydropower Projects*

SL 316 *Code for Safety Appraisal of Pumping Stations*

SL 317 *Specification for Equipment Installation and Acceptance of Pumping Stations*

SL/T 352 *Test Code for Hydraulic Concrete*

SL 379 *Design Specification for Hydraulic Retaining Wall*

SL/T 381 *Specification for Manufacture Installation and Acceptance of Hoist in Water and Hydropower Projects*

SL 548 *The Code of Practice of Field Testing of Performance and Safety for Pumping Station*

SL 551 *Technical Specification for Earth-Rockfill Dam Safety Monitoring*

SL 582 *Directives for Quality Inspection of Manufacture and Installation of Hydro Steel Structure*

SL 631 *Inspection and Assessment Standard for Separated Item Project Construction Quality of Water Conservancy and Hydroelectric Engineering -Earth-Rock Works*

SL 632 *Inspection and Assessment Standard for Separated Item Project Construction Quality of Water Conservancy and Hydroelectric Engineering—Concrete Works*

SL 633 *Inspection and Assessment Standard for Separated Item Project Construction Quality of Water Conservancy and Hydroelectric Engineering -Ground Treatment & Foundation Works*

SL 635 *Inspection and Assessment Standard for Separated Item Project Construction Quality of Water Conservancy and Hydroelectric Engineering -Installation of Metal Structures*

SL 677 *Specifications for Hydraulic Concrete Construction*

SL 721 *Guidelines for Construction Safety Management of Water and Hydropower Projects*

SL 734 *Technical Code for Quality Detection of Water Projects*

TSG Q7002 *Regulation for Type Test of Lifting Appliances*