KCS 11 50 10 : 2019

Cast-In-Place Concrete Pile

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국토교통부

Foreword

• In accordance with the change to the construction standards code system, the duplications and conflicts between existing construction standards (design standards, standard specifications) were compared and reviewed and then integrated into this standard as a standard code.

• This standard was established by integrating the parts of the civil engineering standard specification and the building construction standard specification corresponding to cast-in-place concrete piles, based on the existing road construction standard specification and the highway bridge standard specification. The history of this standard and its revisions is as follows.

Construction Standard	Main Content	Enacted or Revised (Year.Month)
Road construction standard specification	• Established by the Korean Society of Civil Engineers at the request of the Ministry of Construction	Enacted (1967.12)
Road construction standard specification	• Supplemented and revised as a specification for general road construction by reviewing & developing the relevant specifications and guidelines in use	Revised (1985.12)
Road construction standard specification	• Supplemented and revised as a more substantial specification by introducing and developing new theories to conform to the relevant specifications and guidelines in use	Revised (1990.5)
Road construction standard specification	• Revised to improve the quality of road construction and strengthen international competitiveness by reorganizing the system to cope with the opening of the construction market following the launch of WTO	Revised (1996.7)
Road construction standard specification	• Revised to reflect the revisions to other standards, such as KS and the concrete standard specification, and reorganized and supplemented according to the construction standard maintenance guidelines to establish the system as a national standard	Revised (2003.11)
Road construction standard specification	• Revised to address the problems in the road construction process, to harmonize with other standards such as KS, concrete and tunnel standard specifications, to prevent faulty construction, and to induce solid construction through thorough quality control	Revised (2009.3)
Road construction standard specification	• Revised by changing the order of standard specifications, professional specifications, and design drawings, and by reflecting the opinions of the central committee	Revised (2015.9)

Construction Standard	Main Content	Enacted or Revised (Year.Month)
Road construction standard specification	• Partial revision of general, tree protection materials, and general construction	Revised (2016.5)
Highway bridge standard specification	• Established highway bridge standard specification	Enacted (1977.12)
Highway bridge standard specification	• Revised to reflect the revisions to the concrete construction standard specification	Revised (1983.12)
Highway bridge standard specification	• Revised to reflect the latest domestic and international specifications and technological advancements	Revised (1992.11)
Highway bridge standard specification	• Content divided into design and construction, and maintenance included	Enacted (1996.4)
Highway bridge standard specification	• Reorganized into a new system to resolve conflicts among sectors	Revised (1999.8)
Highway bridge standard specification	• Added TMC steel standard and improved welding standard	Revised (2005.2)
Highway bridge standard specification	• Added new regulations for the construction of high performance materials such as rolled steel for bridge structures and high-strength concrete, and added quality control technologies for centrifugal concrete piles	Revised (2013.2)
Highway bridge standard specification	• For non-destructive inspection methods, ultrasonic inspection may be selected in addition to radiographic inspection	Partially revised (2015.6)
KCS 11 50 10 : 2016	• Integrated and maintained as code according to the changes to the construction standards code system	Enacted (2016.6)
KCS 11 50 10 : 2016	• Amended according to Korean Industry Standards and Construction Standards	Amended (2018.7)

Table of Contents

1. General

1.1 Scope of application

(1) This standard provides the specifications for cast-in-place concrete piles reinforced with rebars by excavating the ground under the structure.

1.2 Reference

1.2.1 Related laws and regulations

No content

1.2.2 Related standards

- KCS 11 50 15 Precast pile
- KCS 11 50 40 Pile loading test
- KCS 14 20 11 Reinforcement work
- KCS 14 20 10 General concrete
- KCS 14 31 10 Fabrication
- KCS 14 31 20 Welding
- KS D 3504 Steel bars for concrete reinforcement
- KS F 4602 Steel pipe piles for foundations

1.3 Materials to submit

1.3.1 Construction plan

(1) Subject to the applicable requirements of KCS 11 50 15.

1.3.2 Construction report

(1) Prepare a construction report that includes the construction plan and progress, a list of the workers and their qualifications, materials, and equipment allocation status.

1.4 General requirements

1.4.1 Construction standard

(1) Construct the cast-in-place piles according to the contract plan and approved detailed drawings.

1.4.2 Tolerances

(1) Variation of center position measured from the ground: Less than 75 ㎜

(2) Bottom surface diameter: 0 ㎜ ~ 150 ㎜
(3) Variation of vertical axis: Less than 1/40
(4) Variation of floor elevation: Less than ±50 ㎜

1.4.3 Vertical shaft excavation work inspection

(1) Inspect the excavation dimensions of each excavation work in the presence of the construction supervisor. Measure the final excavation depth using a tapeline with weights or through other approved methods (drilling efficiency of the excavator, strength of rocks, etc.) after the final cleaning.
(2) The maximum depth of sediment or debris on the bottom of the shaft shall not exceed 50 ㎜. Under dry conditions, the construction supervisor shall judge the cleaning conditions in the hole and decide the appropriate method for underwater conditions.

1.5 Order of work

(1) Develop a schedule to insert the reinforcing mesh and pour concrete on the same day after completing excavation.
(2) Prevent vibration and restrict vehicle traffic near the excavation site until the concrete placement is complete, and always maintain a stable drilling hole condition.

2. Materials

2.1 Reinforcement

(1) Rebars shall follow the applicable requirements of KCS 14 20 11, and the grades and dimensions shall be as specified.

2.2 Concrete

(1) Matters related to concrete shall follow the applicable requirements of KCS 14 20 10, with the strength specified in the contract plan.

2.3 Casing

(1) Steel pipes shall conform to the standards specified in KS F 4602 and shall have the specified diameter and thickness.
(2) Steel plates shall follow the applicable requirements of KCS 14 31 10.
(3) Welding shall be in accordance with the applicable requirements of KCS 14 31 20.

3. Construction

3.1 General

3.1.1 Preparing for construction

(1) Maintain the ground to ensure the safe installation of relevant construction machines and the safety of the work.

(2) In addition to the area occupied by the main body of each construction method, secure space for the crane, vehicles transporting the excavated soil, area for the entry/exit of truck mixers, and casing tube yard.

(3) Conduct a reconnaissance survey to clarify the position and elevation of the pile and install bench marks and inspection piles for easy detection during construction.

(4) Review matters related to the discharge of excavated soil, facilities to treat the stabilizer liquid, water supply and drainage, and electric facilities in advance.

3.1.2 Selecting construction equipment

(1) Select the excavation equipment for cast-in-place concrete piles by considering the ground conditions including soil and rocks and the site conditions.

(2) The excavation equipment shall have the capacity to drill deeper than the depth specified in the contract drawing at the maximum diameter. The tools shall have the proper structure, dimensions, and strength to perform the specified work.

(3) If there is ground that cannot be drilled using conventional tools, use special drilling equipment, such as rock drilling tools, to excavate to the specified dimensions and depth.

3.1.3 Casing and installation of equipment

(1) Install vertically and accurately so that the center of drilling matches the center of the pile in the design.

(2) When drilling, check the level frequently to maintain vertical accuracy.

(3) The installation and joint of steel pipe piles for casings shall be in accordance with KS F 4602 and shall reach the intended ground without any deformation of the fore-end of the steel pipes.

(4) Pressure penetrate the casing first, and then conduct excavation within the penetrated depth of the casing.

(5) When installing pipes, review the following before excavation.

① Burial depth of the stand pipe

② Vertical degree of the stand pipe

③ Diameter of the stand pipe

④ Put the stabilizing liquid 2m higher than the water level inside the hole, and measure the water level over time to check for leaks.

3.2 Test pile

(1) In principle, test piles should be installed before starting construction. Test piles are used to confirm the adequacy of the design and the constructability, so if there is a difference between the design and the results of the loading test, change the design and the construction method based on the results. If you are only checking the constructability, you may omit the installation of test piles after consulting with the construction supervisor if the constructability of the pile has already been determined for the construction site.

(2) Apply the test piles properly to test the excavation method and the adequacy of the equipment, determine the number of test piles by consulting with the construction supervisor, and include excavation, reinforcement installation and concrete placement.

(3) Install the test piles near the foundation site at a location specified in the drawing or approved by the construction supervisor, and excavate to the deepest point of elevation of the specified excavation depth.

(4) Conduct a loading test on the test piles to confirm the capacity of the ground or pile as well as the design load. Use the test results as data to change the design.

(5) Depending on the results of testing the selected construction method and equipment, the construction supervisor may require the contractor to change the method and equipment.

(6) If the construction of cast-in-place concrete piles is approved, the method or equipment used to construct the test piles cannot be changed without the written approval of the construction supervisor.

3.3 Loading test

(1) Subject to the provisions of KCS 11 50 40.

3.4 Excavation

3.4.1 General

(1) Construct the cast-in-place concrete piles according to the method approved when installing the test piles, and conduct excavation according to the specified dimensions, depth, and tolerance, regardless of the geological features.

(2) When requested by the construction supervisor, drill down to a maximum of 3 times the diameter of the pile or to the extent of stress below the end of the pile to recover the core, and fill the borehole with grout.

(3) Protect the excavation surface with a steel cylindrical casing to prevent pitting, displacement of the surrounding soil, water leaks, and injury, and damage caused by work.

(4) Level the bottom surface within the specified tolerance and remove loose materials, debris, and muck.

3.4.2 Suppressing groundwater

(1) If groundwater appears during the excavation work, pump the water after consulting with a geotechnical engineer without washing away boreholes or causing any damage to the ground or adjacent structures.

(2) If a groundwater leakage threatens the safety of adjacent property or structures or exceeds the normal pumping capacity, apply additional groundwater suppression measures.

3.4.3 Inspection

(1) After completing the excavation, the construction supervisor shall inspect the excavation conditions before installing the rebars. In addition, soil, rocks, or loose materials must be removed from the excavated floor before installing rebars and placing concrete.

3.5 Installing rebars

3.5.1 Fabrication and assembly of rebars

(1) Fabricate and assemble the rebars to be robust according to the design drawing.

(2) Maintain the verticality and position of the rebars accurately in order to place the rebars upright. If using the RCD method or the earth drilling method, carefully lower inside the drilling hole to prevent contact with the wall and the collapse of soil.

(3) Prevent torsion, bending, and buckling during and after placing the rebars upright.

(4) If suspending a reinforcing mesh, tie the assembly hoop at the top of the reinforcing mesh with steel to maintain verticality and prevent shaking.

(5) Attach spacers to the reinforcing mesh to secure a cover. The spacers shall be of a shape that does not fall off or cut the borehole when inserting the reinforcing mesh.

(6) Attach spacers at intervals of 3m ~ 5m in depth and 4 to 6 spacers in the same depth, and determine the protruding height of the spacers and the gap between the inner surface of the borehole casing by considering the excavation precision of the borehole surface and to prevent the spacers from falling out when extracting the casing.

(7) Arrange a reinforced cushion at the bottom or develop other methods to prevent damage to the reinforcing mesh in the event of concrete placement and casing pull-out.

(8) The reinforcement of piles installed in a marine environment shall comply with KS D 3504 in consideration of corrosion.

3.6 Concrete placement

(1) Concrete should be applied in dry conditions, and all possible means should be used to maintain dry conditions before and during concrete placement. If groundwater leaks more than 6 ㎜ per minute at or near the bottom of the vertical shaft, this should be regarded as an underwater

condition; in this situation, use an approved tremie concrete placement method to continuously place the concrete.

(2) To prevent the mixing of laitance near the concrete surface and the outflow of sediments from the bottom of the hole, install the tremie at the center of the drilling hole and bury the spillway at least 2m deep in the concrete at all times.

(3) If the bottom of the casing tube is raised from the concrete surface, the soil from the borehole may collapse and be mixed into the concrete, so the bottom of the casing tube shall be at least 2m lower than the top of the concrete.

(4) The amount and height of concrete placement shall be accurately measured at all times.

(5) Place enough concrete at the pile head to prepare for quality degradation and break off the concrete to the design height after hardening.

(6) Take precautions and prevent any harmful effects during the curing process.

(7) Examine the hydration heat of concrete for piles with a diameter that may cause hydration heat problems.

3.7 Preventing the collapse of boreholes

3.7.1 General

(1) Depending on the drilling machine, ground conditions, and construction details, prevent the collapse of the borehole by applying cast-in-place piles through fully inserting the casing into the drilling hole and pulling out the casing while pouring the concrete, or by applying the slurry method in which slurry is placed in the drilling hole to protect the borehole by water pressure and inserts a casing near the surface.

3.7.2 Recovery of steel casing

(1) Unless the steel casing used to prevent the collapse of the borehole is used as a permanent steel pipe casing, recover the casing while placing concrete. When recovering the steel casing, insert the lower end of the casing at least 2m from the surface of the placed concrete to prevent the inflow of groundwater at the bottom of the casing. Tamp the concrete while drawing out the steel casings.

3.8 Field quality management

3.8.1 Inspection and testing

(1) The construction supervisor shall conduct inspections and tests according to the regulations specified in KCS 14 20 10.

3.8.2 Records and reports

(1) Maintain the construction records in an approved reporting format for individual cast-in-place concrete piles. The reporting format must include the construction location, dimensions, depth of excavation, the elevation of the crest and excavated floor, the elevation of the groundwater level during excavation, the condition of the excavated floor, the quantity of water inflow in the borehole during concrete placement, concrete placement data, and other data required by the form or related to the foundation.

3.9 Integrity test

3.9.1 General

(1) Perform an ultrasonic inspection on the entire length of the pile to confirm the integrity of the concrete on the cast-in-pile concrete piles.

(2) Submit the following materials.

① Ultrasonic inspection plan

② Ultrasonic test result report

③ Ultrasonic model test plan

3.9.2 Materials

(1) The diameter of the inspection tube shall be sufficiently wide to easily insert inspection sensors, and the materials shall have the strength of steel pipes or equivalent materials.

(2) The construction supervisor must approve the inspection equipment before warehousing the equipment. To verify the performance of the equipment, particularly its accuracy, perform a model test before inspecting the main piles and receive confirmation from the construction supervisor.

(3) The minimum configuration of the test equipment shall be as follows.

(4) Ultrasonic transmitting and receiving sensors and cables

(5) Automatic depth measuring equipment using cables

(6) Receiving electronic device capable of detecting transmitted signals

(7) Monitoring device and printer capable of verifying received signals

3.9.3 Installing inspection tubes

(1) There shall be no rust or clogging inside the inspection tube, and the connecting part shall be completely waterproofed through a screw connection method using couplings.

(2) Bury the inspection tubes in the reinforcing mesh by binding the quantities specified in Table 3.9-1 below.

Table 3.9-1 Size of circular piles and the number of inspection tubes

Diameter of circular pile (D) (m)	Number of inspection tubes	Remarks
D ≤ 0.6	2	
0.6 < D ≤ 1.2	3	
1.2 < D ≤ 1.5	4	
1.5 < D ≤ 2.0	5	
2.0 < D ≤ 2.5	7	
2.5 < D	8	

(3) Match the lower end of the inspection tube to the lower surface of the reinforcing mesh, and in consideration of the ground conditions of the fore-end of the pile, install the tube 50～100 ㎜ when penetrating the reinforcing mesh so that the tube does not bend or burst.

(4) Maintain a regular spacing between the inspection tubes. Tubes should be parallel to each other as much as possible.

(5) The upper end of the inspection tube shall protrude beyond the finished surface of the cast-in-place piles to facilitate inspection.

(6) Apply waterproof caps to both ends (upper and lower) of the inspection tube to prevent the inflow of foreign substances, and to prevent damage during the construction.

3.9.4 Quantity and timing of tests

(1) The quantity of ultrasonic inspection for the cast-in-place piles shall be in accordance with the standard in Table 3.9-2 below.

Table 3.9-2 Ultrasonic testing frequency

Average pile length (m)	Test quantity (%)	Remarks
Less than 20	10	• Frequency: Percentage of pile quantity per intersecting angle (At least 1 per intersecting angle) • Consult with the construction supervisor in terms of other structures
20 ~ 30	20	
More than 30	30	

(2) Conduct ultrasonic inspection at least 7 days after placing the concrete.

3.9.5 Inspection method

(1) Adjust the incoming and outgoing lengths of the cable so that the sender and receiver inside the inspection tube are placed on the same plane perpendicular to the direction of the pile length.

(2) The length of ultrasonic transmitting and receiving cables shall be sufficiently long in consideration

of the length of the pile to be inspected.

(3) Record the measuring depth of the ultrasonic inspection simultaneously with the transmission of the ultrasonic waves, and measure it continuously by simultaneously raising the sender and receiver from the fore-end of the pile.

(4) The inspector shall measure the profile showing the ultrasonic wave propagation time, energy intensity, and the waveform of the time-distance curve according to the depth of the pile from a sender and receiver pair through the monitor screen or printout.

(5) After the inspection, apply a protective cover on the inspection tube to prevent the inflow of foreign substances until the construction supervisor confirms the results of the inspection.

3.9.6 Determining the integrity

(1) Determine the integrity of the cast-in-place piles by applying the criteria in Table 3.9-3 below and calculating the average defect score for the entire profile graph by depth based on the following equation, which calculates the defect score by depth for each profile graph with different inspection paths, and then submit the results to the construction supervisor.

Average defect score by pile depth = $\frac{1}{N}\sum$ (Defect score of profile graph by inspection path)

Where, N : Number of profile graphs (Number of inspection paths)

Table 3.9-3 Acceptance standard for internal defects of cast-in-place piles

Grade	Acceptance standard	Defect score	Remarks
A (Acceptable)	• Almost no signal distortion in the ultrasonic time-distance curve • Propagation time corresponding to a reduction of less than 10 % in the ultrasonic propagation velocity of sound concrete	0	V=S/T V: Propagation velocity T: Propagation time S: Distance between tubes
B (Potential defects)	• Some signal distortion in the ultrasonic time-distance curve • Propagation time corresponding to a reduction of 10~20 % in the ultrasonic propagation velocity of sound concrete	30	
C (Unacceptable)	• Severe signal distortion of the ultrasonic time-distance curve • Propagation time corresponding to a reduction of more than 20% in the ultrasonic propagation velocity of sound concrete	50	
D (Critical defects)	• No detection of ultrasonic signals • The propagation time is close to the ultrasonic propagation velocity of 1500 ㎧	100	

(2) If the results according to procedure (1) above correspond to grade A (average defect score less

than 30 points) and each profile graph is good and reinforcement is not required, the construction supervisor shall completely remove any water inside the inspection tube and conduct grouting above the design strength of the pile concrete before proceeding with the subsequent work of the corresponding pile.

(3) If the results according to procedure (1) above correspond to grade B (average defect score more than 30 points), determine whether to reinforce by consulting with an ultrasonic inspection expert, geotechnical expert, and a structural engineering expert. If reinforcement is required, follow the procedure of 3.9.7. The contractor shall cover the reinforcement cost in full.

3.9.7 Reinforcement of defects

(1) To investigate the location of defects and the cause of failure in piles that need to be reinforced, the contractor shall drill the corresponding piles with the approval of the construction supervisor, and identify the cause and carry out reinforcement by consulting with geotechnical and structural engineering experts.

(2) Conduct loading tests on the reinforced piles, and submit a report of the test results to the construction supervisor by attaching the results according to the test methods.

3.9.8 Report of test results

(1) The inspector shall prepare and submit a test report of an inspection of the integrity of the cast-in-place concrete piles to the construction supervisor.