

KCS 11 30 45 : 2019

Soil Grouting

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KC CODE



국토교통부



Foreword

- This standard was organized and integrated as the code by comparing and reviewing duplicate or contradictory content within the existing construction standards (design standards, standard specifications) due to the transition of the construction standards code system.
- This standard is established by integrating and organizing the parts that correspond to soil grouting in the existing Standard Specifications for General Civil Works. The history of the standard are as follows:

Construction Standard	Main Content	Enacted or Revised (Year.Month)
Road Construction Standard Specification	· Established by the Korean Society of Civil Engineers commissioned by the Ministry of Construction	Establishment (Dec. 1967)
Road Construction Standard Specifications	· The specifications were improved and revised to become general specifications of overall road work by reviewing the related existing specifications and guidelines that were used and being developed.	Revision (Dec. 1985)
Road Construction Standard Specifications	· The specifications were improved and revised to be better specifications by advancing and complying with the currently used specifications and guidelines, along with the introduction of new theories.	Revision (May 1990)
Road Construction Standard Specifications	· The specifications were revised to enhance the international competitiveness and to promote quality improvements of road works by reorganizing the system to cope with the openness of the construction market as a result of the launch of the World Trade Organization (WTO).	Revision (July 1996)
Road Construction Standard Specifications	· The specifications were re-organized to establish a system of national standards and to reflect the revision of contents and other standards, such as the Korean Industrial Standard (KS) and the Standard Specification of Concrete according to the Construction Standard Organization Guideline, and to improved and revise standards to address the problems.	Revision (Nov. 2003)

Construction Standard	Main Content	Enacted or Revised (Year.Month)
Road Construction Standard Specifications	· The specifications were revised to improve the problems produced during the road construction and to induce reliable constructions through consistency with other standards such as the KS, Standard Specification of Concretes , and Standard Specifications of Tunnels, ensuring the prevention of shoddy and faulty construction thorough quality control.	Revision (Mar. 2009)
Road Construction Standard Specifications	· The specifications were revised to reflect the recommendations from the Central Construction Technology Deliberation Committee and changed the standard specifications, specialized specifications, and design drawings.	Revision (Sep. 2015)
Road Construction Standard Specifications	· Partial revision, including overview, forest and tree protection materials, and general construction works.	Revision (May 2016)
Standards Specifications of Harbor Construction	· Establishment of the Standards Specifications for Harbor Construction	Establishment (Dec. 1976)
Standards Specifications of Harbor Construction	· Revision of the Standards Specifications for Harbor Construction	Revision (Dec. 1977)
Standards Specifications of Harbor Construction	· The specifications added various design conditions for harbor construction, and included general policies and standards of designs in relation to harbor facilities, counter facilities, and other facilities for harbor construction.	Revision (Dec. 1986)
Standards Specifications of Harbor Construction	· The standards were significantly revised to provide a basis to apply the re-estimation of deep-sea waves, the estimation of wind speeds, and load coefficient to improve the safety of harbor facility and equipment, including coastal maintenance facilities.	Revision (Dec. 1996)
Standard Specifications of Harbor and Fishing Port Construction	· The standards were completely revised to include preemptive countermeasure against climate changes and to reflect the changing port construction conditions.	Revision (Nov. 2005)
Standard Specifications of Harbor and Fishing Port Construction	· The specifications were significantly revised to reflect the modified contents in the upper technical standards and other fields standards, improving related specifications, such as mass concrete and cap concrete and other related specifications such as filter mats, ships, quay walls, and other attached facilities, and added specifications concerning marina facilities.	Revision (Dec. 2012)

Construction Standard	Main Content	Enacted or Revised (Year.Month)
KCS 11 30 05 : 2016	· Integrated and organized the code system due to the transition to the code system of construction standards.	Establishment (Jun. 2016)
KCS 11 30 05 : 2016	· Modified to satisfy the Korean Industrial Standards and Construction Standards.	Modification (Jul. 2018)





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1. General

1.1 Scope of Application

- (1) This standard proposes the specifications of grouting, rock mass pressure grouting, and contact surface grouting.
- (2) This standard is applied to construction works that are performed for the purpose of water stop effects or strength improvements of the ground by inserting a grouting tube into the ground and injecting or mixing a proper amount of grout by pressure, thereby cementing or hardening the ground.

1.2 Documents to be submitted

- (1) Work schedule, inspection and test plan, construction plan, test grouting plan, and test grouting report
- (2) Grouting equipment specifications: Work drawings, scheduled grouting equipment's written specifications, and job specifications
- (3) Job record columnar sections of all drillings, time of change in grouting works, pressure, grouting velocity and other data required by construction supervisor
- (4) Grout mix design grout's mix proportion and mixture test results
- (5) Fine aggregate particle size: Particle size test results of fine aggregates
- (6) Grouting procedure including decision making on mixture, recirculation, grouting progress and filled space.
- (7) Grouting completion and grout collection report: The report follows the form provided by construction supervisor.

1.3 Reference standards

1.3.1 Related laws

No contents.

1.3.2 Related standards

- KS F 2426 Testing method of compressive strength of grouting mortar
- KS L 5105 Testing method of compressive strength of hydraulic cement mortar
- KS L 5201 Portland cement

1.4 Delivery, storage, and handling

- (1) The products shall be delivered, stored, protected, and operated in the site in accordance with the manufacturer's instructions.

- (2) The packed materials shall be dried cleanly, and protected from humidity, icing, and foreign materials.

1.5 Construction environment requirements

- (1) The temperature of material and the atmosphere shall be 5 °C or higher prior to or during the work, and 10 °C or higher for 48 hours after the completion of the work.
- (2) The temperature of material and the atmosphere shall be 30°C or lower prior to and during the work and for 48 hours after work completion.

2. Material

2.1 Materials

- (1) For cements, refer to the corresponding requirements of ordinary Portland cements in KS L 5201.
- (2) For blended cements, refer to the corresponding requirements of blended cements.
- (3) For aggregates, refer to the corresponding requirements of fine aggregates for concretes, which shall be filtered through 1. mm sieves.
- (4) Water shall be clean and have no harmful impurities.
- (5) For grouts, the following considerations shall be considered.
 - ① Cement-based, clay-based, and asphalt-based grouts are found as a type of suspension type.
 - ② Solution type
 - A. Alkaline-based, non-alkaline-based, specialized silica-based, and gas and liquid reaction-based grouts are found as a type of water glass.
 - B. Chrome-lignin-based, Acryl-amide, and urethane-based grouts are found as a polymer-based type.
- (6) All grouts shall not only satisfy the quality requirements but also not include substance harmful to the ground environment.

2.2 Mix test

- (1) The mix tests of grouts shall be conducted in accordance with KS L 5105 and KS F 2426.

2.3 Grouting hoses, cover caps, and connector

- (1) Grouting hoses, grouting hole cover caps, washers, and connectors shall be inspected and approved by the construction supervisor prior to the starting of grouting.

3. Construction

3.1. Equipment

3.1.1 Drilling equipment

- (1) All grouting holes shall be drilled with approved drilling machines. When drilling is complete, the borehole shall be cleaned with water and air so that all debris inside the hole is removed. Removing debris from the bored holes with only air is not permitted.

3.1.2 Grouting equipment

- (1) Job requirements
 - ① The equipment used shall have a suitable configuration for injection and performances that can mix grouts sufficiently and inject the grouts into the rock mass or the bottom layer and banked materials at a continuous flow rate with the required pressure.
- (2) Cleansing capability
 - ① The grouting equipment shall be equipped with a form that can be cleansed without external support.
- (3) Inspection of stand-by grouting equipment
 - ① Stand-by grouting equipment shall be inspected every week, and grouting workers shall perform exercise training every other week for the emergency use of the stand-by grouting equipment.
- (4) Components
 - ① The capacity of the mixer, precision of the water supply meter, mixing tank and pump's performance, hose's diameter and resisting force, and pressure range and precision of pressure gauge shall not impede the work.
- (5) The valves installed in the grouting hole connecting part of the shutoff valves shall be able to retain the required pressure until the grouts are set evenly after the injection is complete.

3.1.3 Compressor

- (1) The compressor shall have a performance that can supply compressed air to each part of the equipment at 0.6 MPa or higher pressure.

3.1.4 Packer

- (1) The packer shall have expansion tubes that are suitable to be connected to the grout supply tube and be configured to be able to be expanded by machine or other approved means. The packer shall be able to seal the boring holes and can endure up to 1.0 MPa pressure without leakage at any location when it is expanded, and shall be equipped with valves that shut off the

holes when the injection is complete.

3.2 Pressure grouting to rock mass

3.2.1 Overview

- (1) Whether pressure grouting to rock masses is needed shall be verified according to the instruction of the construction supervisor.
- (2) All pressure grouting works shall be executed in the presence of the construction supervisor. The grouts that are composed of cements and water shall be injected by applying a pressure to each hole that is penetrated in the rock mass. The pressure shall not exceed 4 MPa although it is set by the instruction of the construction supervisor. A mix proportion of cement and water shall be instructed by the construction supervisor.
- (3) All required drilling machines and injection pumps shall be able to be used at the start position immediately once the need of grouting is determined.
- (4) It is necessary to delay the rock mass excavation when the grouts are filled inside the hole after injection is complete at the start position. A stand-by time of less than four hours, which is determined by the construction supervisor, is not regarded as work suspension.

3.2.2 Pipes and connector

- (1) Required pipes and connectors shall be installed to enable pressure grouting to rock masses located in the grouting holes as required. The pipes and connectors are made of 40 mm diameter steel pipes that shall be able to sustain the internal pressure of 4 MPa.
- (2) The grouting pipes are anchored inside the rock mass and the space around the pipes shall be sealed with appropriate materials. All soil dusts, grease, grouts, and mortar found in the pipes and connectors shall be cleansed fully before they are buried inside the rock mass. If possible, appropriate packers may be used instead of grouting pipes.

3.2.3 Grouting hole drilling

- (1) The grouting holes for pressure grouting shall be drilled before tunnel excavation as many are required to reduce the water discharge.
- (2) The gap shall be maintained not to contact between adjacent grouting holes when grouts are inserted to the grouting holes. To do this, drilling may be restricted until the grouts are injected to the holes. A diameter of each grouting hole shall not be smaller than that penetrated with the standard size (approximately 38 mm) bit. Gaps that may block or hinder the hole prior to connecting to the grouting hole shall be covered with caps properly or connected after protecting them separately. The grouting holes shall be cleansed before injection.

3.2.4 Pressure grouting work

- (1) Bursting layer, seams, and faults are cleansed as needed, and the grouting holes shall be tested with clean water while raising the grouting pressure to the required pressure to determine a leak amount and range.
- (2) Packers shall be used at all pressure grouting holes ahead of the tunnel face. At any stage, injection shall continue to receive 30 L or less grouts in 15 min. when the pressure is 0.8 MPa at the grouting hole or the connector, 30 L or less in 10 min. when the pressure is 1.5 MPa to 3 MPa, and 30 L or less in five min. when the pressure is 3 MPa to 4 MPa. Once the injection is complete at the grouting hole or the connector, the pressure is maintained by appropriate valves until the grouts are fully set so that the grouts shall fill the grout hole or the connector.

3.3 Grouting into the contact surface

3.3.1 Overview

- (1) The contact surface grouting is pressure grouting that is conducted to fill the gaps between steel or concrete's tunnel lining and rock mass or ground surface, and between steel lining and concrete lining.

3.3.2 Grouting

- (1) General procedure
 - ① Grouting pressure
 - A. It varies according to the grouting conditions, and grouts shall not be injected with 0.2 MPa or higher or pressure that is sufficiently large to cause a local torsion in the tunnel lining section.
 - B. After the grouts are fully discharged, the grouting pressure shall not be maintained.
 - ② Grout delivery
 - A. A pump shall be operated to make the grout delivered uniformly and continuously. The grouts shall be injected continuously until the work is complete unless otherwise instructed by the construction supervisor.
 - ③ Grouting order
 - A. Grouting starts from the lowest grouting hole first, and continues to the highest grouting hole. Grouting shall be done from the bottom to the top on the both sides of the lining.
 - B. Grouts shall not be injected to the higher grouting hole until the space in the lower grouting holes is fully filled with grouts.
 - ④ Determination whether the space is filled
 - A. The loss of grouts at the higher grouting hole means that the lower space is fully filled with grouts unless the construction supervisor determines it differently.

B. The lost grouts shall be disposed of until they exhibit the required consistency.

⑤ Grouting completion

A. If the lost grout is observed in the grouting hole with the required consistency and unless the construction supervisor decides otherwise, grouting is deemed to be complete when the grout at the required mix proportion and consistency is unable to be injected with the required pressure anymore.

(2) Grouting of steel lining

① Grouting method

A. Two-phase grouting shall be used. The first phase shall be conducted while the lining section that is not injected is advanced and is followed as it is departing from the shield's tail, or after the lining section has departed from the shield's tail.

B. More than one lining section that is not injected shall not be placed in the tail of the tunnel shield. The grouting pressure shall not cause a displacement of the lining or the surrounding materials or damage lining and the pressure shall be less than 0.2 MPa.

C. The grouting starts from the grouting hole in the bottom section of the lining, and the grouting hole in the above shall be opened as a vent hole or observation hole.

D. The second phase grouting shall be conducted in less than 24 hours after the first phase grouting is complete, and within 15m distance from the first phase grouting to fill the discovered gap.

E. The above-described grouting pressure shall be employed.

F. The grouts shall be injected according to the method approved by the construction supervisor. The tunnel lining section where the shield's tail is already installed shall leave as soon as possible, and the gaps between the lining and surrounding materials including the gaps made when supporting a newly made section shall be filled.

G. The grouts shall be poured into a space between the tunnel shield's tail and lining, or poured at the tip in the travel direction around the cutting edge of the shield thereby preventing the waste of grouts in other places.

② The grouting hole cover caps are located in the section where the grouts will be injected are removed to connect the grouting hole, and the hose of the grouting machine shall be connected to the nipple.

③ The nipple is removed from the grouting hole to replace the grouting hole cover cap once the injection is complete in each lining section. Then, the threads in the cover cap and grouting hole are cleansed, and cover cap thread is placed, and a washer is inserted to tighten the cover cap.

(3) Grouting of concrete tunnel lining

① The grouting pressure at the grouting point shall not be high enough to damage or cause a displacement of lining, or shall not exceed 0.2 MPa.

② Grouting pipes

- A. The metal pipes buried inside the concrete lining for the vent hole and connection of the grouting hole shall be penetrated and installed through the tunnel lining located in the place designated by the construction supervisor. The grouting pipe shall be arranged so that the grouts can be freely introduced to the gap between the rock mass or the ground surface and the concrete lining. The pipe arrangement shall be ended at 25mm or longer away from the inner surface finished with the concrete lining. The diameters of the grouting pipe and the vent hole in each grouting hole shall be at least 40mm.
- B. The grouting pipe shall be suspended tightly in place and protected not to be damaged during the placement of the concrete lining. Caps or other devices shall be attached to the end of the pipe to prevent concrete or other foreign matters from being introduced prior to grouting, and facilitate finding the location of the grouting pipe easily after removing the form. A drilling depth of 150mm shall be made into the rock mass and ground surface through each grouting pipe and vent pipe after pipes are buried inside the concrete and before the grouting is conducted. Blocking or obstructions shall be avoided prior to the grout connection, and pipes that are blocked or obstructed shall be cleansed thoroughly.

- ③ A grouting hole is needed for grouting at the drilling contact surface. When a grouting pipe is not buried inside the concrete lining, a grouting hole shall be drilled at a place designated by the construction supervisor through the concrete lining. Unless otherwise instructed, a drilling depth of 150mm shall be made into the undisturbed surface around the lining section. A diameter at the bottom of each grouting hole shall be 40mm or longer. Pipe blocking obstructions shall be avoided prior to grout connection, and pipes that are blocked or obstructed shall be cleansed thoroughly. The constructor may install a normal nipple at the drilled hole for the connection of grouting hole, or expansion packers may be used inside the concrete for the connection of grouting hole.

④ Grouting work

- A. A grouting hole shall be equipped with corks or valves to prevent leakage by connection with packers or threaded connector with sufficient strength and water-tightness. The caps located in the upper end of the grouting hole shall be removed and replaced if checking is needed to determine air and water leakage and whether all spaces are filled with grouts. Once the grouting is complete in each connecting part, the valve is closed, and the valves and connectors shall be put in place until the grouts are set. The valves and connectors are allowed to be removed only after the grouts are set.
- B. A grout hole shall be thoroughly cleansed if the construction supervisor does not approve the pressure grouting just before it starts.
- C. The contact surface grouting pump shall be operated and managed to inject grouts

uniformly and gradually. The grouting work shall not be executed until all concretes within a 15m distance are placed for at least seven days. The grouting hole adjacent to the grouting machine shall be opened during grouting work to facilitate air and water to be easily bled from the pocket in the space around the tunnel lining. The connecting part may be blocked with caps temporarily if grout leakage occurs that may cause a considerable loss of grout or seriously obstruct the grouting work in the adjacent grouting holes.

- D. All spaces in the tunnel's arch that are not filled yet even after the concrete lining pouring or backfill concrete shall be filled with the grouts. The vent holes where the grouts that fill the arch's spaces shall be filled and blocked with the grouts.
- E. Once the grouting is complete, all connections of the buried pipes shall be removed up to at least 2 mm of depth below the concrete surface, and the holes are filled with firm grouts and the surface shall be finished smoothly to get along with the surrounding lining surface.

3.4 Grouting into the ground

3.4.1 Overview

- (1) The constructor shall be thoroughly prepared for work environments and equipment operations to achieve the accuracy and continuity of the construction.
- (2) The constructor shall investigate and prepare the work environments prior to starting the construction as follows:
 - ① Location and available area of the work place
 - ② Delivery and shipment conditions of equipment
 - ③ Traffic conditions and control
 - ④ Civil complaints factors
 - ⑤ Structure and characteristics of existing facilities
 - ⑥ Water and power supply source in construction
 - ⑦ Water drainage location and conditions
- (3) The constructor shall diagram and put the following items to make workers to easily understand the overall matters required for construction prior to the start of construction.
 - ① Composition status of the strata (columnar section)
 - ② Ground characteristics for each stratum
 - A. Standard penetration test
 - B. Permeability coefficient
 - C. Unit weight
 - D. Water content

- E. Strength characteristic (c , ϕ)
 - F. Location of underground water
 - G. Development state of the joints
- (4) The constructor shall install pre-instrumentation points and measure the initial values to identify the effects of the construction on the surrounding facilities or grounds rapidly.
 - (5) The indoor grouting model tests shall be conducted during design to prevent grouting solutions from being diluted or lost due to underground stream in the aquifer or hydraulic ground to adjust the selection of grouts, setting time, grouting amount, grouting pressure, grouting solution concentration, and grouting rate according to the flow rate of the underground water.
 - (6) The grouting pressure, grouting solution concentration, and grouting rate shall be reviewed to prevent hydro-fracturing or soil arching due to fracturing grouting, and the main construction of grouting solution injection shall be done after going through the test grouting construction in the site.
 - (7) The grouts that are suitable to the grouting target ground shall be selected to achieve smooth infiltration grouting for suspension (proper specific surface area).
 - (8) The grouting construction method shall be selected according to the characteristics of ground soil and underground water. Generally, a constant pressure grouting method is more effective than a fixed amount grouting method.
 - (9) When a grouting width is thick due to a large permeability coefficient, a gap of the grouting hole shall be reduced, and the grouting rate shall be increased.
 - (10) The verticality and construction depth shall be carefully managed during construction. In particular, much care should be taken to prevent damage to existing facilities.
 - (11) The occurrences of boiling or heaving during or after construction shall be inspected by the construction supervisor.
 - (12) The verification test shall be conducted after construction to check whether the set purpose is met by grouting.
 - (13) For verification, the reinforced regions are divided uniformly to check and verify the reinforced target areas equally by referring to the following methods to determine whether the grouts are well distributed over the ground and shall be inspected by the construction supervisor.
 - ① Verification through bare eyes after excavation
 - ② Verification through geotechnical investigation and tests
 - ③ Verification through non-destructive inspection via geophysical survey
 - ④ Indirect verification through grouting circumstances or records

3.5 Site quality management

- (1) The in-situ inspection and tests are conducted in accordance with the quality management plan.
- (2) The test grouting shall be conducted in the presence of construction supervisor, and following

grouting shall be conducted in accordance with the test grouting results approved by the construction supervisor.

3.6 Cleaning

- (1) The final site cleaning shall be conducted prior to the final completion inspection.
- (2) All waste and waste water shall be properly processed during the grouting work for cleaning during construction, and all grout waste generated during the grouting process shall be removed. The setting of grouts exposed on the surface shall be prevented.

