

KCS 11 30 20 : 2019

# Vertical Drain and Preloading Works

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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 are related to vertical drain work and preloading in the Harbor and Fishing Ports Construction Standard Specifications, Standard Specifications of Sewage Pipes, and Building Construction Standard Specifications based on existing Road Construction Standard Specifications and Standard Specifications for General Civil Works. The history of the standards are as follows:

Construction standards	Main contents	Establishment or revision (Month Year)
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 standards	Main contents	Establishment or revision (Month Year)
Road Construction Standard Specifications	<ul style="list-style-type: none"> <li>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.</li> </ul>	Revision (Mar. 2009)
Road Construction Standard Specifications	<ul style="list-style-type: none"> <li>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.</li> </ul>	Revision (Sep. 2015)
Road Construction Standard Specifications	<ul style="list-style-type: none"> <li>Partial revision, including overview, forest and tree protection materials, and general construction works.</li> </ul>	Revision (May 2016)
Standards Specifications of Harbor Construction	<ul style="list-style-type: none"> <li>Establishment of the Standards Specifications for Harbor Construction</li> </ul>	Establishment (Dec. 1976)
Standards Specifications of Harbor Construction	<ul style="list-style-type: none"> <li>Revision of the Standards Specifications for Harbor Construction</li> </ul>	Revision (Dec. 1977)
Standards Specifications of Harbor Construction	<ul style="list-style-type: none"> <li>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.</li> </ul>	Revision (Dec. 1986)
Standards Specifications of Harbor Construction	<ul style="list-style-type: none"> <li>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.</li> </ul>	Revision (Dec. 1996)
Standard Specifications of Harbor and Fishing Port Construction	<ul style="list-style-type: none"> <li>The standards were completely revised to include preemptive countermeasure against climate changes and to reflect the changing port construction conditions.</li> </ul>	Revision (Nov. 2005)
Standard Specifications of Harbor and Fishing Port Construction	<ul style="list-style-type: none"> <li>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.</li> </ul>	Revision (Dec. 2012)

Construction standards	Main contents	Establishment or revision (Month Year)
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 is applied to vertical drain work that installs drain columns to facilitate the consolidation of soft ground, and the preloading method that induces the settlement of soft ground by applying equal or larger loading than that of planned structure in advance in order to improve the engineering properties of the soft ground.

### 1.2 Documents to be submitted

- (1) The contractor shall create the construction plan documents according to the construction plan and submit them.
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- (1) Since the specification and quality inspections of the materials cannot be checked after construction, they shall be tested prior to construction and only approved products shall be used.
- (2) The inspection of the ground improvement results shall be conducted by dividing the tests into initial inspection, mid-inspection, and final inspection phases.
- (3) The criteria of pass or fail shall follow the criteria proposed in the construction specifications.
- (4) If the construction supervisor deems it necessary, the construction supervisor may dispatch inspectors, at any time, to the required production facilities to test the products or inspect the production process.

### 3. Construction

#### 3.1 Vertical drain method

- (1) The vertical drain method is a construction method that improves ground via consolidation by installing a drain system in the vertical direction underground to discharge water in the soft ground to the surface at a faster rate. It is applied to cohesive soil ground.
- (2) The selection of the method is determined considering the site circumstances, ground conditions, and the required construction period. The drains, such as sand drains, pack drains, and geosynthetic prefabricated vertical drains (PVD) shall be applied according to the installation spacing and depth in accordance with the characteristics of each consi

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the design intruding level, the verified penetration characteristics of the equipment during test construction, and other appropriate geotechnical investigations (drilling investigation, static cone penetration test, and vane shear test etc.).

  - ④ The corrective actions and countermeasures shall be established for the following cases, and reported to the construction supervisor, and executed upon the instruction of the construction supervisor.
    - A. Cases in which unexpected changes in strata occur during construction.
    - B. Cases in which the placement of the drains and the inclination exceed the allowable range.
    - C. Case in which drains are cut or the material input amount is not sufficient.
- (5) Placement
  - ① The reference point is installed around the construction site before the sand drain

construction starts, and based on the reference point, construction positions shall be marked in accordance with the construction pitch.

- ② The construction position shall be selected after surveying. If the position mark is damaged or moved by heavy machinery, it shall be re-installed immediately.
- ③ The sand drain construction shall be conducted in the presence of the construction supervisor. If instruments fail, construction shall be suspended.
- ④ When the sand drain is constructed, the verticality of the casing is checked with a leader, and then the approval of the construction supervisor shall be obtained.
- ⑤ The water-jet, which is prepared to facilitate the penetration of casing, can be used only in the upper sand layer, and its use must be approved by the construction supervisor.
- ⑥ If a modification of the construction location, depth, spacing, and construction method is inevitable based on the additional geological surveys it shall be reported to the construction supervisor and secured.
- ⑦ If a modification of the construction location, depth, spacing, and construction method is inevitable based on the additional geological surveys it shall be reported to the construction supervisor and secured.
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  - A. Yarns and shape of the pack
    - (A) The yarn of the pack is made of 100% polyethylene, and the standard thickness of the thread is 380 denier ( $\pm 7\%$  of allowable tolerance).
    - (B) For pack's burlap bags, yarns are woven to make a balanced plain weave fabric, and two of the fabrics are overlapped and heat-welded or sewed at with 20mm inner spacing from the both edges. The completed diameter shall be more than 120mm.
  - ③ The tensile strength and density criteria of the pack drain are presented in Table 3.1-1.
  - ④ The sands that are used in the pack drain comply with Section 3.1.1(3) of this standard.

## (4) Construction

- ① The spacing, arrangement, and diameter of the pack drain follows the design drawings.
- ② The allowable tolerance of placement location shall be less than 300mm.
- ③ The allowable inclination angle of pack drain shall be less than 2° and instrumentation of inclination angle is conducted inside the casing if necessary.
- ④ The placement of the pack drain shall be done in the backward direction.
- ⑤ Test construction of pack drain is conducted in every 50 m × 50 m area to divide the areas by penetration depth. Then, the casing length is adjusted from the deepest area in the construction.
- ⑥ The construction management record of pack drain complies with the instructions specified in Section 3.1.1(4) of this standard.
- ⑦ The corrective actions and countermeasures shall be established for the following
 

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## 3.1.3 Pr

- (1) Pref: \_\_\_\_\_ tate the consolidation of soft foundation ground.
- (2) The documents to be submitted follow the instruction in Section 3.1.1(2) of this standard.
- (3) Materials
  - ① Geosynthetic drains are products made of synthetic or natural fibers, which shall be shipped out with the test result and reports concerning mechanical properties. A length of a single roll shall be 200m or longer. During the transportation and storage, much care should be taken not to expose to the drains to sunlight, water, or other chemical agents.
  - ② The drain materials used in the PVD shall have good permeability, even in wet conditions and shall not be damaged during the drain formation due to insufficient strength.

- ③ The drains shall have no damage in the core due to ground pressure and superior adaptability to consolidation settlement. They shall also have no cuts or blockages during bending.
- ④ The filters shall have a sufficient permeability coefficient to discharge consolidation waters and prevent the clogging if soil particles enter the drain. They shall also have a high resistance to acids, alkalis, and bacteria.
- ⑤ Geosynthetic core materials shall not use recycled products because the molecules are easily fractured, thereby reducing the tensile strength and having an uneven quality, resulting in a high possibility of consolidation settlement delay.
- ⑥ The test methods and quality test frequency of the geotextile are presented in Table 3.1-2.

Table 3.1-2 Frequency of quality test of geotextile for drainage

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⑥ Generally, the drainage effect of PVD work is calculated as the same as that of a sand drain that has 50mm diameter drain columns set up with the minimum installation spacing.	
⑦ The contractor shall select a driver considering the following matters for the efficient driving of PVD.	
A. Good trafficability shall be ensured over super soft ground.	
B. Driving force shall be good.	
C. The minimum casing sectional area of the static driving mode shall be held as much as possible to minimize smear.	
⑧ Corrective actions and countermeasures shall be established for the following cases, and reported to the construction supervisor, and executed upon the instruction of the construction supervisor.	
A. Case in which unexpected changes in strata occur during construction.	

B. Case in which the placement location of drains and the inclination exceed the allowable range.

### 3.2 Preloading

- (1) The preloading method is applied by filling more than the planned load on the soft ground to lessen the residual settlement after pavement and structure construction, and the preloading method conducts filling in advance, before structure construction, or other loading methods.
- (2) Since the filling method takes a long period of time, it shall be fully reviewed in advance before it is applied. Since the required consolidation period is long in grounds whose consolidation coefficient is small, vertical drains shall be used together. The required load is applied with a number of steps and the stabilization of the final loading.
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  - ⑦ During con nting work, concerning ground apit and cam level, conspec shall be carefully observed, and a record shall be made to submit the results to the construction supervisor.
  - ⑧ The loading work shall achieve stable construction through settlement and stabilization management using instrumentation results.

