Korean Construction Standard

KCS 11 20 10 : 2019

EarthCutting

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국토교통부

Foreword

• To address needs caused by changes in the construction standard code system, the overlaps and conflicts between existing construction standards (design standard, standard specification) were compared and reviewed and then integrated into the newly enacted Construction Standard Code.

• This code was revised and enacted as a standard by integrating the parts of the Road Work Standard Specification and Civil Engineering Standard General Specification related to earth cutting. Major matters related to the enactment and revision of this code are as follows:

Construction Standard	Main Contents	Enactment · Revision (Month, Year)
Road Work Standard Specification	• Enacted by the Ministry of Construction by entrusting it to the Korean Society of Civil Engineering	Enactment (1967.12)
Road Work Standard Specification	• All specifications and guidelines used were reviewed for correlations, and revised and improved to prepare a specification for general road works.	Revision (1985.12)
Road Work Standard Specification	• Compensated and revised to prepare a more detailed specification by introducing new theories to all specifications and guidelines being used.	Revision (1990.5)
Road Work Standard Specification	• Revised to improve road work quality and increase international competitiveness by modifying the systems in response to the opening of the construction market that followed the initiation of the WTO system.	Revision (1996.7)
Road Work Standard Specification	• Reconstructed and compensated according to construction standard maintenance guidelines to reflect the revision of other standards including Korean Industrial Standards (KS) and Concrete Standard Specification, and to establish the system as a national standard.	Revision (2003.11)
Road Work Standard Specification	• Revised to address problems found in road work procedures, to harmonize with other standards, including Korean Industrial Standards (KS), Concrete Standard Specification, and Tunnel Standard Specification, to prevent faulty construction works, and to induce solid construction works through thorough quality control.	Revision (2009.3)
Road Work Standard Specification	• Revised to change the sequence of standard specification, specialized specification, and design drawings, and to reflect the opinions of the Central Committee.	Revision (2015.9)

Road Work Standard Specification	• Partially revised in the area of general matters, tree protection materials, general construction works, etc.	Revision (2016)
Civil Engineering Construction Standard General Specification	• Enacted as a Civil Engineering Construction Standard General Specification	Enactment (1962)
Civil Engineering Construction Standard General Specification	• Revised as a Civil Engineering Construction Standard General Specification	Revision (1967)
Civil Engineering Construction Standard General Specification	• Revised on the basis of the drafts submitted by individual subcommittees of the Korean Society of Civil Engineers in accordance with the continuous progress in construction technologies, including the scaling-up and diversification of construction works and the development of new engineering methods and materials.	Revision (1977)
Civil Engineering Construction Standard General Specification	• Revised to prepare a general specification for the entire scope of civil engineering by reviewing the correlations between all the specifications and guidelines under application.	Revision (1985.12)
Civil Engineering Construction Standard General Specification	• Revised to arrange the individual specifications for each engineering process, to add the specifications on grouting, spraying, and waterproofing as well as those for advanced engineering methods, equipment, and materials, and to harmonize with various other standards and regulations, including various specifications that have already been revised.	Revision (1992.12)
Civil Engineering Construction Standard General Specification	• Revised to be partially modified and compensated by arranging for each subdivided engineering process and to modify the name to the Civil Engineering Construction Standard General Specification.	Revision (1996.3)
Civil Engineering Construction Standard General Specification	• Revised to be partially modified and compensated by arranging for each subdivided engineering process for each handling to respond to the changes in the construction work operation management and the construction work standards.	Revision (2004)
Civil Engineering Construction Standard General Specification	• Revised by adding, compensating and modifying the information in accordance with the updated construction engineering works. Revised particularly by reflecting the details of new technologies, new engineering methods, and new materials and by modifying the units to those of the SI system.	Revision (2005.2)
Civil Engineering Construction Standard General Specification	• Revised by specifying that low-flowability cementation agents and soil-cement are used for back filling to prevent road sinking, ground loss, and sink holes in cases where the surrounding ground is sand or dredged soil.	Partial Revision (2015.8)
KCS 11 20 10 : 2016	• Integrated and maintained as code according to changes in the construction standard code system.	Enactment (2016.6)
KCS 11 20 10 : 2016	• Revised to accord with Korean Standard and Construction Specification.	Revision (2018.7)
KCS 11 20 10 : 2019	• In construction preparation, revised by adding the preliminary dewatering, surveying station post and formation level. And in rock cutting slope, demand to summit the face mapping products, quotation of standard blast method group in design criteria to accord with construction standard code system.	Revision (2019.12)

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1. General

1.1 Scope of Application

1.1.1 General Matters of Scope of Application

(1) This standard is applied to the earth cutting, rock cutting, and rock blasting works that are performed according to the forms, slopes, and dimensions established in the design drawings and the regulations described in the construction specification.

(2) Earth cutting refers to the earth cutting works for roads, parting lots, intersection facilities, ramps, waterways and gutters, the formation of stages for slope surfaces, the removal of inappropriate materials from the subgrades of earth cutting areas or the original ground of banking areas, and the cutting of any materials instructed by the construction supervisor for any future purposes. The soil types for earth cutting are classified as follows:

① Earth and sand: A soil layer where a bulldozer may be effectively used, wherein the soil layer includes a mixture of soil sand, gravel, and cobble stones.
② Ripping rock: A soil layer that has been considerably weathered to the extent that a bulldozer with a hydraulic ripper may be effectively used for earth cutting.
③ Blasting rock: A soil layer where blasting is the most effective method for earth cutting.

1.1.2 Establishment of Layer Boundaries

(1) In cases where the layers need to be classified in order to calculate the construction cost during or after the completion of earth cutting, rock cutting, and rock blasting works, the contractor should submit the relevant data to the construction supervisor and ask for verification. The layer boundaries should be established based on the findings of a joint survey by a rock judgment committee appointed by the head of the ordering body.

(2) If the layer boundaries are difficult to determine with the submitted data or through visual observation, a test ripping by using a hydraulic ripper may be performed, or a review comment filed by specialized engineers may be referred to.

1.1.3 Cautions in Rock Blasting

(1) Rock blasting can be divided into vibration-free excavation, precise vibration-controlled blasting, vibration-controlled blasting, general blasting, and large-scale blasting. The blasting pattern should be determined according to the design drawings, and a test-blasting should be performed to modify and compensate the blasting pattern in order to prepare an appropriate blasting pattern, which should be approved by the construction supervisor before execution.

1.2 Reference Standard

1.2.1 Relevant Laws and Regulations

- Framework Act on the Construction Industry
- Engineering Industry Promotion Act
- Environmental Impact Assessment Act
- Wastes Control Act

1.2.2 Relevant Standards

- KCS 10 10 10 Public Administrative Requirements
- KCS 10 10 15 Quality Control
- KCS 11 20 20 Earth Cutting
- KCS 21 30 00 Temporary Earth Retaining Work
- KCS 11 70 00 Slope Surface Construction
- KCS 11 73 00 Slope Surface Protection
- KS F 2324 Engineering-Based Soil Classification Method
- KS M 4801 Explosives Analysis and Test Method
- KS M 4802 Explosives Performance Test Method
- KS M 4803 Electric Detonator
- KS M 4804 Industrial Explosives
- KS M 4807 Industrial Detonator
- KS M 4808 Fuse
- KS M 4811 Detonating Fuse
- KS M 4812 Water Gel Explosives

1.3 Definitions of Terms

Not applicable.

1.4 Deliverables

1.4.1 Construction Plan

(1) The contractor should prepare a construction work plan according to the construction plan with reference to KCS 10 10 10 and submit it to the construction supervisor.

1.4.2 Additional Deliverables

(1) Earth cutting in road construction

① A soil type survey and test result sheet, if the soil type on the finishing surface of the road in the earth cutting area is inappropriate as a subgrade material

② A vibration and noise damage prevention plan, if damage to nearby structures (houses and buildings) and facilities, residents, livestock, and fish farms is expected or if required by the construction supervisor

③ A slope surface stabilization and countermeasure review sheet, if the inclination of the slope surface needs to be changed

④ A test-blasting plan in case of including the rock blasting method in earth cutting

⑤ A drainage plan during construction

⑥ A cutting slope status map

⑦ A surface corrosion protection (temporary protection) plan during construction

(2) Earth cutting in borrow pit

① Borrow pit utilization application

② Written consent from borrow pit land owner

③ Certificate confirming the fulfillment of the requirements of ordering bodies regarding borrow pits and transport paths

④ Field investigation results for the location and size of the borrow pit

(3) Rock cutting

① A rock cutting method selection plan, according to the rock type and discontinuous surface characteristics during construction

② A vibration and noise damage prevention plan, if damage to nearby structures (houses and buildings) and facilities, residents, livestock, and fish farms is expected or if required by the construction supervisor

③ A slope surface stabilization and countermeasure review sheet, if the slope surface is unstable

④ A detailed construction drawing specifying the blasting method, blasting delay, types of explosives to be used, types of mat and coverings for blasting, and method of removing rocks

⑤ Face map data recording the slope conditions before the greenification of the rock cutting slope.

(4) Rock blasting

① A rock blasting method selection plan and a test-blasting plan depending on the rock blasting pattern in construction works

② Preliminary survey reports on facilities within the range affected by blasting

③ A vibration and noise damage prevention plan, if damage to nearby structures (houses and buildings) and facilities, residents, livestock, and fish farms close to the blasting source is expected or if required by the construction supervisor

④ A slope surface stability review paper

⑤ A blast vibration and noise measurement plan

1.5 Quality Assurance

1.5.1 Quality Assurance in Rock Blasting

(1) The explosives company should be a dedicated company with experience in rock blasting, and should be approved by the construction supervisor.

(2) The seismic exploration company should be a dedicated company with experience in seismic exploration, and should be approved by the construction supervisor.

2. Materials

2.1 Materials

2.1.1 Rock Blasting Materials

(1) The explosives should be of the type recommended by the dedicated explosive company based on the result of the seismic exploration, and required by the relevant authorities.

(2) The blasting delay device should be the one recommended by the dedicated explosive company.

(3) The blasting mat material should be the one recommended by the dedicated

explosive company.

(4) The mechanical degradation agent should be a compound that expands during the curing.

3. Construction

3.1 Verification of Construction Conditions

3.1.1 Earth Cutting Work Conditions

(1) The measurement reference points and the formation level that are used to establish the construction positions should be verified to confirm that they are the same as those specified in the design drawings.

(2) The measurement lines, formation levels, contours and reference surfaces should be verified.

(3) Existing facilities should be verified with regard to the positions and the state, and should be protected to avoid any damage.

(4) The removal and transportation of a facility should be reported to the facility manager.

(5) Trees, grasses, outcrops, and other objects that will remain in the final landscape should be protected.

(6) The bench marks, measurement reference points, existing structures, and other facilities in the area should be protected to avoid the damage that may be caused by the earth cutting equipment or the passage of vehicles.

(7) The safety regulations should be observed, and safety education should be provided to the workers before the cutting works.

3.1.2 Rock Cutting Work Conditions

(1) If a rock is found during the cutting work, the contractor should remove the soil layer as soon as possible to perform a topographic survey. After the removal of the soil layer, the result should be reported to and confirmed by the construction supervisor. Then, a topographic survey should be performed under the supervision of the contractor, and the result should be submitted in writing to the construction

supervisor for inspection. Following the inspection, the contractor and the ordering body should sign on the inspection result, which should be preserved as the basis for calculating the construction supplies. This procedure should be repeated each time a new rock type is found.

(2) For a rocky slope surface, the inclination of the discontinuous surface, joint gap, rock type, lithology, spring water positions, and crack-filling materials should be investigated to judge the safety of the slope surface. The result should be reported to the construction supervisor.

(3) For structures such as underground water tanks, wastewater treatment facilities, utility tunnels, and sewer boxes, rock trenching should be completed before the construction of nearby buildings to avoid any harmful effect on the buildings.

(4) According to the construction plan, the contractor should prepare and submit the following documents:

① The contractor should submit product data about blasting materials, including explosives, detonators, vibration-free blasting agents, and power shock cells, and their accessories; and the product specifications and construction guidelines provided by the manufacturers.

② Construction Work Plan

a. A rock cutting plan should be submitted, and such plan must include information about the rock cutting methods, types of explosives, utilization period, number of times of utilization, amount of explosive charge, drilling depth, drilling interval, blasting methods, types of mat and coverings for blasting, installation of facilities for preventing noise and vibration, predicted noise and vibration, plans for protecting surrounding houses, types of detonators, methods of wiring leading wires and auxiliary wires, blasting instruments, etc.

b. A measurement instrument installation plan (installation positions, instrument types, installation period, and depth), measurement data, and details about the follow-up actions should be submitted.

c. Other details required by the construction supervisor

③ Specimens of the standard size should be prepared for each area and lithology in the presence of the construction supervisor, and entrusted to a specialized quality test institution. The compressive strength test report, obtained through the test, should be immediately submitted to the construction supervisor.

④ A map showing the rock measurement should be submitted to and verified by the construction supervisor. The rock samples from each area as well as the photo images showing the sampling procedures and the front view of the rock should also be submitted.

⑤ Test-blasting plan

a. Review of allowable standard considering the surrounding environment

b. Review of the range affected by blasting, estimated using the design blast vibration calculation equation

c. Review of design blast pattern, etc.

⑥ To prevent civil complaints from the residents about blast vibration, a preliminary survey should be performed to check cracks on the houses and buildings and the groundwater within the range affected by the blasting, and the report of the preliminary survey result should be submitted.

⑦ A plan for water drainage during the construction should be submitted.

(5) Handling of the explosive should be performed in accordance with the requirements specified in the relevant laws and regulations.

(6) Before the entry of the explosives to the construction site or before the start of drilling, the works should be authorized by the relevant authorities, and copies of such authorization should be submitted to the construction supervisor.

(7) Before the blasting, the conditions of the buildings close to the rock cutting positions should be investigated. Photographic images should be taken where there are irregular conditions and saved as evidence.

(8) To determine the maximum explosive charge that can be used without damaging nearby properties and construction works, seismic exploration should be performed before rock cutting works at multiple positions in the rock cutting area.

(9) Before performing seismic exploration, details of the blasting plan and the survey works should be reported to the owners or managers of the nearby buildings or structures.

(10) The schedule of the blasting works should be submitted according to the conditions specified in KCS 10 10 10. A blasting work schedule should be prepared in order to minimize any disturbance to humans and animals, equipment, or residential buildings in the vicinity.

3.1.3RockBlastingWorkConditions

(1) For a rock that is difficult to cut using a hydraulic ripper mounted on a bulldozer, rock cutting by blasting should be performed after obtaining the approval of the construction supervisor.

(2) Rock blasting can be divided into general blasting, vibration-controlled blasting, precise vibration-controlled blasting, rock blast crushing, and large-scale blasting. The blasting pattern should be determined according to the design drawings, and a test-blasting should be performed to modify and compensate the blasting pattern in order to prepare an appropriate blasting pattern that may minimize damage to the rock cutting slope surface; this should be approved by the construction supervisor before blasting is performed.

(3) Explosives and detonators should be stored separately, and the remaining explosives and detonators should be returned.

(4) Minor transportation of explosives in the blasting positions should be performed by a designated worker using the specific container and transportation method.

(5) Rock blasting works in the construction may cause environmental pollution, including noise, vibration, and flying rocks, due to the crushing, as well as civil complaints. As such, a method that may reduce the environmental pollution should be employed, and the method may be adjusted in the application after obtaining the approval of the construction supervisor.

(6) The blasting works should be carefully performed with respect to the drilling depth, interval, direction, and the amount of explosive charge in order to minimize the disturbance, relaxation, and overbreak of the completed slope surfaces.

(7) Unless otherwise approved by the construction supervisor, blasting work should not be performed within 15 m of an existing structure or a structure under construction.

(8) To determine the maximum explosive charge that can be used without damaging nearby buildings or other construction works, seismic exploration may be performed before rock blasting. Before performing seismic exploration, the details of the blasting plan and the survey works should be reported to the owners or managers of the nearby structures.

(9) If the construction supervisor decides that blasting and vibration measurement records are necessary and thus instructs the installation of the relevant

measurement instruments, the contractor should follow the instruction.

3.2 Work Preparation

3.2.1 Rock Blasting Work Preparation

(1) When a briefing session must be held, the contractor should perform public relations with the residents. To investigate the damage caused by the blast vibration through sufficient communication with the residents, a preliminary survey should be performed in the presence of the residents, facility owners, and construction supervisor.

(2) Before the initiation of the blasting works, the building status and cracks should be investigated for all nearby safety targets to understand the effects that the blast vibration may have on them. Images of the crack status of all facilities within the range affected by the blasting should be taken as photos and videos to be used as evidentiary materials for determining the damages in future civil complaint cases.

3.2.2 Slope Drainage

(1) Slope Drainage should be performed according to KCS 11 40 30.

(2) Temporary drain and/or silting basin have to be installed to avoid the harm damage of surrounding facilities and the clogging of the existing drain by the soil loss in heavy rainfall.

(3) Backfill space of the mountain ridge gutter has to be completely stopped up to prevent the collapse of slope due to the permeation of rainwater.

3.2.3 Post of measuring and formation level

(1) Post of measuring point and formation level should be performed according to KCS 11 20 25 (3.2.2).

3.3 Construction Standard

3.3.1 Generals of Construction

(1) Cutting should be performed accurately as specified in the drawings. The cutting slope should be finished according to the dimensions and shapes specified in the drawings and the directions given by the construction supervisor. In addition, when necessary, scaffolds, struts, earth retaining walls, and diversion waterways should be installed.

(2) In the verification drilling areas in the earth cutting areas specified in the design drawings, verification drilling should be performed before the construction works, or if necessary, an in-situ test and a mechanical test should be carried out. If the slope surface stability analysis shows that the earth cutting slope surface inclination presented in the design drawings is difficult to apply, the earth cutting works should be performed after comparing and reviewing the reinforcement construction cost required to secure the slope surface stability, purchasing additional land for the application of a slope surface inclination relaxation method and obtaining the approval of the construction supervisor.

(3) Earth cutting works should be performed after clearing and grubbing and topsoil removal, disassembly of existing structures and obstacles, installation of leading frames, and blocking of external inflow. The earth cutting works and soil transportation should be performed after preparing a work plan that does not disturb other construction processes and obtaining the construction supervisor's approval of the work plan.

(4) The leading frames installed for cutting represent the positions and inclinations of slope surfaces. Therefore, they should be installed accurately and firmly. The interval of the leading frame installation should be in accordance with the design drawings. However, the interval may be adjusted to be 60 m or over, if a linear part or a curved part with a constant curve radius continues over 100 m, after obtaining the approval of the construction supervisor. In addition, a leading frame should be installed at each step, and on the top of the cutting area. A leading frame that is damaged or lost during the construction should be promptly re-installed, with the cost paid by the contractor.

(5) The areas of earth cutting should be appropriately drained to avoid stagnation of the surface water or leakage water. In particular, in the finishing works for roads, drainage facilities such as ditches should be installed according to the design drawings, since the rainwater or groundwater may infiltrate to the subgrade.

(6) In the earth cutting works, the contractor should make the inclination of the slope surface the same as the one specified in the design drawings, and prepare a status map for efficient slope surface management. However, in cases where the slope surfaces are found to be unstable in the earth cutting work process due to the changes of the layer, the development of discontinuous surfaces including joints and faults, and the resurgence of groundwater that were not anticipated in the

design stage, the contractor may prepare a cutting slope surface status map, submit a slope surface stability analysis and countermeasure review report to the construction supervisor, and adjust the slope surface inclination and reinforce the slope surfaces after obtaining the approval of the construction supervisor.

(7) Cutting should be performed sequentially from the top to the bottom.

(8) Loose rocks, tree roots, and separated soil lumps on the slope surfaces or near the slope tops should be completely removed. The slope surfaces should have the same inclination as specified in the design drawings, and flexures should be removed as much as possible.

(9) Mass cutting at once should not be performed at the tip of the slope surfaces. If a slope surface becomes soft during or after the cutting works, a review report should be prepared by an advanced engineer in the relevant field and submitted to the construction supervisor.

3.3.2UtilizationofMaterials

(1) The materials generated from the earth cutting works should be subject to an on-site soil quality test to determine the possibility of recycling. The materials should be recycled as much as possible for the purposes specified in the design drawings, including earth banking.

(2) The materials generated from the earth cutting works that have been determined by the construction supervisor as appropriate for the protection of the subgrade or slope surface or for other purposes should be stored at a designated place or transported to the location of recycling.

(3) Among the rocks generated from the earth cutting works, the solid rocks that may be used as the quarry stones for the crushed stone aggregates should be preserved for recycling by avoiding the mixing of soil and weathered rocks.

3.3.3Overbreak

(1) In cases of overbreak where earth cutting has been performed outside of the designated range specified in the design drawings due to the contractor's carelessness, the overbreak should be back filled and compacted or reinforced with an approved material, with the cost paid by the contractor. Appropriate actions should be taken to the overbreak on a slope surface to secure the stability.

3.3.4 Treatment and Replacement of Poor Materials

(1) If the materials generated from the earth cutting areas are considered as inappropriate for banking, a soil property test should be performed, and the results should be submitted to the construction supervisor, after which the contractor should follow the supervisor's directions. In a pure soil area, even if the soil generated from the earth cutting works is inappropriate for banking, the possibility of recycling should be reviewed before disposal, if the soil is not an organic soil.

(2) If replacement is needed due to the reason described in (1) above, a material that satisfies the quality code of KCS 11 20 20 should be substituted for finishing works.

3.3.5 Gutter Trenching

(1) The materials generated from trenching works for gutters, waterways, and various drainage facilities should be recycled as per Section 3.3.2.

(2) A gutter should be excavated in accordance with the positions and dimensions specified in the drawing designs, and tree roots and extruding rocks should not be on the cross-sections.

(3) The contractor is responsible for ongoing management to maintain the slope surfaces after the gutter trenching until the completion of the gutter construction works.

3.3.6 Earth Cutting Slope Surface

(1) Earth cutting slope surfaces should be effectively investigated and tested with respect to the topographic and geological features, the engineering conditions and properties of the ground, groundwater, and the status of damages requiring compensation. The slope surface inclination should be measured following the technical decisions.

(2) If necessary, drainage plans should be prepared for the earth cutting slope surfaces and the surrounding areas to prevent any excessive increase of the pore water pressure in the slope surfaces.

(3) Earth cutting slope surfaces should be protected to prevent decreased stability over time due to erosion, ground relaxation, and weathering.

(4) If a potentially sliding surface is found on an earth cutting surface, including a discontinuous surface or a structurally vulnerable surface of the ground, the stability

should be reviewed by considering such surface, and an appropriate stabilization measure should be prepared.

(5) Precise investigation is required for high earth cutting slope surfaces and rocky slope surfaces.

(6) During the slope surface earth cutting works, if a spring, groundwater, an eroding soil layer, a heavily weathered rock, a rock being rapidly weathered, a rock with a joint angle disadvantageous to the slope surface, or a structurally vulnerable layer is found, it should be immediately reported to the construction supervisor, whose directions should be followed.

(7) Steps should be installed at every 5 to 10 m of height on a high earth cutting slope. The positions and width of the steps should be determined by considering the construction conditions and the intended purposes.

3.3.7 Subgrade in Cutting Area (Road Work)

(1) Bumps generated by the excavation in a rock cutting area should be smaller than 150 mm. Drainage treatment should be performed at concave parts (凹) to avoid water stagnation. Concave parts should be back filled and compacted with a material approved by the construction supervisor.

(2) Since the subgrade in an earth cutting area may easily become soft due to the concentration of infiltrating water, drainage treatment should be performed thoroughly. If the drainage facilities specified in the design drawings need to be compensated, it should be reported to the construction supervisor, and the contractor should follow the directions of the construction supervisor.

(3) If the materials found on the finishing surface of an earth cutting area are inappropriate to use as the material for the subgrade, the materials at the depth of 200 mm from the top should be scraped up, and their water content should be adjusted to the optimal water content. Next, the materials should be compacted according to the subgrade standard. If the materials are inappropriate to use as the material for the subgrade, the fact should be reported to the construction supervisor, and the contractor should follow the directions of the construction supervisor.

3.3.8Finishing

(1) The finishing surfaces and slope surfaces in earth cutting works should be arranged so that the shapes and inclinations are the same as the ones specified in the design drawings. Materials below the baseline should be handled carefully to avoid relaxation.

(2) Relaxed and unstable stones with cracks caused by blasting should be removed manually or with appropriate equipment.

(3) The boundaries between the slope surfaces of the earth cutting areas and the natural slope surfaces should be curved. The inclination of a slope surface at the position where the earth cutting area intersects the banking area should be adjusted to allow mutual overlapping or slow attaching to the natural ground in order to avoid the formation of a distinctive bending part.

(4) A proof rolling test should be performed on the subgrade of an earth cutting area using the same method as that for the subgrade in a banking area. The test codes are found in KCS 11 20 20 (3.2.28).

(5) When performing earth cutting works in an area with many cores stones, the inclination should be adjusted by considering the safety of the slope surface after obtaining the approval of the construction supervisor.

3.3.9TreatmentofSurfaceWaterandSpringWaterandProtectionofRoadSurface

(1) In cases where a slope surface may be scoured or collapse during construction due to the surface water or spring water, drainage facilities should be installed while the earth cutting works are performed, or a temporary facility may be installed.

(2) The road surface should be maintained to ensure smooth drainage during the construction period. A gutter or a link canal should be installed at the boundary between an earth cutting area and a banking area to prevent scouring.

(3) If the finishing surface of the earth cutting work consists of earth and sand, the vehicle traffic should be restricted or detoured in the rainy season and winter to minimize the deterioration of the finishing surface.

(4) In an area where weathering may occur rapidly due to the exposure of the earth cutting slope surface, protection of the slope surface should be performed early,

including the greening specified in the design drawings.

3.3.10 Protection of Earth Cutting Slope Surface

(1) Protection of earth cutting slope surfaces should be performed according to KCS 11 70 00 and KCS 11 73 00.

3.3.11 Slope Surface Inclination

(1) If the slope surface becomes unstable during the construction works due to a factor that was not anticipated in the design stage, the contractor may change the inclination of the slope surface according to 3.3.1(6) after obtaining approval from the construction supervisor.

3.3.12 Borrow Pit Earth Cutting

(1) If the amount of recyclable materials generated from the earth cutting works in the construction site is not sufficient or if the properties of the materials are inappropriate for the requirements of the construction works, the contractor should find a borrow pit to obtain sufficient and appropriate materials for the construction works.

(2) Before using a borrow pit, the contractor should submit a borrow pit utilization application to the construction supervisor and obtain approval in writing from the construction supervisor. The borrow pit utilization application should specify the location of the borrow pit, the thickness of the surface soil to be removed, the types of materials to be used, the soil survey and test results, and the average transportation distance to the banking site.

(3) The contractor should not perform earth cutting works out of the designated range, even in an approved borrow pit. The earth cutting works should be carried out after performing longitudinal and transverse surveying of the ground, submitting the survey results to the construction supervisor and obtaining the approval of the construction supervisor.

(4) Drainage facilities should be installed for smooth drainage of the borrow pit, and earth cutting should be performed to ensure the inclination is harmonized with the surrounding topographic features. After the completion of the earth cutting works,

the contractor should trim and arrange the bottom and the slope surface to allow accurate measurement of the amount.

(5) After completing the utilization of a borrow pit or a quarry, the contractor should neatly arrange not only the borrow pit or quarry but also the surrounding facilities occupied during the construction. In addition, the contractor should fulfill the restoration and landscaping duties directed by the authority permitting the development of the borrow pit or quarry as well as the duties of stabilizing the slope surface formed by the borrow pit earth cutting and repairing and arranging the roads used as transport paths in order to eliminate any causes of ex post conflict. After the completion of the finishing works, a certificate showing the fulfillment of these duties should be issued by the permitting authority, and a copy of the certificate should be submitted to the construction supervisor.

(6) Even if the materials generated from the earth cutting works in the construction site are appropriate for banking, the design may need to be changed because the transportation from a borrow pit is considered to be more beneficial to banking works in terms of the economic feasibility or constructability. In such a case, the design may be changed after obtaining the approval of the construction supervisor.

3.3.13RockCutting

(1) Rock cutting works may cause environmental pollution, including noise, vibration, and flying rocks, due to the crushing process, as well as civil complaints. Therefore, a method that may reduce the environmental pollution should be employed, and this method may be adjusted in the application after obtaining the approval of the construction supervisor.

(2) In blasting, warning signs should be installed at the access roads outside of the flying distance of the rocks for the safety of people and construction site workers.

3.3.14BreakerMethod

(1) A breaker-based crushing method is applied to the removal of existing structures and the cutting of small blast rocks in areas where safety is a concern due to blast vibration and flying stones, or where other methods are difficult to apply. The range of the works and the dimensions and specifications of the equipment should be determined based on the design drawings or after obtaining the approval of the

construction supervisor.

(2) The noise and vibration generated by the breaker-based crushing works should be controlled to satisfy the regulatory standards specified in the relevant laws and regulations in Korea.

(3) In the cutting or repairing works for existing slope surfaces, rock pieces may fly due to the breaker crushing or crushed rocks may roll down and cause danger to the facilities located below the slope surface or the passage of vehicles. Therefore, safety protection facilities should be installed before the crushing works.

(4) For rock or concrete crushing works in an urban area or a place near an important structure or facility, a vibration-free or micro-vibration method may be applied according to the design drawings. A hydraulic crushing method or an expansive crushing agent method should be selected by considering the site conditions and construction conditions, and carried out after obtaining the approval of the construction supervisor.

3.3.15Micro-VibrationRockBlastingMethod

(1) A micro-vibration rock blasting method should be performed in accordance with the design drawings with respect to the drilling arrangement, direction, and depth. A test-cracking should be performed, and the result should be verified by the construction supervisor before the construction works are carried out.

3.3.16BlastingPlan

(1) A test-blasting should be performed before the blasting works to prepare the blasting pattern and blasting plan with regard to the drilling field, drilling arrangement, types of explosives, and allowable charge per delay in order to precisely manage the construction works.

(2) In the blasting works, the blasting pattern, including the drilling interval, drilling field, and explosive charge, should adjusted and reviewed according to the site rock properties, such as the geological features and the rock hardness, as well as the characteristics of the safety targets. The classification of the standard blasting methods is according to KDS 44 30 00 (4.4.1).

(3) In preparing the blasting plan, the effects on the surrounding environment should

be considered. If necessary, countermeasures against vibration and noise should be prepared.

(4) If the materials on the surface have been relaxed by blasting, the materials should be replaced with an approved material, and compacting should be performed according to the standard. Unevenness beyond the allowable range should be adjusted after consultation with the construction supervisor.

(5) Blasting should be performed that does not exceed the vibration velocity design application standard for each safety target shown in KDS 44 30 00 (4.4.1). However, a separate vibration standard should be applied to facilities where the design application standard may not be appropriately applied, including livestock farms, nursing homes, and religious facilities that are sensitive to blasting noise.

3.3.17DrillingandCharging

(1) Before drilling works, actions should be taken, including the inspection of ground surface, removal of separated stones, and checkup and returning of residual explosives to prevent explosion accidents resulting from the explosives remaining in holes.

(2) Drilling and charging should be performed accurately and safely according to the blasting pattern approved by the construction supervisor.

(3) Drilling should be performed carefully after checking for the presence of undetonated residual explosives. Drilling should not be performed at blasting holes used in the previous blasting session, and explosives should not be recharged to these holes. The workers should be cautious if abnormal water spring, gas discharge, and geological changes are observed.

(4) Drilling works should be performed accurately with regard to the positions, directions, and depths according to the predetermined hole arrangement. Drilling should not be performed again at holes where the presence of charged explosives has not been confirmed after the blast.

3.3.18Blasting

(1) Blasting works should be carried out by the person responsible for blasting. The person responsible for blasting should perform the blasting works after confirming the evacuation and safety of the workers, and taking protective measures.

(2) The blasting positions may be accessed after the time required to secure safety has passed following the blast.

(3) The presence of undetonated residual explosives must be checked, and necessary actions should be taken if any are detected.

(4) Measurement instruments should be installed to measure and record the PPV at blasting.

(5) If the blasting positions are located in a dense residential area or close to existing structures, public facilities, and roads, blasting work should only be performed after taking protective measures against flying objects and performing a preliminary survey of existing structures.

(6) In cases where nearby facilities or residents may be affected by the vibration or noise from the blasting works and civil complaints are expected, appropriate methods of reducing the vibration and noise should be reviewed through a test-blasting, and the design should be changed with the approval of the construction supervisor.

(7) The maximum current of the blasting machine should be appropriate for the number of blasting detonators, and preliminary examination should be performed with the machine.

(8) For the blasting works in areas of springwater, the explosives should be waterproofed, and the blasting works should be performed carefully to avoid failure of the blasting due to electric leakage.

(9) Where there is a risk of rainfall and lightning, electric detonator works should be suspended, and explosives already charged should be detonated immediately. Remaining explosives should be reported to the jurisdictional police agency and safely returned to an explosives handling office according to the directions.

(10) The contractor should take protective measures before the performance of blasting works with regard to the determination of blasting, methods of warning, securing and surveillance, protective facilities in evacuation sites, and protection from flying stones.

3.3.19 Blast Effect Regulation and Measurement Management

(1) Blasting works should be performed carefully so as not to damage nearby

structures. The allowable blasting vibration and noise for individual safety targets should be determined according to the design application standard, and the regulatory values should not be exceeded during the blasting works.

(2) Blast noise and vibration measurement management

① In case that measurement management should be required so as not to cause any damage to the obstacles around the blasting positions, it must be performed strictly to manage the blasting works with the greatest care because even at the same allowable charge per delay, the vibration may be greatly increased or decreased depending on the number of free surfaces, the accuracy of drilling and charging, and the blasting pattern under different working conditions.

② The vibration and noise should be measured at each blasting. If possible, the blast noise should be measured as sound pressure level (dB(L)) and noise level (dB(A)).

③ In the areas where civil complaints are expected due to the noise from blasting works, the noise level should be lowered by installing noise-reducing facilities.

④ Unlike blast vibration, blast noise is sensitive to changes in the topographic features, wind direction, and temperature. Therefore, these factors should be considered in advance for the measurement. The acquired measurement data should be stored by recording and arranging the data according to the blasting time and data of each blasting.

⑤ If the vibration velocity and noise must be measured during the blasting works, the measurement should be carried out from a safety target.

3.3.20 Test-Blasting Implementation Method

(1) The purpose of test-blasting is to plan a safety pattern by analyzing the crushing effects and the degree of pollution (ground vibration, noise, flying objects, etc.). The explosive charge and drilling size are varied at the on-site rocks in the rock cutting area, because the level of ground vibration is dependent on the geological features, strength of rocks, blasting method, types of explosives, and detonation methods.

(2) Considering the importance to blasting works and the risk factors, test-blasting should be entrusted to an agency regulated by the Engineering Industry Promotion Act or a professional engineer office for explosives management according to the Professional Engineers Act.

(3) Various blasting patterns are applied to the test-blasting by varying the drilling and

charging. However, if a single blasting pattern is applied, the measurement distance may be varied to secure various scaled distances.

(4) In a test-blasting, the number of times blasting is performed and the number of measurement instruments employed should be considered in advance to acquire measurement data from at least 30 measurement positions.

(5) The statistical analysis of the measurement data should be performed through a regression analysis method. The input data should be based on the peak particle velocity (PPV) of the individual elements.

(6) If the vibration measured at a test-blasting exceeds the allowable vibration value, a separate vibration-reducing measure should be prepared to reduce the blast vibration, and submitted to and approved by the construction supervisor for implementation.

(7) If the correlation coefficient of the measurement result estimation equation is less than 0.7, the test-blasting should be performed again.

(8) Vibration-reducing measures to reduce the vibration to below the allowable value include the modification of the blasting methods, such as the drilling field, drilling interval, charge per hole, and charge per delay, as well as the blockage of the vibration propagation paths.

(9) In the analysis of the test-blasting results, not only the vibration and noise measurements but also the accumulation state and size of crushed rocks, status of flying stones, excavation rate, and generation amount of big sized spring stones should be carefully observed, recorded, and reported to the construction supervisor. If necessary, the countermeasures for compensating and improving the blasting works should be included in the test-blasting report, which should be prepared and submitted.

(10) The test-blasting report should specify the blast vibration estimation equation for the construction site, the blast application pattern for individual distances to safety targets, and the relevant technological specifications.

3.3.21 Micro-Vibration Excavation Method

(1) Micro-vibration excavation methods include the methods that may reduce the vibration to below the vibration level of Type II methods around safety targets.

(2) The representative micro-vibration excavation methods are blasting methods using

explosives less than the minimum unit, a micro-vibration crusher, a micro-vibration crushing agent, and a mixed explosive, and excavation methods using a large breaker, a hydraulic rock splitting method, and a non-explosive crushing agent.

(3) For a micro-vibration excavation method, test-blasting should be performed considering the drilling field, burden line of least resistance, hole interval, and amount of charging according to the design drawings to choose the most reasonable and safest method after acquiring the approval from the ordering body.

(4) Since the vibration mechanism of micro-vibration excavation methods is different from that of the general blasting methods, a test-blasting should be performed to predict and evaluate the vibration level, and measurement management should be carried out. Due to the short drilling field, explosion noise or empty blasting is also a concern, and thus protection works, including the installation of a blasting cover, are necessary.

3.3.22 Precise Vibration-Controlled Blast Methods

(1) Precise vibration-controlled blasting is a method in which a small amount of explosives, equal to or more than the minimum package unit and less than 0.5 kg, is used for blasting to generate cracks on rocks, and then secondary crushing is carried out by using a large breaker. This method is effective in cases where the rock excavating area is close to a residential area or a safety target.

(2) A large breaker is employed for precise vibration-controlled blasting, wherein the ratio of the explosive-based primary crushing and cracking to the secondary crushing with a breaker is 70:30.

(3) Noise may be caused by the charging of explosives in the precise vibration-controlled blasting. Unexpected vibration may be caused due to incomplete blasting. Therefore, measurement and blast protection works are necessary.

3.3.23 Vibration-Controlled Blast Methods

(1) Vibration-controlled blasting is a method that is applied in cases where a safety target exists within the range affected by blasting. The blasting design is prepared according to the result from a test-blasting to satisfy the regulatory standard. Explosives equal to or more than 0.5 kg and less than 1.6 kg are used for

small-scale vibration-controlled blasting, while explosives equal to or more than 1.6 kg and less than 5 kg are used for large-scale vibration-controlled blasting.

(2) The standard hole diameter of 51 mm to 76 mm is applied to the drilling performed by using an air-compressing or hydraulic crawler drill.

(3) Since vibration-controlled blasting is a method that induces crushing and cracking by using explosives, measurement and blast protection works are necessary. However, secondary crushing with a large breaker is not necessary.

3.3.24 General Blast Methods

(1) General blast methods are applied according to the noise and vibration standard and distance standard for safety targets.

(2) General blast methods are applied to an area sufficiently separate from a safety target so that the maximum charge per hole may satisfy the blast regulatory standard. In a general blast, the effects of explosives on blast crushing are shown to the full.

(3) The design is based on emulsion-based explosives. The charge is in the range equal to or more than 5 kg and less than 15 kg, and the standard pattern charge considering the on-site workability is 7.5 kg.

(4) Measurement is optional, but is beneficial when possible. Blast protection works are difficult to perform due to the high bench height, but covering may be performed when there is the risk of empty blasting.

3.3.25 Large-Scale Blasting

(1) Large-scale blasting methods are applied to a remote mountainous area or a borrow pit where no safety target exists within the range affected by blasting, considering only the blasting efficiency. The main explosive is ammonium nitrate fuel oil mixture (ANFO), and the standard primary explosive is an emulsion-based explosive. In areas of springwater, emulsion-based explosives can be used as the large-scale blasting.

(2) Since ANFO is a low specific weight explosive, the hole diameter should be over ϕ76 mm.

(3) Because of the relatively long stemming column length in large-scale blasting, the possibility of generating boulders with the crushing should be considered.

Measurement is generally unnecessary, and blast protection works are inapplicable due to the high bench height.

3.4 Allowable Construction Error

(1) The allowable construction errors in earth cutting works are shown below. However, the allowable error standards may be adjusted on the basis of the surface geological survey results after obtaining the approval of the construction supervisor during rock cutting works in an area without severe cracks, including joints, provided that the slope surface safety is not affected even in the absence of the cutting works for extruding parts.

① Subgrade: ± 30 mm if soil

② Subgrade: if rock, + 30 mm, - 150 mm

③ Soil slope surface: ± 100 mm

④ Ripping rock slope surface: ± 200 mm

⑤ Blast rock slope surface: ± 300 mm

3.5 On-Site Quality Control

3.5.1 Quality Control

(1) Quality control should be performed according to the requirements specified in KCS 10 10 15.

3.5.2 Test and Reporting

(1) Cut ground surface, foundation supporting face, and rock cutting cavities should be examined visually.

(2) If a new soil type is found during the cutting works, it should be immediately reported to the construction supervisor, and the cutting works may be resumed after receiving the approval from the construction supervisor.

(3) Slope surface cutting should be performed carefully so as not to affect the stability of the slope surface. The changes of the geological features and springwater status during the construction works should be observed, recorded, and then reported to the construction supervisor.

(4) Any unexpected ground conditions found during the cutting works should be reported to the construction supervisor, and the work should be discontinued until the direction for resuming the works is given.

(5) The contractor should perform a test on the quality and dimensions of the cutting works. If there is no problem, the next work may be performed after receiving the approval from the construction supervisor.

(6) In cases where the construction supervisor entrusts a test to a company or performs a test independently to confirm the quality of the construction works, the contractor should follow the directions. If the result shows that the construction works have failed to pass the test, the construction works should be carried out again or supplemented to obtain approval in a re-test.