

KCS 11 73 15 : 2019

Slope Surface Greening

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KC CODE



Foreword

- To address needs that were caused by changes in the construction standards code system, the overlaps and conflicts between existing construction standards (design standards, standard specification) were compared and reviewed and then integrated into a new document that can be maintained as a standard code.
- These standards were revised and enacted as standards by integrating the Construction Work Slope Surface Standard Specification and the corresponding parts of the Road Work Standard Specification, the Construction Environment Management Standard Specification, and the Waterwork Standard Specification. Major matters related to the enactment and revision of these standards are as follows:

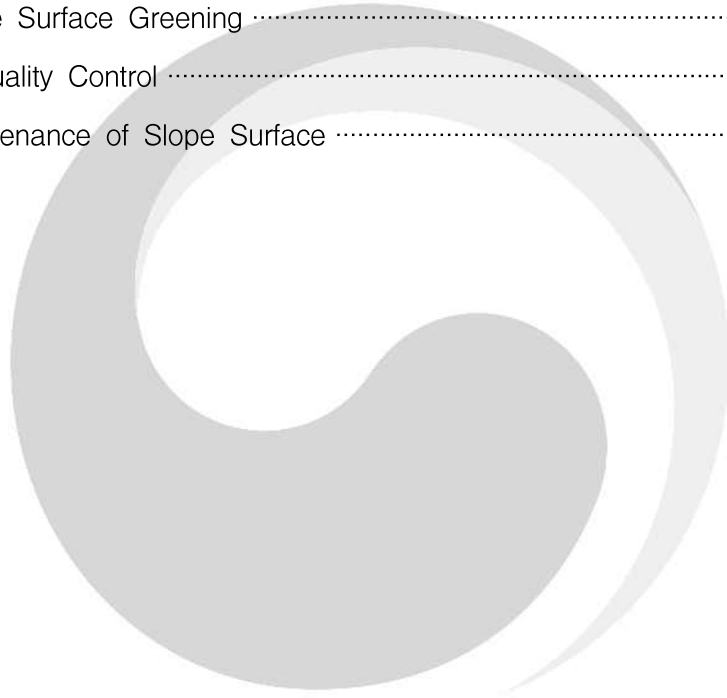
Construction Standard	Major Contents	Enactment · Revision (Month, Year)
Construction Work Slope Surface Standard Specification	• Construction Work Slope Surface Design Standards enacted.	Enactment (May 2006)
Construction Work Slope Surface Standard Specification	• Construction Work Slope Surface Design Standards revised.	Revision (Dec 2011)
KCS 11 73 15 : 2016	• Integrated and maintained as a code according to changes in the construction standard code system.	Enactment (June 2016)
KCS 11 73 15 : 2016	• Revised to harmonize Korean Standards with Construction Standards.	Revision (July 2018)



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1. General Matters

1.1 Scope of Application

- (1) This standard applies to general slope surface greening works to stabilize the ground surface, to form a plant colony, and to preserve the landscape using artificial materials or plant materials on both artificial slope surfaces formed by cut-off or stacking, or natural slope surfaces formed by erosion.
- (2) Slope surface greening works are basically performed on slope surfaces having a stable inclination.
- (3) For the calculation of construction costs during or after slope surface construction works, construction work details that are different from the design specifications shall be submitted by the contractor with the relevant data to the construction supervisor for verification. Slope surface greening construction may be applied after the stratum boundary is determined by the joint investigation by the Rock Judgement Committee appointed by the Head of the Ordering Authority.
- (4) If test construction work is performed, the soil and earth conditions, regional conditions, weather conditions, slope surface inclination and height, material quality, and seeds specified in the design drawing & specification shall be determined in accordance with the slope surface greening standards. The construction shall be performed by entrusting to an executive senior engineer in the field of ground and an expert in slope surface greening, and approval from the construction supervisor shall be obtained after the construction work.

1.2 Transportation, Storage, Handling

1.2.1 Storage of Materials

- (1) Seeds and fertilizers shall be stored in a cool and dry place. Slope surface auxiliary materials, metallic protection goods, and other vegetation materials shall be stored separately in a place that is well ventilated and that allows protection from rainfall and snowfall.

2. Materials

2.1 Materials

2.1.1 Selection of Implementing Vegetation

- (1) The vegetation to be implemented shall be selected by considering the plant growth

characteristics, target greening recovery rate, and locational conditions, including the soil quality and inclination of the slope surface. The implementing vegetation shall be a vegetation that grows well in barren areas, germinates rapidly, and develops roots well, and whose seeds may be easily purchased in a large amount.

- (2) The selected vegetation for each construction method shall satisfy the target greening recovery rate. Foreign seeds and native seeds shall be mixed in an appropriate ratio, but they shall not compete with each other or suppress each other.
- (3) When a plant colony is to be formed by seeding, the ratio between foreign seeds and native woody plants and herbaceous plants shall be determined by considering the greening areas and the target greening recovery rate, but may be adjusted in accordance with the seed mixing plan submitted by the contractor.

2.1.2 Planted Vegetation

- (1) The names of plants shall be the trivial names in Korean, but the scientific names may be written together when necessary.
- (2) Among those that are in conformity with the specifications, priority is given to plants that grow well, have dense foliage, maintain the unique shape of the kind, and have the ability to purify air pollutants.
- (3) The selected plants shall not have damage caused by blight or harmful insects and shall maintain sound growth conditions. However, plants that have minor damage caused by blight or harmful insects and which damage has less concern to be propagated, the plants can be selected if appropriate remedial measures are subjected to be taken.
- (4) The selected plants shall be grown products with developed rootlets that are prepared by advanced transplantation or root wrenching or root pruning for easy rooting. Plant products cultivated in containers, such as those cultured in pots or containers, may consist up to 10% of the entire vegetation selection.
- (5) When natural dug-up plants are used, the trees shall have sufficient earth balls and their tree shape and foliage shall be equal to or better than the standards. Only those that have earth balls larger than the specified size may be adopted after obtaining approval from the construction supervisor.
- (6) Inspection shall be conducted separately as a preliminary inspection at the cultivation area and a post-entry inspection at a designated place. Even the plants that have been accepted through the preliminary inspection may not be accepted through the post-entry inspection at a designated place if the plants have been improperly handled during digging and transporting or if a long time has passed since the digging. If necessary, the preliminary inspection at the cultivation area may be omitted. The

inspection at the time of digging a wild tree may replace the preliminary inspection.

2.1.3 Ground-Covers and Herbaceous Flowers Planting

- (1) Ground-covers and herbaceous flowers are divided as annual plants, biennial plants, perennial plants, and bulbous plants.
- (2) The specifications of the seeds are specified in terms of the amount in weight, purity percentage, and germination rate. The specifications of the herbaceous flowers are specified in terms of tillers and stumps.
- (3) The seeds shall be fresh and free of any a damage caused by blight or harmful insects. The seeds of weeds shall not be mixed, and the germination rate shall be appropriate.
- (4) The ground-covers and herbaceous flowers shall comply with the specifications and have well developed stems, foliage, and flower buds. They shall be free of any damage caused by blight or harmful insects, and have decent roots with a sufficient amount of earth attached to the roots.
- (5) The selected products of ground-covers, herbaceous flowers, wild herbaceous flowers, and marsh herbaceous flowers shall be those cultivated in pots. The allowed wild products shall have a quality equal to or better than the cultivated products.
- (6) The tiller specifications shall satisfy the specified requirements. The plants shall show uniform growth conditions and have been grown for a certain period of time after tillering.

2.1.4 Lawn Grass and Lawn Grass Seed

(1) Lawn Grass

- ① Lawn grass is divided into common lawn grass and roll-type lawn grass. The common lawn grass shall be either natural or cultivated lawn grass products of which dimensions are 0.3 m wide, 0.3 m long, and 30 mm thick. If the supplied lawn grass products are small in size, the construction work shall be performed in consultation with the construction supervisor. Roll-type lawn grass products shall be those obtained by cultivating tropical lawn grass or temperate lawn grass, detaching them by using a sod cutter, and rolling them. The area of the lawn grass product shall be over 1 m².
- ② The lawn grass shall be either natural or cultivated lawn grass products that satisfy the following requirements:
 - a. Be free of any weeds, and have densely developed underground stems.
 - b. Have no irregular leaves or broken leaf tips.
 - c. Be free of any weeds and without any damage caused by blight or harmful

insects.

d. Have been dug to have uniform thickness and size.

e. Without corruption due to long-term storing.

- ③ Lawn grass products shall be planted within one day after being transported to the construction site.

(2) Lawn Grass Seed

- ① The native lawn grass seeds shall be Korean native Zoysia seeds and Poa seeds. The variety shall be selected in consultation with the construction supervisor. The lawn grass seed products shall be those that have been obtained within the previous two years via promoted germination treatment. The germination rate shall be over 6%, and the purity percentage shall be over 98%.

- ② The lawn grass seed variety to be planted shall be determined according to the site conditions in consultation with the construction supervisor. The germination rate shall be over 80%, and the purity percentage shall be over 98%. In the cases where seed products of mixed varieties are used, a certificate of origin and a certificate of quality shall be attached with the submitted material supply plan. The mixing ratio shall be approved by the construction supervisor.

- ③ Surface stem or underground stem

The surface stem or underground stem shall be prepared by removing the earth from the lawn grass and cutting in a length of 50 to 100mm. They shall not be dry or corrupt.

2.1.5 Native Variety of Herbaceous Plant Seed

- (1) The germination rate shall be over 30%, and the purity percentage shall be over 60%.

2.1.6 Woody Plant Seed

- (1) The germination rate shall be over 20%, and the purity percentage shall be over 50%.

2.1.7 Fertilizer

- (1) A compound fertilizer having the quality equal to or higher than that of the official fertilizer standard product of the Ministry of Agriculture, Food and Rural Affairs shall be used, and the type of the fertilizer shall be determined by the instruction of the construction supervisor and in accordance with the construction specifications.
- (2) The landscape organic fertilizer shall be a byproduct fertilizer consisting completely decomposed organic byproducts such as compost, leaf mold, decomposed chaff or sawdust. The fertilizer may be prepared by mixing an admixture to prevent odor or to change the physical properties. The organic material content shall be over 25%, and

the ratio of organic materials to the nitrogen compounds shall be below 50.

2.1.8 Growth Base Material

- (1) The organic material content shall be over 5% in dry weight ratio, the earth hardness shall be below 24 mm, and the porosity shall be over 60%.

2.1.9 Vegetation Base Material

- (1) The vegetation base material shall be an organic soil mixture consisting seeds, organic or inorganic soil conditioner, soil or soil with high organic content. The vegetation base material shall be harmless to animals and plants and shall not contaminate the soil. The mixing ratios of the components shall be determined according to the manufacturer's instructions.

2.1.10 Pesticides

- (1) The applied pesticides shall be one of the product items that are produced by the manufacturers registered in accordance with Article 3, Paragraph 1 of the Pesticide Control Act and that satisfy the symptoms of the damage by blight and harmful insects. The applied pesticides may be changed in consultation with the relevant government departments.

2.1.11 Insecticides

- (1) The basic insecticide shall be wettable trichlorfon powder, which is a wide-range insecticide.

2.1.12 Trees for Screen Planting Work

- (1) Trees for screen planting work shall be arboreal trees with the screening characteristic.

2.1.13 Vegetation Hole Construction

- (1) When small planting pots are used or when trees are used for vegetation hole construction, plants that have been cultivated for more than two years shall be used.

2.1.14 Mulching Material

- (1) Mulching materials shall have quality equal to or higher than that specified in the design drawing & specification and by the instruction given by the construction supervisor.

2.1.15 Vegetation Box

- (1) Artificial wood, logs, reinforced concrete, or synthetic resin shall be used, and the

materials shall be equal to or better than KS products. Vegetation boxes shall be manufactured to be solid, considering adequate drainage for stable vegetation maintenance.

2.1.16 Other Materials

(1) Other materials shall be harmless to animals and plants and shall not contaminate the environment. The materials shall be used according to the product specifications provided by the manufacturers.

2.1.17 Erosion Control Net

(1) Erosion control nets shall have moisturizing and heat-insulating effects and a high tensional strength. The erosion control net shall be harmless to seed germination and have no damage due to blight or harmful insects.

2.1.18 Grid Frame and Block Products

(1) The joints shall allow integration as one body, and the earth layer depth shall be more than the survival conditions of different plants.

2.1.19 Rockfall Prevention Net

(1) Rockfall prevention nets shall have corrosion resistance, allow easy assembly, and have a sufficiently high strength to tolerate rockfall from a slope surface.

2.1.20 Nesting Material

(1) Natural stones and other stones shall be used as much as possible.

2.1.21 Water

(1) Clean stream water or water supply shall be used. Polluted water or water containing substances harmful to plant growth shall not be used.

2.1.22 Quality of Other Materials

(1) The quality of other materials shall satisfy the design drawing & specification and construction specifications. Changes or adjustment of the specifications shall be approved by the construction supervisor.

3. Construction

3.1 Verification of Construction Conditions

3.1.1 Items for Review Before Construction

- (1) From the early stage of the earth construction planning, slope land scape and greening plans shall be established on the condition of slope surface stabilization in order to prepare a sustainable greening plan allowing easy maintenance.
- (2) Establishment of target greening recovery rate
 - ① The goal shall be to promote the stabilization and protection of a slope surface by preventing surface erosion and scouring.
 - ② The goal shall be to form a plant colony that is effective for ecosystem recovery and harmonized with surrounding native vegetation by allowing easy ecological succession while being in harmony with nature.
 - ③ Considering the surrounding land use, forest structure, slope surface soil quality, inclination, and direction, the goal shall be to form a high forest, low forest, or herbaceous colony. Native plants appropriate for the area shall be positively used.
- (3) Stabilization of growth base on slope surface
 - ① If the earth quality, soil type, and inclination of the slope surface are not appropriate for the growth of the targeted plant colony, another surface protection method shall be considered or the works for improving the plant growth environment or stabilizing the growth base shall be performed in advance.
 - ② In areas where slope surface scouring or collapse is of concern due to surface water or spring water, drainage facilities shall including slope shaller drain, banquette drain, longitudinal drain, slope tip drain, culvert, and perforated drainpipe shall be planned,.

3.2 Construction Standard

3.2.1 Construction

- (1) General matters of construction
 - ① The selected greening method shall be the one that is most appropriate for the growth of the selected greening plants to form a plant colony while considering stability and the economic feasibility. In principle, the same construction method shall be applied to the same slope surfaces.
 - ② Soil that is surface is highly fissured and flows due to weathering and erosion, or deposited at the berm, or the stones that are slightly stuck or caught shall be removed.
 - ③ The slope surface needed for foundation construction shall be well arranged so that the basic protection materials may be easily attached.

- ④ The top and bottom parts of the slope surface shall be finished in a natural shape without an acute angle to harmonize with the surrounding natural landscape and to prevent freezing and erosion. However, in the presence of good vegetation, the leveling may not be performed after reviewing the conditions.
- ⑤ If the constructed surface causes losses due to rainwater, such as erosion and collapse, the surface shall be protected by a plastic covering.

3.2.2 Suitable and Unsuitable Construction Period

- (1) Any type of vegetation construction may be performed during the optimal period when the daily average temperature is between 10°C and 25°C.
- (2) Since the vegetation may be damaged by heat when the daily average temperature is over 25°C, construction shall be avoided in summer. However, when construction needs to be performed unavoidably despite the air conditions, the plants that are not vulnerable to heat may be used. Strip sodding, vegetation strip sodding, and vegetation mat construction may be performed for an embankment slope surface, and vegetation belt construction, partial soil transport construction, and vegetation mat construction may be performed for a cut-off slope surface.
- (3) Due to the risk of dehydration and collapsing by freezing under 10 °C, construction work shall be avoided in winter. However, when the construction shall be performed unavoidably, vegetation mat construction may be performed to reduce the detachment of seeds.
- (4) Sod pitching construction works may be performed except in winter (December to February), and the optimal periods are between March and April and between October and November. It is best to perform seeding in early summer (May to June), but may be performed between April and September.

3.2.3 Growth Base Formation

- (1) Surface arranging and leveling
 - ① Surface arranging and leveling on soil ground
 - a. Fissured soil that becomes detached from the ground surface and flows due to weathering and erosion, or deposited at the berm, or the stones that are slightly stuck or caught shall be removed.
 - b. The slope surface needed for foundation construction shall be well arranged so that the basic protection materials may be easily attached.
 - c. The top and bottom parts of the slope surface shall be finished in a natural shape without an acute angle to harmonize with the surrounding natural landscape and to prevent freezing and erosion. However, in the presence of

good vegetation, the leveling may not be performed after reviewing the conditions.

- d. If the constructed surface may cause losses due to rainwater, such as erosion and collapse, the surface shall be protected by a plastic covering.

② Surface arranging and leveling on rock ground

- a. The surface arranging and leveling works shall be performed by considering the actual civil engineering construction surface. For greening works in harmony with the surrounding natural environment, a curved bedrock shall be formed by not smoothing the surface.
- b. Loose stones generated by cutting and blasting shall be removed. However, crushed stones of various sizes do not need to be removed if they are naturally and stably stacked.

(2) Slope surface drainage work

- ① In areas where slope surface scouring or collapse is of concern due to the surface water or spring water, drainage facilities shall be installed according to the design drawing & specification, including slope shaller drain, berm drain, longitudinal drain, slope tip drain, perforated culvert drainpipe, and drain board.
- ② At a berm, despite being a rocky slope surface, a transverse inclination shall be formed or a drain shall be installed to prevent erosion of the growth base materials.
- ③ On a wet slope surface, being always saturated with the absorbed growth base materials, damage caused by blight and harmful insects may occur, and plant growth may be difficult. Therefore, water catchment shall be performed by installing longitudinal and transverse drains, drain mats, drain nets, and drain boards.
- ④ A surface drain shall be installed according to the design drawing & specification to treat the spring water. A drain layer, separated from the growth base, shall be formed before starting the slope surface greening work.
- ⑤ Drainage facilities shall be installed according to the corresponding items of the General Civil Engineering Standard Specification and the Construction Specification.
- ⑥ The shape and position of a ridge side gutter shall be determined in order to prevent the inflow of surface water from the upper ground to the slope surface.

(3) Slope surface greening base

- ① For the recovery and conservation of the ecological system and landscape of a damaged slope surface, a stable growth environment shall be formed to allow continuous and healthy plant growth.
- ② Piling of cribs for reinforcing slope surface
 - a. To promote stable attachment of growth base materials to a slope surface, slope

- cribs, such as piles and reinforcing bars, shall be vertically piled to a sufficient depth on the slope surface within an overall density of 3 to 4ea/m².
- b. If there is a bedrock on the slope surface, the direction and inclination of bedrock joints shall be investigated, and the crib piling angle shall be adjusted accordingly.
- ③ Slope surface erosion control net
- a. Surface erosion and seed loss on the slope surface can be prevented by using an erosion control net in order to promote germination and rooting.
- b. After seeds spraying, the seeds shall be rolled down from the top of the slope surface so that they may be naturally spread. The erosion control net shall not be tight in order to let the net be completely attached to the ground surface. In addition, the erosion nets shall be overlapped by 10 to 20cm, and anchoring lines shall be installed transversely. At least one anchoring pin per 1 m² shall be piled for anchoring.
- ④ Grid block for slope surface protection
- a. A small channel shall be divided in grids for distributed water catchment and drainage in order to prevent ground surface erosion. Before the greening works, the collected surface soil and growth base materials shall be filled.
- b. For the installation of grid blocks, the slope surface shall be leveled to be flat, and the grid blocks shall be tightly interlocked with each other to prevent sliding.
- c. When an interlocking is used at the intersections of the grids, the interlocking shall be sufficiently fixed with the grid.
- d. For planting in the grids, the grids shall be filled with the collected surface soil and leveled for good growth of the planted plants. If collected surface soil is not available, a growth base material shall be filled.
- ⑤ Covering of rockfall prevention net
- a. Unstable rock blocks or stones falling along the slope surface shall be allowed to slide between the slope surface and the net. Loose stones shall be pressed by the net so that the growth base of the plants may be preserved.
- b. The net shall be attached to the curved part of the rocky slope surface as tightly as possible so that the eroded layer may be deposited.
- c. When the covering of the rockfall prevention net is performed with the spraying of vegetation greening soil, anchoring pins shall be piled into a depth that allows to sufficiently support the greening soil.
- d. The anchoring pins and the transverse and longitudinal anchoring lines shall be sufficiently installed to anchor the net.

- ⑥ Fence
 - a. A linear fence that allows good growth of trees is installed at the berm of a rock slope surface, and the surface soil and the growth base materials may be filled for greening.
 - b. The fence shall be installed in a way that allows sufficient storage and drainage of earth moisture.
- ⑦ Concrete slope stabilizing crib work
 - a. A cast-in-situ concrete grid shall be prepared to prevent the collapse and fall of the surface of a steep slope to form the plant growth base.
 - b. Growth base material filling shall be sufficiently deep depending on the slope surface conditions so that the concrete surface may be hidden by the plants.
- ⑧ Gabion
 - a. The wires used to prepare a gabion include galvanized wire, synthesis resin-covered wire, and aluminized wire.
 - b. The gabion filling material shall be stones with a diameter larger than the maximum net mesh and smaller than 250 mm. The material shall have a good size distribution, a high solidity and a good durability.
 - c. The base ground shall be arranged and leveled in accordance with the slope and shape specified in the design drawings to prevent uneven settlement.
- ⑨ Other slope surface protection works
 - a. The construction works shall be performed to stabilize and protect the slope surface, and to make good form in the perspective of landscaping.
 - b. Artificial rock pitching shall be performed to assemble the individual units tightly with each other and attach them to the original ground solidly. The assembly joints shall be completely filled with a material of the same color as the rock for water-proof treatment.
 - c. Mortar and concrete spraying shall be performed to create unevenness on the construction surface to give naturalness and to allow the formation of at least one planting hole in 10 m².
 - d. Sufficiently deep planting holes shall be prepared to perform other vegetation works such as nesting, and growth base materials of high quality shall be supplied to promote rooting of vegetation.
 - e. For a poor slope surface condition, such as a mudstone slope surface, actions shall be taken to protect the vegetation and structures and reduce stone weathering in consultation with an expert.

3.2.4 Slope Surface Greening

(1) Lawn grass planting on slope surface

- ① If the inclination of the slope surface with the soil appropriate for lawn grass growth is gentler than 1:1, cultivated lawn grass with soil shall be used for greening of the entire slope surface at one time.
- ② The pitching on the front slope surface (block sods) shall be performed by attaching masonry joints compactly and zig-zag not to form a cross-joint. The lawn grass area shall be the same as the slope surface area.
- ③ The strip sodding shall be performed to keep the lawn grass width over 10 cm. A horizontal valley shall be dug to pitch the strip sods horizontally. Then, leveling shall be performed thoroughly.
- ④ For the pitching of retaining sods, horizontal steps shall be made in a constant height interval on the slope surface. The sods shall be pitched vertically on the back-filled front surface. The surface shall be completely leveled by using a slope tamping plate so that the sods may be completely attached to the soil layer. The masonry joints shall be prepared horizontally, and over-stacking shall be performed over the planned height, considering the settlement rate. The dimensions of the sods at each part shall be determined according to the design drawings and the instruction given by the construction supervisor.
- ⑤ The lawn grass shall be solidly anchored by using sod fixing sticks at least two sticks for one sheet of lawn grass. After the construction works, the sodding surface shall be thinly covered with sand or soil, and then leveled by uniformly tapping a slope tamping plate.
- ⑥ Lawn grass blocks shall be tightly attached and anchored onto the slope surface in order to prevent erosion and promote rooting.

(2) Seed spraying

- ① Seed spraying is applied to sandy areas. Seed spraying may be partially applied to ripping rock areas to protect the slope surface.
- ② Seed spraying may be performed anytime in a year except in winter (November to February), but it is usually performed between March and June and between August and October.
- ③ On the slope surface to which seed spraying is to be applied, stones shall be removed and the surface shall be arranged.
- ④ In the case of a dry slope surface, water of 1 to 3 ℓ/m² shall be sprayed in advance to promote seed germination and easy infiltration of sprayed materials.
- ⑤ The materials (herbaceous plant seeds, composite fertilizer, pulp or fiber, synthetic adhesive, pigment, etc.) applied to 1 m² shall be mixed with 4 ℓ of water, and the mixture shall be sprayed using a spraying machine according to the standard. After

the spraying, the entire slope surface shall be covered with a fibrous material (pulp or fiber).

- ⑥ In the parts where the seeds may not be well settled, horizontal or inclined valleys shall be dug at appropriate intervals according to the instruction given by the construction supervisor.
- ⑦ The seeds in the spraying machine tank shall be well mixed and uniformly sprayed so that the seeds may be uniformly sprayed over the entire slope surface.
- ⑧ If erosion may occur after the seeding, the entire surface shall be covered with a covering material, such as a plastic cover, to prevent the seeds from flying away via wind.
- ⑨ Seeding shall be performed again if the germination rate after 3 months of seeding is less than 60% or if the germination occurred only in a part of the area. However, if the seeding is performed in October or later, the next seeding shall be scheduled before early June of the upcoming year.

(3) Planting holes (seeding holes)

- ① Holes shall be made on the slope surface in a constant interval, and vegetation shall be planted for greening.
- ② Fully fermented compost or composite fertilizer shall be put into the bottom of holes . Then, the holes shall be filled with the growth base materials, and the seed shall be put on the top of the holes, which are then covered with soil.
- ③ The planting holes shall have a depth appropriate for the growth of the planted trees.

(4) Vegetation plate (vegetation board or seed plate)

- ① The growth base materials are prepared in a platy shape having seeds attached. Then, the plate is laid on the horizontal trench of the slope surface temporary to get greening works to be done.
- ② At least two sod fixing sticks shall be used to anchor the vegetation plate on the ground. If necessary, straw ropes may be used for anchoring.
- ③ The vegetation plates shall be arranged on the horizontal trenches sequentially from the top to the bottom of the slope surface.
- ④ The vegetation plates shall be tightly attached to the ground by filling the gaps with the growth base material.

(5) Vegetation belt (seed belt)

- ① Seeds and fertilizer are attached to vegetation belts having the same dimensions. The vegetation belts are installed in a constant interval on the slope surface for greening.
- ② The vegetation base shall be slightly protruding from the ground surface, and the

seeds shall be placed inside of the surface.

(6) Vegetation sack (seed sack)

- ① Growth base materials and seeds are contained in sacks. The prepared vegetation sacks are put into the horizontal trenches on the slope surface to perform the greening works at once.
- ② The holes which the sacks will be pushed into shall be dug to the specified depth. The holes shall be sufficiently deep not to allow the sacks to heave out from the hole. The gaps shall be filled with soil, and a solid fertilizer shall be placed under the sacks.
- ③ The sacks shall be anchored by using sod fixing sticks of hard PVC U-type wire (25 cm long) or of a woody plant branch having good germination and rooting power. One or two sod fixing sticks shall be used for one sack.

(7) Vegetation mat (seed mat)

- ① Planar mats with attached seeds are placed on and attached to a slope surface to perform early greening work at once.
- ② The slope surface shall be finished to be flat, and sod fixing sticks shall be anchored to tightly place the mats and prevent detachment due to wind.
- ③ More than 0.2 m of the slope surface top shall be covered with soil, and the end parts shall be dipped into the earth in order to prevent water infiltration from the slope surface shaller.
- ④ When long mats are used, the mats shall be laid longitudinally from the top to the bottom of the slope surface. When applied to a banking slope surface, the mats shall be layed horizontally, and both ends shall be overlapped at least 50 mm.

(8) Vegetation base material spraying (seed fertilizer soil material spaying)

- ① For a slope surface where natural plant growth is difficult, a qualified mixture of growth base materials and seeds can be used to encourage early landscape greening and ecological recovery and preservation.
- ② Water spraying is performed before the vegetation base material spraying if the slope surface is particularly dry or contaminated with impurities.
- ③ Before the spraying work, a preliminary material mixing management experiment must be performed in accordance with the design drawing & specification.
- ④ For a rocky slope surface, rather than the full-coverage greening, partial greening shall be undertaken in the presence of cracks and unevenness to promote harmony with the surrounding vegetation.
- ⑤ The spraying thickness shall be increased for wider bedrock cracks.
- ⑥ Greening work shall not be performed on protruding bedrock and vertical or reversely inclined areas. The spraying work may be focused on dent areas.

- ⑦ Vegetation base material spraying is divided into shallow vegetation base material spraying and thick vegetation base material spraying. The thickness of vegetation base material spraying is generally dependent on the inclination of the rock cutting surface and the culture soil characteristics. In dry thick vegetation base material spraying work, the thickness is basically 0.1 to 0.15m with an inclination around 1:0.5. The thickness may be increased or decreased depending on the rock quality and the joint direction of blast surface.
 - ⑧ For dry vegetation base material spraying work, the nozzle shall be more than 1 m away from the spraying surface. The spraying work shall be commenced from the top to the bottom of the slope surface. The minimum thickness of the spraying shall be at least 80% of the design thickness.
 - ⑨ After the surface is completely arranged, a net shall be attached to prevent rockfall and to promote the attachment of special cultured soil. The net shall be solidly anchored by using anchoring pins, wire nets, wires, and landing pins.
 - ⑩ For the inspection after the completion of the work, at least one measurement hole shall be installed in 500m². If measurement is difficult to carry out, the input amount data may replace the measurements.
 - ⑪ Growth judgment shall be made in terms of the coverage and the number of established trees. The coverage ratio shall be adjusted according to the inclination and the seed mixing. The coverage ratio shall be over 60% for inclination over 55°, over 80% for inclination between 45 and 55°, and 100% for inclination below 45°. When woody plants are mixed, the coverage ratio shall be reduced to 70% for all aforementioned inclination criteria. The number of established trees shall be over 300/m² when only herbaceous plants are mixed, and over 200/m² when herbaceous plants and woody plants are mixed together.
 - ⑫ The time for growth judgement shall be 180 days after construction in principle. However, 70% of the period shall be applied to the greening work focused on woody plants, considering potential germination. The time for growth judgement shall be June to early July the following year, if the greening work is performed in October or later in the year.
- (9) Straw mat covering
- ① The stones on the slope surface are removed, and the surface is arranged.
 - ② After performing seed spraying work, the entire slope surface may be covered with straw mats. Alternatively, the seeds and fertilizer may be attached to the vegetation area, and the vegetation area may be covered with a product with straws.
 - ③ The straw mats shall be anchored with anchoring pins according to the design drawings to prevent them from flying away due to wind.

- ④ The straw mats shall be laid longitudinally from the top to the bottom of the slope surface, and both ends shall be overlapped over 50 mm.

3.3 On-site Quality Control

3.3.1 Maintenance of Slope Surface

(1) Scope of application

Slope surface maintenance is applied to vegetation management works to prepare an ecological landscape that is well harmonized with the surrounding vegetation by accomplishing the recovery goals through continuous and healthy growth of the plants introduced to the slope surface.

(2) General matters relating to materials

- ① The mulching materials shall have a quality equal to or better than the quality specified in the design drawings or instructed by the construction supervisor.
- ② The fertilizer shall have a quality equal to or better than the quality of the official fertilizer standard product certified by the Rural Development Administration. The type of the fertilizer shall be determined by the construction specifications and the instruction given by the construction supervisor.

(3) General matters related to construction

- ① Slope surface greening works, including mulching, watering, and fertilizing, shall be performed until the completion date according to the design drawing & specification, considering the slope surface conditions and the regional and climate situations.
- ② Depending on the regional characteristics and recovering goals, mowing or other works may be performed as specified by the design drawings or the instruction given by the construction supervisor.
- ③ Additional complementary planting may be performed depending on the recovering goals in accordance with the separate vegetation management plan and the instructions given by the construction supervisor.
- ④ Maintenance works shall be performed by considering the vegetation succession.
- ⑤ Mowing shall be performed only in the necessary areas. Forestation shall be carried out through vegetation succession in order to promote diversity of the vegetation and to secure various vegetation layers as animal habitats.
- ⑥ Rather than performing large-scale mowing, grasslands shall be partially preserved to provide refuges for small animals.
- ⑦ Mowing shall not be performed too often in one season in order to minimize damage to insect life.
- ⑧ Mowing in winter shall be avoided where possible as it affects the hibernation of

the insects. Mowing shall also be avoided in the breeding seasons, larval stages, and hibernating stages depending on the regions and the insect varieties.

- ⑨ Leaf mold, containing fallen leaves and other materials, shall be effectively used as it activates the soil ecosystem and makes the soil healthy.
- ⑩ Physical mowing is more appropriate than extensive chemical mowing.

