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Code for design for applications of geosynthetics on subgrade of railway

铁路基土工合成材料应用设计规范

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Foreword

This Code was revised on the basis of "Technical code for geosynthetic application on subgrade of railway" (TB 10118-99) upon the requirements of "Notice on Printing (Railway Engineering Construction Code, Rating and Standard Design and Development Plan in 2003)" (Tie Jian She Han [2003] No. 41) issued by the Ministry of Railways.

This Code was revised by seriously summarizing the railway subgrade construction experiences and lessons in China and using the requirements of the relevant domestic and foreign standards for reference.

The engineering technical personnel must treat in accordance with local conditions, give full play to the subjective motility, positively adopt safe, reliable, advanced, mature, economic and applicable new technologies according to the railway construction logos of "people oriented, serving for transportation, emphasizing priorities and streamline procedures, system optimization, and focusing on development", in combination of the specific circumstance of engineering, and shall not apply the standards mechanically. The reconnaissance and design organization shall implement (or adopt) single or local standards, but that will not exempt design organization and designers from their legal responsibilities on problems in the whole engineering and the system service quality.

This Code comprises 8 chapters, with the main contents as follows: General Provisions, Terms and Symbols, Basic Requirements, Bed Strengthening and Treatment, Subgrade Protection, Subgrade Drainage, Reinforcement Soil Engineering and Foundation Treatment.

The significant changes in this revision include:

1. The application scope was modified to the design for the applications of geosynthetics on subgrade of railway;

2. The Section-"Construction quality inspection" in the former code was deleted;

3. The Chapter-"Basic requirements" was added;

4. The requirements for the application of new-type mature geosynthetics in the subgrade protection and severe cold zone were added;

5. The requirements for flexible permeable hoses constituting drainage system were added;

Code for design for applications of geosynthetics on subgrade of railway

1 General

1.0.1 This Code is formulated with a view to standardizing the technical requirements for the application of geosynthetics on subgrade of railway, improving the engineering quality of subgrade of railway, and meeting the requirements of railway engineering construction.

1.0.2 This Code is applicable to the design for the applications of geosynthetics on subgrade of railway.

1.0.3 The applications of geosynthetics on subgrade of railway shall be designed according to the railway grade, structural type of subgrade, as well as geological, hydrological and meteorological conditions. The design shall comply with the principles of adaptation to local conditions, safety and reliability, economy and rationality, and integrated application with other engineering materials and measures.

1.0.4 The applications of geosynthetics on subgrade of railway shall not only comply with this Code, but also meet those specified in the relevant current compulsory standards of the state.

2 Terms and symbols

2.1 Terms

2.1.1 geosynthetics

Generic term of the synthetic materials products applied in the geotechnical engineering

2.1.2 geotextile

Permeable cloth geosynthetics made of polymer fibers as the raw material

2.1.3 woven geotextile

Geotextile woven with fiber yarn or filament yarn along a certain direction

2.1.4 nonwoven geotextile

2.1.14 warp-knitted geogrid

Geogrid products made of high-strength dacron or fiber glass as the raw material, by biaxial knitting technology and polyvinyl chloride or modified asphalt coating finish process.

2.1.15 geocell

Three-dimensional geosynthetics products, with honeycomb structures, welded or assembled by the geosynthetics pieces

2.1.16 geomat

Three-dimensional net-shaped geosynthetics made of thread-line synthetic materials through a certain process treatment and by fusing on the nodes

2.1.17 three-dimensional vegetation grids

A kind of cell-shaped (similar to prismatic shape) vegetation geonet, made of plastic fiber through textile processing

2.1.18 expanded polystyrene

Light-duty geomaterials made of polystyrene by expanding after added with foaming agent and through moulding or extrusion process

2.1.19 flexible permeable hose

Tubular drain materials made of high-strength circular support externally wrapped with coating of geotextile and strong synthetic fibres

2.1.20 composite geobelt

Strip tensile material fabricated through extrusion, tension and reinforcement

2.1.21 sand well with geotextile bag

Vertical drain formed by knocking sand bag (made by filling sand in the geotextile bag) into the soft soil

2.1.22 filtration

The process making the fluid pass and keeping the soil particles under the action of osmotic pressure not losing

2.1.23 separation

To prevent the different adjacent media from mixing

problems.

6 Transverse drainage gradient of geosynthetics should not be less than 4%.

4.2.2 During the design for the constructed railway bed strengthening and treatment, the following geosynthetics may be selected according to the specific conditions:

1 Waterproof composite geomembrane, geomembrane, drain board and so on may be selected to prevent the infiltration of surface water;

2 During the drainage of underground water, the relatively thick geotextile wrapping crushed stone, sand and gravel may be selected as the filter body and drain body;

3 Expanded polystyrene or polyurethane insulating layer may be laid in the freezing injury zones.

4.2.3 During the treatment for the existing railway subgrade bed problems, the geosynthetics shall be selected according to the following requirements:

1 Waterproof geosynthetics such as composite geomembrane may be selected for the treatment of frost boiling in the existing railway bed;

2 For the handling of existing railway bed problems such as bed under-capacity, sinking, ballast collapse and water accumulation, the geocells may be adopted, and their heights and welding distances shall be selected according to the problem severity; for the strengthening and reinforcement, the geocell height and replacement depth should be determined through calculation or determined with reference to the successful handling experiences of the same type of problems; the geocells should be filled and compacted with medium coarse sand and gravel;

3 Flexible permeable hose or other drainage materials may be selected for the treatment of the existing railway problems such as ballast collapse and water accumulation;

4 The existing railway bed freezing injury may be prevented and treated with the composite geomembrane or geomembrane; relatively thick nonwoven geotextile may be selected in the case of relatively light freezing injury; insulation materials shall be laid in the case of severe freezing injury, for which the expanded polystyrene or polyurethane may be selected.

4.2.4 The technical performance of geosynthetics shall meet the following requirements:

horizontal slope along the line, the newly-laid end may be cushioned under the adjacent laid end.

4 Expanded polystyrene or polyurethane shall be firmly connected, and their seams shall be solid.

5 Two units of geocell shall be firmly connected with connecting pieces and the connection strength shall not be less than the design strength.

4.3.4 After laid, the geosynthetics shall be timely covered with cushion layer and compacted.

4.3.5 The problem treatment construction for the existing railway subgrade bed must ensure the travel safety. Blockade line, by-pass or overhead track, speed-limiting traveling crane, and section construction methods may be adopted in the construction according to the construction conditions.

5 Subgrade protection

5.1 General requirements

5.1.1 Integrated protection measures of geosynthetics and other engineering materials and engineering measures shall be adopted for the subgrade side slope.

5.1.2 Geomat, three-dimensional vegetation grids and geonet may be used to the protection for the soil quality side slope suitable for the growth of vegetations.

5.1.3 Geosynthetic rock cage or sinking pillow and geofabriform scour protection may combine with soil, stone and concrete and cover on the slope surface or river bottom, to constitute the anti-scour slope protection.

5.1.4 Geosynthetics may be used to the subgrade side slope protection in the sandstorm zone.

5.2 Slope surface protection

5.2.1 Cut slope with soil, weathered rock, soft rock easy of weathering and underground water seepage on the slope surface as well as embankment slope with slope surface subject to the rainfall erosion should adopt three-dimensional vegetation grids, geomat and geonet in combination with green protective measures such as planting vegetations and vegetation zone.

5.2.2 The technical performance of geosynthetics shall meet the following requirements:

the woven geotextile and their warp and weft direction fracture strength shall not be less than 12kN/m.

3 Upper and lower ends within the range of protection should be arranged with anchoring measures.

4 Geogrid or geonet rock cages shall be filled with pebble and block stone; the block diameter shall be greater than the mesh dimension.

5.3.3 Geofabriform scour protection engineering design shall meet the following requirements:

1 Geofabriform shall be laid on the stable side slope, the slope stability analysis shall be carried out if necessary, its stability shall be checked, and generally the geofabriform slope protection gradient shall not be steeper than 1:1.5.

2 Concrete or mortar geofabriform shall be selected for the geofabriform design according to the engineering conditions; and the geofabriform concrete slope protection thickness calculation, stability calculation checking and drainage & seepage calculation checking shall be carried out.

3 Geofabriform slope protection thickness may be calculated respectively according to the bending resistance stress, anti-floating thrust and ice resistant thrust and take the larger value; generally, the average thickness of mortar geofabriform slope protection after completion shall not be less than 10cm and the average thickness of concrete geofabriform slope protection shall not be less than 15cm.

4 Geofabriform shall be possessed of certain tensile strength and aging resistant capacity and be able to bear over 0.2 MPa pressure.

5.4 Sandstorm protection

5.4.1 Subgrade protection design in the sandstorm zone shall meet the following requirements:

1 As for the embankment slope filled with silty sand and fine sand and the powder fine sand stratum cut slope, the three-dimensional vegetation grids, geonet and geomat may be adopted as the wind erosion protective layer; the protection section forms are as shown in Figure 5.4.1-1 and Figure 5.4.1-2.

2 The section size of seepage ditch as well as the permeable pipe diameter shall be determined through the calculation according to the drainage requirement and seepage amount.

3 The plastic permeable pipe diameter should range from 20cm to 30cm, while the flexible permeable hose diameter should range from 5 to 20cm.

4 When there is impermeable soft stratum under the seepage ditch, a foundation of 0.1~0.3m in thickness shall be provided under the permeable pipe. According to the stratum conditions, the foundation may adopt sand cushions with geomembrane or composite geomembrane, concrete, and grouting slab-stone laid in between, and a drainage slope not less than 10% shall be arranged to the plan axis of the permeable pipe.

6.2.7 In the case of the drainage of underground water inside the cut slope or landslide mass, flexible permeable hoses or plastic permeable pipes should be inserted into the elevated oblique release holes. The position layout, diameter and length of the release hole shall be determined according to the hydrogeological conditions of the aquifer, and the elevated oblique angle should range from 10° to 15° and shall not be less than 5° in difficult cases.

6.2.8 As for the retaining wall of cutting from an underground water-developing section, several flexible permeable hoses or plastic permeable pipes may be parallelly arranged in inclined direction along the wall back, with an inclination angle of 45°, and connected to the permeable pipe which is arranged in longitudinal direction along the wall bottom and is larger in pipe diameter. The inclined permeable pipe diameter and layout shall be determined according to the developmental condition of underground water, and the pipe spacing should be 2~3m and pipe diameter 5~10 cm; and the longitudinal permeable pipe diameter should be 8~20 cm.

6.2.9 The plastic permeable pipe diameter as well as the seep hole size and layout shall be determined according to the pipe material type, seepage and drainage requirements, and protected soil conditions. Geotextiles should be adopted to envelop outside the plastic permeable pipe as a filtration layer.

6.2.10 The calculation of discharge capacity and seepage amount for flexible permeable hoses, plastic permeable pipes and seepage ditch made of geotextile-enveloped sand and stone may comply with relevant specifications and provisions.

6.2.11 The technical performances of geosynthetics shall meet the following requirements:

6.3.6 After the laying of geosynthetics, backfilling or covering shall be carried out timely, and measures shall be taken to protect the geotextile and permeable pipes against damage when backfilling fillers like crushed stones.

6.3.7 Elevated oblique borehole for water drainage shall be smooth and straight, and after the hole forming, the permeable pipe shall be inserted timely and then pipe orifice shall be fixed.

7 Reinforcement soil engineering

7.1 General requirements

7.1.1 In the case that the embankment filler is fine-grained soil or soft rock, the stability of the widened subgrade from a reconstructed or extended secondary line is poor, and steepening embankment slope is required due to the limit of topography, geosynthetics reinforcement may be adopted for strengthening.

7.1.2 The main track of railways whose speed is 200km/h or above should not adopt geosynthetics reinforcement soil retaining wall and reinforcement for steep side slope easing.

7.1.3 As for reinforcement soil retaining wall which adopts geosynthetics as tie-piece, the single-layer height should not be larger than 10m otherwise a special design shall be carried out.

7.1.4 The foundation treatment for reinforcement soil retaining wall must be well done.

7.1.5 The reinforcement material for reinforcement soil in severe cold zones shall select low-temperature-resistant geosynthetics.

7.2 Reinforcement soil embankment

7.2.1 Geosynthetics in embankment may adopt the following structural types:

1 The embankment slope which adopts fillers like fine-grained soil or soft rock should select the structural type of reinforcement strengthening for the slope as shown in Figure 7.2.1-1 in order to prevent the superficial layer of the slope from sliding and to enhance the anti-washout capacity of the slope.

Note: In Figures 7.2.1-1~2, m refers to the slope ratio specified in "Design Code for Railway Foundation" (TB 10001) or " Code for design on special subgrade of railway" (TB 10035), and m1 refers to the slope ratio of the steepening embankment slope.

7.2.2 When the embankment adopts multi-layer geosynthetics reinforcement, the spacing

between each layer of geosynthetics should neither be less than the minimum thickness of each filling layers nor be greater than 1m and the minimum laying width of the reinforcement materials shall not be less than 2.5m.

7.2.3 The layer number and length of the geosynthetics laying for reinforcement soil embankment shall be determined through the computational check for stability by means of circular sliding and wedge sliding, and the safety coefficient shall not be less than 1.3. The anchorage length of reinforcement material shall not only meet the computational check requirement of pull resistance stability but also not be less than 2.5 m.

7.2.4 The technical performance indices of reinforcement materials shall meet the following requirements:

1 When adopted for the reinforcement strengthening of embankment slope, geogrids and geonets should be selected, and their ultimate tensile strength shall not be less than 25kN/m;

2 The geosynthetics for reinforcement soil embankment should select geogrids which are of high strength, small deformation, great roughness, ageing resistance and small creep deformation, and their ultimate tensile strength shall not be less than 35kN/m;

3 Filling interface reinforcement should select geogrids.

7.3 Reinforcement soil retaining wall

7.3.1 Reinforcement soil retaining wall may adopt structural types like the enveloped type and plate-suspended type.

7.3.2 The structural type of reinforcement soil retaining wall shall meet the following requirements:

1 The retaining wall which adopts geosynthetics as reinforcement materials may adopt the structural types shown as Figures 7.3.2-1~4, or should adopt the one of Figure 7.3.2-3 when the wall height is greater than 6.0 m.

deformation and those can generate enough frictional force with the fillers, and their laying, joining and faceplate connection shall be simple and easy to carry out.

2 The ultimate tensile strength of geogrids shall not be less than 35kN/m;

3 As for the elongation rate of geogrid corresponding to its ultimate tensile strength, that of HDPE geogrid shall not be larger than 12%, which those of other geogrids shall not be larger than 10%;

4 When a composite geobelt fractures, its tensile strain shall not be greater than 2%, the breaking force of a single one shall not be less than 9 kN, and its surface shall be provided with coarse patterns.

7.4 Key points of construction

7.4.1 The construction of reinforcement soil embankment shall meet the following requirements:

1 When laying geosynthetics, the direction of the high strength shall be placed vertically to the axis direction of the embankment.

2 The connection in the stressed direction of geosynthetics must be firm, the connection strength shall not be less than the allowable design tensile strength of the material, and the other direction shall be arranged closely.

3 Geosynthetics shall be tensioned when laying and shall be free from any wrinkles, and if necessary, sprigging may be used for fixation; in the case of multi-layer laying, the joint between the upper- and lower-layers shall be staggered.

4 The filling surface with geosynthetics laid shall be flat and smooth and free from any hard protrusions. Rolling machines are strictly prohibited to directly roll on the geosynthetics surface.

5 After the paving of geosynthetics, fillers shall be applied timely so as to avoid long-time direct radiation from the sunlight.

7.4.2 The construction of reinforcement soil retaining wall shall meet the following requirements:

1 As for the geogrids used as tie-pieces, their directions of the high strength shall be laid vertical to the wall surface; composite geobelts shall be laid vertical to the wall surface, dispersing in fan shape, and distributed uniformly, and overlapping shall not exist out of the range from the wall faceplate to 1/3 of the geobelt length.

8 Foundation treatment

8.1 General requirements

8.1.1 Geosynthetics may be used for strengthening the reinforcement, accelerating drainage consolidation and separating capillary water in the cases of soft soil, loose-soft soil and salty soil foundations. Reinforcement strengthening for foundations should select geogrids, geotextiles or geocells which are of a high strength and small elongation rate. Drainage consolidation accelerating for foundations should select strip geodrains or sand well with geotextile bags, and capillary water separating should adopt composite geomembranes.

8.1.2 The measures for soft soil foundation treatment by using geosynthetics shall be determined according to the foundation conditions, embankment height and stability, post-work sedimentation, construction period, etc.

8.1.3 When the height of embankments in saline soil regions is less than the minimum one of secondary salinization nonoccurrence embankments and measures like ground water lowering are difficult to be taken, a composite geomembrane separate layer for capillary water may be arranged.

8.2 Design

8.2.1 The design of reinforcement strengthening for soft soil foundation shall meet the following requirements:

1 When geosynthetics are adopted for the reinforcement strengthening of soft soil foundation, single-layer or multi-layer geosynthetics, which constitute the reinforcement cushion layer with sand and stones, shall be laid under the embankment so as to restraint the lateral deformation of the foundation, homogenize the stress distribution of the base, improve the bearing capacity of foundation and enhance the embankment stability against sliding.

2 When geosynthetics are adopted for the reinforcement strengthening of soft soil foundation, the stability computational check and sedimentation calculation shall be carried out according to possible failure modes.

3 The deformation of geosynthetics should be compatible to that of the soil mass.

4 Medium coarse sands or other homogeneous-seepage-material cushion layers of good permeability shall be laid on the ground surface and the thickness of the cushion layers should not be less than 40 cm and the

fed into the sleeve, via the sleeve inlet roller, and hold onto the bag tail, and may be loosened after the sleeve is lifted by 0.5m so as to let the sand bags fall into the hole; when placing the sand bags, they shall avoid kink, necking down, fracture and abrasion.

5 When pulling up the sleeve, the vibrator shall be started firstly and then the sleeve lifting, which shall be carried out vertically so as to keep the sand bags from being brought out and damaged.

6 The length of the sand bag exceeding the orifice shall be guaranteed to stretch into the sand cushion for 0.3~0.5 m.

7 As for the sand well with geotextile bag which has been subjected to beating, sand infilling shall be timely carried out for the bags once every other 3 d and 2~3 times in general as well as after raining.

8.3.4 The construction of geomembrane separate layer for salty soil subgrade shall meet the following requirements:

1 The laying side of geomembrane shall be arranged with sand cushion which shall be made into a 4% cross slope form the line center to the both sides;

2 The connection of geomembrane shall be ensured to be seepage- and leakage-free;

3 After the geomembrane separate layer is laid, soil filling shall be carried out timely, and the first layer filling shall adopt manual paving with a thickness of not less than 0.3m and be free of angular stones, and rolling by using taper foot roller is strictly prohibited.

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