Section 4
Road Embankment

SECTION 4

ROAD EMBANKMENT

4.1 General

4.1.1 The design and construction of road embankment and cuttings shall meet the requirements, standards and specifications given in this Section. This Section also covers specifications for subgrade and earthen shoulders.

4.1.2 Where the Project Highway involves improvement to an existing road, efforts should be made to remove the inherent deficiencies in plan, profile and the roadway width. It shall be ensured that the final centre line of the road and the road levels are fixed with great care, duly considering all the relevant factors covering structural soundness, safety and functional requirements.

4.1.3 The existing roadway, where deficient, shall be widened to the roadway width in accordance with para 2.6.

4.2 Road Embankment

4.2.1 The width of the embankment shall be in accordance with the cross-sectional details specified in Section 2 of this Manual.

4.2.2 The height of the embankment shall be based on the final road levels. The following principles shall be kept in view while fixing the road level:

(i) For Improvement/Widening of the existing road;

(a) In case, bottom of the existing subgrade is 0.6 m above the HFL, the existing height of embankment can be retained.

(b) In case, it is less, then the bottom of subgrade should be raised to ensure a minimum 1 m clearance of the bottom of the subgrade from HFL. If raising of any section (s) of the Project Highway is required, that shall be specified in Schedule-B of the Concession Agreement.

(c) In case, Project Highway is passing through an area not affected by floods and is free from any drainage problem/ water ponding/over-topping situations with water table being quite deep, to the extent that subgrade is not likely to be affected by the capillary saturation, then the employer may avoid raising in larger stretches to save cost, even though the minimum clearance of 0.6 m from existing ground level is desirable.

(ii) New two lane road;

(a) Bottom of subgrade is 1.0 m above the high flood level/highest water table/ ponded water level. The HFL should be decided by intelligent inspections, local observations, enquiries and studying the past records.

(b) Portions forming approaches to structures provide smooth vertical profile and fulfil the minimum free board requirement.

4.2.3 Portions forming approaches to structures provide smooth vertical profile.

4.2.4 Deficiencies in the existing vertical profile of the road shall be corrected.

4.2.5 Construction of embankment, subgrade and earthen shoulders shall conform to the requirements of Clause 305 of MOSRTH Specifications as a minimum requirement.

4.2.6 *Materials and Physical Requirements*

4.2.6.1 Sourcing of materials for embankment and subgrade construction, as well as compliance with environmental requirements in respect of excavation and borrow areas under the applicable laws shall be the sole responsibility of the Concessionaire.

4.2.6.2 Borrow pits shall not be located within the right of way or along the road. Clause 305.2.2 of MOSRTH Specifications shall apply.

4.2.6.3 The materials used in embankment, subgrade and earthen shoulders shall be soil, moorum, gravel, a mixture of these or any other material conforming to the requirements of Clause 305.2 of MOSRTH Specifications. Pond ash can also be used subject to requirement indicated in para 4.2.16 of this Section.

4.2.6.4 The following types of materials shall be considered unsuitable for embankment construction and shall not be used:

(i) Materials from swamps, marshes and bogs;

(ii) Peat, log, stump and perishable material, any soil that is classified as OL, OI, OH in accordance with IS: 1498;

(iii) Materials susceptible to spontaneous combustion;

(iv) Materials in frozen conditions;

(v) Clay having Liquid Limit (LL) exceeding 70 and Plasticity Index (PI) exceeding 45;

(vi) Materials with salt resulting in leaching in the embankment;

(vii) Expansive clays, 'Free Swelling Index' (FSI) exceeding 50% when tested as per IS: 2720 (Part 40).

4.2.6.5 Expansive clays/black cotton soil shall not be used for subgrade construction.

4.2.6.6 Where expansive clay with acceptable Free Swelling Index value is used as a fill material, subgrade and top 500 mm portion of the embankment just below subgrade shall be non-expansive in nature.

4.2.6.7 The size of the coarse material in the mixture of earth shall not exceed 75 mm when placed in the embankment and 50 mm when placed in the subgrade.

4.2.6.8 Only the materials satisfying the density requirements given in Table 4.1 shall be employed for the construction of the embankment and the subgrade.

Table 4.1 : Density of Materials of Embankment and Subgrade

Type of Work	**Maximum Dry Density with heavy Compaction – IS: 2720 (Part 8)**
Embankment upto 3 m height, not subjected to extensive flooding.	Not less than 15.2 kN/cu. m
Embankments exceeding 3 m height or embankments of any height subject to long periods of inundation.	Not less than 16.0 kN/cu. m
Subgrade and earthen shoulders/verges/backfill.	Not less than 17.5 kN/cu. m

4.2.6.9 The density requirements specified in Table 4.1 shall not be applicable to light weight material e.g. pond ash.

4.2.6.10 The material to be used, in subgrade shall satisfy the design CBR at the specified density and moisture content.

4.2.6.11 The embankment and subgrade shall be compacted to satisfy the minimum compaction requirements given in Table 4.2.

4.2.7.4 The type of retaining structure shall be aesthetically pleasing and compatible with the adjoining structures.

4.2.7.5 Where the embankment is to be supported on a weak stratum, it shall be necessary to carry out adequate soil testing and to specially design the embankment and also adopt appropriate remedial / ground improvement measures in consultation with the Independent Engineer.

Table 4.2 : Compaction of Embankment and Subgrade

Type of Work/Material	**Relative Compaction as percentage of max. laboratory dry density - IS:2720 (Part 8)**
Subgrade and earthen shoulders	Not less than 97
Embankment	Not less than 95
Expansive Clays (of acceptable FSI)	
(a) Subgrade and 500 mm portion just below the subgrade.	Not allowed
(b) Remaining portion of Embankment	Not less than 90

4.2.7 *Structural Features and Design of Embankment*

4.2.7.1 Embankment shall be designed to ensure the stability of the roadway and shall incorporate only those materials, which are suitable for embankment construction as per para 4.2.6 of this Section.

4.2.7.2 The design of side slopes shall be governed by slope stability and traffic safety considerations.

4.2.7.3 Side slopes shall not be steeper than 2H: 1V unless soil is retained by suitable soil retaining structures. The reinforced earth where provided, shall conform to the requirements of Section 7 of this Manual.

4.2.7.6 Where the embankment is more than 3 m high and fill material consists of heavy clay or any problematic soil, the embankment stability shall be analysed and ascertained for safe design.

4.2.7.7 High embankments (height 6 m or above) in all soils shall be designed from stability considerations.

4.2.7.8 For design of high embankments IRC:75 may be referred to.

4.2.7.9 The side slopes shall be protected against erosion by providing a suitable vegetative cover, kerbs channel, chute, stone pitching/cement concrete block pitching or any other suitable protection measures, depending

on the height of the embankment and susceptibility of soil to erosion. Drainage arrangement shall be provided as per Section 6 of this Manual.

4.2.7.10 Stone pitching/cement concrete block pitching shall conform to Clause 2504 of MOSRTH Specifications.

4.2.8 *Embankment Construction Operations*

4.2.8.1 Embankment, subgrade and earthen shoulders shall be constructed in accordance with Clause 305.3 of MOSRTH Specifications.

4.2.8.2 Any unsuitable material occurring in the embankment foundation shall be removed and replaced by acceptable fill material in accordance with Clause 305.3.4 of MOSRTH Specifications.

4.2.8.3 Where construction of embankment and subgrade is required to be carried out under the special conditions such as given in paras 4.2.7 to 4.2.13, the earthwork shall be done in accordance with the procedure and requirements described in Clause 305.4 of MOSRTH Specifications.

4.2.9 *Earthwork for Widening Existing Road*

Where an existing embankment/subgrade is to be widened and its slopes are steeper than 1V: 4H, continuous horizontal benches each at least 300 mm wide shall be cut into the old slope for each lift of earthwork, for ensuring adequate bond with the fresh material to be added.

4.2.10 *Earthwork for Embankment and Subgrade to be Placed Against Sloping Ground*

Requirements of Clause 305.4.2 of MOSRTH Specifications shall apply.

4.2.11 *Earthwork over Existing Road Surface*

Requirements of Clause 305.4.3 of MOSRTH Specifications shall apply.

4.2.12 *Embankment and Subgrade around Structures*

(i) The work shall be carried out in accordance with the requirements of Clause 305.4.4 of MOSRTH Specifications.

(ii) Filling behind abutments, retaining walls, head walls and wing walls for structures shall conform to the general guidelines given in Appendix 6 of IRC:78.

(iii) The filter medium shall conform to the requirements of Clause 2504 of MOSRTH Specifications.

4.2.13 *Construction of Embankment on Ground Incapable of Supporting Construction Equipment*

For construction of embankment on ground, which is not capable of supporting construction equipment such as marshy land, any of the methods given in Clause 305.4.5 of MOSRTH Specifications may be used.

4.2.14 *Embankment Construction Under Water*

Where construction of embankment is required to be done under water, only granular material or rock consisting of graded hard and durable particles with maximum size not exceeding 75 mm shall be used. The material shall be non-plastic with uniformity coefficient of not less than 10. For further details refer IRC:34.

4.2.15 *Earthwork for High Embankment*

Where stage construction/controlled rate of filling is required for high embankments, the methodology together with details of necessary instrumentation and monitoring plan shall be communicated by the Concessionaire to the Independent Engineer for review and comments, if any.

4.2.16 *Use of Pond Ash for Embankment Construction*

4.2.16.1 Where Pond ash is used for embankment construction in pursuance of the instructions of the Ministry of Environment and Forests or otherwise, the embankment shall be designed and constructed in accordance with IRC:SP:58.

4.2.16.2 The thickness of soil cover shall not be less than 1 m for embankments up to 3m high. For high embankments, the thickness of soil cover shall be increased as per design.

4.2.16.3 The side slopes of the embankment shall be protected against erosion by providing turfing or stone/cc block pitching.

4.2.17 *Surface Finish and Quality Control of Work*

The surface finish and quality control of materials and works shall conform to the requirements of Clauses 902 and 903 of MOSRTH Specifications and Para 5 of IRC:SP:58 (relevant to Pond ash).

4.3 Roadway in Cutting

4.3.1 The width of the roadway in cutting shall be in accordance with the cross section details specified in Section 2 of this Manual.

4.3.2 The road level shall be fixed, keeping in view the following requirement:-

The difference between the bottom of subgrade and the highest water table is not less than 1.0 m. Exceptionally, where this requirement is not satisfied, drain shall be provided to lower down the water table.

4.3.3 *Soil Investigations for Cut Sections*

(i) Soil investigations shall be carried out to ascertain the type of cutting involved and in-situ soil conditions at the subgrade level. Reference may be made to IRC:SP:19.

(ii) The side slopes of cuttings shall be provided in accordance with the nature of the soil encountered. The slope shall be stable for the type of strata. Where required, benching including use of slope stability measures like pitching, breast walls, etc. shall be adopted to make the slopes stable and safe.

(iii) In the case of rock cutting, trial pits or boreholes shall be carried out at 30-50 m intervals to assess the type of rock.

4.3.4 Excavation for roadway in soil/rock shall be carried out in accordance with Clauses 301, 302 and 303 of MOSRTH Specifications, as relevant.

While executing excavation, adequate precautions against soil erosion, water pollution shall be taken as per Clause 306 of MOSRTH Specifications.

Appropriate drainage measures shall be taken to keep the site free of water in accordance with Clause 311 of MOSRTH Specifications.

No back filling shall be resorted to obtain the required slopes.

Adequate precautions shall be taken to ensure that during construction, the slopes are not rendered unstable or give rise to recurrent slides after construction.

In cut sections in hilly terrain, the problem of seepage flow is common. Where such conditions exist, necessary measures including provision of deep side drains to intercept the seepage flow and to avoid any damage to road and cut slopes shall be provided.

4.3.5 *Excavation of Road Shoulders for Widening of Pavement*

For widening of existing pavements or providing paved shoulders, the existing shoulders shall be removed to their full width and to the requisite depth. Care shall be taken to see that no portion of the existing pavement designated for retention is loosened or disturbed.

4.3.6 *Preparation of Cut Formation*

(i) The cut formation, which serves as a subgrade, shall be prepared as per Clause 301.6 of MOSRTH Specifications.

(ii) Where the material in the subgrade has a density less than that specified in Table 4.1, the same shall be loosened to a depth of 500 mm and compacted in layers in accordance with the requirements of Clause 305 of MOSRTH Specifications.

(iii) Any unsuitable material encountered in the subgrade shall be removed and replaced with suitable material and compacted in accordance with Clause 305 of MOSRTH Specifications.

4.3.7 *Finishing Operations*

(i) All excavated surfaces shall be properly shaped and dressed.

(ii) No point on the completed slopes shall vary from the designated slopes by more than 150 mm (in case of soils) and 300 mm (in case of rocks) measured at right angle to the line of slope.

(iii) The finished cut formation shall satisfy the surface tolerances specified in Clause 902 of MOSRTH Specifications.

4.4 Soil Survey Investigations and Design Report

The Concessionaire shall carry out necessary soil surveys and field and laboratory investigations for selecting appropriate borrow pits, identifying problematic ground locations if any, requiring treatment and for finalizing structural features and design of the embankment and cut sections. The soil survey and investigations report and design report shall be submitted to the Independent Engineer for review, if any.

4.4.1 *Soil Survey and Investigations Report*

The report shall include:

(i) Road Embankment

(a) The report shall include soil investigations and tests in accordance with the requirements specified in IRC:SP:19 and shall be reported in the Proforma given in Table 1 of IRC:SP:19. In addition to this, all tests as per the requirements of MOSRTH Specifications shall be reported.

(b) In respect of high embankment, the report shall include additional investigations and soil tests as per IRC:75 and Appendix 10 of IRC:SP:19.

(c) Information regarding the topography, high flood level, natural drainage conditions, highest sub-soil water level, and the nature and extent of inundation, if any.

(d) The characteristics of embankment foundation including the presence of any unsuitable/weak strata, marshy areas, water logged areas, etc.

(e) Along the alignment of the road, where unstable strata, soft material or poor

subsoil conditions have been met with at the foundation level, the soil profile shall be drawn after determining through borings, the type of soil at different levels. The boring shall be at intervals of 100 to 200 m to a depth of 2 m below the existing ground. In the case of high embankments, the borings shall be taken down to a depth equal to twice the height of the embankment.

(f) Any particular construction problems of the area or other important features.

(g) Geotechnical properties of Pond ash, covering parameters specified in Table 1 of IRC:SP:58 and OMC-dry density relationship for heavy compaction. This information shall be furnished, in case Pond ash is used in embankment construction.

(ii) Cut Sections

The report shall include soil investigations and tests in accordance with the requirements specified in IRC:SP:19 and information regarding depth of water table, seepage flow, presence of any weak, unstable or problematic strata.

4.4.2 *Design Report*

The Concessionaire shall furnish the design report including the following to the Independent Engineer for review and comments, if any.

(i) Road Embankment

(a) The detailed design of the embankment, remedial/ground improvement treatment where required, and construction methodology for high embankments.

(b) Design of retaining walls/reinforced earth structures.

(c) Design of protection measures for embankment slope and drainage arrangement.

(d) Design of Pond ash embankment in case use of Pond ash is proposed.

(e) Any additional information relevant to the design report.

(ii) Cut Section

(a) Type of cutting involved and proposed cut slopes.

(b) Design and details of erosion control, slope protection measures, etc.

(c) Design and details of drainage arrangement for sub-soil and surface water.

(d) Any other additional information relevant to the design of cut slopes.