Section 2107. Embankments

2107.01 DESCRIPTION.

A. Prepare the site.

B. Place and compact excavated materials.

2107.02 MATERIALS.

Specified in the contract documents.

2107.03 CONSTRUCTION.

A. General.

1. Prepare the site, and place and compact excavated materials to the required elevation and cross section shown in the contract documents.

2. If the type of compaction is not specified, Type A compaction will be required.

B. Equipment.

Use equipment that meets the requirements of Section 2001 and the following:

1. Compaction Equipment.

a. When compaction with moisture and density control is not specified, use equipment that meets the requirements of Article 2001.05, A. Other types of compacting equipment may be used as provided in Article 2107.03, G.

b. For compaction of sand or other granular material, use either a:

- Self propelled pneumatic roller meeting the requirements of Article 2001.05, C, or
- Self propelled vibratory roller meeting the requirements of Article 2001.05, F.

c. Compact special backfill material with equipment meeting the requirements of Article 2001.05, Paragraphs B, C, D, F, or other types of compacting equipment as provided in Article 2107.03, G.

d. When compaction with moisture and density control is specified, any type of equipment which will produce the desired results may be used for compaction.

2. Equipment for Applying Water.

Apply Article 2001.09.

C. Preparation of the Site.

1. Where the height of proposed embankment at the center line is 5 feet (1.5 m) or less, remove sod (after thorough disking) from the area. Place the sod on the area to be occupied by the outer portion of the embankment as provided in Article 2107.03, D.

2. When an embankment is placed on or against an existing slope which is generally steeper than 3 horizontal to 1 vertical and is more than 10 feet (3 m) high, cut the slope into steps as the construction of the new embankment progresses. Assure that sod or other potential sliding surfaces are removed. Cut each step or series of steps to approximate horizontal planes with vertical slope cut dimensions of no less than 3 feet (1 m).

D. Depositing Embankment Material.

1. Comply with the following:

- **a.** Except for rock fills and granular blankets, deposit embankments in horizontal layers not over 8 inches (200 mm) in loose thickness.
- **b.** Keep the outer portion lower than its center.
- **c.** When construction will be suspended for a period during which rain is likely to occur, smooth the surface to produce a smooth and compact surface to shed water.
- **d.** Deposit soils containing quantities of roots, sod, or other vegetable matter outside of the shoulder line and within the outer 3 feet (1 m) of the embankment.
- **e.** Do not deposit tree stumps and other large woody objects in embankments.
- **f.** Alternate layers of drier soils with wetter soils whenever it is practical to do so without an increase in average haul.
- **g.** Do not construct embankments on frozen ground. Do not use frozen material to construct embankments.

2. Apply the following where Type A or Type B compaction operations are to be used:

- **a.** When the width at the attained height is 30 feet (10 m) or more, divide the area upon which the layer is to be placed into separate and distinct dump areas having widths no less than 15 feet (5 m). If hauling equipment is operated within a dump area, disk the area with a least one pass of a tandem axle disk or two passes with a single axle disk prior to compaction.
- **b.** During compacting operations, keep hauling equipment off dump areas of embankments 36 feet (11 m) wide or more. Empty hauling units may travel on the dump area during compaction operations as necessary to pass loaded hauling units if:
  - Within 36 feet (11 m) of a bridge or other limiting structure.
  - The width of the embankment is less than 36 feet (11 m) at the attained height.
- **c.** If the design width of embankment is less than 30 feet (10 m) at the attained height, hauling units will be allowed to travel through areas where compaction operations are in progress. Ensure hauling equipment passing through compaction operations does not force water, disking, and compacting equipment to deviate from their intended paths.
- **d.** Deposit the material over the dump area as a separate and distinct operation. If the material, as deposited, contains an average of more than 1 lump per square yard (square meter) large enough to have at least one dimension greater than 12 inches (0.3 m), disk

the area with at least one pass of a tandem axle disk or two passes of a single axle disk. Use a disk designed and operated to cut and stir to the full depth of the layer.

3. After depositing and disking (if required), smooth the material to a uniform depth using a suitable motor patrol, bulldozer, or self propelled sheepsfoot type roller with a blade attachment. In addition to the initial smoothing, continue smoothing and leveling during compaction as necessary to provide a surface area free from ruts and other objectionable irregularities. The self propelled, sheepsfoot type roller with blade attachment may be used under the following conditions:
   a. Leveling is completed according to the prescribed rolling pattern.
   b. Compaction is the major function of this unit.
   c. Power drums are prevented from spinning.

4. When, in the Engineer's opinion, the unit cannot satisfactorily accomplish both leveling and rolling, use a separate dozer or motor patrol for the leveling operation prior to initiation of compaction.

E. Type A Compaction.

1. Type A compaction refers to compaction requiring a minimum of one rolling per inch (25 mm) depth of each lift. A further requirement is that the roller continues operation until it is supported on its feet, or the equivalent.

2. After smoothing the surface of the layer and before depositing material for the next layer, compact the layer with at least one pass of the sheepsfoot type roller for each inch (25 mm) of loose thickness of the layer. Compact until the roller is supported entirely on its feet. This occurs when the tamping feet penetrate no more than 3 inches (75 mm) into an 8 inch (200 mm) lift or 33% of the depth of the layer being placed.

3. Determine if the moisture content of the material is excessive or suitable for satisfactory compaction. The Contractor may elect to start rolling operations immediately after the smoothing operation, or may elect to delay rolling operations, and instead, aerate the material in preparation for rolling. Proceed with aeration and compaction operations in an orderly fashion without unreasonable and unnecessary delay. Rolling operations made prior to any aeration operations for a lift will not be counted as any of the required coverages.

4. Should the material be dry to the extent that it is likely to fail to be satisfactorily compacted by rolling, the Contractor may moisten the material. The Engineer may order the material to be moistened uniformly before compacting. Authorization may be given for the use of water in the final finishing of the roadbed.

5. Compensation will not be allowed for delays occasioned by the ordering of moistening or by drying.

6. The Contractor may request approval of other methods and equipment according to Article 2107.03, G.

F. Type B Compaction.

1. Type B compaction refers to compaction requiring a specified number of diskings and roller coverages, or the equivalent.

2. After smoothing the surface of the layer and before depositing the next layer, compact or smooth and compact the layer.

3. If the entire weight (mass) of the roller is supported on its feet after one pass of the roller for each inch (25 mm) of loose thickness of the layer, no further compacting is necessary. A roller will be considered to be supported entirely on its feet when the feet penetrate no more than 3 inches (75 mm) into an 8 inch (200 mm) lift or 33% of the depth of the layer being placed.

4. If the soil in the layer is too wet when it is deposited to compact to the degree that the entire weight (mass) of the roller is supported on its feet, the Engineer may require one disking per 2 inches (50 mm) of loose thickness of the layer in addition to the disking required in the smoothing operation. A disking consists of a complete coverage of the layer with either a tandem axle disk or a single axle disk. Use a disk designed and operated to cut and stir to the full depth of the layer. The Engineer may require an interval no longer than 2 hours between successive diskings. After the disking has been completed, compact the layer with one pass of a sheepsfoot type roller per inch (25 mm) of loose thickness of the layer.

5. The manipulation and compaction specified above is incidental to Class 10 or Class 13 excavation. The Engineer may require additional manipulation and compaction as extra work. If the soil is so dry that it will fail to be satisfactorily compacted by rolling, the Engineer may require the Contractor to moisten the material uniformly before it is compacted.

6. Compensation will not be allowed for delays caused by the ordering of moistening or by disking.

7. The Contractor may substitute Type A compaction at no additional cost to the Contracting Authority where Type B compaction is specified, by written notification to the Engineer, or the Contractor may request approval of other methods and equipment according to Article 2107.03, G.

G. Compaction by Other Methods and Equipment.

1. Other methods of compaction may be used. Demonstrate they will obtain suitable compaction of a variety of soil types and moistures normally encountered. Compaction will be considered suitable if the resulting density, with adequate moisture, is both:

- Reasonably uniform throughout the compacted lift.
- At least 95% of maximum density, determined according to Materials Laboratory Test Method No. Iowa 103.

2. Other types of compacting equipment may be used. Demonstrate they will obtain equivalent compaction results using a variety of soil types and moistures normally encountered. Demonstrations are to be such that results can be compared.

3. For Type A compaction, equivalent compaction must be recognizable by roller penetration or other significant characteristic.

4. For other methods or other equipment, a definite approval will be necessary, including any limitations the Engineer deems advisable.

5. Use of other methods and equipment prior to approval, except for demonstration tests, must provide 6 inch (150 mm) compacted lifts at 95% of maximum density, during which moisture is maintained no drier than 3 percentage points below optimum moisture.

H. Compaction with Moisture and Density Control.

1. The contract documents will show areas in which embankments shall be constructed with moisture and density control. The contract documents will also show the distance below the elevation of the completed grading work to which such methods are to be applied.

2. Where construction with moisture and density control is indicated in cut sections:

a. Excavate the roadbed below proposed subgrade elevation to a plane 6 inches (150 mm) above the elevation shown for the bottom of the moisture and density control section.
b. Thoroughly scarify the remaining 6 inch (150 mm) layer.
c. Increase or reduce the moisture content as necessary to bring the moisture throughout this 6 inch (150 mm) layer within the moisture limits specified.
d. Compact this 6 inch (150 mm) layer to no less than 90% of maximum density determined according to Materials Laboratory Test Method No. Iowa 03.
e. Deposit the remainder of the cut section to the completed grade elevation in layers according to Article 2107.03, D.
f. Uniformly moisten each layer as necessary to bring to within the specified moisture limits.
g. Compact each layer to no less than 95% of maximum density.

3. Where construction with moisture and density control is indicated in embankment sections outside cuts:

a. Deposit in layers, according to Article 2107.03, D, all material in fill above the designated elevation for compaction with moisture and density control.
b. Uniformly moisten or dry as necessary to bring each layer within the specified moisture limits.

c. Compact the first layer placed with moisture and density control to no less than 90% of maximum determined according to Materials Laboratory Test Method No. Iowa 103.

d. Compact each succeeding layer to no less than 95% of maximum density.

4. Prior to compaction, bring the moisture content of each layer of earth to be compacted with controlled moisture and density to within the specified limits of the optimum moisture content. After field tests determine that a layer is within the specified moisture limits, begin compaction and continue until the required density is obtained. If compaction is interrupted or delayed on a layer, bring the moisture of the layer to within the specified limits before resuming compaction.

I. Compaction with Moisture Control.

1. The contract documents will show:

a. Areas in which embankments are to be constructed with moisture control.

b. The distance below the elevation of the completed grading work to which such methods are to be applied.

c. The moisture limits.

2. Where construction with moisture control is indicated in cut sections:

a. Excavate the roadbed below proposed subgrade elevation to a plane 6 inches (150 mm) above the elevation shown for the bottom of the moisture control section.

b. Thoroughly scarify the remaining 6 inch (150 mm) layer.

c. Increase or reduce the moisture content as necessary to bring the moisture throughout this 6 inch (150 mm) layer within the moisture limits specified.

d. Compact this 6 inch (150 mm) layer as specified in Article 2107.03, E.

e. Deposit the remainder of the cut section in layers according to Article 2107.03, D.

f. Uniformly moisten or dry as necessary to bring each layer within the specified moisture limits.

g. Compact each succeeding layer as specified in Article 2107.03, E.

3. Where construction with moisture control is indicated in embankment sections outside cuts:

a. Deposit in layers, according to Article 2107.03, D, all material in fill above the designated elevation for compaction with moisture control.

b. Uniformly moisten or dry as necessary to bring each layer within the specified moisture limits.

c. Compact layers placed with moisture control as specified in Article 2107.03, E.

4. Prior to compaction, bring the moisture content of each layer of earth to be compacted with controlled moisture within the specified limits of the optimum moisture content. After field tests determine that a layer is

within the specified moisture limits, begin compaction and continue unit the requirements of Article 2107.03, E, are obtained. If compaction is interrupted or delayed for more than 1 hour on a layer, bring the layer within the specified moisture limits before resuming compaction.

J. Rock Fills.

1. When the excavated material consists of rock fragments too large to be placed in layers of the thickness prescribed without further breaking them down, it may be placed in the embankment in horizontal layers 4 feet (1.2 m) or less in thickness. Place each layer to avoid future water entrapment. In most cases, this will require placement to full embankment width, except for topsoil on the foreslope. Level each layer with a suitable dozer. Smooth each layer by choking the surface of the rock with spalls and finer fragments or earth.

2. Do not construct the 4 foot (1.2 m) lifts above an elevation 2 feet (0.6 m) below the finished grade line. The next foot (0.3 m) of embankment height may be placed in one layer using rock spalls and finer fragments which may be satisfactorily consolidated by the dozer and tractor. For the last foot (0.3 m) below the finished grade line, use either:

- Earth smoothed and placed in layers not exceeding 8 inches (200 mm) thickness and rolled as described above, or
- Special backfill material placed as shown in the contract documents.

3. Conduct operations in such a way that the Engineer is given the opportunity to take cross sectional measurements required before the earth cover is placed.

K. Granular Blankets.

1. Where a granular blanket is specified, spread material meeting the requirements of Section 4133 to the width and thickness shown in the contract documents. Do not use compaction equipment. The blanket may be constructed in several lifts. Do not incorporate foreign material from hauling equipment or other sources.

2. In areas requiring both granular blanket and subdrain backfill material, the sequence of operations will be the option of the Contractor. Ensure that contact areas between porous backfill material, granular material for subdrains, and granular blankets are free from clay or silt.

L. Rebuilding Embankments.

1. Do not place a pavement partly on an old and partly on a newly constructed embankment. Remove the part of the old embankment that would be under the pavement as below grade excavation to the natural ground line, or to a depth of 5 feet (1.5 m) below the proposed grade line, whichever is higher. Rebuild as prescribed for new embankments.

2. Rebuild embankments according to Article 2107.03, C, unless otherwise specified in the contract documents. Compact the material according to Article 2107.03, E.

3. At locations where the width of embankment widening is less than 4 feet (1.2 m), widening material may be placed and shaped to the bottom of pavement or base elevation without compaction other than that obtained with wheels of motor graders and hauling equipment. Placement and compaction may be accomplished in 8 inch (200 mm) lifts parallel to the finished slope, provided the existing slope has been roughened by disking or scarification.

4. In all cases of embankment widening, remove surface vegetation from slopes against which the widening material is to be placed. Deposit this material according to Article 2107.03, D.

M. Compacting Trench Bottom.

When designated in the contract documents, excavate the roadbed for the width shown to 1 foot (0.3 m) below subgrade elevation. Scarify the next 6 inch (150 mm) depth and compact as for Type B compaction, unless otherwise specified. When the bottom of the trench has been compacted, place suitable backfill material in the excavation and compact. If the type of compaction is not specified for this upper 1 foot (0.3 m), Type A compaction will be required on Primary projects and Type B compaction on Secondary projects.

N. Use of Unsuitable Soils.

1. Unsuitable soils may be used in embankments according to Standard Road Plan RL-1B, unless the Engineer directs otherwise.

2. Unless otherwise specified, when used in embankments, spread unsuitable material in uniform layers no more than 8 inches (200 mm) in loose thickness. Cover each layer with a layer or layers of suitable material.

O. Embankments Adjacent to Culverts and Structures.

1. When the contract documents require embankment construction adjacent to a bridge, culvert, or other structure, construct the compacted embankment to the height shown and to the full width of the roadway. Secure material for constructing these embankments from within the right-of-way or authorized borrow area as directed by the Engineer. Waste the material from within the waterway of bridges or culverts which is too wet to be suitable for compaction. Do not place this material in the embankment.

2. Place embankments adjacent to bridges, culverts, and structures with the same precautions and methods described in Article 2402.03, H. The contract documents may require moisture control.

3. Use mechanical or pneumatic tampers for compaction in areas occupied by embankments which are too narrow for the operation of rollers. The Contractor may elect to enlarge the area in which the embankment is to be constructed by cutting down the elevation of the old fill to permit rolling equipment to operate efficiently. When old fill is removed for this purpose, step it up to its original height such that each step has a horizontal dimension no less than 3 feet (1 m) with a vertical rise.

4. Flowable mortar may be placed as backfill material adjacent to bridges, culverts, and structures, at no additional cost to the Contracting Authority. Place this backfill material according to Section 2506.

2107.04 METHOD OF MEASUREMENT.

A. Measurement will be as provided in Article 2102.04. The following will be included in Class 10 excavation:

1. Excavation in preparation for constructing embankment by compaction with moisture control.

2. Excavation in preparation for constructing embankment by compaction with moisture and density control.

3. Excavation in preparation for compacting trench bottom.

4. Excavation in preparation for rebuilding embankment.

B. Embankment construction will not be measured separately for payment except as follows:

1. **Compaction with Moisture and Density Control.**
Cubic yards (cubic meters) shown on the contract documents as determined by the template fill volume. Shrinkage will not be included in moisture and density control quantity.

2. **Compaction with Moisture Control.**
   a. Cubic yards (cubic meters) shown on the contract documents as determined by the template fill volume. Shrinkage will not be included in moisture control quantity.
   b. When moisture control is required adjacent to culverts and stockpasses (Article 2107.03, O) the volume will be computed using the formula in Article 2107.04, B, 4. When moisture control is required adjacent to pipe culverts, the volume will be computed as provided in Article 2402.04.

3. **Compacting Trench Bottom.**
Stations (meters) shown on the contract documents as determined along the center line of the roadbed.

4. **Compacting Backfill Adjacent to Bridges, Culverts, or Structures.** The quantity of backfill material placed and compacted by the grading contractor adjacent to bridges, box culverts, or structures or their extensions will be the quantity obtained by the following formula:

English	Metric
$Q = \frac{(4\text{ ft.} \times L \times H)}{27}$	$Q = (1.2\text{ m} \times L \times H)$

Where:
- Q = quantity of compacted backfill material in cubic yards (cubic meters);
- L = (1) length in feet (meters) of the culvert or stock pass from back to back of parapet, or (2) length in feet (meters) from back of existing parapet to back of parapet of the extension;
- H = nominal height of structure opening, feet (meters).

5. **Granular Material for Blanket and Subdrain.** Cubic yards (cubic meters) according to Article 2312.04, A.

6. **Water for Embankment Construction.** Except when compaction with control of moisture and density or moisture is specified, water for embankment construction required for moistening materials to be placed in embankment will be measured in thousands of gallons (kiloliters) by gauging the contents of the transporting vehicle or by metering the supply. Authorized water for finishing the roadbed will not be measured for payment if a period in excess of 2 calendar days has elapsed between final compaction of a dump area and final finishing of the same area.

2107.05 BASIS OF PAYMENT.

A. Payment for embankment construction will be contract unit price as for Embankment-In-Place according to Article 2102.05, with the following additions:

1. **Compaction with Moisture and Density Control.**
   - **a.** Per cubic yard (cubic meter).
   - **b.** Payment is full compensation for the work of drying material, furnishing and applying water, controlling moisture content of the materials, and compacting the materials to the specified density.

2. **Compaction with Moisture Control.**
   - **a.** Per cubic yard (cubic meter).
   - **b.** Payment is full compensation for the work of drying material, furnishing and applying water, controlling moisture content of the materials, and compacting the materials, as specified.

3. **Compacting Trench Bottom.**
   - **a.** Per station (meter).

b. Payment is full compensation for the work of scarifying, drying material, furnishing and applying water, controlling moisture content of the materials, and compacting the materials, as specified.

4. Compacting Backfill Adjacent to Bridges, Culverts, or Structures.
Per cubic yard (cubic meter).

5. Granular Material for Blanket and Subdrain.
Per cubic yard (cubic meter).

6. Water for Embankment Construction.

a. Except when compaction with moisture and density control or moisture control is specified, payment for water for embankment construction added at the Engineer's direction will be the contract unit price per 1000 gallons (kiloliter).

b. In case the contract does not contain a unit price for water, and moistening of the material is authorized or ordered, payment for water will be as extra work at the rate of $12.00 per 1000 gallons ($3.20 per kiloliter).

c. When Type A compaction or compacting embankments with moisture and density control or moisture control is specified, manipulation necessary to incorporate water or work necessary to dry the material will be considered as incidental work and will not be paid for separately.

d. When Type B compaction is specified, manipulation necessary to incorporate water will be considered incidental to other work. Work performed at the Engineer's direction to dry or compact the material, in excess of that obtained by the maximum number of diskings and roller coverages specified for Type B compaction, will be paid for as extra work according to Article 1109.03, B.

B. Payment for Compaction with Moisture and Density Control, Compaction with Moisture Control, Compacting Trench Bottom, and Compacting Backfill Adjacent to Culverts and Stockpasses will be for plan quantities in conjunction with quantities shown in the contract documents described in Article 2102.04 and under the conditions described therein.