
USACE / NAVFAC / AFCEA / NASA UFGS-35 73 13 (January 2008)

Preparing Activity: USACE Superseding
UFGS-35 73 13 (April 2006)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated July 2011

SECTION TABLE OF CONTENTS

DIVISION 35 - WATERWAY AND MARINE CONSTRUCTION

SECTION 35 73 13

EMBANKMENT FOR EARTH DAMS

01/08

PART 1 GENERAL

1.1 UNIT PRICES

- 1.1.1 Compacted Fill, Impervious
 - 1.1.1.1 Payment
 - 1.1.1.2 Measurement
 - 1.1.1.3 Unit of Measure
- 1.1.2 Compacted Fill, Pervious
 - 1.1.2.1 Payment
 - 1.1.2.2 Measurement
 - 1.1.2.3 Unit of Measure
- 1.1.3 Compacted Fill, Random
 - 1.1.3.1 Payment
 - 1.1.3.2 Measurement
 - 1.1.3.3 Unit of Measure
- 1.1.4 Backfill, Impervious
 - 1.1.4.1 Payment
 - 1.1.4.2 Measurement
 - 1.1.4.3 Unit of Measure
- 1.1.5 Backfill, [Pervious] [Random]
 - 1.1.5.1 Payment
 - 1.1.5.2 Measurement
 - 1.1.5.3 Unit of Measure
- 1.1.6 Filters
 - 1.1.6.1 Payment
 - 1.1.6.2 Measurement
 - 1.1.6.3 Unit of Measure
- 1.1.7 Rock Fill
 - 1.1.7.1 Payment
 - 1.1.7.2 Measurement
 - 1.1.7.3 Unit of Measure
- 1.1.8 [Embankment for Foundation Settlement]
 - 1.1.8.1 Payment
 - 1.1.8.2 Measurement
 - 1.1.8.3 Unit of Measure
- 1.1.9 Additional Rolling for Compaction

- 1.1.9.1 Payment
- 1.1.9.2 Measurement
- 1.1.9.3 Unit of Measure
- 1.1.10 Piezometer
 - 1.1.10.1 Payment
 - 1.1.10.2 Measurement
 - 1.1.10.3 Unit of Measure
- 1.1.11 [Settlement Gages]
 - 1.1.11.1 Payment
 - 1.1.11.2 Measurement
 - 1.1.11.3 Unit of Measure
- 1.1.12 Surface Reference Marks
 - 1.1.12.1 Payment
 - 1.1.12.2 Measurement
 - 1.1.12.3 Unit of Measure
- 1.1.13 Mortar and Concrete for Foundation Preparation
 - 1.1.13.1 Payment
 - 1.1.13.2 Payment
 - 1.1.13.3 Unit of Measure
- 1.2 REFERENCES
- 1.3 DEFINITIONS
 - 1.3.1 Embankment
 - 1.3.2 Compacted Fill
 - 1.3.3 Uncompacted Fill
 - 1.3.4 Backfill
 - 1.3.5 Spalls
 - 1.3.6 Rock Fill
- 1.4 SYSTEM DESCRIPTION
 - 1.4.1 Haul Roads
 - 1.4.2 Stockpiling from Approved Borrow Sources

PART 2 PRODUCTS

- 2.1 MATERIALS
 - 2.1.1 General
 - 2.1.2 Impervious Fill
 - 2.1.3 Random Fill
 - 2.1.4 Pervious Fill
 - 2.1.5 Uncompacted Fill
 - 2.1.6 Backfill
 - 2.1.7 Filter Drainage Layers
 - 2.1.8 Rock Fill
 - 2.1.8.1 Rock
 - 2.1.8.2 Spalls

PART 3 EXECUTION

- 3.1 CONSTRUCTION
 - 3.1.1 Lines and Grades
 - 3.1.2 Conduct on the Work
- 3.2 PREPARATION OF FOUNDATION, PARTIAL FILL SURFACES AND ABUTMENTS
 - 3.2.1 Earth
 - 3.2.2 Rock
- 3.3 PLACEMENT
 - 3.3.1 General
 - 3.3.2 Frozen Material
 - 3.3.3 Rate of Placement
 - 3.3.4 Impervious Fill
 - 3.3.5 Random Fill

3.3.6	Pervious Fill
3.3.7	Filter Drainage Layers
3.3.8	Rock
3.3.8.1	Rock Spalls
3.3.8.2	Rock Fill
3.3.9	Spreading
3.4	MOISTURE CONTROL
3.4.1	Impervious Sections
3.4.2	Random Sections
3.4.3	Pervious Section
3.4.4	Filter Drainage Layers
3.4.5	Rock Fill
3.5	COMPACTION
3.5.1	Equipment
3.5.1.1	Tamping Rollers
3.5.1.2	Vibratory Rollers
3.5.1.3	Rubber-tired Rollers
3.5.1.4	Power Tampers
3.5.2	Impervious and Random Fill
3.5.3	Pervious Fill
3.5.4	Additional Rolling for Compaction
3.5.5	Filter and Transition Drainage Layers
3.5.6	Rock Fill
3.6	UNCOMPACTED FILL
3.7	BACKFILL
3.7.1	General
3.7.2	Placement
3.8	SLIDES
3.9	PIEZOMETERS, SETTLEMENT GAGES AND SURFACE REFERENCE MARKS
3.9.1	Government Installed Piezometers
3.9.2	Location and Installation of Settlement Gages
3.9.3	Surface Reference Marks

-- End of Section Table of Contents --

USACE / NAVFAC / AFCEA / NASA UFGS-35 73 13 (January 2008)

Preparing Activity: USACE Superseding
UFGS-35 73 13 (April 2006)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated July 2011

SECTION 35 73 13

EMBANKMENT FOR EARTH DAMS 01/08

NOTES: This guide specification covers the requirements for preparing the embankment and blanket foundations and placing and compacting all permanent fills and backfills. This section was originally developed for USACE Civil Works projects.

Adhere to UFC 1-300-02 Unified Facilities Guide Specifications (UFGS) Format Standard when editing this guide specification or preparing new project specification sections. Edit this guide specification for project specific requirements by adding, deleting, or revising text. For bracketed items, choose applicable items(s) or insert appropriate information.

Remove information and requirements not required in respective project, whether or not brackets are present.

Comments, suggestions and recommended changes for this guide specification are welcome and should be submitted as a Criteria Change Request (CCR).

PART 1 GENERAL

NOTE: This guide specification provides for furnishing all plant, labor, and equipment, and performing all operations in connection with the installation of settlement gages for the determination of increases in quantities of embankment materials resulting from settlement of the embankment foundation during construction, and for payment to the Contractor for such increases in quantities all in accordance with the contract drawings and these specifications. These provisions will be included in a project specification when it is determined by the Contracting Officer that settlement in the range of 5 percent or more of the

planned embankment height is anticipated over a considerable portion of the embankment foundation area. They will also be used when gages are needed for engineering control purposes. When settlement gages are to be used the following information will be indicated on the plans:

1. The location of the gages as well as the stations at which zero settlement will be assumed.
2. The detail construction of the foundation settlement gages to be used. Any applicable type of gage may be selected by the Contracting Officer.

The requirements for rock as prescribed herein are intended to be used on embankments involving rock fill sections. Where rock for slope protection is specified, Section 35 31 19 STONE, CHANNEL. SHORELINE/COASTAL PROTECTION FOR STRUCTURES should be used.

1.1 UNIT PRICES

NOTE: If Section 01 22 00.00 10 MEASUREMENT AND PAYMENT is included in the project specifications, this paragraph title (UNIT PRICES) should be deleted from this section and the remaining appropriately edited subparagraphs below should be inserted into Section 01 22 00.00 10.

1.1.1 Compacted Fill, Impervious

1.1.1.1 Payment

Payment will be made for costs associated with preparing the foundation of the embankment; spreading, harrowing, sprinkling, compacting, removing objectionable materials; and all other incidental work required for the construction, protection, and maintenance of the embankment. This payment is in addition to any payment for excavating and transporting of the material as specified in Section 31 00 00 EARTHWORK. No separate payment will be made for uncompacted fill and all costs incidental to spreading, protecting, and maintenance of such fill shall be included in the contract price for excavation of the material.

1.1.1.2 Measurement

Compacted fill, impervious, will be measured for payment in place based upon the established limit lines and the payment lines indicated on the cross sections shown or as otherwise established. Limit lines will be established by the volume between the foundation lines as determined on the basis of a survey made from excavation [including the cut-off trench] and accomplishment of foundation preparation (except scarifying) and the lines, grades and slopes of the accepted embankment.

1.1.1.3 Unit of Measure

Unit of measure: cubic meter yard.

1.1.2 Compacted Fill, Pervious

1.1.2.1 Payment

Payment will be made for costs associated with preparing the foundation of the embankment; spreading, harrowing, sprinkling, compacting, removing objectionable materials; and all other incidental work required for the construction, protection, and maintenance of the embankment. This payment is in addition to any payment for excavating and transporting of the material as specified in Section 31 00 00 EARTHWORK. No separate payment will be made for uncompacted fill and all costs incidental to spreading, protecting, and maintenance of such fill shall be included in the contract price for excavation of the material.

1.1.2.2 Measurement

Compacted fill, pervious, will be measured for payment in place based upon the established limit lines and the payment lines indicated on the cross sections shown or as otherwise established. Limit lines will be established by the volume between the foundation lines as determined on the basis of a survey made from excavation [including the cut-off trench]and accomplishment of foundation preparation (except scarifying) and the lines, grades and slopes of the accepted embankment.

1.1.2.3 Unit of Measure

Unit of measure: cubic meter yard.

1.1.3 Compacted Fill, Random

1.1.3.1 Payment

Payment will be made for costs associated with preparing the foundation of the embankment and blanket; spreading, harrowing, sprinkling, compacting, removing objectionable materials; and all other incidental work required for the construction, protection, and maintenance of the embankment. This payment is in addition to any payment for excavating and transporting of the material as specified in Section 31 00 00 EARTHWORK. No separate payment will be made for uncompacted fill and all costs incidental to spreading, protecting, and maintenance of such fill shall be included in the contract price for excavation of the material.

1.1.3.2 Measurement

Compacted fill, random, will be measured for payment in place based upon the established limit lines and the payment lines indicated on the cross sections shown or as otherwise established. Limit lines will be established by the volume between the foundation lines as determined on the basis of a survey made from excavation [including the cut-off trench]and accomplishment of foundation preparation (except scarifying) and the lines, grades and slopes of the accepted embankment.

1.1.3.3 Unit of Measure

Unit of measure: cubic meter yard.

1.1.4 Backfill, Impervious

1.1.4.1 Payment

Payment will be made for costs associated with preparing the foundation or contacting surfaces, and the spreading, compacting, wetting, and all other operations incidental to the placement of the backfill. This payment is in addition to any payment for excavating and transporting of the material as specified in Section 31 00 00 EARTHWORK.

1.1.4.2 Measurement

Backfill, impervious, will be measured for payment in place based upon the established limit lines and the payment lines indicated on the cross sections shown or as otherwise established. Limit lines will be established by the volume between the foundation lines as determined on the basis of a survey made from excavation and accomplishment of foundation preparation (except scarifying) and the lines, grades and slopes of the accepted embankment.

1.1.4.3 Unit of Measure

Unit of measure: cubic meter yard.

1.1.5 Backfill, [Pervious] [Random]

1.1.5.1 Payment

Payment will be made for costs associated with preparing the foundation or contacting surfaces, and the spreading, compacting, wetting, and all other operations incidental to the placement of the backfill. This payment is in addition to any payment for excavating and transporting of the material as specified in Section 31 00 00 EARTHWORK.

1.1.5.2 Measurement

Backfill, [pervious] [random], will be measured for payment in place based upon the established limit lines and the payment lines indicated on the cross sections shown or as otherwise established. Limit lines will be established by the volume between the foundation lines as determined on the basis of a survey made from excavation [including the cut-off trench] and accomplishment of foundation preparation (except scarifying) and the lines, grades and slopes of the accepted embankment.

1.1.5.3 Unit of Measure

Unit of measure: cubic meter yard.

1.1.6 Filters

NOTE: If several classes of material are used, as
in the case of a multi-layer filter, a separate pay
item should be included for each class.

1.1.6.1 Payment

Payment will be made for costs associated with mixing the materials to the required gradation, spreading, compacting, removing objectionable materials, and all other incidental work required for the construction, protection, and maintenance of the filter. This payment is in addition to any payment for transporting of the material as specified in Section 31 00 00 EARTHWORK.

1.1.6.2 Measurement

Filters will be measured for payment in place based upon the established limit lines and the payment lines indicated on the cross sections shown or as otherwise established. Limit lines will be established by the volume between the foundation lines as determined on the basis of a survey made from excavation and accomplishment of foundation preparation (except scarifying) and the lines, grades and slopes of the accepted embankment.

1.1.6.3 Unit of Measure

Unit of measure: cubic meter yard.

1.1.7 Rock Fill

NOTE: If several classes of material are used, as
in the case of a multi-layer filter, a separate pay
item should be included for each class.

1.1.7.1 Payment

Payment will be made for costs associated with rock fill, including all operations with quarrying, stockpiling, hauling, placing, removing objectionable material, and all other operations incidental to the placement of the rock fill.

1.1.7.2 Measurement

Rock fill will be measured for payment in place based upon the established limit lines and the payment lines indicated on the cross sections shown or as otherwise established. Limit lines will be established by the volume between the foundation lines as determined on the basis of a survey made from excavation and accomplishment of foundation preparation (except scarifying) and the lines, grades and slopes of the accepted embankment.

1.1.7.3 Unit of Measure

Unit of measure: cubic meter yard.

1.1.8 [Embankment for Foundation Settlement]

NOTE: Delete this pay item if settlement gages are
not specified.

1.1.8.1 Payment

Payment for costs associated with additional material placed because of foundation settlement will be made at the same contract price as the overlying embankment material.

1.1.8.2 Measurement

NOTE: Delete the bracketed reference to Section
35 73 13 if this paragraph is not moved to Section
01 22 00.00 10.

Embankment for foundation settlement will be measured for payment based upon readings of settlement gages installed under the provisions of [Section 35 73 13 EMBANKMENT FOR EARTH DAMS,]paragraph PIEZOMETERS, SETTLEMENT GAGES, AND SURFACE REFERENCE MARKS, which will be computed as follows:

- a. Zero settlement will be assumed at the upstream and downstream toes of the embankment and at the transverse [line] [lines] indicated on the plans, which separate the zones where settlement gages will govern from the areas where no foundation settlement is anticipated and for which no volumetric adjustment will be made.
- b. A straight line variation will be assumed between individual settlement gages as well as between settlement gages and points of zero settlement.

1.1.8.3 Unit of Measure

Unit of measure: cubic meter yard.

1.1.9 Additional Rolling for Compaction

1.1.9.1 Payment

Payment will be made for costs associated with additional rolling for compaction.

1.1.9.2 Measurement

NOTE: Delete the bracketed reference to Section
35 73 13 if this paragraph is not moved to Section
01 22 00.00 10.

Additional rolling for compaction will be measured for payment on the basis of the number of roller hours the compaction equipment is operated in accomplishing the compaction specified in [Section 35 73 13 EMBANKMENT FOR EARTH DAMS,]paragraph COMPACTION.

1.1.9.3 Unit of Measure

Unit of measure: hour.

1.1.10 Piezometer

1.1.10.1 Payment

NOTE: Delete the bracketed reference to Section
35 73 13 if this paragraph is not moved to Section
01 22 00.00 10.

Payment will be made for costs associated with extending and maintaining the piezometers specified[in Section 35 73 13 EMBANKMENT FOR EARTH DAMS] during construction, including measurements required to be made by the Contractor.

1.1.10.2 Measurement

NOTE: Delete the bracketed reference to Section
35 73 13 if this paragraph is not moved to Section
01 22 00.00 10.

Piezometers will be measured for payment on the basis of the number of piezometers specified[in Section 35 73 13 EMBANKMENT FOR EARTH DAMS].

1.1.10.3 Unit of Measure

Unit of measure: each.

1.1.11 [Settlement Gages]

NOTE: Delete this pay item if settlement gages are
not specified.

1.1.11.1 Payment

NOTE: Delete the bracketed reference to Section
35 73 13 if this paragraph is not moved to Section
01 22 00.00 10.

Payment will be made for costs associated with furnishing, installing, and maintaining the settlement gages during construction as specified[in Section 35 73 13 EMBANKMENT FOR EARTH DAMS], including measurements required to be made by the Contractor.

1.1.11.2 Measurement

NOTE: Delete the bracketed reference to Section
35 73 13 if this paragraph is not moved to Section
01 22 00.00 10.

Settlement gages will be measured for payment on the basis of the number of

gages to be installed as specified[in Section 35 73 13 EMBANKMENT FOR EARTH DAMS].

1.1.11.3 Unit of Measure

Unit of measure: each.

1.1.12 Surface Reference Marks

1.1.12.1 Payment

NOTE: Delete the bracketed reference to Section
35 73 13 if this paragraph is not moved to Section
01 22 00.00 10.

Payment will be made for costs associated with furnishing, installing, and maintaining the surface reference marks during construction as specified[in Section 35 73 13 EMBANKMENT FOR EARTH DAMS], including measurements required to be made by the Contractor.

1.1.12.2 Measurement

NOTE: Delete the bracketed reference to Section
35 73 13 if this paragraph is not moved to Section
01 22 00.00 10.

Surface reference marks will be measured for payment on the basis of the number of marks to be installed as specified[in Section 35 73 13 EMBANKMENT FOR EARTH DAMS].

1.1.12.3 Unit of Measure

Unit of measure: each.

1.1.13 Mortar and Concrete for Foundation Preparation

1.1.13.1 Payment

NOTE: See Section 03 30 53 MISCELLANEOUS
CAST-IN-PLACE CONCRETE, paragraph UNIT PRICES, to
determine the appropriate unit price pay item which
includes cement that should be inserted in this
paragraph.

Delete the bracketed references to Section 35 73 13
if this paragraph is not moved to Section
01 22 00.00 10. Retain the bracketed reference to
Section 03 30 53 if this paragraph is not moved to
Section 01 22 00.00 10.

Payment will be made for costs associated with [manufacturing,]furnishing, delivering, placing, [finishing,]and curing of mortar and concrete for foundation and abutment preparation, except that the cement used in the

mortar or concrete will be measured and paid for as specified in unit price pay item [_____] [in accordance with Section 03 30 53 MISCELLANEOUS CAST-IN-PLACE CONCRETE, paragraph UNIT PRICES]. No separate payment will be made for mortar used in filling open joints and cracks in bedrock surfaces in accordance with [Section 35 73 13 EMBANKMENT FOR EARTH DAMS,]paragraph ROCK.

1.1.13.2 Payment

NOTE: Delete the bracketed references to Section
35 73 13 if this paragraph is not moved to Section
01 22 00.00 10.

Mortar and concrete used in foundation and abutment preparation will be measured for payment in place based upon the established limit lines and the payment lines indicated on the cross sections shown or as otherwise established. Limit lines will be established by the volume between the foundation lines as determined on the basis of a survey made from excavation [including the cut-off trench]and accomplishment of foundation preparation (except scarifying) and the lines, grades and slopes of the accepted embankment. Mortar and concrete used in filling spaces beneath rock overhangs and around protrusions as specified in [Section 35 73 13 EMBANKMENT FOR EARTH DAMS,]paragraph ROCK, will be measured for payment as the actual volumes of such mortar and concrete as determined by field surveys made before and after placement of the mortar and concrete. No measurement will be made for the mortar used in filling the open joints and cracks in the rock surface as specified in [Section 35 73 13 EMBANKMENT FOR EARTH DAMS,]paragraph ROCK.

1.1.13.3 Unit of Measure

Unit of measure: cubic meter yard.

1.2 REFERENCES

NOTE: This paragraph is used to list the
publications cited in the text of the guide
specification. The publications are referred to in
the text by basic designation only and listed in
this paragraph by organization, designation, date,
and title.

Use the Reference Wizard's Check Reference feature
when you add a RID outside of the Section's
Reference Article to automatically place the
reference in the Reference Article. Also use the
Reference Wizard's Check Reference feature to update
the issue dates.

References not used in the text will automatically
be deleted from this section of the project
specification when you choose to reconcile
references in the publish print process.

The publications listed below form a part of this specification to the

extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM D 1556	(2007) Density and Unit Weight of Soil in Place by the Sand-Cone Method
ASTM D 2167	(2008) Density and Unit Weight of Soil in Place by the Rubber Balloon Method
ASTM D 2216	(2010) Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
ASTM D 2487	(2010) Soils for Engineering Purposes (Unified Soil Classification System)
ASTM D 6938	(2010) Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)
ASTM D 698	(2007e1) Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/cu. ft. (600 kN-m/cu. m.))

U.S. ARMY CORPS OF ENGINEERS (USACE)

EM 1110-2-1906	(1986) Laboratory Soils Testing
----------------	---------------------------------

1.3 DEFINITIONS

1.3.1 Embankment

Embankment, as used in these specifications, is defined as the earth [and rock]fill portions of the dam structure and includes all types of earth fill and filter materials for the dam [and cut-off trench,]and all other specified or directed earth and rock fills within the limits of the dam[, excepting those stone and filter materials used for slope protection].

1.3.2 Compacted Fill

Compacted fill includes all fill, except backfill, deposited in layers and compacted by rolling or tamping. The types of compacted earth fill are:

- a. Impervious fill for the [cut-off trench][, horizontal and inclined impervious blankets,][and]impervious section of the embankment;
- b. Random fill adjacent to the impervious section and blankets;
- c. Pervious fill forming the upstream and downstream sections of the embankment, and
- d. Filter drainage layers forming the horizontal [and/or vertical or inclined] pervious drainage blankets[designed to prevent the detrimental movement of soil particles].

1.3.3 Uncompacted Fill

All fill, deposited in layers but not compacted except by the controlled movement of hauling and spreading equipment.

1.3.4 Backfill

Backfill, as used in these specifications, is defined as that excavation refill which cannot be placed around or adjacent to a structure until the structure is completed or until a specified time interval has elapsed after completion.

1.3.5 Spalls

Stone fragments placed as transition between rock fill and[earth fill][filter material].

1.3.6 Rock Fill

Those portions of the embankment where rock is used for purposes other than slope protection.

1.4 SYSTEM DESCRIPTION

1.4.1 Haul Roads

NOTES: Where roads are to be used by other Contractors, the limits of responsibility should be stated in the specifications.

With reference to the coverage in this paragraph, it has been found advantageous to establish a project traffic pattern for jobs of considerable scope and to indicate on the plans acceptable haul road locations and to specify maximum grades and minimum road widths which are considered suitable. Where project operations are varied and the use of haul roads by other Contractors is required, the specifications should so indicate. Detailed requirements for haul roads should be based upon the anticipated length of time the roads will be in use, traffic load and probable types of hauling equipment applicable to the specific project. This paragraph should be modified as necessary to clarify the requirements of the particular project.

Haul roads shall be [located as indicated and][located and] constructed as approved. They shall be designed to maintain the intended traffic, to be free draining and shall be maintained in good condition throughout the contract period, unless otherwise directed. Haul roads within the area of contact between the embankment and its foundation and abutments shall be removed and the area shall be treated as specified in paragraph PREPARATION OF FOUNDATION, PARTIAL FILL SURFACE, AND ABUTMENTS.

1.4.2 Stockpiling from Approved Borrow Sources

When the excavation from approved borrow sources progresses at a faster

rate than placement in the fill is being accomplished, such excavated material shall be stockpiled at approved locations adjacent to the work until its use is authorized. No payment will be made for such stockpiling nor for the reloading and hauling of this material to its final position in the embankment.

PART 2 PRODUCTS

2.1 MATERIALS

**NOTE: This paragraph may be modified to specify
soils for various types of fill in accordance with
the Unified Soil Classification System. When this
is done, the optional sentence should be selected.**

[Classification of soils will be in accordance with [ASTM D 2487](#).]

2.1.1 General

The origin of any fill material in no way determines where it may be used in the embankment. Materials for embankment fills shall be secured from required excavations and from the borrow areas indicated. The intention is to use the most suitable materials obtainable from these sources. Material to be wasted will be specifically designated at the time the material is excavated. Materials containing brush, roots, sod or other perishable materials will not be considered suitable. The suitability of the materials shall be subject to approval and their disposition in the embankment will be as directed. Excavate in the borrow areas in the location determined by the Contracting Officer, whenever such control is necessary to obtain the type of material required for the embankment. Mixing of materials during the excavating process at the borrow area may be required.

2.1.2 Impervious Fill

Material for compacted impervious fill shall consist of [clays, silty clays, or clayey silts] obtained from the designated borrow areas [or required excavation]. Silts and clays containing sand may be used, if such materials are sufficiently impermeable and suitable for compacting with a [tamping] [or] [rubber-tired] roller.

2.1.3 Random Fill

Material for compacted random fill shall consist of any or all types of material which, from the standpoint of compacted stability, are suitable for use in the dam embankment. Soft weathered rock, which breaks up under rolling to form essentially a soil and which compacts without excessive voids, may be used for random fill, if approved.

2.1.4 Pervious Fill

Material for compacted pervious fill shall be clean, free draining sand or sand and gravel obtained from natural deposits [within borrow areas and from designated excavations] [or] [from sources designated]. Particles of material shall be free from any objectionable coating and not more than [____] (____) percent of the material, by weight, shall pass a [0.075 mm No. 200 sieve](#).

2.1.5 Uncompacted Fill

Except as otherwise [indicated or]required, material for uncompacted fill may consist of any or all types of material available from required excavations and designated borrow areas.

2.1.6 Backfill

Backfill shall consist of material of a type and quality conforming to that specified for the contiguous embankment fill material, unless otherwise directed.

2.1.7 Filter Drainage Layers

Filter materials shall be composed of tough, durable particles; shall be reasonably free from thin, flat and elongated pieces; and shall contain no organic matter nor soft, friable particles in quantities considered objectionable by the Contracting Officer. Filter materials shall consist of sand, gravel, or crushed stone, well graded between the limits specified below:

SIEVE SIZE	PERCENT BY WEIGHT PASSING
[_____]	[_____]
[_____]	[_____]
[_____]	[_____]

Gradation of the material shall be determined in accordance with [EM 1110-2-1906](#). All points on individual grading curves obtained from representative samples of filter material shall lie between the boundary limits as defined by smooth curves drawn through the tabulated grading limits plotted on a mechanical analysis diagram. The individual grading curves within these limits shall not exhibit abrupt changes in slope denoting skip grading, scalping of certain sizes or other irregularities which would be detrimental to the proper functioning of the filter.

2.1.8 Rock Fill

2.1.8.1 Rock

Stone classed as "rock" shall be sound; well graded and free draining.[The presence of rock meeting the requirements of slope protection, Section [35 31 19](#) STONE, CHANNEL, SHORELINE/COASTAL PROTECTION FOR STRUCTURES, will not be objectionable.] Rock shall be obtained from required excavation[and from already existing stockpiles][and from designated quarries]. Shales unsuitable for use as rock fill, mudstone and other unsuitable excavated material shall be wasted in designated spoil areas.

2.1.8.2 Spalls

Spalls shall be obtained from the finer materials resulting from rock excavation. The spalls shall be free of clay, silt, sand or debris and shall be composed of durable fragments of stone, reasonably well graded in sizes varying from [_____] as a minimum to [_____] [mm inches](#) as a maximum.[Crushed stone of like sizes and at least equal in quality will be acceptable in lieu of spalls.]

PART 3 EXECUTION

3.1 CONSTRUCTION

3.1.1 Lines and Grades

Construct the embankment to the lines, grades and cross sections indicated, unless otherwise directed. The Government reserves the right to increase or decrease the foundation widths or the embankment slopes or make such other changes in the embankment sections as may be deemed necessary to produce a safe structure. Increases in height of section, made to compensate for shrinkage or consolidation of the embankment material subsequent to the completion of the embankment, will not exceed five (5) percent of the height above the foundation indicated. The end slopes and side slopes of partial fill sections shall not be steeper than [one vertical on [_____] horizontal] [those shown].

3.1.2 Conduct on the Work

Maintain and protect the embankment in a satisfactory condition at all times until final completion and acceptance of all work under the contract. If in the opinion of the Contracting Officer the hauling equipment causes horizontal shears or slick sides, rutting, quaking, heaving, cracking or excessive deformation of the embankment, limit the type, load or travel speed of the hauling equipment on the embankment. Any approved embankment material which is lost in transit or rendered unsuitable after being placed in the embankment and before final acceptance of the work, shall be replaced in a satisfactory manner and no additional payment will be made therefor. Excavate and remove from the embankment any material which the Contracting Officer considers objectionable, dispose of such material, and refill the excavated area as directed, all at no cost to the Government. The Contractor may be required to remove, without additional payment, any embankment material placed outside of prescribed slope lines.

3.2 PREPARATION OF FOUNDATION, PARTIAL FILL SURFACES AND ABUTMENTS

3.2.1 Earth

**NOTE: Require twice as many coverages by the
compaction equipment for the embankment foundation
area as required for adjacent fills.**

After excavation or stripping of the embankment foundation [and excavation of the cut-off trench] to the extent indicated or otherwise required, the sides of stump holes, test pits, and other similar cavities or depressions shall be broken down, where so directed, so as to flatten out the slopes, and the sides of the cut or hole shall be scarified to provide bond between the foundation material and the fill. [The slopes and bottom of the cut-off trench shall be scarified, as directed.] Unless otherwise directed, each depression shall be filled with either pervious, random, or impervious [or rock] material dependent upon the type of material which is to be placed immediately above the foundation. The fill shall be placed in layers, moistened, and compacted in accordance with the applicable provisions of paragraphs PLACEMENT, MOISTURE CONTROL, and COMPACTION. Materials which cannot be compacted by roller equipment because of

inadequate clearances shall be spread in [_____] -mm-inch layers and compacted with power tampers to an extent equal to that of the contiguous embankment fill material. After filling of depressions[and cut-off trench] and immediately prior to placement of compacted fill in any section of the embankment, the foundation of such section shall be loosened thoroughly by scarifying, plowing, discing or harrowing to a minimum depth of 150 mm 6 inches, and the moisture content shall be adjusted to the amount specified in paragraph MOISTURE CONTROL for the appropriate type of material, except in areas where this requirement is waived by the Contracting Officer. After removal of roots or other debris turned up in the process of loosening, the entire surface of the embankment foundation area shall be compacted by [_____] complete coverages of the compaction equipment as specified for the appropriate type of fill. Prior to placement of compacted fill on or against the surfaces of any partial fill section, all soft or loose material, all material containing cracks or gullies, and all material that does not conform with the specified zoning of the embankment shall be removed. The remaining surface of the partial fill shall be loosened by scarifying, plowing, discing or harrowing to a minimum depth of 150 mm 6 inches, and the moisture content shall be adjusted as specified in paragraph MOISTURE CONTROL for the appropriate type of material. The surface of the partial fill section upon which fill is to be placed shall then be compacted as hereinafter specified for the appropriate type of fill. No separate payment will be made for loosening and rolling the foundation area, the abutment area, or the surfaces of partial fill sections, but the entire cost thereof shall be included in the applicable contract price for fill.

3.2.2 Rock

All rock surfaces upon which or against which embankment materials are to be placed shall be cleaned in accordance with the applicable provisions of Section 31 00 00 EARTHWORK. Prior to the placement of embankment material upon or against a rock surface, all open joints and cracks in that surface shall be filled with mortar to the depths cleaned. Those portions of such rock surfaces where, in the opinion of the Contracting Officer, the compaction of the embankment materials cannot be accomplished satisfactorily with power tampers or other specified compaction equipment, shall be filled with mortar or concrete as directed to the extent necessary to permit satisfactory use of the compaction equipment. In no case shall a thin coat of mortar be left on smooth, intact rock surfaces. Large rock overhangs and protrusions shall be removed by the use of pre-splitting or line drilling techniques in such a manner as to minimize damage to the underlying rock, or the spaces beneath overhangs and around protrusions shall be filled with tamped concrete so that satisfactory compaction of embankment materials can be accomplished. Vertical surfaces shall not be more than 1.5 meters 5 feet in height, and benches of sufficient width shall be provided as necessary so that the average slope of any rock face is not steeper than [_____] vertical on [_____] horizontal. Mortar and concrete, including forming as necessary, shall conform with the applicable provisions of Section [03 30 53 MISCELLANEOUS CAST-IN-PLACE CONCRETE] [03 30 00.00 10 CAST-IN-PLACE CONCRETE] [_____] .

3.3 PLACEMENT

3.3.1 General

No fill shall be placed on any part of the embankment foundation until such areas have been inspected and approved. The gradation and distribution of materials throughout the compacted earth fill section of the dam shall be

such that the embankment will be free from lenses, pockets, streaks, and layers of material differing substantially in texture or gradation from surrounding material of the same class. Successive loads of material shall be dumped at locations on the fill as directed or approved. No fill shall be placed upon a frozen surface, nor shall snow, ice, or frozen earth be incorporated in the embankment.

3.3.2 Frozen Material

Embankment shall not be placed on a foundation which contains frozen material, [or which has been subjected to freeze-thaw action]. This prohibition encompasses all foundation types, including the natural ground, all prepared subgrades, whether in an excavation or on an embankment, and all layers of previously placed and compacted earth fill which become the foundations for successive layers of earthfill. All material that freezes or has been subjected to freeze-thaw action during the construction work, or during periods of temporary shutdowns, such as, but not limited to, nights, holidays, weekends, or winter shutdowns or earthwork operations, shall be removed to a depth that is acceptable to the Contracting Officer and replaced with new material. Alternatively, the material shall be thawed, dried, reworked, and recompactd to the specified criteria before additional material is placed. The Contracting Officer will determine when placement of fill shall cease due to cold weather. The Contracting officer may elect to use average daily air temperatures, and/or physical observation of the soils for his determination. Levee embankment material shall not contain frozen clumps of soil, snow, or ice.

3.3.3 Rate of Placement

Unless otherwise directed, the embankment shall be maintained at approximately the same level regardless of the number of types of materials being placed, [except that rock fills and the adjoining filter blankets shall be placed with sufficient lag to prevent mixture of embankment and filter blanket and/or rock materials] [and also excepting that placement of rock fill in the closure section may be delayed until completion of the compacted fill to elevation [_____] meters feet m.s.l.]. The rate of placement of materials in the embankment closure section shall be such that this section will be completed to elevation [_____] meters feet m.s.l. within a period of [_____] calendar days from the authorized date of diversion, but in no event shall the rate of placement in this section be faster than required to construct the embankment to elevation [_____] meters feet m.s.l. within [_____] days from the beginning of fill operations. Subsequent to completion of the embankment closure section to elevation [_____] meters feet m.s.l. and prior to the beginning of topping operations a period of [_____] calendar days shall elapse, unless this provision is waived in writing by the Contracting Officer at the time of construction.

3.3.4 Impervious Fill

Impervious fill shall be placed in the impervious section[, cut-off trench,] [and impervious blanket]. In general, the more impervious materials shall be placed towards the center of the impervious section and the less impervious materials toward the [random] [or] [pervious] sections so that a transition in permeability is effected from the core to the [random] [or] [pervious] sections.

3.3.5 Random Fill

Random fill shall be placed in the random sections of the embankment.

Except as specified below, limits of random sections shown indicate the maximum extent of random material. When approved, pervious material may be substituted for random material in areas where random sections adjoin pervious sections. In general, the more impervious of the random material shall be placed toward the impervious section or blanket and the more pervious of the random material shall be towards the outer edge of the random section so that a transition in permeability is effected from the impervious section to the [pervious section] [outer portions of the embankment]. Where random materials are shown, in the upper portion of the central core, elevation [_____] and above, the more impervious of available random materials shall be placed to the full core lines and no substitution with pervious material shall be made.

3.3.6 Pervious Fill

Pervious fill shall be placed in the pervious sections of the embankment. In general, the pervious sections of embankment shall be placed with the less pervious material near the [random] [impervious] sections of the embankment and the more pervious materials near the outer slopes of the embankment.

3.3.7 Filter Drainage Layers

**NOTE: Where there are vertical or inclined filters
and horizontal filters, a different tolerance may be
indicated for each.**

[Sand filters][, gravel filters,][and][sand and gravel filters] shall be placed in the embankment in the manner described and to the lines and grades indicated. Tolerance of plus or minus [_____] mm inches will be allowed.

3.3.8 Rock

3.3.8.1 Rock Spalls

Spalls [and stones of 300 mm 12 inch maximum size]shall be placed on or against the gravel filter[and on stripped and other areas] where indicated.

3.3.8.2 Rock Fill

The [upstream][,][and][downstream][and rock drain] sections of the embankment shall be constructed of quarry run sizes of durable rock dumped and bulldozed into place in not greater than [_____] mm foot lifts to the lines and grades shown, or as staked in the field, and in such manner as to produce a reasonably well graded mass with the smaller stones adjacent to [the filter material][the core section] and the larger sizes on the outer slopes of the embankment with no objectionable pockets of small stones or clusters of larger stones. The placing shall be supplemented by such hand methods as are required to obtain even surfaces on the outside faces. A tolerance of plus 300 mm 12 inches and minus 150 mm 6 inches from the slope lines and grades shown will be allowed in the finished surfaces of the rock fills, except that the extreme minus tolerance shall not be continuous over an area greater than 20 square meters 200 square feet. All bridging in rock fills shall be broken as well as all slabs and slabby rock. Special care shall be exercised in placing rock fill in all areas within 1 m 3 feet of structures to avoid damage to such structures.

3.3.9 Spreading

After dumping, the materials shall be spread by bulldozers or other approved means in approximately horizontal layers over the entire fill areas. Unless otherwise directed, the thickness of these layers before compaction with tamping type rollers shall not be more than [_____] mm inches for impervious materials nor more than [_____] mm inches for other embankment materials, except backfill which shall be spread in accordance with paragraph BACKFILL. Unless otherwise directed, the thickness of layers before compaction with rubber-tired rollers shall not be more than [_____] mm inches for impervious materials, nor more than [_____] mm inches for other embankment materials except backfill. Pervious fill and filters, including spalls, shall be spread in layers not more than [_____] mm inches in thickness. As soon as practicable after commencement of construction of any section of the embankment, the [central portion thereof] [area adjacent to the inclined or vertical filter drain] shall be raised or crowned with grades not to exceed [_____] percent so that the surface of the fill will drain freely and shall be so maintained throughout construction. If the compacted surface of any layer of material, exclusive of filter material [and rock fill], is determined to be too smooth to bond properly with the succeeding layers, it shall be loosened by harrowing, or by any other approved method, before the succeeding layer is placed. At all times during the dumping and spreading processes, maintain a force of men adequate to remove all roots and debris from all embankment materials and all stones of greater than [_____] mm inches in maximum dimension from impervious materials and greater than [_____] mm inches in maximum dimension from pervious materials, except filters. Stone so removed shall be placed in the outer slopes of the [fill] [rock fill] and the roots and debris shall be removed from the embankment and disposed of in an approved manner. The entire surface of any section of the embankment under construction shall be maintained in such condition that construction equipment can travel on any part of any one section. Ruts in the surface of any layer shall be removed by scarifying before placing and compacting additional material.

3.4 MOISTURE CONTROL

The materials in each layer of the fill shall contain the amount of moisture, within the limits, specified below or as directed, necessary to obtain the specified compaction. Material that is not within the specified limits after compaction shall be reworked, regardless of density.

3.4.1 Impervious Sections

**NOTE: The Contracting Officer will normally use the
test method prescribed by EM 1110-2-1906, LABORATORY
SOILS TESTING.**

The moisture content after compaction shall be as uniform as practicable throughout any one layer of impervious materials. The moisture content after compaction as determined by ASTM D 2216 shall be within the limits of [_____] percentage points above optimum and [_____] percentage points below optimum moisture content. Material that is too wet shall be spread on the embankment and permitted to dry, assisted by discing or harrowing, if necessary, until the moisture content is reduced to an amount within the specified limits. When the material is too dry, the Contractor will be

required to sprinkle each layer on the fill. Harrowing, or other approved methods will be required to work the moisture into the material until a uniform distribution of moisture is obtained. Water applied on a layer of fill shall be accurately controlled in amount so that free water will not appear on the surface during or subsequent to rolling. Should too much water be added to any part of the embankment, so that the material is too wet to obtain the desired compaction, the rolling on that section of the embankment shall be delayed until the moisture content of the material is reduced to an amount within the specified limits. If it is impracticable to obtain the specified moisture content by wetting or drying the material on the fill, the Contractor may be required to prewet or dry back the material at the sources of excavation. If, in the opinion of the Contracting Officer, the top or contact surfaces of the partial fill section become too dry to permit suitable bond between these surfaces and the additional fill to be placed thereon, loosen the dried materials by scarifying or discing to such depths as may be directed; dampen the loosened material to an acceptable moisture content; and compact this layer in accordance with the applicable requirements of paragraph COMPACTION, subparagraph IMPERVIOUS FILL, to densities comparable to the underlying embankment.

3.4.2 Random Sections

The upper and lower limits of moisture content, and the moisture control procedures for random materials shall be the same as that specified for impervious material, or pervious material, dependent upon which of these types it most nearly resembles.

3.4.3 Pervious Section

Pervious material shall be wetted by sprinkling after spreading on the embankment and [the moisture content of each layer shall be maintained at the optimum for compaction] [each layer shall be kept in an approximately saturated condition] during rolling. Prewetting of pervious material at the sources of excavation or borrow will not be required. Sprinkling shall be done with hoses connected to header pipes along the faces of the embankment, by water trucks with pressure spray bars, or by any other approved method. All connections in the water supply system, including the hose connections to the header pipes, shall be watertight. Jets shall not be directed at the embankment with such force that the finer materials will be washed out. The capacities of pumps and sizes of header pipes shall be sufficient to supply the required amount of water at all times.

3.4.4 Filter Drainage Layers

Moisture control of graded gravel filter and bedding layers will not be required and sluicing will not be permitted. Moisture control of filters containing a predominate amount of sand particles will be as required for pervious materials specified in paragraph PERVIOUS SECTION.

3.4.5 Rock Fill

No moisture control will be necessary on rock fills.

3.5 COMPACTION

3.5.1 Equipment

NOTES: With reference to the use of compaction equipment in this paragraph, the following precautions should be noted:

1. Specifications should be written to insure that the type of compaction equipment will be used which, in the judgment of the Contracting Officer, is best suited to obtain the desired compaction of the material being utilized. A requirement should be included in the specifications for the performance evaluation of each type of compaction equipment conforming with the specifications and intended for use by the Contractor at an early stage of embankment construction. This equipment evaluation should be accomplished through analysis of test fill areas that are carefully constructed under representative working conditions with materials and moisture contents as specified. Test fill areas may either be separate or part of the permanent work, and for clarity to prospective bidders, payment under a separate item is recommended to equitably cover costs of required variations in equipment coverages, possible changes in equipment loading or foot sizes, as well as intensified field soils testing.

2. For tamping rollers that are either towed or self-propelled, with drums capable of being ballasted with fluid, the provision for a pressure relief valve and safety head is optional, and should be included at the discretion of the designer based on local experience and practice. Over-pressurization of fluid ballasted compaction drums to the level of a safety hazard has been rare, but has occurred on several occasions at locations of high elevation and temperature.

3. In compacting materials consisting of shales, sandstones, weathered rock and similar random materials, consideration should be given to specifying sheepfoot-type tamping equipment that has been modified by replacing the standard feet with "chisel" point tamper feet generally referred to as "shale breakers". The end areas of these modified tamper feet range from 650 to 1000 square millimeters (1 to 1-1/2 square inches) and tend to break up weathered rock to prevent the bridling effect sometimes created by large rock particles.

4. For compaction of sand and gravel fills or filter and drainage layers, equipment characteristics for both a large and small vibratory roller have been provided for optional selection by the designer, depending upon location, selected lift thickness, gradation, grain shape, and durability properties of the materials. The smaller roller, which utilizes an upper limit of 40 kN/m (9000 lbs. per foot) of drum length applied force, should be specified for materials which exhibit degradation

under compaction. Other options, based on construction experience may also be exercised. For example, it has been found that improved trafficability can often be achieved when compacting clean, fine grained, uniform sands by specifying a drum driven self-propelled vibratory roller.

Compaction equipment shall conform to the following requirements and shall be used as prescribed in subsequent paragraphs.

3.5.1.1 Tamping Rollers

- a. Towed - Tamping rollers shall consist of two or more non-vibratory roller drums mounted side-by-side in a suitable frame and towed by either a crawler-type or rubber tired tractor having sufficient power to pull the roller satisfactorily when the drums are fully ballasted. Each drum shall be free to pivot about an axis parallel to the direction of travel. Rollers operated in tandem sets shall be controlled in a manner such that the prints produced by the tamping feet of the tandem units are staggered. Each drum of a roller shall have an outside diameter of not less than 1.5 m 5 feet and shall be not less than 1.5 m 5 feet in length. The space between two adjacent drums, when on a level surface, shall not be less than 300 mm 12 inches nor more than 375 mm 15 inches.[Each drum ballasted with fluid shall be equipped with at least one pressure-relief valve and with at least one safety head. The safety head shall be equal to union-type safety heads equipped with rupture discs suitable for rupturing pressures between 350 and 500 kPa 50 and 75 psi as manufactured by the Fike Metal Products Corporation, Blue Spring, Missouri. The pressure relief valve is a manually operated valve and shall be opened periodically. Personnel responsible for opening pressure-relief valves shall be periodically instructed to ascertain that valve openings are free from plugging to assure that any pressure developed in roller drums is released at each inspection]. At least one tamping foot shall be provided for each 186 000 square mm 2 square feet of drum surface. The length of each tamping foot from the outside surface of the drum shall be not more than 275 mm 11 inches and shall be maintained at not less than 225 mm 9 inches. The bearing surface of each tamping foot shall be flat with a surface area not less than 4500 square mm 7 square inches nor more than 6500 square mm 10 square inches. During the operation of rolling, the spaces between the tamping feet shall be maintained clear of materials which would impair the effectiveness of the tamping rollers. The weight of a roller when fully loaded shall be not less than 58 400 N/m 4,000 pounds per foot of drum length, and the weight of a roller empty shall be not more than 36 500 N/m 2,500 pounds per foot of drum length. The bearing surface, tamping foot size, the drum loading, and the operation of the rollers shall be as required to obtain the desired compaction. If more than one roller is used on any one layer of fill, all rollers so used shall be of the same type and essentially of the same dimensions. Rollers shall be drawn by crawler-type or rubber-tired tractors at a speed not to exceed 8 km/h 5.0 mph. The use of rubber-tired towing equipment shall be discontinued if the tires leave ruts that prevent uniform compaction by the tamping roller, and the substitution of crawler-type towing equipment may be directed.
- b. Self-propelled - The use of self-propelled non-vibratory tamping rollers conforming with the following specification will be permitted,

and their design and operation shall be subject to approval , and subject to the right, at any time during the prosecution of the work, to direct such modifications to the tamping feet or variations in roller drum weight where applicable, as may be found necessary to secure optimum compaction of the earth fill materials. If use of self-propelled tamping rollers causes shearing of the fill, laminations in the fill, or results in inadequate compaction, the Contracting Officer may direct that such rollers be removed from the fill and that appropriate towed tamping rollers be used. Two-or three-drum side-by-side units that are either in drive position or drawn by separate power equipment shall have a clearance between adjacent drums not less than 300 mm 12 inches nor more than 375 mm 15 inches. Two-drum or four-drum equipment separated by cab and differential and arranged in tandem must have its static weight equally distributed to all compaction drums and must have the tandem drums positioned such that the prints of the tamping feet produced by the tandem drums are staggered. The surface on which the tamping feet are mounted shall have a minimum outside diameter of 1200 mm 4 feet and at least one tamping foot for each 186 000 square mm 2 square feet of drum surface. The distance between the centers of any two adjacent tamping feet shall be not less than 225 mm 9 inches. The length of each tamping foot from the outside mounting surface of the drum shall be not more than 275 mm 11 inches and shall be maintained at not less than 225 mm 9 inches. The bearing surface of each tamping foot shall be flat and have a surface area not less than 4500 square mm 7 square inches nor more than 9000 square mm 14 square inches. Cupped recesses within the bearing surface of each tamping foot will be permitted but shall not exceed 13 mm 0.5 inches in depth. During rolling operations, the spaces between the tamping feet shall be maintained clear of materials which would impair the effectiveness of the tamping roller. The weight of all roller drums during compaction of fill materials shall be maintained uniform and with the weight per foot of drum length not less than 62 800 N 4,300 pounds. [For self-propelled rollers with drums capable of being ballasted with fluid, each drum shall be equipped with at least one pressure-relief valve and with at least one safety head. The safety head shall be equal to union type safety heads equipped with rupture discs suitable for rupturing pressures between 350 and 500 kPa 50 and 75 psi as manufactured by the Fike Metal Products Corporation, Blue Springs, Missouri. The pressure relief valve is a manually operated valve and shall be opened periodically. Personnel responsible for opening pressure-relief valves shall be periodically instructed to ascertain that valve openings are free from plugging to assure that any pressure developed in roller drums is released at each inspection.] For self-propelled rollers in which steering is accomplished through the use of rubber-tired wheels, the tire pressure shall not exceed 275 kPa 40 psi. The use of the compactor shall be discontinued if the tires leave ruts that prevent uniform compaction by the tamping roller and the substitution of appropriate towed tamping rollers may be directed. When a self-propelled roller is provided with a dozer blade, coverages made with the blade in operation shall not be counted as compaction coverages. Self-propelled rollers shall be operated at a speed not to exceed 8 km/h 5.0 mph.

3.5.1.2 Vibratory Rollers

Vibratory rollers for compacting rock fills, pervious sand and gravel fills, or filter and transition drainage layers shall be equipped with a smooth steel compaction drum and shall be operated at a frequency of vibration during compaction operations between 1100 and 1500 vpm.

Vibratory rollers may be either towed or self-propelled and shall have an unsprung drum weight that is a minimum of 60 percent of the rollers' static weight. Towed rollers shall have at least 90 percent of their weight transmitted to the ground through the compaction drum when the roller is standing in a level position hitched to the towing vehicle. Rollers for compacting rock fill, [sand and gravel fills, or filter and drainage layers] shall have a minimum static weight of 90 kN 20,000 pounds, a minimum dynamic force of 180 kN 40,000 pounds when operating at 1400 vpm, and an applied force not less than 130 kN/m 9,000 pounds per foot of compaction drum length. [Rollers for compacting sand and gravel fills or filter and drainage layers shall have a minimum static weight of 36 kN 8,000 pounds, a minimum dynamic force of 71 kN 16,000 pounds when operating at 1400 vpm, and an applied force not less than 22 kN 5,000 pounds nor greater than 130 kN/m 9,000 pounds per foot of compaction drum length.] The level of amplitude and vibration frequency during compaction will be maintained uniform throughout the embankment zone within which it is operating. Rollers shall be operated at speeds not to exceed 2.4 km/h 1.5 mph. The equipment manufacturer shall furnish sufficient data, drawings, and computation for verification of the above specifications, and the character and efficiency of this equipment shall be subject to approval.

3.5.1.3 Rubber-tired Rollers

Rubber-tired rollers shall have a minimum of four wheels equipped with pneumatic tires. The tires shall be of such size and ply as can be maintained at tire pressures between 550 and 700 kPa 80 and 100 psi for a 110 kN 25,000 pound wheel load during rolling operations. The roller wheels shall be located abreast and be so designed that each wheel will carry approximately equal load in traversing uneven ground. The spacing of the wheels will be such that the distance between the nearest edges of adjacent tires will be greater than 50 percent of the tire width of a single tire at the operating pressure for a 110 kN 25,000 pound wheel load. The roller shall be provided with a body suitable for ballast loading such that the load per wheel may be varied, from 80 to 110 kN 18,000 to 25,000 pounds. The roller shall be towed at speeds not to exceed 8 km/h 5 mph. The character and efficiency of this equipment shall be subject to approval.

3.5.1.4 Power Tampers

Compaction of material, in areas where it is impracticable to use a roller or tractor, as provided in paragraph EARTH, shall be performed by the use of approved power tampers.

3.5.2 Impervious and Random Fill

After a layer of impervious or random fill material has been dumped and spread, it shall be harrowed if required, to break up and blend the fill materials, unless harrowing, as specified under paragraph IMPERVIOUS SECTIONS, is performed to obtain uniform moisture distribution. Harrowing shall be performed with a heavy disc plow, or other approved harrow, to the full depth of the layer. If one pass of the harrow does not accomplish the breaking up and blending of the materials, additional passes of the harrow may be required, but in no case will more than three passes of the harrow on any one layer be required for this purpose. When the moisture content and the condition of the layer is satisfactory, the lift shall be compacted [to at least [_____] percent of maximum density as determined by ASTM D 698, prior to placement of the next layer. Determination of in-place density shall be in accordance with ASTM D 1556, ASTM D 2167, and ASTM D 6938.] [by

[not less than][[_____] complete coverages of the tampering roller][[_____] complete coverages of the rubber-tired roller].][A complete coverage shall consist of the coverage of the entire lift to be compacted with the roller specified.][A complete coverage shall consist of the application of compactive effort to the entire lift to be compacted with a single roller drum having the characteristics as specified in paragraph SELF-PROPELLED. The use of four-drum self-propelled equipment that is laterally separated by operator's cab and differential may be used; however, two complete coverages of the lift to be compacted will be achieved by a subsequent offset trip of the roller for coverage of the previously uncompacted central portion of the roller path.] Portions of the fill which are not accessible to the roller shall be placed in [_____] mm inch layers loose measurement and compacted with power tampers to a degree equal to that obtained on the other portions of the compacted fill by rolling as specified. Dumping, spreading, sprinkling, and compacting may be performed at the same time at different points along a section when there is sufficient area to permit these operations to proceed simultaneously.

3.5.3 Pervious Fill

After each layer of pervious material has been dumped and spread, and the moisture content is in accordance with the provisions of paragraph PERVIOUS SECTION, the entire surface of the layer shall be compacted [to an average of [_____] percent minimum relative density][by not less than [_____] complete coverages of [the rubber-tired roller][the vibratory roller]].

3.5.4 Additional Rolling for Compaction

If, in the opinion of the Contracting Officer, the desired compaction of any portion of the embankment is not secured by the minimum number of coverages specified, additional complete coverages shall be made over the surface area of such designated portion until the desired compaction has been obtained.

3.5.5 Filter and Transition Drainage Layers

The requirements for compacted pervious fills will apply to these materials except for bedding layers under dumped riprap. Bedding layers under dumped riprap will require no special compaction other than controlled movement of dumping and spreading equipment.

3.5.6 Rock Fill

After the rock fill has been dumped and spread to the thickness specified, the entire surface of the layer shall be compacted by not less than [_____] complete coverages of the vibratory roller specified in paragraph VIBRATORY ROLLERS. A complete coverage shall consist of the entire coverage of the area with one trip of the equipment specified. Each trip of the roller shall overlap the adjacent trip not less than [_____] mm feet.

3.6 UNCOMPACTED FILL

Material from required excavations and from the designated borrow areas shall be placed in the berms upstream and downstream from the dam embankment, as indicated or otherwise required. The fill shall be dumped and spread in horizontal layers not to exceed [_____] mm inches in thickness. Compaction other than that obtained by the controlled movement of the hauling and spreading equipment over the area will not be required.

3.7 BACKFILL

3.7.1 General

No backfill or other load shall be placed on or against concrete surfaces before expiration of the minimum period after placing the concrete as indicated below:

Walls and Vertical Faces	[_____] days
Conduit	[_____] days

Subsequent to [_____] days but prior to [_____] days after placing concrete in the conduit, backfill operations may be initiated but no rolling or hauling equipment will be permitted to pass over the conduit, or within 600 mm 2 feet of any part of the conduit. During this period, backfill may be placed against the sides of the conduit and conduit collars and to a thickness of not more than 600 mm 2 feet over the top of the conduit, if compaction is accomplished by power tampers as specified in paragraph POWER TAMPERS. Before passage of hauling and rolling equipment over the top of the conduit or other structure will be permitted, the depth of fill over the concrete shall be sufficient to permit such passage without inducing harmful stresses or vibrations in the structure.

3.7.2 Placement

Backfill shall be placed in [_____] mm inch layers and thoroughly compacted. Unless otherwise directed, the placing and compacting of all backfill material and the control of its moisture content shall conform to the applicable provisions of paragraphs PLACEMENT, MOISTURE CONTROL, and COMPACTION. Fill in back of wing walls shall be kept at approximately the same elevations as that of the backfill, gravel blankets, riprap, or derrick stone on the opposite side of the wall until placement has reached the maximum elevation of the materials to be placed on the toe of the wall. Drainage openings through walls shall be kept open at all times.

3.8 SLIDES

In the event of slides, in any part of the embankment prior to final acceptance of the work, remove material from the slide area, as directed, and rebuild such portion of the embankment. In case it is determined that the slide was caused through the fault of the Contractor, the removal and disposal of material and the rebuilding of the embankment shall be performed without cost to the Government; otherwise this work will be paid for at the applicable contract unit prices for borrow excavation and compacted fill or backfill.

3.9 PIEZOMETERS, SETTLEMENT GAGES AND SURFACE REFERENCE MARKS

3.9.1 Government Installed Piezometers

A number of piezometers will be installed on the embankment foundations by the Government with its own forces. Connections and extensions of riser pipes shall be made by the Contractor with materials furnished by the Government. The elevation of the top of the riser pipe shall be determined immediately before and immediately after each extension is added to the pipe. The top of such pipes shall be kept at least 600 mm 2 feet above the

embankment surface. During construction, a mound of fill shall be placed around the riser pipes and shall be compacted to the same density and moisture content as the surrounding fill material. Conduct the required operations in such a manner that the devices will not be damaged. Suitable markers and guard posts shall be placed around the gages for protection. No separate payment will be made for such protection or for special measures required in connection with the installation of these devices; all costs thereof shall be included in the contract prices bid for related items of work.

3.9.2 Location and Installation of Settlement Gages

Furnish and install settlement gages for determining foundation settlement during construction. Type, arrangement and location of gages shall be as shown. The areas in which adjustment in quantities will be made as a result of foundation settlement are as indicated on the plans. The base plate shall be placed on a level surface of well compacted foundation material. Determine the elevations of the base plates before placing fill material and again within 48 hours after completion of the embankment. The elevation of the stem shall be determined immediately before and immediately after each extension is added. These elevations will be verified by the Contracting Officer. Care shall be taken to install the stem plumb. Extend the stem in increments as the embankment rises but at no time shall the top of the stem be lower than 600 mm 2 feet above the surface of the embankment. Conduct these operations in such a manner that the gages will not be damaged. Suitable guard posts shall be placed around the gages for protection. Fill around the stem shall be compacted to the same density and moisture content as the surrounding material. Any settlement gage damaged or destroyed due to fault or negligence shall be restored or replaced at no additional cost to the Government. No additional payment will be made for compaction of fill around and over the settlement gages or for interference with the Contractor's operations resulting from the settlement gage installations.

3.9.3 Surface Reference Marks

Furnish and install surface reference marks as shown. Furnish the horizontal and vertical location of each reference mark with respect to established bench marks at the time of installation, and every [_____] calendar days thereafter until completion of the contract. Conduct these operations in such a manner that the reference marks will not be disturbed or damaged. Any reference mark disturbed or damaged due to negligence on the Contractor's part shall be replaced or repaired and the correct horizontal and vertical locations shall be furnished at the Contractor's expense.

-- End of Section --