

## SECTION 102 - LEVEE CONSTRUCTION

### PART 1 GENERAL

#### 1.1 REFERENCES

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 C 33	(2003) Concrete Aggregates
ASTM C 150	(2007) Standard Specification for Portland Cement
ASTM C 260	(2006) Standard Specification for Air-Entraining Admixtures for Concrete
ASTM C 618	(2005) Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
ASTM D 1556	(2000) Density and Unit Weight of Soil in Place by the Sand-Cone Method
ASTM D 2167	(1994; R 2001) Density and Unit Weight of Soil in Place by the Rubber Balloon Method
ASTM D 2216	(2005) Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
ASTM D 2487	(2000) Soils for Engineering Purposes (Unified Soil Classification System)
ASTM D 2922	(2004) Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth)
ASTM D 3017	(2004) Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth)
ASTM D 422	(1963; R 2002) Particle-Size Analysis of Soils
ASTM D 4253	(2000) Maximum Index Density and Unit Weight of Soils Using a Vibratory Table

ASTM D 4254	(2000) Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density
ASTM D 4318	(2000) Liquid Limit, Plastic Limit and Plasticity Index of Soils
ASTM D 4643	(2000) Determination of Water (Moisture) Content of Soil by the Microwave Oven Method
ASTM D 698	(2000a <sup>el</sup> ) Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/cu. ft.)

## 1.2 DEFINITIONS

### 1.2.1 Clearing

Clearing shall consist of the removal and satisfactory disposal of all above ground and below ground trees, downed timber, snags, slash, brush, garbage, trash, debris, fencing, and other items occurring in the designated areas to be cleared.

### 1.2.2 Grubbing

Grubbing shall consist of the removal and satisfactory disposal of stumps, roots larger than 3 inches in diameter, and matted roots from the designated grubbing areas. Grubbing also includes filling of holes from the grubbing operation.

### 1.2.3 Stripping

Stripping shall consist of the removal and satisfactory disposal of crops, weeds, grass, and other vegetative materials to the ground surface and topsoil to a minimum depth of 4 inches or as required.

### 1.2.4 Satisfactory Materials

Satisfactory materials shall consist of materials classified in accordance with ASTM D 2487 as CL, CH (with PI<30), CL-ML, ML, SC, SP, SW and SM free from: roots and other organic matter; contamination from hazardous, toxic or radiological substances; trash, debris; and frozen materials. Not all satisfactory materials can be used in the levee. Only the satisfactory materials stated above, meeting the additional or modified requirements of paragraph TYPES OF FILL MATERIALS, can be used for levee construction.

### 1.2.5 Unsatisfactory Materials

Unsatisfactory materials shall not be used in any levee or other required fill. Unsatisfactory materials includes all other materials that are not defined above as satisfactory materials.

### 1.2.6 Embankment

The terms “levee” or “embankment” as used in these specifications are defined as the earth and rock fill portions of the levee structure or other fills related to the levee structure, including and includes all types of earth fill for the levee and all other fills within the limits of the levee critical zone (500 feet landward and 300 feet riverward of the levee centerline).

### 1.2.7 Backfill

Backfill as used in this section is defined as that fill material 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.

### 1.2.8 Excavation

Excavation shall consist of removal of material to the lines and grades shown on the drawings, or as otherwise directed or approved by the City Engineer and as described in paragraph EXCAVATION in PART 3 EXECUTION.

### 1.2.9 Classification of Soils

Materials used to construct the embankments and for backfills shall be classified in accordance with ASTM D 2487 (Unified Soil Classification System). Cohesionless materials shall include materials classified in ASTM D 2487 as GW, GP, SW and SP. Cohesive materials include materials classified as SC, ML, CL and CH (with  $PI < 30$ ). Materials classified as SM will be identified as cohesionless only when the fines are nonplastic.

### 1.2.10 Degree of Compaction

#### 1.2.10.1 Cohesive Material

Degree of compaction shall be expressed as a percentage of the maximum density obtained by the test procedure presented in ASTM D 698, abbreviated hereinafter as percent laboratory maximum density.

#### 1.2.10.2 Cohesionless Material

Degree of compaction shall be expressed as percentage of the relative density in accordance with ASTM D 4253 and ASTM D 4254.

### 1.3 Submittals

Submit a written excavation plan 15 days prior to the beginning of any excavation. Approval of the detailed plan shall be obtained from the City Engineer prior to starting the work. If necessary, the plan shall be modified as required to meet field

conditions, and modifications shall be approved prior to use. As a minimum, the plan shall contain the following:

- a. Proposed methods for preventing interference with, or damage to, existing underground or overhead utility lines, trees designated to remain and other man-made facilities or natural features designated to remain within or adjacent to the construction rights-of-way.
- b. Provision for coordinating the work with other Contractors working in the construction rights-of-way or on facilities crossing or adjacent to this work.
- c. The proposed methods for controlling surface and ground water in the borrow areas and required excavations.
- d. Stockpiling plan for embankment material before it is transported to the project site showing locations, stockpile heights, slopes, limits, and drainage around the stockpile areas.
- e. A complete listing of equipment used for excavation and to transport the excavated material.
- f. The Contractor's proposed sequence of work for excavating the borrow areas with plan and cross sectional views showing starting and final work locations and clearing, grubbing and stripping limits.
- g. The Contractor's proposals for conserving arable land and for making optimum use of available borrow, including the Contractor's proposed methods for grading the bottom of the borrow areas after completing use of the borrow areas.
- h. The Contractor's proposed road pattern, and plan for implementing dust control measures.
- i. Bracing and shoring plan, with proposed design in areas constrained by existing utilities or other features.

#### Borrow Areas

Submit a written statement to the Government not later than 15 days after receipt of Notice to Proceed indicating the Contractor's intention to use the specified borrow area(s).

#### Plan of Operations

Fifteen (15) days prior to commencement of haul road construction or placing embankment and backfill whichever is earlier, the Contractor shall submit for approval a Plan of Operations for accomplishing all embankment and backfill

construction and for the location and construction of haul roads. This plan shall include but not be limited to the Contractor's proposed sequence of construction for embankment and backfill items, and methods and types of equipment to be utilized for all embankment and backfill operations, including transporting, placing and compaction. This plan shall also include the names and addresses of the commercial testing labs which will perform the soil testing and inspection and describe how all required soils testing will be performed.

#### Embankment and Backfill Materials

At least fifteen (15) days prior to delivery of any Contractor-furnished material to the site of the work, the Contractor shall submit soil classification test results, moisture-density curves, gradation curves, and laboratory results of the required tests of the proposed material.

### 1.4 SYSTEM DESCRIPTION

The work covered by this section consists of furnishing all equipment, labor, materials and incidentals, and performing all operations necessary for the clearing, grubbing, and stripping of the areas specified herein, indicated on the drawings, or necessary for completion of the work shown on the drawings, and for the removal and disposal of cleared, grubbed and stripped materials, and refilling of holes resulting from grubbing; excavation of borrow areas and existing levees, and for all other excavations incidental to the construction of levee, channels, ditches, structures, and ponding areas as specified and shown; foundation preparation and the construction of levee embankments, including new levee, enlargement of existing levee, backfill of inspection trenches, cutoff trenches, berms, road crossings, backfill at drainage structures, and other incidental earthwork as may be necessary to complete the levee as specified.

### 1.5 GENERAL CONDITIONS

#### 1.5.1 Lines and Grades

The embankment and backfill shall be constructed to the lines, grades, and cross sections indicated on the drawings, unless otherwise directed by the City Engineer. The City reserves the right to increase or decrease the foundation widths and embankment slopes or to make such other changes in the embankment or backfill sections as may be deemed necessary to produce a safe structure. Increases in height of section, made to compensate for settlement or consolidation of the embankment material subsequent to the completion of the embankment, will not exceed 5 percent of the height above the foundation at the levee centerline indicated. The end slopes and side slopes of partial fill sections shall not be steeper than one vertical on 3 horizontal unless otherwise noted.

### 1.5.2 Conduct of the Work

The Contractor shall maintain and protect the embankment and backfill in a satisfactory condition at all times until completion and acceptance of all work under the Contract. If, in the opinion of the City Engineer, the hauling equipment causes horizontal shear planes or slicken sides, rutting, quaking, heaving, cracking, or excessive deformation of the embankment or backfill, the Contractor shall limit the type, load, or travel speed of the hauling equipment on the embankment or backfill. The Contractor may be required to remove, at his own expense, any embankment material placed outside of prescribed slope lines. Any approved embankment or backfill material which is lost in transit or rendered unsuitable after being placed in the embankment or backfill and before final acceptance of the work shall be replaced by the Contractor in a satisfactory manner and no additional payment will be made therefore. The Contractor shall excavate and remove from the embankment or backfill any material which is unsatisfactory and shall also dispose of such material and refill the excavated area as directed, all at no cost to the City.

### 1.5.3 Embankment and Backfill Materials

Materials for embankment and backfill construction will be obtained from the borrow sources and required excavation. Materials obtained from the required excavation which meet or which can be processed to meet the requirements for each embankment material, or any other material required for this project, as specified herein, may be utilized in the appropriate zone of the embankment or as backfill. All roots, limbs, and wood fragments shall be removed from embankment materials. Materials containing sod, other organic or perishable material, trash, debris, and frozen materials shall not be used in the embankment. The Contractor shall submit to the City Engineer the source or sources from which he intends to obtain materials for embankment construction. If a source is selected other than a commercial quarry or other commercial entity from which earth or rock material will be directly purchased and where the Contractor or his subcontractor will perform the borrow excavation, a written statement will be provided to the City Engineer indicating permission to utilize the area. It shall be the responsibility of the Contractor to obtain Federal, State, and local permits which may be required for excavation and reclamation of the borrow area. A copy of the plan and procedures to be utilized for reclamation shall be furnished to the City Engineer. The City Engineer will require material samples from any proposed borrow source to be submitted as indicated in paragraph Quality Control.

### 1.5.6 Stockpiling

Any on-site stockpiling of embankment materials shall be in accordance with paragraph STOCKPILES. No payment will be made for such stockpiling nor for the reloading and hauling of these materials to their final position.

### 1.5.7 Slide and Foundation Failures

When sliding occurs in any part of the embankment and backfills prescribed in this section after they have been placed, but prior to final acceptance of all work under the contract, the

Contractor shall repair and slide as directed by the City Engineer. When the slide is caused through the fault of the Contractor, the repair shall be made at no cost to the City. When the slide is not the fault of the Contractor, an equitable adjustment in the contract price shall be made pursuant to the Contract Clause CHANGES to cover the cost of repairs.

#### 1.5.8 Drainage Requirements

The Contractor shall not block or restrict the flow in a natural drain, existing culvert, ditch or channel at any time without obtaining prior written approval from the City Engineer. This approval shall not relieve the Contractor from responsibility for any damage caused by his operation. The Contractor shall monitor the river or stream flow and provide sufficient free discharge areas so that conditions are not worsened upstream or downstream by possible floods during construction. Surface water shall be directed away from excavations and construction sites so as to prevent erosion and undermining of foundations. Diversion ditches, dikes, and grading shall be provided and maintained as necessary during construction. Excavated slopes and backfill surfaces shall be protected to prevent erosion and sloughing. Excavation shall be performed so that the site and the area immediately surrounding the site and affecting operations at the site shall be continually and effectively drained. If private property is to be used for drainage, submit written evidence that the right has been obtained from the property owner for drainage on his property.

#### 1.5.9 Historical, Archeological and Cultural Resources

Historical, archeological, and cultural resources within the Contractor's work limits may exist. If, during construction activities, the Contractor observes items that may have historical or archeological value, such observations shall be reported immediately to the City Engineer so that appropriate authorities may be notified and a determination made as to their significance and what, if any, special disposition of the finds should be made. The Contractor shall cease all activities that may result in the destruction of these resources and shall prevent his employees from trespassing or otherwise damaging such resources.

## PART 2 PRODUCTS

### 2.1 HAUL ROAD MATERIALS

Haul Roads may be constructed of any material approved by the City Engineer.

### 2.2 TYPES OF FILL MATERIALS

#### 2.2.1 Select Fill

The select fill material shall consist of satisfactory materials classified in accordance with ASTM D 2487 as CL and ML.

### 2.2.2 Impervious Fill

This material shall consist of satisfactory impervious material classified as low plasticity clay (CL), high plasticity clay (CH) with PI < 30, low plasticity silt (ML), and borderline clay and silt (CL-ML) in accordance with ASTM D 2487.

### 2.2.3 Random Fill

Random fill shall consist of any satisfactory materials other than those classified in ASTM D 2487 as Organic or Peat. Random fill may consist of select fill, impervious fill and pervious fill or a combination of them.

### 2.2.5 Topsoil

Topsoil consists of organic soil and shall be placed on the levee slopes as shown on the contract drawings and as specified in Section SEEDING.

## PART 3 EXECUTION

### 3.1 Clearing

Clearing shall be accomplished within the limits of existing ground to receive embankment and structures, together with strips 5 feet wide, beyond and contiguous thereto, existing levees to be degraded, ponding areas, ditches, structures, traverses, channels, riprap, revetment, borrow areas and ramps. Trees, downed timber, snags, slash, brush, garbage, trash, debris, fencing and other items shall be cleared flush with the existing ground surface. Trees and vegetation designated to be left standing or to remain shall be protected from damage from construction operations. Clearing of borrow areas shall be limited to the minimum area required for construction operations.

### 3.2 GRUBBING

Grubbing shall be accomplished within the limits of existing ground to receive embankment and structures, together with strips 5 feet wide, beyond and contiguous thereto, existing levees to be degraded, ponding areas and ramps. Grubbing shall be accomplished to a depth of at least 3 feet below the existing ground surface. All holes caused by grubbing operations and removal of pipes and drains, excluding holes in borrow areas, channels and ditches shall be filled with satisfactory material as specified in paragraph PLACEMENT AND SPREADING. This material shall be placed in 8 inch maximum layers to the elevation of the adjacent ground surface and each layer compacted to a density at least equal to that of the adjoining undisturbed material.

### 3.3 STRIPPING

The entire area within the limits of existing ground to receive embankment and structures, together with strips 5 feet wide, beyond and contiguous thereto, existing levees to be degraded, ponding areas, and ditches shown on the drawing shall be stripped to remove crops, weeds, grass, and other vegetative materials to be the ground surface and topsoil to a depth of 4 inches maximum.

### 3.4 DISPOSITION OF CLEARED, GRUBBED AND STRIPPED MATERIAL

Except as otherwise specified or indicated on the drawings, all materials resulting from clearing and grubbing operations shall be disposed of by removal from the site. In no case shall any material resulting from clearing and grubbing operations be buried or permanently placed within the levee foundation or any structural foundation. The topsoil material resulting from the stripping operations shall be temporarily stockpiled.

### 3.5 DEWATERING AND DIVERSION

Surface and groundwater control shall be accomplished in coordination with the required excavation and embankment construction. Surface and/or groundwater control may necessitate the use of temporary diversion ditches, cofferdams and/or dewatering by the use of pumping. Methods for care of surface water and for controlling the surface and groundwater levels shall be subject to approval of the City Engineer.

### 3.6 EXCAVATION

Excavation shall consist of removal of material in preparing the foundations to the lines and grades shown on the drawings, removal of objectionable materials and obtaining required fill materials from the borrow areas. Blasting will not be permitted. Over excavation shall be backfilled to grade with similar over excavated material or satisfactory material and compacted to a density of at least that of the surrounding material.

#### 3.6.1 Over Excavation

##### 3.6.1.1 Outside Limits of Levee Foundation or Structures

Over excavation outside the limits of the foundations of levees or structures shall be backfilled to grade with similar over excavated material or satisfactory material and compacted to a density of at least that of the surrounding material.

#### 3.6.2 Slopes and Surcharges

Temporary excavation slopes for any channel, structure excavation, or other required excavation shall not be steeper than the specified finished slope or the specified construction slope, as applicable, and subject to the approval of the City Engineer. This may be accomplished by benching the temporary slope so that the average slope is not steeper than the

specified slope. In addition, no temporary, permanent, or construction slope shall be surcharged with excavated or stockpiled material or with heavy construction equipment which would have the same effect as the surcharge material. The toe of stockpiled material shall be maintained a minimum distance back from the top of the finished excavation equal to the depth of the excavation. The maximum height of such stockpile without causing instability of the excavation slope shall be determined by the Contractor. Any slide or other adverse conditions caused by failure of the Contractor to maintain these conditions shall be considered the responsibility of the Contractor and remedial measure shall be at the Contractor's expense.

### 3.7 TOLERANCES

All embankments and backfills shall be constructed to the grades, lines and cross-sections shown on the drawings. At all points a tolerance of 1 inch above or below the prescribed grade will be permitted in the final dressing, provided that any excess material is so distributed that the crown of the levee drains and that there are no abrupt humps or depressions in any surfaces. For topsoil, a tolerance of 3 inches above the thickness as shown on the drawings will be permitted.

### 3.8 SLIDES

In case sliding occurs in any part of the excavations prescribed in this section after they have been excavated, but prior to final acceptance of all work under the contract, the Contractor shall repair the slide as directed by the City Engineer. In case the slide is caused through the fault of the Contractor, it shall be repaired at no cost to the City. In case the slide is due to no fault of the Contractor, an equitable adjustment in the contract price will be made for the repairs in accordance with the Contract Clause CHANGES.

### 3.9 STOCKPILES

Provisions of paragraph SLOPES AND SURCHARGES are applicable to all stockpiled materials. Upon completion of construction operations, all remaining stockpiled material shall be removed and disposed of by the disposal methods specified in paragraph DISPOSITION OF EXCAVATED MATERIALS.

### 3.10 SURFACE DRAINAGE OF COMPLETED AREAS

The areas shown on the drawings designated as "GRADE FOR SURFACE DRAINAGE," the borrow areas, the finished embankment, and all areas disturbed by construction shall be graded to the lines and grades shown on the drawings. The surface shall be free from sharp ridges, gullies, potholes, sinkholes and any other surface irregularities. A tolerance of 1 inch above or below the prescribed grade will be allowed provided that the surface drains in the direction as indicated on the drawings.

### 3.11 DISPOSITION OF EXCAVATED MATERIALS

#### 3.11.1 Satisfactory Materials

Satisfactory excavated material shall be incorporated in the appropriate zones of the embankment. Satisfactory material shall consist of material as defined in paragraph DEFINITIONS, subparagraph SATISFACTORY MATERIALS. When direct placement is not practicable, satisfactory material from the excavation shall be stockpiled for subsequent use in parts of the work for which it is specified herein and/or as indicated on the drawings. Satisfactory materials in excess of the quantity necessary to construct backfills and embankments shall be disposed of as specified for unsatisfactory materials.

#### 3.11.2 Unsatisfactory Materials

Unsatisfactory materials shall be as defined in paragraph DEFINITIONS, subparagraph UNSATISFACTORY MATERIALS. Unsatisfactory materials from the excavations prescribed in this section shall be permanently disposed of by removal from the site to a Contractor-furnished disposal area. No additional payment will be made for Contractor-furnished disposal areas.

### 3.12 PREPARATION OF FOUNDATION, PARTIAL FILL SURFACES AND ABUTMENTS

#### 3.12.1 Benching

Benching into existing levee embankment and abutments is required in order to place and compact the material in horizontal layers. The vertical face cut into the existing embankment or abutment resulting from the benching operation shall be a minimum of 4 inches in height but shall not exceed 12 inches in height.

### 3.13 PLACEMENT AND SPREADING

#### 3.13.1 General

Prior to beginning embankment placement on the levee foundation the Contractor shall notify the City that the foundation is ready to receive fill. No fill shall be placed on any part of the embankment foundation until such areas have been inspected and given final approval by the City Engineer.

##### 3.13.1.1 Gradation and Distribution

The gradation and distribution of materials throughout each zone of the levee 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. If lenses, pockets, or layers of materials differing substantially in texture or gradation from surrounding material occur in the spread material, the layer shall be mixed by harrowing or any other

approved method to blend the materials. During the placing and spreading process, the Contractor shall maintain at all times a force of workers adequate to remove all roots, debris, and oversize stone from all embankment materials. All stones and rock fragments larger than 3 inches in any dimension shall be removed from the fill. No fill shall be placed upon a frozen surface, nor shall snow, ice, or frozen earth be incorporated in the embankment.

#### 3.13.1.2 Foundations and Partial Embankment Fills

The foundations and all partial embankment receiving fills shall be kept thoroughly drained. Placing operations will be such as to avoid mixing of materials from adjacent sections as much as practicable.

#### 3.13.1.3 Equipment Traffic

Equipment traffic on any embankment zone shall be routed to distribute the compactive effort as much as practicable. Ruts formed in the surface of any layer of spread material will be filled before that material is compacted. If, in the opinion of the City Engineer, the compacted surface of any layer of material is too smooth to bond properly with the succeeding layer, the surface shall be loosened by scarifying or other approved methods before material from the succeeding layer is placed.

#### 3.13.2 Placement on Surfaces Containing Frozen Materials

Embankment shall not be placed on a foundation which contains frozen material, or which has been subject 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 earth fill. 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 of earthwork operations, shall be removed to a depth that is acceptable to the City Engineer and replaced with new material. Alternatively, the material shall be thawed, dried, reworked and recompacted to the specified criteria before additional material is placed. The City Engineer will determine when placement of fill shall cease due to cold weather. The City Engineer may elect to use average daily air temperatures, and/or physical observation of the soils for the determination. Levee embankment material shall not contain frozen clumps of soil, snow or ice.

#### 3.13.3 Select Fill

Select fill material shall be placed and spread in layers not more than 8 inches in uncompacted thickness. Layers should be started full out to the slope stakes and shall be carried substantially horizontal and parallel to the levee centerline with sufficient crown or slope to provide satisfactory drainage during construction.

#### 3.13.4 Impervious Fill

The impervious fill material shall be placed and spread in layers not more than 8 inches in uncompacted thickness. Layers should be started full out to the slope stakes and shall be carried substantially horizontal and parallel to the levee centerline with sufficient crown or slope to provide satisfactory drainage during construction.

#### 3.13.5 Random Fill

Random fill material shall be placed and spread in layers not more than 8 inches in uncompacted thickness. . Layers should be started full out to the slope stakes and shall be carried substantially horizontal and parallel to the levee centerline with sufficient crown or slope to provide satisfactory drainage during construction.

### 3.14 MOISTURE CONTROL

#### 3.14.1 General

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

##### 3.14.1.1 Insufficient Moisture for Suitable Bond

If the top or contact surfaces of a partial fill section become too dry to permit suitable bond between these surfaces and the additional fill to be placed thereon, the Contractor shall loosen the dried materials by scarifying or discing to such depths as may be directed by the City Engineer, shall dampen the loosened material to an acceptable moisture content, and shall compact this layer in accordance with the applicable requirements of paragraph COMPACTION.

##### 3.14.1.2 Excessive Moisture for Suitable Bond

If the top or contact surfaces of a partial fill section become too wet to permit suitable bond between these surfaces and the additional fill to be placed thereon, the wet material shall be scarified and permitted to dry, assisted by discing or harrowing, if necessary, to such depths as may be directed by the City Engineer. The material shall be dried to an acceptable moisture content, and shall be compacted in accordance with the applicable requirements of paragraph COMPACTION.

##### 3.14.1.3 Drying Wet Material

Material that is too wet shall be dried in the borrow area prior to bringing to the levee embankment by assisted by discing or harrowing, if necessary, until the moisture content is reduced to an amount within the specified limits.

#### 3.14.1.4 Increasing Wet Material

The moisture content of material that is too dry, will be adjusted in the borrow area prior to bringing to the levee embankment. The Contractor will add water to the fill material and by harrowing, or other approved methods, work the moisture into the material until a uniform distribution of moisture within the specified limits is obtained. Water applied on a layer of fill on the levee embankment 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, the rolling on that section of the embankment shall be delayed until the moisture content of the materials 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 pre-wet or dry back the material at the source of excavation or in the borrow area.

#### 3.14.2 Select Fill

The moisture content after compaction shall be within the limits of 4 percentage points above optimum to 2 percentage point below optimum moisture content as determined by ASTM D 698.

#### 3.14.3 Random Fill

The moisture content shall be that which will facilitate obtaining the specified compaction.

### 3.15 COMPACTION

#### 3.15.1 Compaction Equipment

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

##### 3.15.1.1 Tamping Rollers

Tamping rollers shall be as follows:

- a. Towed-Tamping rollers shall consist of a heavy duty double drum unit, with a drum diameter not less than **60 inches**, and an individual drum length of not less than **60 inches**. The drums shall be capable of being ballasted with water or a combination of sand and water. Each drum shall have staggered feet uniformly spaced over the cylindrical surface such as to provide approximately three tamping feet for each 2 square feet of drum surface. The tamping feet shall be 7 to 9 inches in clear projection from the cylindrical surface of the roller and shall have a face area of not less than **5 square inches** nor more than **7 square inches**. The roller shall be equipped with cleaning fingers, so designed and attached as to prevent the accumulation of material between the tamping feet, and these cleaning fingers shall be maintained at their full-

length throughout the periods of use of the roller. The weight of the roller shall not be less than **3500 psf** of linear drum length empty and shall be more than 2000 psf of drum length empty. The two drums comprising one roller unit shall be yoked such that they will oscillate when traversing uneven surfaces. The design and operation of the tamping roller shall be subject to the approval of the City Engineer who shall have the right at any time during the prosecution of the work to direct such repairs to the tamping feet, minor alterations in the roller and variations in the weight as may be found necessary to secure optimum compaction of the earth fill materials. The contractor may be required to add ballast to the roller to the maximum capacity specified by the manufacturer of the roller. The roller shall be drawn by a crawler-type or a rubber-tired tractor at a speed not to exceed **3.5 miles** per hour. The use of the rubber-tired tractor shall be discontinued if the tires leave ruts that prevent uniform compaction by the tamping roller. If tamping rollers are used in tandem, not more than two rollers in tandem will be permitted and in such case, one trip of the tandem rollers over any surface will be considered as two passes. When tamping rollers are used in tandem, the tamper foot spacing shall be offset so that the circumferential rows on the rear drums are in line with the midpoint of the circumferential rows on the forward drums.

- b. Self-propelled – Self propelled tamping rollers may be used in lieu of tractor drawn tamping rollers provided the foot pressure on the tamping feet of the self-propelled roller are approximately the same as the foot pressure on the towed roller. For self-propelled rollers steered with rubber-tired wheels, the tire pressure shall not exceed **40 psi**. Self-propelled rollers shall be operated at speeds not exceeding **3.5 miles** per hour. The City Engineer has the authority to limit or eliminate the use of self-propelled rollers if they are found to cause shearing or laminations of the compacted fill.

#### 3.15.1.2 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 rockfill, sand and gravel fills, or filter and drainage layers shall have a minimum static weight of **20,000 pounds**, a minimum dynamic force of **40,000 pounds** when operating at 1400 vpm, and an applied force not less than **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 **8,000 pounds**, a minimum dynamic force of **16,000 pounds** when operating at 1400 vpm, and an applied force not less than **5,000 pounds** nor greater than **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 **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.

#### 3.15.1.3 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 to be capable of being operated at tire pressures between **80 and 100 psi** at an **25,000 pound** wheel load. The roller wheels shall be located abreast and so designed that each wheel will carry approximately equal load in traversing uneven ground. The spacing of the wheels shall be such that the distance between the nearest edges of adjacent tires will not be greater than 50 percent of the rated tire width of a single tire at the operating pressure for a **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, as directed by the City Engineer, from **18,000 to 25,000 pounds**. The character and efficiency of this equipment shall be subject to the approval of the City Engineer.

#### 3.15.1.4 Hand Operated Compactors

Compaction of material, in areas where it is impracticable to use a roller or tractor compaction shall be performed by the use of approved hand operated power compactors.

a. Power Tampers: Power tampers shall be hand operated equipment capable of compacting material in confined areas. The compactors shall be either an internal combustion or pneumatic activated tamper. Tampers shall have sufficient weight and striking power to produce the specified compaction. The character and efficiency of this equipment shall be subject to the approval of the City Engineer.

b. Vibratory Plate Compactor: Vibratory compactors operated by hand in confined areas shall utilize the oscillating cam principal and shall deliver an impact of not less than **2,000 lbf** at a rate of approximately 2,000 impulses per minute. The character and efficiency of this equipment shall be subject to the approval of the City Engineer.

#### 3.15.1.5 Crawler-type Tractors

Crawler-type tractors used for spreading or compaction shall weigh not less than **20,000 pounds**, shall exert a unit tread pressure of not less than **6 psi**, and shall be operated at a speed not to exceed **3.5 miles** per hour.

#### 3.15.1.6 Sprinkling Equipment

Sprinkling equipment shall consist of tank trucks, pressure distributors or other equipment designed to apply water uniformly and in controlled quantities to variable width of surface.

### 3.15.1.7 Miscellaneous Equipment

Scarifiers, disks, spring-tooth or spike-tooth harrows, spreaders, and other equipment shall be suitable for use in embankment construction and approved by the City Engineer. Equipment used for blending fill material shall be capable of penetrating the full loose lift thickness of the specific material type.

### 3.15.2 Compaction of Select Fill

After a layer of material has been dumped and spread, it shall be harrowed to break up and blend the fill materials and to obtain uniform moisture distribution. Harrowing shall be performed with a heavy disk 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 shall be required, but in no case will more than four passes of the harrow on any one layer be required for this purpose. When the moisture content and the condition of the layer are satisfactory, the lift shall be compacted to a minimum of 95 percent of the maximum dry density as determined by the Contractor in accordance with ASTM D 698. In areas which are not accessible by roller, the fill shall be placed in layers not more than **4 inches** in uncompacted depth and compacted with an approved hand operated compactor to a density equal to that obtained in other areas which are accessible to rollers. 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. Compaction equipment shall be operated such that the strip being traversed by the roller shall overlap the rolled adjacent strip by not less than **3 feet**.

### 3.15.3 Compaction of Random Fill

After a layer of material has been dumped and spread, it shall be harrowed to break up and blend the fill materials to obtain uniform moisture distribution. Harrowing shall be performed with a heavy disk 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 shall be required, but in no case will more than four passes of the harrow on any one layer be required for this purpose. When the moisture content and the condition of the layer are satisfactory, the lift shall be compacted with not less than six complete coverages of an approved tamping roller or four complete coverages of an approved **50-ton** rubber-tired roller traversing in a direction parallel to the axis of the levee. In areas which are not accessible by roller, the fill shall be placed in layers not more than **4 inches** in uncompacted depth and compacted with an approved hand operated compactor to a density equal to that obtained in other areas which are accessible to rollers. 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. Compaction equipment shall be operated such that the strip being traversed by the roller shall overlap the rolled adjacent strip by not less than **3 feet**.

#### 3.15.4 Additional Rolling for Compaction

If the City Engineer determines that the desired compaction of any portion of the embankment is not achieved by the number of coverages specified, additional complete coverages shall be made over the surface area as directed by the City Engineer.

#### 3.15.5 Topsoil

Topsoil shall be placed on the embankment surfaces as shown on the contract drawings and as specified in SECTION SEEDING.

### 3.16 FIELD QUALITY CONTROL

#### 3.16.1 Clearing, Grubbing and Stripping

The Contractor shall establish and maintain quality control for clearing, grubbing, and stripping operations to assure compliance with contract requirements, and maintain records of the quality control for all construction operations including but not limited to the items indicated below. These records, as well as the records of corrective actions taken, shall be furnished to the City.

##### 3.16.1.2 Clearing

Station to station limits, transverse clearing limits from applicable centerline; percentage of area complete; types of materials cleared.

##### 3.16.1.3 Grubbing

Station to station limits, transverse grubbing limits from applicable centerline; percentage of area complete; type of material; filling of grubbed holes.

##### 3.16.1.4 Stripping

Station to station limits, transverse stripping limits from applicable centerline; percentage of area complete; type of material; depth of stripping.

#### 3.16.2 Excavation

The Contractor shall establish and maintain quality control for excavation operations to assure compliance with contract requirements, and maintain records of the Contractor's quality control for all construction operations including but not limited to the following:

- a. Lines, grades and tolerances,
- b. Segregation of materials,
- c. Disposal and/or stockpiling of materials,

- d. Unsatisfactory materials,
- e. Conditions that may induce seepage or weaken the foundation or embankment,
- f. Stability of excavations.

Records of inspection and tests, as well as the records of corrective actions taken, shall be furnished to the City.

### 3.16.3 Embankment

#### 3.16.3.1 General

The Contactor shall establish and maintain filed quality control for foundation preparation, embankment and backfill operations to assure compliance with contract requirements and maintain detailed records of field quality control for all operations including but not limited to the following:

- a. Earthwork Equipment

Type, size, number of units and suitability for construction of the prescribed work.

- b. Foundation Preparation

Methods of preparing the foundations in advance of embankment and backfill construction and methods for providing drainage of the foundation and partially completed fills.

#### 3.16.3.2 Materials Testing

The contractor shall perform sufficient testing to insure that the fill is being constructed as specified. The testing program specified below shall be considered the minimum acceptable frequency of testing. This does not relieve the Contractor from the responsibility of performing additional testing, if required to ensure compliance with these specifications.

- a. Soil Classification Tests

Soil classification tests shall be performed in accordance with ASTM D 2487. One initial classification test shall be required for each different classification of material to be utilized as embankment fill or backfill. As prescribed in ASTM D2487, grain size analyses in accordance with ASTM D 422 and Atterberg limits in accordance with ASMT D 4318 shall be performed on each different classification. The Contractor shall submit additional tests for every 3000 cubic yards of embankment or backfill material. Soil classification tests shall be performed on foundation material as

required to determine the acceptability of the in-situ soils. Additional tests will be required if noticeable changes in the material occur.

b. Cohesive Material Testing

(1) Moisture Density Relationships. The moisture-density relations for each different classification of cohesive material utilized shall be determined in accordance with ASTM D698. Prior to placing any fill material containing cohesive material a minimum of 3 (5) five-point compaction tests shall be performed on representative samples of the material to be used as fill. During fill placement a minimum of one additional moisture-density test shall be performed for every 5000 cubic yard placed. Additional tests will be required each time a new material is encountered. The moisture-density curves will be compiled to form a family of curves which will be utilized to estimate optimum properties (maximum dry density and optimum moisture content) to be used with field density test.

(2) Water (Moisture) Content Tests. Determination of water content shall be performed in accordance with ASTM D 2216. ASTM D 4643 may be used when rapid moisture content results are needed. All rapid results obtained by ASTM D 4643 shall be confirmed by a test on a duplicate sample performed in accordance with ASTM D2216. In the event of disagreement between the results, ASTM D 2216 shall govern. One water content test will be performed for each 1000 cubic yards of material placed or each lift of material whichever is less. These tests will be in addition to the water content tests performed in conjunction with in-place density tests. Backfill and fills not meeting the required specifications for water content shall be retested after corrective measures have been applied.

(3) In-place Density Testing for Cohesive Materials. The in-place density of the cohesive materials shall be determined in accordance with ASTM D 1556 or ASTM 2922. At least one (1) in-place density test shall be performed on each lift of material or every 10000 cubic yards of completed fill whichever is more frequent with the horizontal locations randomly staggered in the fill. At each field density test location, soil samples shall be obtained and one one-point compaction test, one moisture content and one Atterberg limits test, if applicable, shall be performed on the sample. The results of the one-point compaction test and the moisture content test will be utilized to obtain the optimum properties to compare to the results of the in-place density test. Fill not meeting the required specifications for in-place density shall be retested after additional compaction has been completed. When nuclear method is used for in-place density testing according to ASTM D 2922 and ASTM D 3017, the first test and every 10th test thereafter for each material type shall include a sand cone correlation test in accordance with ASTM D 1556. The sand cone test shall be performed adjacent to the location of the nuclear test, shall include a nominal **6 inch** diameter sand cone, and shall include a minimum wet soil weight of **6 pounds** extracted from the hole. Nuclear density testing equipment shall not be used during rain. The density correlations shall be submitted with test results. Each transmittal

including density test data shall include a summary of all density correlations for the job neatly prepared on a summary sheet including at a minimum:

- (i) Meter serial number and operators initials.
- (ii) Standard count for each test.
- (iii) Material type.
- (iv) Probe depth.
- (v) Moisture content by each test method and the deviation.
- (vi) Wet density by each test method and the deviation.

(4) Water (Moisture) Content Tests. Determination of water content shall be performed in accordance with ASTM D 2216. ASTM D 4643 may be used when rapid moisture content results are needed. All rapid results obtained by ASTM D 4643 shall be confirmed by a test on a duplicate sample performed in accordance with ASTM D 2216. In the event of disagreement between the results, ASTM D 2216 shall govern. One water content test will be performed for each 1000 cubic yards of material placed or each lift of material whichever is less. These tests will be in addition to the water content tests performed in conjunction with in-place density tests. Backfill and fills not meeting the required specifications for water content shall be retested after corrective measure have been applied.

d. Additional Testing

The City Engineer may request additional tests if there is reason to doubt the adequacy of the compaction, or special compaction procedures are being used, or materials change or if the City Engineer determines that the Contractor's testing is inadequate or the Contractor is concentrating backfill and fill operations in a relatively small area.

3.16.3.3 Materials

Suitability of materials for use in embankment and backfill.

3.16.3.4 Fill Placement

Layout, maintaining existing drainage, moisture control, thickness of layers, removal of oversized material, spreading and compaction for embankment and backfill.

3.16.3.5 Grade and Cross Section

Surveys to verify that the dimensions, slopes, lines and grades conform to those shown on the drawings.

3.16.3.6 Testing by the City

During the life of this contract, the City or its Contractors may perform quality assurance tests.

### 3.16.3.7 Reporting

The Contractor shall furnish the inspection records and all material testing results, the quantity of fill placed, as well as the records of corrective action taken.

--End of Section --