

SECTION 31 20 00

EARTH MOVING AND EMBANKMENTS

PART 1 GENERAL

1.01 SUMMARY

- A. Provide earth moving and embankment work as shown and as specified. Comply with applicable provisions of Divisions 00 and 01.

1.02 RELATED SECTIONS

- 31 05 10 Site Preparation.
- 33 41 66 Drain Fill.
- 33 42 15 Piping and Accessories.

1.03 CLASSIFICATION

- A. Excavation of materials encountered under this work will be unclassified without regard to type, difficulty to remove, or suitability for use in construction.

1.04 SUBMITTALS

- A. Test Reports: Submit reports for laboratory and field tests required under "Testing" article.
- B. Make submittals in accordance with Section 01 33 00.
- C. For footing, slab and pavement subgrades.
 - 1. Test reports for footing, slab, and pavement subgrades shall be submitted prior to placing concrete or paving materials. .
- D. For Embankment Fill materials:
 - 1. Two weeks prior to start of construction, submit source and sample results of proposed materials.
 - 2. Grain size analysis in accordance with ASTM C136 and, if more than 15% passes the #200 sieve, use ASTM C117 to demonstrate acceptability of source.
 - 3. Optimum moisture-maximum density curve for fill materials in accordance with ASTM D1557.
 - 4. Direct shear tests performed at 95% Modified Proctor density, near optimum moisture in accordance with ASTM D3080.
- E. If additional Rock and Cobble fill is needed, provide source and gradation.
- F. A/E will review submittals for conformance with the specified requirements and the design parameters. A/E will also confirm material compatibility with Drain Fill.
- G. During construction, submit test reports for field tests.

1.05 TESTING (SUBGRADES)

- A. Contractor shall arrange and pay for soil sampling and testing by a qualified testing agency, acceptable to Owner and independent of Contractor.
- B. Contractor shall notify A/E ahead of sampling and testing to allow A/E opportunity to observe testing and sampling.

- C. Test subgrade and fill materials for gradation in accordance with ASTM C136 for conformance with ASTM D2487 gradation limits. Test materials for liquid limit and plasticity index in accordance with ASTM D4318.
- D. Provide one optimum moisture-maximum density curve for each type of soil encountered in subgrade and fills under foundations, structure slabs, and paved areas; determine maximum densities in accordance with ASTM D1557.
- E. During course of work, testing agency shall inspect and approve subgrades and fill layers before further construction work is performed on each layer. Perform field density tests in accordance with ASTM D6938 or ASTM D1556. Take tests as follows:
 - 1. Footing Subgrade: Perform at least one field test for every 10,000 sq ft of structure area, but in no case less than three tests, to verify that the bearing capacity requirements are met.
 - 2. Structure Slabs and Paved Areas: Perform at least one field density test on fill subgrade for every 2000 sq ft of structure slab or paved area, but in no case less than three tests. In each compacted fill layer, perform at least one field density test for every 2000 sq ft of overlaying structure slab or paved area, but in no case less than three tests.
 - 3. Foundation Wall Backfill: Perform at least two field density tests at locations and elevations as directed.
- F. If in opinion of A/E, based on reports of testing agency and inspection, subgrade or fills which have been placed are below specified density, provide additional compaction and testing at no additional cost to Owner.

1.06 TESTING (EMBANKMENTS)

- A. Laboratory Testing:
 - 1. Perform at least two sets of laboratory tests for each 1,000 cu yd of compacted material used from each source.
 - 2. Fill materials shall be tested for gradation in accordance with ASTM C136 and ASTM C117 for conformance with ASTM D2487 gradation limits, and for liquid limit and plasticity index in accordance with ASTM D4318. Optimum moisture-maximum density curve for fill material shall be determined in accordance with ASTM D1557.
 - 3. Results of laboratory tests shall be received prior to any material placement.
- B. Field Testing:
 - 1. Perform a minimum of one field density test for each vertical foot of fill for every 100 lin ft of embankment fill.
 - 2. Field density tests shall be in accordance with ASTM D6938 or ASTM D1556.
 - 3. Where soil materials do not conform to type or density specified, soil shall be replaced or reworked to conform. Cost of extra tests for replaced or reworked areas shall be paid for by Contractor.

1.07 PROTECTION

- A. Protect existing improvements, utilities, trees and shrubs, and reference marks in accordance with Section 31 05 10.

1.08 BLASTING

- A. Use of explosives is not permitted.

PART 2 PRODUCTS

2.01 SOIL MATERIALS, GENERAL

- A. Soil materials shall be free of organic matter, debris, frozen soils, ice, and other objectionable materials. Rock particles larger than maximum size specified shall be removed prior to placement of soil. If not otherwise specified, rock particles shall be no larger than 1/2 the specified lift (layer) thickness.
- B. Select existing material from required excavations may be used for fill or backfill if it meets the specified product requirements. If necessary, furnish additional approved material from suitable off-site sources.

2.02 EMBANKMENT FILL

- A. Select, natural, free draining soils complying with ASTM D2487 soil classification groups CL or SC, or combinations thereof, and suitable for compaction. Plasticity Index for material shall be greater than 10.
- B. Embankment fill shall comply with the following gradation by weight

<u>Sieve Designation</u>	<u>Percent Passing</u>
3/4"	95-100
3/8"	85-90
No. 4	75-80
No. 40	50-60
No. 100	45-55
No. 200	40-50

2.03 COBBLE AND ROCK SHELL

- A. This material is existing on site and consists of well graded riprap from sand size material to 24-inch diameter riprap. If importing of additional Cobble Rock Shell material is needed, it needs to match a similar gradation to existing material.
- B. Imported cobble and rock shell shall comply with requirements of Colorado DOT Std. Spec., Section 506, Table 506-2 for d50 = 12" riprap with the following gradation by weight:

<u>Typical Stone Dimension (inches)</u>	<u>Percent Material Smaller Than Typical Stone</u>
21"	70-100
18"	50-70
12"	35-50
4"	2-10

2.04 GRANULAR FILL

- A. Select soils complying with ASTM D2487 soil classification groups GW (well-graded gravel), GP (poorly-graded gravel), SW (well-graded sand), or SP (poorly-graded sand). Aggregate shall pass a 1-1/2-in. sieve and not more than 35% shall be retained on a No. 10 sieve. Maximum 5% by weight shall pass a No. 200 sieve.

2.05 STRUCTURAL FILL

- A. Select soils complying with ASTM D2487 soil classification groups GW, GP, SW, or SP; or these groups in combination with groups GM, GC, SM, or SC (dual symbol soils). Aggregate shall pass a 1-1/2-in. sieve and not more than 35% shall be retained on a No. 10 sieve. Maximum 12% by weight shall pass a No. 200 sieve; plasticity index shall not exceed 5.

2.06 GENERAL SITE FILL

- A. Select, natural, free draining soils complying with ASTM D2487 soil classification groups GW, GP, SW, SP, GM, GC, SM, SC, or combinations thereof, and suitable for compaction. Maximum aggregate size shall be 1/2 specified lift thickness.

PART 3 EXECUTION

3.01 PREPARATION

- A. Prepare site for work in accordance with Section 31 05 10.
- B. Layout and stake lines and grades as required to complete the work.
- C. Layout of work is to be performed and certified in writing by a licensed surveyor.

3.02 EMBANKMENT FOUNDATION PREPARATION

- A. Foundations for embankment fill shall be stripped in accordance with Section 31 05 10 to remove vegetation and topsoil. If shown, or required to remove unsuitable materials, provide excavation work.
- B. Except as otherwise specified, grade earth foundation surfaces to remove surface irregularities and scarify parallel to axis of fill or otherwise acceptably score and loosen to a minimum depth of 2 in. Control moisture content of loosened material as specified for Embankment Fill, and compact and bond surface materials with first layer of fill as specified for subsequent layers of fill.
- C. Foundation and abutment surfaces shall be not steeper than 1 horizontal to 1 vertical, unless otherwise specified. Fill test pits and other cavities with material conforming to specifications for earth fill.
- D. Keep earth abutment surfaces free of loose, uncompacted earth in excess of 2 in. in depth normal to slope and at a moisture content that embankment fill can be compacted against them to affect a good bond between fill and abutments. Clear rock foundation of loose materials by hand or other effective means. Keep foundations and abutments free of standing water when fill is placed.

3.03 EXCAVATION FOR STRUCTURES

- A. Excavate to achieve necessary dimensions, lines, and grades. Conform to elevations and dimensions shown within a tolerance of plus or minus 1 in., and extending a sufficient distance from footings and foundations as required for bracing and supports, concrete formwork, installation of services, other required construction, and for inspection.
- B. For footings and foundations, take care not to disturb bottom of excavation. Excavate to final grade just before concrete is placed. Trim bottoms to required lines and grades to leave solid, undisturbed base to receive granular fill, base course, or concrete as shown.

3.04 TRENCHING

- A. Excavate trenches so that pipe can be laid safely and accurately to required line and grade. Hand excavate for bells, fittings and projections to allow for proper jointing and to ensure that pipe rests evenly along barrel and is not resting on bell.
- B. In sand and gravel soils, bottom of trench may be shaped to fit bottom 1/3 of pipe. In silt or clay soils, bottom of trench shall be 4 in. below pipe barrel and 3 in. below bell. In rock, bottom of trench shall be 6 in. below pipe barrel. Under foundations and footings, bottom of trench shall be 8 in. below pipe. Provide Granular Bedding as specified below.
- C. Trench widths in ordinary soil shall be limited at top of pipe to not less than a 6 in. clearance on either side of barrel to allow for installation of bedding material between pipe and trench wall. Maximum trench width at top of pipe shall be outside pipe diameter plus 24 in. (30 in. minimum). Trench above top of pipe may be sloped, stepped or vertical to comply with state and federal regulations regarding trenches.
- D. Minimum trench width in rock shall not be less than that for ordinary soil. Maximum trench width shall be outside pipe diameter plus 18 in. for an unsheathed trench, and outside pipe diameter plus 24 in. for sheathed trench.

3.05 UNAUTHORIZED EXCAVATION

- A. Unauthorized excavation consists of removal of materials beyond indicated elevations or side dimensions without specific direction of A/E. Unauthorized excavation, as well as remedial work, shall be at Contractor's expense. Notify A/E prior to backfilling if unauthorized excavations are made.
- B. Under footings, foundations, underpinning, equipment bases, and retaining walls, fill unauthorized excavation by extending indicated bottom elevation of footing or base to excavation bottom, without altering required top elevation. Lean concrete or compacted fill may be used to bring elevations to proper position when approved by A/E.
- C. Elsewhere, backfill and compact unauthorized excavations as specified for authorized excavations of same classification, unless otherwise directed.

3.06 STABILITY OF EXCAVATIONS

- A. Maintain sides and slopes of excavations in a safe condition until completion of backfilling. Slope sides of excavations to angle of repose of material excavated; otherwise, shore and brace where sloping is not possible either because of space restrictions or stability of material excavated. Take precautions to prevent slides or cave-ins when excavations are made in locations adjacent to backfilled excavations, and when sides of excavations are subjected to vibrations from traffic, machinery, or any other source. Comply with applicable codes and ordinances.

3.07 SHORING AND BRACING

- A. Carry down shoring and bracing as required as excavation progresses. Maintain shoring and bracing while excavations are open.
- B. Provide and maintain shoring and bracing, such as sheet piling, uprights, stringers and cross-braces, in good serviceable condition. Use timbers that are sound and free of large or loose knots.
- C. Provide permanent steel sheet piling or pressure treated timber sheet piling wherever subsequent removal of sheet piling might permit lateral movement of soil under adjacent structures. Cut off tops as required and leave permanently in place.

3.08 DEWATERING

- A. Perform earthwork in a manner to prevent surface water and ground water from flowing into excavations. Promptly remove water from excavations using pumps, sumps, and dewatering system components necessary to convey water away from excavations. If underground springs are encountered, notify A/E before proceeding.
- B. Convey water removed from excavations and rain water to collection or run-off areas. Provide and maintain temporary drainage ditches and other diversions outside excavation limits for each structure. Do not use foundation or utility trench excavations as temporary drainage ditches.
- C. Provide filter material, trash screens, and other devices around pumps and intakes to avoid pumping or discharging sediment from construction site.
- D. Provide pumping to maintain water level in work areas at least 12 inches below prepared subgrade.

3.09 STOCKPILING

- A. Stockpile excavated materials meeting the requirements for fill and backfill where directed until required for the work. Place, grade, and shape stockpiles for proper drainage. Locate stockpiles a sufficient distance from edge of excavations, even though such excavations may be sheeted and braced, to prevent such material from falling or sliding into excavations and to prevent cave-ins.

3.10 COLD WEATHER PROTECTION

- A. Protect excavation bottoms against freezing when atmospheric temperature is less than 35 deg F by covering with dry insulating materials of sufficient depth to prevent frost penetration.

3.11 SUBGRADE EXAMINATION AND PREPARATION

- A. Examine subgrade prior to placing fill. Remove organic materials and debris subject to rot or corrosion. Plow, strip, or break-up sloped surfaces steeper than 1 vertical to 4 horizontal so that fill material will bond with subgrade.
- B. In structure and pavement areas, proof-roll exposed subgrade in overlapping passes in a perpendicular grid pattern with a fully-loaded tandem-axle dump truck weighing not less than 10 tons, or other equipment of similar size and weight, to compact subgrade and detect areas which must be undercut or improved. Inform A/E of unsuitable, unconsolidated subgrade soils.
- C. After subgrade soil is stable, scarify top 6 to 8 in., moisture condition, and compact surface to density specified in Part 4 Schedules.
- D. Reconstruct subgrades damaged by freezing temperatures, frost, rain, accumulated water, or construction activities, as directed by A/E, without additional compensation.

3.12 ADDITIONAL EXCAVATION (OVER EXCAVATION)

- A. If unsuitable bearing materials, such as poorly compacted fill, existing foundations, rubble, debris, or organic deposits, are encountered at required subgrade elevations, carry excavations deeper and replace excavated material with properly compacted Structural Fill as directed by A/E.
- B. Where over excavation below footing subgrade is required, widen over excavation beyond footing edges at least 1 ft for each 1 ft of over excavation depth.

- C. Removal of unsuitable material and its replacement as directed will be paid for as extra work, unless a pay item is included in the Bid Schedule. Do not proceed with extra or unit price work until authorized.

3.13 EQUIPMENT-PLACED ROCK AND COBBLE SHELL

- A. Place Rock and Cobble Shell material at the locations, thicknesses, lines, and grades shown on the Drawings.
- B. Stones with typical stone dimensions that are equal to D50 and larger shall be placed at the top surface with faces and shapes matched to minimize voids and form as smooth a surface as practical. Dumping and backhoe placement alone is not sufficient to ensure a properly interlocked system. The material may be machine-placed and then arranged as necessary by use of an excavator with a multi-prong grappling device or by hand to interlock and form a substantial bond.
- C. Hand placement will be required where necessary to correct obvious irregularities and to prevent damage to adjacent improvements and wherever equipment placement methods are unsatisfactory.

3.14 PLACEMENT

- A. Do not place fill until required excavation and foundation preparation have been inspected and approved. Do not place fill upon frozen surface; no snow, ice, or frozen material shall be incorporated in fill.
- B. Place fill in approximately horizontal layers; do not exceed maximum loose layer thickness specified. Spread piles and windrows uniformly. Spreading and compacting equipment shall travel approximately parallel to centerline of embankment.
- C. Place fill to be hand compacted or compacted by manually directed power tampers in layers not to exceed maximum thickness specified for manually compacted fill.
- D. Adjacent to structures, place fill to prevent damage and allow structures to assume loads gradually and uniformly at approximately the same rate on all sides of structure. Do not travel heavy equipment over cast-in-place concrete work until cured a minimum of 14 days, unless otherwise approved.
- E. Earth fill in dams, levees, and embankments designed to retain water shall meet the following requirements:
 - 1. Distribute materials throughout each zone uniformly, free from lenses, pockets, or layers differing substantially in texture or gradation.
 - 2. Scarify layers too hard and smooth for proper bond with succeeding layer; scarify parallel to axis of fill to a depth of 2 in.
 - 3. Where fill material is placed adjacent to existing embankment, cut the face of the existing embankment with minimum of 12 inch vertical cuts stepped up the face of embankment prior to placement of new fill.
 - 4. Maintain top surfaces of fills approximately level during construction, except provide a crown or cross-slope of not less than 2 percent for drainage. If the work requires fill to be placed higher at parts of an embankment, maintain top surface of each part level as specified above.
 - 5. Place fill in continuous layers from abutment to abutment, except where openings to facilitate construction or to allow stream flow are authorized. Route equipment travel approximately parallel to embankment centerline.
 - 6. Construct embankments required to be built at different levels so slopes of bonding surfaces between adjacent levels of embankment are not steeper than 3 horizontal to 1 vertical. Strip bonding surface of loose material and scarify, moisten, and recompact at specified moisture content and density to insure good bond with new fill.

3.15 CONTROL OF MOISTURE CONTENT

- A. During placement and compaction of fill, maintain moisture content of materials being placed within the specified range.
- B. Apply water to fill materials by sprinkling at excavation site or during placement of fill if necessary. Obtain uniform moisture distribution by discing, blading, or other approved methods prior to compaction of layer. If material is too wet when deposited on fill remove or dry it to specified moisture content prior to compaction.
- C. If top surface of preceding layer of compacted fill or a foundation or abutment surface in zone of contact with fill becomes too dry to permit suitable bond, scarify and moisten it by sprinkling to an acceptable moisture content prior to placement of next layer of fill.

3.16 COMPACTION

- A. Compact each layer of fill to a mass density not less than the percent of maximum density specified in 4.01 Compaction Schedule.
- B. Provide compaction equipment required to obtain specified compaction. Compaction by travel of grading equipment is not considered adequate for uniform compaction. Small vibratory compactors are required wherever fill is placed adjacent to foundation walls, footings, and piers. Pipe bedding and initial backfill shall be hand or mechanically tamped.
- C. Manually compact fill adjacent to structures to density of surrounding fill by means of manually directed power tampers or plate vibrators. Do not operate heavy equipment within 2 ft of any structure; do not operate vibrating rollers within 5 ft of any structure. Compaction by means of drop weights will not be permitted.
- D. Do not pass compacting equipment over cast-in-place concrete until cured 14 days (7 days for precast concrete with a concrete cradle) or over conduits until backfill has been placed above structure to a height equal to one-half the clear span width of structure or pipe or 2 ft, whichever is greater.
- E. Compacting of fill adjacent to structures may be started when concrete has attained design strength, determined by test cylinders (ASTM C31). If concrete strength is not determined by tests, passage of heavy equipment and compaction of fill adjacent to structures may not be started until the following curing periods have elapsed:

<u>Structure</u>	<u>Minimum Curing Period</u>
Retaining walls, counterforts, and wing walls	14 days
Cast-in-place conduits and risers (forms removed)	14 days
Cast-in-place concrete conduits and risers (with inside forms in place)	7 days
Walls backfilled on both sides simultaneously	7 days
Footings	4 days

3.17 SOIL FILL

- A. Place and compact fill materials in layers to required elevations as follows:
 - 1. Under turf and planted areas: Use General Site Fill.
 - 2. Under footing, foundation, building slab, pavement, and walk areas: Use Structural Fill.
 - 3. For upper 6 in. immediately under building slabs and walks: Use Granular Fill.

4. For backfill behind retaining walls: Use Structural Fill.
- B. Do not place soil fill on frozen subgrades.

3.18 GRADING

- A. Grade areas within project limits to achieve cross sections, lines, and elevations indicated. Slope grades to direct water away from structures and to prevent ponding. Finish surface to be reasonably smooth and free from irregular surface changes. Provide a smooth transition between adjacent existing grades and new grades.
- B. Finish subgrades to required elevations within the following tolerances:
1. Turf and Unpaved Areas: Plus or minus 1 in.
 2. Pavements and Walks: Plus or minus 0.5 in.
 3. Structure Slabs: Tolerance of 0.5 in. when tested with 10 ft straightedge.

3.19 MAINTENANCE

- A. Where completed compacted areas are disturbed by subsequent construction operations or adverse weather, scarify surface, re-shape, and compact to required density prior to further construction.
- B. Where settling is measurable or observable at excavated areas during general project warranty period, remove surface (pavement, lawn or other finish), add fill or backfill material, compact, and replace surface treatment. Restore appearance, quality, and condition of surface or finish to match adjacent work, and eliminate evidence of restoration to greatest extent possible.

3.20 DISPOSAL OF EXCESS AND WASTE MATERIALS

- A. Remove excess excavated material and trash, debris, and other waste materials and legally dispose of them off-site.

PART 4 SCHEDULES

4.01 COMPACTION SCHEDULE

<u>Material Type</u>	<u>Usage</u>	<u>Lift Thickness ⁽¹⁾</u>	<u>Compaction ⁽²⁾</u>
Granular Fill	Below concrete slabs.	6"	95%
	Other designated areas.	8"	95%
Structural Fill	Under foundations.	8"	95%
	Below concrete slabs.	8"	95%
General Site Fill	Unpaved areas 10 ft. or less outside structure line.	8"	95%
	Unpaved areas more than 10 ft. outside structure line.	12"	90%
Embankment Fill	Embankment	8"-10" ⁽³⁾	95% ⁽⁴⁾

(1) Place manually compacted materials in maximum 4 in. layers.

(2) Percent of maximum density determined in accordance with ASTM D1557 (Modified Proctor test).

(3) Hand compaction of embankment fill is not allowed.

(4) Moisture content of embankment fill to be within 3% of optimum.

END OF SECTION