

Drainage Guidelines

A. Excavation:

1. Trenches 1.5 meters (5 ft) and greater in depth shall provide for worker safety by either laying back the soils to a 1.5:1 slope or providing shielding with a properly designed "trench box". This is not required for excavations in stable rock. There is no additional payment for laying back slopes beyond the trench payment lines. (Spec Ref.) and 29 CFR 1926
2. When excavations occur in unstable soils, select granular material will be required below the pipe invert (steel pipe) or bedding control line (concrete pipe). For steel pipes, the sub-excavation limit shall not exceed 0.6 meters (2 ft.) in such unstable soil. For concrete pipe, the sub-excavation below the bedding control line can vary 0.3 to 0.6 meters (min/max). When excavations occur in rock, the sub-excavation will be 0.3 meters for steel pipe. For concrete pipe, the sub-excavation will be the bedding thickness for the appropriate pipe size. As such, the Standard Sheets should be consulted.
3. For open trenches in publicly accessible areas, fence or barricade no less than 1.2 meters (4 ft) high, having supports at no greater than 3 meter (10 ft) spacing, will be provided. "DANGER - KEEP OUT" signs 400mm high x 600mm wide will be mounted thereupon at no less than 30 meter (100 ft) intervals. Sheeting box extensions to 1.2 meter above ground surface elevation or a substantial covering over the excavation are alternate protective measures. (Spec ref.)
4. Before conduit and direct burial cable is placed in an excavation, the engineer must approve the excavation depth and cross-section. NOTE: All excavated material is the property of the contractor for either disposal or for use as another pay item within the contract. (spec ref.)
5. Excavation is typically completed to either the invert elevation of the steel pipe, conduit or culvert or for concrete pipe, the bottom of bedding. This is the bottom payment line. For pipes, conduits or culverts 300 to 3700 mm diameter (1 ft to 12 ft), excavation and payment widths will be either the diameter plus 1.2 meters (4 ft) or 3 times the diameter, whichever is

greater. For concrete pipe, add 2x the wall thickness. For sizes greater than 3700 millimeters diameter, see the Standard Sheets.

6. Drainage basin, manhole and other minor structure excavations are made to the bottom of footing (base or foundation slab) elevation. Excavation width and payment line is 0.6 meters (2 ft) outwards in all directions from the structure walls. (Spec ref.)
7. The top of excavation (payment line) varies for cut and fill sections. For cuts, it is usually the ground elevation following unclassified excavation. In fills, it is the ground surface prior to commencing work on the contract. These same parameters apply to drainage basins, manholes and other minor structures. (Spec ref.)

B. Culvert, Storm Drain and Minor Structure Installation:

1. The bottom of trench, which is coincidental with the invert of the steel pipe, conduit or culvert, is either carefully shaped to fit the pipe or buttressed on both sides by compacted Select Granular material (see F1 below for gradation requirements). For concrete pipe, the bedding material is not shaped. However, the material directly below the center of pipe (1/3 the outside diameter) shall remain un-compacted. All pipe shall be laid in close conformity with the line and grade having full, firm and even bearing. Spec ref.
2. Concrete pipe will be laid with the bell-end upstream. The minimum pipe length for a "run" which is open at either end, will be 2300mm (7.5 ft) for pipe sizes between 600mm and 1525mm (24 and 60 inch) diameters. All other sizes have a minimum length of 1800mm (6 ft). When necessary to obtain an exact length of culvert, a shorter pipe "run" can be approved by the engineer. For closed drainage runs (connecting minor structures), the minimum section length is unspecified. Spec ref
3. Round corrugated metal and pipe arches (steel or aluminum) shall be placed with the longitudinal seams at the sides. The circumferential seams are placed so that lapping occurs in the downstream direction, directing water flow over versus under the succeeding pipe section. For metal pipe, the contractor shall supply measuring devices to verify gauge and steel coating thickness. Spec ref.
4. Polyethylene pipe will be handled, stored and assembled in accordance with the approved Materials

Details. Joint misalignment greater than 6mm (0.25 inches) or joint separations greater than 13mm (0.50 inches) between adjoining sections of pipe will not be allowed. Field cutting is permitted for the terminal end only but the minimum length of pipe will be 1 meter (3.30 ft). Spec ref.

C. Pipe Repairs:

1. Concrete pipe damage can be repaired with a Materials Bureau approved "Concrete Repair Material" (such material be found in the State's Approved List). The repair shall be properly finished and cured per the manufacturer's specifications or normal procedures. Spec ref
2. Bituminous coatings and paving damage, when less than a 0.2 square meter (2 sq. ft.) area, can be repaired with material from the State's Approved List. Pipes having coating and paving damage greater than 0.2 square meters will be rejected. Spec ref.
3. Polyethylene pipe having damaged ends can be incorporated into the work provided the damaged portion is removed by field cutting. For other mid section damage, the pipe may be incorporated. However, after backfilling, the interior shall be checked to assure no more than 5% percent deflection of the interior diameter has occurred. Spec ref.

D. Pipe Joints:

1. Round concrete pipe uses flexible water-tight elastomeric gaskets. Elliptical concrete pipe uses a joint sealing compound conforming to AASHTO M198 Type B or ASTM C990 and Spec ref.
2. The last three full-length concrete pipe sections shall be joined together at the springline on each side with a restraining device (minimum length described under B2 above shall be considered a "full length". Also, an end-section is considered as a "full-length"). For circular pipes 1300mm (48 inches) diameter and smaller, the device will be a 6mm x 57mm (0.5 x 2.25 inch) steel strap conforming to ASTM A36. Nuts, bolts and washers will be used to secure through the wall and the holes shall be no closer than 450mm (1.5 ft) from the pipe end or end of flared end-section. For all other concrete pipes, the restraining device will be detailed on the plans. Note: the device may be placed on the either the inside or outside. Spec ref.

3. Ductile iron pipe joints are sealed by caulking a gasket of jute or oakum into the hub. Caulking can be either equal parts cement and sand mortar or a preformed and/or poured caulking compound approved by the engineer. Spec ref.
4. Corrugated metal pipe is joined by corrugated band connections. The band is lapped on equal sections of the corrugated pipe. Spec ref.
5. Polyethylene pipe joints are the manufactured ends. No field cuts are permitted unless approved by the engineer. The pipe may protrude 50mm (2 inches) into a basin to allow for a 45-degree mortar seal. This seal is placed at both the interior and exterior faces of the basin. Spec ref.

E. Concrete Drainage Structures and Manholes:

1. Unless specified otherwise, contractors have the option to use pre-cast or cast-in-place drainage structures. Cast-in-place structures shall be constructed of Class 'A' concrete meeting all the requirements for structural concrete. Drainage structure changes from the details shown in the Standard Plans or in the Contract Plans will require submittal and approval of working drawings and design calculations. Spec ref.
2. Pipe entries will be flush with the inside face of the structure (except polyethylene pipe). Concrete pipe bell-ends will be cut off where the bell enters the drainage structure. Sealing the space around the pipe shall be done with concrete mortar, grout or repair material. Spec. ref.
3. Pre-cast concrete drainage unit sections shall be joined by a male-female joint and sealed with a choice of flexible elastomeric gaskets, pipe joint sealing compounds or concrete mortar, grout or repair material. Elastomeric gasket shape, size and placement follows the recommendations of the precast manufacturer. Spec ref
4. Drainage unit steps may be cast or bolted in place during construction and mortared with a concrete grout after completed or attached by friction locking into preformed and/or drilled holes. The steps shall be placed no further than 400mm (16 inches) apart to form a continuous ladder and shall project a clear distance of 100mm (4 inches) from the face-of-wall. Spec ref

5. Units containing minor defects caused by mishandling (defined as holes or spalls less than 200mm diameter that do not extend beyond the reinforcement) shall be repaired using a concrete repair material, the same as that described under C1 above. Once finished and cured, the repair shall withstand a moderate blow with a 450g (1 lb) hammer. Spec ref.

F. Backfill and Compaction:

1. All rigid pipe installations, including sub-excavations, shall be backfilled with Select Granular Fill having the following gradation:

Sieve	Percent Passing
100mm	100
75µm	0 to 15
425µm	0 to 70

2. Note: For corrugated aluminum pipe (Type 1R spiral ribbed pipe), 100% shall also pass the 50mm sieve. For plastic pipe, 100% shall also pass the 19mm sieve. Spec ref.
3. Fill shall be deposited in horizontal layers 150mm (6 inches) in thickness before compaction (However, the first 150mm backfill over conduit and cable installations will remain un-compacted). A minimum 95% percent Standard Proctor Maximum Density is required. Material will be deposited to progressively bury the pipe to equal depths on both sides. Spec ref.
4. Select Granular Fill will be placed to 300mm (1 ft) above the pipe in cut sections. In embankment fill sections and off-road areas, the granular material will be placed to a height 0.6 x O.D. alongside the pipe. This is the top pay limit for "Select Granular". Beyond this point, subgrade area material will be used in the fill and off-road sections to 0.3 meters above the pipe. Suitable material is then used for the remainder of the backfill. Spec ref.

G. Underdrain:

1. Underdrain excavation is completed to 100 mm (4 inches) below invert elevation. The excavation width is the diameter plus 300 millimeters (plus 1ft). Filter material is then placed and compacted to a depth of 100 millimeters minimum (4 inches) as "bedding" for the underdrain.

2. Underdrain filter material shall be stockpiled and have the following gradations:

Type 1		Type 2	
Sieve Size	% Passing	Sieve Size	% Passing
25.0mm	100	12.5mm	100
12.5mm	30 to 100	6.3mm	20 to 100
6.3mm	0 to 30	2.0mm	0 to 15
2.0mm	0 to 10	850µm	0 to 5
850µm	0 to 5		

3. For polyethylene underdrain, the up-gradient end shall be closed with a cap. All other underdrain types shall use a suitable plug. Unless the plans show otherwise, perforations will always be placed down. For semi-circular steel pipe underdrain, the flat surface will face upwards.
4. Filter material is placed to a depth of 150 millimeters (6 inches) and shall remain uncompacted. Successive "lifts" will be 150 millimeters thick and compacted by two vibratory passes of a pad or drum type compactor. For polyethylene pipe, the depth of filter placement shall be such that 300 millimeters will extend over the underdrain following three vibratory passes with a pad or drum type compactor (i.e. approximately 450 millimeters or 1.5 ft of filter material will be placed before compacting).
5. Polyethylene underdrain outlets are protected from the sun by connection to precast "aprons" (as detailed in the plans) or the placement of a minimum 1m long (3.3 ft) section of corrugated steel or aluminum pipe over the outlet end. When using the metal pipe option with 100 to 150 mm diameter underdrain, it shall extend 150 millimeters into the ground and overlap the underdrain a similar distance. The joint can be 'sealed' by using a reducer fitting or wrapping roofing felt over the joint. NOTE: For 200 to 300 millimeter diameter underdrain piping, the burial distance and overlap will be 300 millimeters each.