



SECTION 204

EMBANKMENT MONITORING

SECTION 204.10 SETTLEMENT GAUGES

204.10.1 Description. This work shall consist of installing settlement gauges for the purpose of obtaining foundation settlement data during and following placement of embankment and surcharge construction. An estimated number of settlement gauges will be indicated in the contract. The exact number and locations will be determined by the engineer.

204.10.2 Material. A settlement gauge shall consist of the following:

(a) A plate with a galvanized riser pipe attached perpendicular to the center of the plate.

(b) Lengths, to be approved by the engineer, of 3/4-inch (19 mm) threaded galvanized riser pipe and couplings.

(c) Lengths, to be approved by the engineer, of galvanized 1 1/2-inch (38 mm) threaded pipe and couplings to act as a cover or guard for the riser pipe.

204.10.3 Construction Requirements.

204.10.3.1 The first section of the 3/4-inch (19 mm) pipe shall be firmly attached to the plate. The distance from the top of plate to the top of pipe will be accurately measured and recorded by the engineer.

204.10.3.2 An excavation, slightly larger than the plate, shall be made to a depth approximately 18 inches (450 mm) below the natural ground surface. Care shall be exercised during excavation to ensure that the bottom of the pit is level and that the material at this location is undisturbed. The pit bottom shall be covered with a layer of Portland cement mortar, approximately 3 inches (75 mm) thick, and the plate bedded therein in such position that the riser pipe is vertical. After the mortar has set, the cover pipe, cut approximately 6 inches (150 mm) shorter, shall be slipped over and centered around the riser pipe. The backfill shall then be placed in 6-inch (150 mm) layers and thoroughly compacted. The contractor shall notify the engineer when the installation is complete. No embankment shall be placed around the gauge until the elevation of the top of the riser has been determined by the engineer.

204.10.3.3 Embankment material in the immediate vicinity of the settlement gauge pipe shall be placed and compacted in accordance with [Sec 726.3.5](#). When the elevation of the embankment reaches a level approximately one foot (300 mm) below the top of the cover pipe, the engineer shall be notified and the next section of riser pipe and cover pipe shall be installed in the engineer's presence. As the height of the embankment increases, this procedure shall be repeated until the embankment and surcharge is completed, and the pipe sections, both riser and cover, extend approximately 2 feet (600 mm) above the surface of the completed embankment and surcharge.

204.10.3.4 All necessary precautions shall be taken to keep the alignment of the riser pipe and cover pipe maintained in a vertical position at all times. The contractor shall operate equipment such that the settlement gauges are not damaged or displaced. Protective barriers shall be erected when directed by the engineer. Settlement gauges shall be maintained in a satisfactory operating condition until after placement of the embankment and surcharge and until, in the judgment of the engineer, the settlement readings are no longer necessary. Any damaged gauges shall be repaired or replaced by and at the contractor's expense.

204.10.3.5 The engineer will obtain and record all measurements and elevations necessary for accurate determination of settlement data during and after completion of embankment and surcharge.

204.10.4 Basis of Payment. Accepted settlement gauges, complete in place, will be paid for at the contract unit price. No direct payment will be made for any devices required to protect the gauges.

SECTION 204. 20 PORE PRESSURE MEASUREMENT DEVICES

204.20.1 Description. This work shall consist of placing and maintaining pore pressure measurement devices as shown on the plans for obtaining foundation pore pressure measurements during the placement of embankment. Pore pressure measurement devices, locations, elevations and limits of embankment subject to control by each device will be shown on the plans.

204.20.2 Equipment. Pore pressure measuring devices shall consist of the following types:

(a) Type A. This device shall consist of a pneumatic transducer sealed within a sand chamber which is set into the foundation to the specified elevations.

(b) Type B. This device shall consist of a 1/2-inch (13 mm) PVC standpipe extending to the surface of the embankment from a sand chamber set into the foundation to the specified elevations.

204.20.2.1 The pneumatic transducer, jacketed tubing, and necessary pressurizing and gauging equipment for Type A installations will be furnished by the Commission without cost to the contractor upon two weeks written notice preceding the date of installation. The balance of the material for the Type A installation shall be furnished by the contractor. All material for the Type B installation shall be furnished by the contractor, except for the electrical sounding device.

204.20.3 Construction Requirements.

204.20.3.1 The contractor shall be responsible for the installation, furnishing all incidental material, providing all necessary protection of the installation, and replacement in the event of damage, including cost of any replacement equipment furnished by the Commission. In the event of damage to the installation, the engineer may require suspension of embankment construction in the controlled area until the contractor has restored the installation to satisfactory working order. No embankment may be placed until the installation is complete and tested to the satisfaction of the engineer.

204.20.3.2 A hole of no less than 5 inches (125 mm) or no more than 8 inches (200 mm) in diameter shall be drilled to Elevation "B" as shown on the plans. If necessary, casing shall be used to prevent sloughing of material from the walls of the hole and contamination of the walls or bottom of the hole by sloughed material. The outer diameter of the casing shall be no

smaller than the diameter of the hole. The casing shall have no externally coupled joints in the bottom 10 feet (3 m).

204.20.3.3 If casing is required, the hole shall be washed to the bottom with clean water circulated through the bit until the discharge is clear. Clean sand shall then be poured into the hole to the approximate depth shown on the plans. The assembled pore pressure measurement device shall then be lowered to the device's indicated position with care to avoid contamination with soil from the side of the hole, and additional sand shall be placed around the device to Elevation "A" as shown on the plans. During these steps, any casing shall be pulled ahead of the backfill in increments of 6 to 24 inches (150 to 600 mm) as necessary to prevent collapse or sloughing of the hole. The hole shall be maintained full of clean water during these steps to at least the elevation of the top of the sand chamber. The creation of pockets of soil, air or voids in the sand backfill shall be avoided.

204.20.3.4 After sand is placed to the specified elevation, the hole shall be backfilled with wetted, plastic bentonite clay as the casing is withdrawn, for no less than 4 feet (1.2 m) above the top of the sand filled chamber. If necessary, the clay shall be worked by hand into plastic balls to be dropped into the hole and tamped into a coherent mass. An acceptable alternate is the use of preformed dry bentonite pellets. In dry installation, dry granular bentonite may be tamped in place. The remainder of the hole shall be filled with a thick slurry of bentonite.

204.20.3.5 At natural ground level, or as otherwise directed by the engineer, four layers of 3/4-inch (19 mm) exterior grade plywood, 4 x 4 feet (1200 x 1200 mm), nailed and clinched together with rustproof nails, and with a 3-inch (75 mm) diameter hole cut at the center shall be centered over the installation after the ground is smoothed and leveled with sand. A closet flange or other suitable receptacle shall be securely fastened to the plywood over the 3-inch (75 mm) diameter hole to securely receive a 5-foot (1.5 m) length of 3-inch (75 mm) iron or steel casing. Earth or sand shall be compacted about the casing in 6-inch (150 mm) lifts with care to avoid misalignment after the engineer has established the elevation of the plywood slab and the top of the casing.

204.20.3.6 Upon completion, each installation shall be tested. Type A installations shall be tested in accordance with recommendations of the transducer manufacturer. Type B installations shall be tested by dropping a weighted line through the standpipe to check for possible obstructions. The standpipe shall then be filled with water and periodic readings made of the water level in the standpipe until the level of natural groundwater is reached. If less than a 70 percent drop in head is experienced in the first 24 hours, the standpipe shall be flushed and retested. Records of rate of head loss shall be kept for subsequent evaluation of possible time lags in the response of water levels to embankment placement.

204.20.3.7 The engineer may require the installation of additional pore pressure measurement devices, at the contract unit price, within any area subject to control by such devices, at any time during construction of the embankment. The engineer will determine the type of device, location and elevation of additional installations. Any such additional pore pressure measurement devices shall govern the rate of construction in the same manner as the original devices. The reference pressure levels for additional devices shall be either that of the original devices or as determined from boreholes located outside the loaded area, as directed by the engineer.

204.20.4 Pore Pressure Measurements and Records.

204.20.4.1 The engineer will make and record all observations and measurements required to determine natural ground water pressures and pore water pressures induced by embankment construction. The pressure of the natural ground water existing at the time of installation and prior to placement of any embankment will be used as a reference to determine pore pressures

induced by subsequent embankment placement. The engineer may subsequently require borings outside the loaded area to facilitate observations to determine if the natural groundwater table has lowered due to seasonal or climatic variations. Such observations may be used to lower, but not raise, the initial reference groundwater pressure.

204.20.4.2 The engineer will make all records of groundwater and pore water pressures readily available to the contractor for guidance in the planning of the contractor's work.

204.20.4.3 If foundation pore pressure, in excess of pressure from the natural water table, equals or exceeds 35 percent of the unit pressure of the embankment in place over the installation at any time, placement of embankment shall be immediately suspended. Construction shall not resume until such excess pressure declines to 25 percent of embankment pressure, unless otherwise authorized by the engineer.

204.20.4.4 After the embankment reaches an elevation equal to 60 percent of the maximum height, the contractor shall control the rate of construction in such a manner that foundation pore pressure, in excess of pressure from the natural water table, will not exceed 35 percent of the unit pressure of the embankment in place over the installation at any time. An example of pressure relationships follows: Soil embankment with an average wet density of 125 pounds per cubic foot (2000 kg/m³) is equal to twice the unit weight (mass) of water. A foot (0.3 m) of such embankment thus has a potential to create, at most, 2 feet (0.6 m) of water rise in a standpipe, or a 0.87 psi (5.9 kPA) increase in a Type A installation. The contractor shall anticipate the maximum possible effect of any load to be added. Type B installations may exhibit some time lag in rate of response to a pressure increment. Records of pore pressure response during placement of the first 60 percent of embankment height shall be examined for evidence of such lag. The time required for dissipation of head during testing will also be indicative of the rate of response.

204.20.4.5 When embankment has advanced to within approximately one foot (300 mm) of the top of the casing, the casing and the 1/2-inch (13 mm) PVC pipe for the Type B installations, shall be advanced in 5-foot (1.5 m) increments. No extension shall be made without the engineer's approval. PVC pipe extensions shall be made using solvent welded couplings exercising care to make smooth, squared cuts with all burrs removed, in accordance with recommendations of the pipe and solvent cement manufacturers. Pneumatic tubing leads used with Type A installations shall be long enough to permit extension, without connections, to the top of the embankment or surcharge. Excess tubing shall be stored in a steel container attached to the last casing extension as shown on the plans.

204.20.5 Settlement Records. The engineer will make and record all measurements and elevations necessary, including elevations of the plywood plate and all casing extensions, for use in establishing a settlement record at the site of the pore pressure measurement device. The 3-inch (75 mm) outer steel casing will be used for this purpose. Care shall be taken to ensure the tightest possible coupling connections, using pipe wrenches, without rotating the bottom pipe. Settlement records obtained in this manner may be used to satisfy such settlement rate requirements as may be outlined in the contract.

204.20.6 Basis of Payment.

204.20.6.1 The contract unit price shall include all effects, impacts and cumulative impacts of possible restraints inherent in the use of these devices upon the rate of construction. No additional compensation will be made for any impact, cumulative impacts, inefficiency or any costs incurred as a result of compliance with this requirement.

204.20.6.2 Accepted pore pressure measurement devices, complete in place, will be paid for at the contract unit price per each.