6.40 EMBANKMENT

The construction of embankments is covered by *Specification 2107.* This chapter provides a more detailed picture of certain procedures mentioned in the specifications. These comments should be regarded as explanatory but in no way supersede or invalidate specification requirements.

6.41 EMBANKMENT CONSTRUCTION

Equipment

- Tamping Type Roller
  Specification 2001 requires that tamping type rollers have studs or feet projecting at least 150 mm (6.5 inches) from the surface of the drum and exert a force of not less than 1.4 MPa (200 pounds per square inch) when the roller is supported on a single row of feet. This requires measurement of the projected length, contact area, and mass (weight) of the roller.

  The contact area of a tamping type roller depends upon design and wear to which the roller has been subjected. For a sheepsfoot roller the measurement should be taken where the worn radius meets the taper of the tooth, usually within 9 mm (3/4 inch) of the tip of the tooth. Special feet such as the Ray Go, Caterpillar, Hyster, etc. will be measured as per the sketch included in *Appendix 6-2*.

  The mass (weight) of the roller may be determined by one of the following:

  A. Having the contractor weigh the roller including the frame and hitch on a platform scale.
  B. Having the contractor supply a statement by the manufacturer giving the mass (weight) of the roller subject to definite roller identification. No modifications shall be allowed for this option.

In general, most sheepsfoot rollers do not meet the required pressure unless they are filled with water, sand, or diesel fuel. To determine the total mass (weight), use 1 kg/L (8.3 pounds per gallon) for water and use 0.84 kg/L (7.0 pounds per gallon) for diesel fuel.

It is very important to check the rollers when they are moved onto a project and record the approval in the field book. The roller should be checked for possible changes during construction and noted in diary.

If the compaction rollers do not meet the requirements of *Specification 2001*, the roller may be used according to *Specification 2107.07.* This specification requires moisture and density control and requires 95% of proctor density. After it has been demonstrated that compaction equipment not meeting *Specification 2001* achieve the specified compaction, there is no need for further moisture and density checks. The method used to obtain 95% of proctor density should be identified and used afterwards to insure proper compaction of similar soils. If soil classification changes, a new proctor determination is required.

If the moisture content of soils containing less than 15% sand is below optimum, over compaction can result; therefore the inspector should be alert to the moisture content of soils on which this unit is used. For any soils not listed, the provisions of *Specification*

2107.07 will be required. This article does not permit testing by "walk-out" of a sheepsfoot roller in lieu of moisture and density testing. "Roller Walk-out" is obtained when the soil is able to support the sheepsfoot type roller on its tamping feet. A roller is considered to be supported on its tamping feet when the tamping feet penetrate not more than 75 mm (3 inches) into a 200 mm (8 inch) lift.

Site Preparation
Except for sod, all trees, shrubs, cornstalks, and other vegetation are to be removed and disposed of according to *Specification 1104*. After cornstalks and tall grass are cut and removed, the area within the need lines is to be thoroughly disked. On embankments less than 2 m (5 feet) high, the sod is to be bladed to the outer portions of the fill. This sod may be placed in the fill outside a plane made by a 1:1 slope down from the shoulder line. Disked sod may be left in areas where the fill height is more than 3 m (5 feet) without causing stability problems. Tree stumps shall not be buried in the toe of embankments, since there is the possibility of a void, settlement, or the development of a slide plane.

On projects where a slope is being widened, the sod shall be removed to the new toe of slope. Benching may be required according to *Specification 2107*.

Deposition of Embankment Material
Specification 2107.04 requires that hauling units be kept off dump areas. Where possible, the dump areas and the compaction areas are to be kept separate. The purpose is to insure uniform compaction.

The self-propelled tamping type roller may be used on the dump area for leveling as long as the unit follows the prescribed rolling pattern, does not spin the power drums, and accomplishes both rolling and leveling to the satisfaction of the project engineer.

The field book should include an entry showing the loose soil lift thickness prior to compaction. This thickness should be measured to assure specification compliance.

Compaction
Type A compaction requires a minimum of one rolling per 25 mm (1 inch) of loose thickness with a maximum thickness of 200 mm (8 inches) and further requires that the roller shall be supported on its feet. The roller is considered to be supported on its feet when not more than 75 mm (3 inches) of penetration into a 200 mm (8-inch) lift occurs. The 75 mm (3 inches) will include any roller pick up.

Note:
There are soils in Iowa which will result in almost no penetration of the roller feet after the minimum number of passes. There are also soils in Iowa which will require more than 1 pass per 25 mm (1 inch) of loose thickness to obtain roller walk-out.

Moisture content of the soil being compacted is very important. Dry soils, including shale, may meet the penetration requirements but still are not properly compacted. Where this occurs, the contractor should add water prior to compaction which will be paid for as extra work at the rate specified. As a general guide, water should be added when the moisture content is more than 2 percentage points below the lower moisture limit specified for moisture and density control. Iowa has some soils which will obtain roller walk-out with moisture contents well above optimum but will not provide stability when placed in high fills. The maximum moisture content should not be more than 2 percentage points above the upper limit for moisture and density control. This does not mean that normal embankment is to be constructed with moisture and density control. A good method of obtaining proper moisture for compaction is to mix wet and dry soil in the

same 200 mm (8-inch) lift. Wet soils may be disked in either the borrow or the fill prior to compaction. The plan soil sheets and the cross sections will show the proctor moisture and density. This proctor information can be used to establish the proper moisture content for compaction.

The mixing of wet and dry soils should be avoided where moisture and density are required, however, if it is unavoidable a new standard proctor must be determined because of the variability of the proctor of the combined soils. This is also the case when different soil types from cut areas are mixed and compacted under the M & D requirements (*Specifications 2107.08 and 2107.09*). A new standard proctor must be determined using the mixed soil from the grade.

Compaction of sand, A-1, A-2, and A-3 with 0 Plasticity index will not produce roller walk-out using Type A compaction with a sheepsfoot roller because the sheepsfoot roller will penetrate the surface more than 75 mm (3 inches). A rubber-tired roller, which has 1.4 Mpa (200 pounds per inch) width of roller, may be used with one pass per 25 mm (1 inch) of lift thickness provided the moisture content is adequate. If other rollers (smooth steel, vibratory, etc.) are used, a comparison with proctor density is required.

Sand embankment directly deposited by dredge pipe will obtain 95% of proctor density by the transporting of water flowing through the fill. For this method of placing sand, other methods of compaction *(Specification 2107.07)* may be required. Testing should be done at regular intervals and recorded in the field book. The time for this test is just after the free water leaves the top 200 mm (8 inches) of fill and can be done very quickly with a nuclear density gauge.

The nuclear gauge for moisture and density determination can be used in soil with less than 85% sand, but does require a moisture correction factor for each different type of soil. If the nuclear gauge is used, complete the "Nuclear Test Report, M & D Embankment Construction" (Form 821258) for the first 10 samples of each soil type. This will initiate a tabulation of correction factors which may result in reducing future testing. Only properly trained and qualified nuclear gauge operators can use a nuclear gauge.

Nuclear gauges are to be operated according to *Materials I.M.'s 206, 334, and 551*. "Nuclear Test Report - M & D Embankment Construction" (Form 821258) should be used and distributed according to the instructions on the form. This form may be used without field book entries.

Sand for Class 10 should be placed in lifts full width of the embankment. If this cannot be done, a sand trench drain should be placed at the low point to eliminate ponding water.

The use of a sheepsfoot roller for proof that the required compaction has been achieved is not acceptable.

Special Compaction of Subgrade
Special compaction of subgrade is usually required under detours, runarounds, and short paving sections. Special compaction is constructed when less than desirable soils are available on a project.

Special compaction requires the following:

- Stability
- Pulverization, if needed

- Compaction to 95% of standard proctor density
- Moisture content not drier than 6 percentage points below optimum moisture.

Moisture content is most important in order to obtain stability. When all requirements are followed, there is usually no problem with the paving operation.

If subgrade rutting occurs to the extent that thickness of the pavement being placed does not conform to the designed dimension, the inspector shall immediately stop construction of the pavement.

Paving shall not be permitted to start again until the rutted subgrade is repaired.

It should be noted that Special Compaction of Subgrade is not inspected on the same basis as Compaction with Moisture and Density Control. Approval of the latter is based on tests to insure compliance with moisture and density limitations during embankment construction, not control of rutting of the subgrade during pavement construction.

Subgrade Treatment
Subgrade treatment is used to improve the grade stability. Therefore it is very important to construct these areas according to plan. Every effort should be made to obtain the best soil possible for select backfill.

1. For select backfill, plans will show the location and soil type to be used. The plans or the specifications identify the moisture limits. If the plan soil sheets show a proctor density for the soil being used, this moisture content may be used.

Where select soil is in limited supply, trench treatments will be used. In this situation a trench should be constructed at low points or end of treatments to provide for drainage as shown on *Road Design Typical 8301*.

2. Some projects may not have select soil available on site. In these cases, the plans may specify a Polymer Grid to be placed. A Polymer Grid is a polypropylene material used to distribute the load over a greater area. Polymer Grid is placed on top of the subgrade, and aggregate (normally special backfill) is then placed on top of the Polymer Grid. The thickness of the special backfill will be specified in the plans, usually in the range of 150 mm (6 inches) to 300 mm (12 inches). Polymer Grid commonly is supplied in widths of 3 m (9.8 feet) and 4 m (13.1 feet).

3. Moisture and density control is used to improve control of compaction of the top lifts of the subgrade. With sand select backfill, the top lifts are placed with moisture control or moisture and density control since the placement is critical to the pavement determination.

Where overloads are required by the plans, they should be constructed using the designated subgrade treatment since a portion of the overload will ultimately become the subgrade on which paving is placed.

In the event that the soil conditions are not stable at the bottom of the subgrade treatment, additional cut should be made until stability is achieved. Payment for this additional excavation should be twice the Class 10 price. Backfill with Class 10 material.

Construction of Embankment Toe Berms
On deep fills, the plans sometime require that a berm be constructed for stability of the embankment. These berms should be constructed at the same time and in the same manner as the embankment.

Toe berms are also built in areas where the roadway is used as a dam for a pond. In these areas the berm is used to protect the embankment from saturation by the standing water. Proper compaction is needed on these berms to reduce permeability of the fill.

Construction of Bridge Approach Fills
Toe stakes should be set and the slopes and the centerline checked during the construction of the embankment. The slopes should be finished to the lines and grade called for on the plans. It should not be necessary for the bridge contractor to move an excessive amount of dirt or break up large lumps to grade the slope for the concrete revetment.

In the construction of these berms, particular attention should be given to prevent the incorporation of rocks over 100 mm (4 inches) in diameter as the lifts are placed. Rocks cause extreme difficulty when driving piling or preboring for piling.

The removal of boulders in bridge berms should be included in the Class 12 boulder item or covered by an extra work order.

Bridge approach fills should be constructed to grade with adequate length along the centerline for the bridge contractor to work. This length should be adequate for the bridge contractor's storage of material. Usually 30 to 45 m (100 to 150 feet) are adequate. This can be shortened by mutual agreement between the contractors.

Embankment in Place
Payment for embankment in place will be based on one of two methods:

- Plan quantity agreement
- Cross sections obtained after placement

Sections of deep fills may have the quantities adjusted, based on settlement plates. (Refer to C.M. 6.43). A graph may be plotted with fill height vs. settlement to determine settlement at intermediate heights of fill. Using this chart, the settlement below the original ground line can be determined and plotted. The volume between the plotted settlement line and original ground can then be calculated using the average end cross section method. This volume is added to the plan quantity for final payment.

Payment for Water for Embankment Construction
When water is required for compaction of normal embankment fill, it should be paid for as extra work if no contract item has been provided. The limits identified in *Construction Manual 6.33* should be used as a guide.

When water is required for moisture and density control *(Specification 2107.09)*, the cost of adding and incorporating water is a part of the item. Therefore, water will not be considered for pay.

Finishing
Finishing work should be completed as the grading in each spread progresses through the project.

If the finishing work is not performed on a timely schedule, the project engineer is advised to follow these progressive steps:

- Project engineer should notify the contractor of the concerns in writing.
- If this does not obtain results, the full quantity of Class 10 should not be paid for on the progress vouchers until the finishing work is improved to the satisfaction of the project engineer. A reduction of 10% of the Class 10 quantity on the first progress voucher following the written notice is recommended.
- If the finishing operation has not improved to the satisfaction of the project engineer, a 30% reduction in the Class 10 is recommended for the 2nd progress voucher following the written notice.
- Suspension of the work on the project can be used if the preceding steps result in little improvement.

6.42 OVERHAUL

Road Design Memorandum 226 (Brown Design Manual) outlines the method used to determine the plan quantity for overhaul. Where overhaul has to be field calculated for final payment quantities, the same procedure should be followed where possible.

The specifications require a center of mass to be used when material is taken from outside the roadway design template. The plan borrow layout should show the station location and the distance right or left to the center of mass used to calculate the plan quantity for overhaul. Any material taken outside the design section as described by the plan sheet, ditch dimension, and *Road Design Typical 4101* should have overhaul determined using the center of mass.

6.43 SETTLEMENT PLATES

General

On some grading projects, settlement plates are required along with delay periods before abutment construction. When new fill is built over a lower layer of compressible soil in natural ground, buried layers (especially weak clays and silts) settle under the weight of new fill. If settlement occurs at bridge abutments after piling has been driven, the compressing layer 'drags' the new piles downward. This 'downdrag' force increases the vertical load in the pile, possibly past the design force on the pile calculated from bridge weight and traffic load.

DOT Soils Design predicts the amount and rate of settlement. Factors are the type and thickness of buried soil, height and rate of new fill, and drainage outlets above or below the compressible layer, which allow water to be squeezed out, speeding up settlement.

Standard Road Plan RL-6 shows details of a settlement plate. A stiff (3'-0" x 3'-0" x 3/16") steel plate is set at the top of natural ground and extended upward with steel pipe lengths. The elevation change of the plate is tracked and is assumed equal to settlement of lower ground. The actual amount and rate of settlement are then checked against values predicted by DOT Soils Design.

General Notes in bridge plans usually require a time delay of a specified number of days after the abutment fill has been completed and before piling can be driven. Notes may also require pile driving to be further contingent upon analysis of settlement readings. Settlement plate readings are sent to Office of Design (Soils Design Section) for comparison with design settlement predictions. With analysis, the time delay period can

be reduced or increased. The settlement readings are to be submitted to Soils Design on a weekly basis (unless no readings were taken) rather than waiting until the final review.

Guidelines for Installation and Monitoring of Settlement Plates

A reporting form for settlement plate readings is available in Appendix 6-3(b). An example of a completed form is included as Appendix 6-3(a).

It is important to ensure that riser pipes are plumb and that the settlement plate is protected against disturbance. Recommendations are:

- Use a carpenters level to check plumb of risers when installing
- Mark exposed risers with spiral fluorescent survey tape, and leave a 'flag' of free tape at the top
- Reference the initial position of the settlement plate pipe with survey ties, similar to that done for survey points such as PI's or POT's on 'G' sheets of project plans. Monitor position during construction as needed, and submit final reference distances with the last settlement plate readings.

If a riser pipe for a settlement plate is hit, dislodged, damaged, etc. during construction, the pipe must be repaired and a stable elevation re-established before further readings are taken. Inspect the pipe and excavate down to an intact section by visual inspection. Previous reading and survey ties can be used to check if a section has been disturbed. Note any damage in the reporting form and resume readings.