WisDOT Std Specs
GPS Machine Guidance
For Subgrade

SECTION 650 CONSTRUCTION STAKING

650.1 Description

(1) This section describes the contractor-performed construction staking required under individual contract bid items to establish the horizontal and vertical position for the following:

Storm sewer	Subgrade	Base
Curb, gutter, and curb & gutter	Pipe culverts	Structure layout
Concrete pavement	Concrete barrier	Resurfacing reference
Electrical installations	Supplemental Control	Slope Stakes

650.2 (Vacant)

650.3 Construction

650.3.1 General

(1) Department and contractor responsibilities for construction staking are specified in 105.6. Conform to 105.6 and the additional requirements specified here in 650.3 for the individual contractor-staking bid items the contract includes.

(2) Protect and preserve known property and survey marks and land monuments as specified in 107.11.3. The contract may require related work under the section 621 bid items.

(3) Obtain or calculate benchmark data, grades, and alignment from plan information. The engineer will furnish data for the horizontal and vertical control points, control point ties, horizontal alignments, profiles, and elevations. Reestablish, set additional, and maintain the horizontal and vertical control points and control point ties, as needed for bid items. Furnish, set, reference, and maintain all stakes and markings necessary to establish the alignment, location, benchmarks, elevations, and continuous profile-grades for all road and structure work as needed for bid items. Supervise and coordinate construction staking.

(4) Check horizontal and vertical information including but not limited to alignments, locations, elevations, and dimensions, that either the plans show or the engineer provides, for compatibility with existing field conditions. Conduct similar compatibility checks and accuracy checks of horizontal and vertical positions either the department or the contractor establishes in the field.

(5) Perform survey work using global positioning or conventional methods. Establish additional benchmarks and control points as necessary to support the method of operation, or as the engineer directs. Do not use global positioning methods to establish the following:

1. Structure layout horizontal or vertical locations.
2. Concrete pavement vertical locations.
3. Curb, gutter, and curb & gutter vertical locations.
4. Concrete barrier vertical locations.

(6) Maintain neat, orderly, and complete survey notes, drawings, and computations used in establishing the lines and grades. Make the survey notes and computations available to the engineer within 24 hours, upon request, as the work progresses.

(7) Furnish all surveying equipment, stakes, flags, pins, lath, whiskers, and other materials necessary to perform this work, subject to the engineer's approval.

650.3.2 Storm Sewer

(1) Set and maintain construction stakes or marks as necessary to achieve the required accuracy and to support the method of operations. Locate all pipe, inlet, catch basin, manhole, and endwall construction stakes to within 0.02 feet horizontally and establish the elevations to within 0.01 feet vertically. Determine that the final elevations of storm sewer pipe outfalls and inlets match the existing field elevations, and provide this information to the engineer at a mutually agreed upon date or least 14 calendar days before ordering inlets, catch basins, manholes, endwalls, and storm sewer pipe.

650.3.3 Subgrade

650.3.3.1 General

(1) Under the Construction Staking Subgrade bid item the contractor may substitute global positioning system (GPS) machine guidance for conventional subgrade staking on all or part of the work. The engineer may require the contractor to revert to conventional subgrade staking methods for all or part of

the work at any point during construction if, in the engineer's opinion, the GPS machine guidance is producing unacceptable results.

650.3.3.2 Subgrade Staking

(1) Set construction stakes or marks at intervals of 100 feet, or more frequently, for rural sections and at intervals of 50 feet, or more frequently, for urban sections. Include additional stakes at each cross-section as necessary to match the plan cross-section, achieve the required accuracy, and to support construction operations. Also set and maintain stakes as necessary to establish the horizontal and vertical positions of intersecting road radii, auxiliary lanes, horizontal and vertical curves, and curve transitions. Locate stakes to within 0.25 feet horizontally and establish the grade elevation to within 0.03 feet vertically.

650.3.3.3 GPS Machine Guidance

650.3.3.3.1 General

(1) No subgrade stakes are required for work completed using GPS machine guidance.

(2) Coordinate with the engineer throughout the course of construction to ensure that work performed using GPS machine guidance conforms to the contract tolerances and that the methods employed conform to the contractor's GPS work plan and accepted industry standards. Address GPS machine guidance issues at weekly progress meetings.

650.3.3.3.2 GPS Work Plan

(1) Submit a comprehensive written GPS work plan for department review at least 5 business days before the preconstruction conference. The engineer will review the plan to determine if it conforms to the contract.

(2) Construct the subgrade as the contractor's GPS work plan provides. Update the plan as necessary during construction of the subgrade.

(3) The GPS work plan should discuss how GPS machine guidance technology will be integrated into other technologies employed on the project. Include, but do not limit the contents to, the following:

1. Designate which portions of the contract will be done using GPS machine guidance and which portions will be done using conventional subgrade staking.
2. Describe the manufacturer, model, and software version of the GPS equipment.
3. Provide information on the qualifications of contractor staff. Include formal training and field experience. Designate a single staff person as the primary contact for GPS technology issues.
4. Describe how project control is to be established. Include a list and map showing control points enveloping the site.
5. Describe site calibration procedures. Include a map of the control points used for site calibration and control points used to check the site calibration. Describe the site calibration and checking frequency as well as how the site calibration and checking information are to be documented.
6. Describe the contractor's quality control procedures. Describe procedures for checking, mechanical calibration, and maintenance of equipment. Include the frequency and type of checks performed to ensure that the constructed subgrade conforms to the contract plans.

650.3.3.3.3 Equipment

(1) Use GPS machine guidance equipment to meet the requirements of the contract.

(2) Perform periodic sensor calibrations, checks for blade wear, and other routine adjustments as required to ensure that the final subgrade conforms to the contract plans.

650.3.3.3.4 Geometric and Surface Information

650.3.3.3.4.1 Department Responsibilities

(1) At any time after the contract is awarded the contractor may request the contractor staking packet. The department will provide the packet within 5 business days of receiving the contractor's request.

650.3.3.3.4.2 Contractor Responsibilities

(1) Develop and maintain the initial design surface DTM for areas of the project employing GPS machine guidance. Confirm that the design surface DTM agrees with the contract plans.

(2) Provide design surface DTM information to the department in LandXML or other engineer-approved format.

650.3.3.3.4.3 Managing and Updating Information

(1) Notify the department of any errors or discrepancies in department-provided information. The department will determine what revisions may be required. The department will revise the contract plans, if necessary, to address errors or discrepancies that the contractor identifies. The department will provide the best available information related to those contract plan revisions.

(2) Revise the design surface DTM as required to support construction operations and to reflect any contract plan revisions the department makes. Perform checks to confirm that the revised design surface DTM agrees with the contract plan revisions. Provide a copy of the resultant revised design surface DTM to the engineer in LandXML or other engineer-approved format. The department will pay for costs incurred to incorporate contract plan revisions as extra work.

650.3.3.3.5 Site Calibration

(1) Designate a set of control points, including a total of at least 6 horizontal and vertical points or 2 per mile, whichever is greater, for site calibration for the portion of the project employing GPS machine guidance. Incorporate the department-provided control framework used for the original survey and design.

(2) Calibrate the site by determining the parameters governing the transformation of GPS information into the project coordinate system. Use the full set of control points designated under 650.3.3.3.5 (1) for the initial site calibration. Provide the resulting site calibration file to the engineer before beginning subgrade construction operations.

650.3.3.3.6 Construction Checks

650.3.3.3.6.1 Daily Calibration Checks

(1) In addition to the site calibration, perform site calibration checks. Perform these checks at individual control points not used in the initial site calibration. At a minimum, check the calibration at the start of each day as described in the contractor's GPS work plan. Report out-of-tolerance checks to the engineer. The measured position must match the established position at each individual control point within the following tolerances:

- Horizontally to 0.10 feet or less.
- Vertically to 0.05 feet or less.

(2) Discuss the previous week's daily calibration check results at the weekly progress meeting for monitoring the GPS work.

650.3.3.3.6.2 Final Subgrade Elevation Checks

(1) Check the subgrade against the plan elevation at randomly selected points on cross sections located at stations evenly divisible by 100. Conduct at least 20 random checks per stage, per project, or per mainline roadway mile whichever results in the most tests. Also check the subgrade at additional points as the engineer directs. Notify the engineer at least 2 business days before making subgrade checks so the engineer can observe the process.

(2) Ensure that at least 4 of any 5 consecutively tested random subgrade points are within 0.10 foot vertically of the plan elevation. Notify the engineer if more than one of any five consecutively tested random subgrade points differs by more than 0.10 feet from the plan elevation.

(3) The department may conduct periodic independent subgrade checks. The department will notify the contractor if any individual check differs by more than 0.10 feet from the design.

650.3.4 Base

(1) Set construction stakes or marks at 100-foot intervals for rural sections and 50-foot intervals for urban sections. Set and maintain sufficient stakes at each cross section to match plan cross-section, achieve the required accuracy, and to support the method of operations. Set and maintain stakes as necessary to establish horizontal and vertical position along intersecting road radii, auxiliary lanes, vertical and horizontal curves, and curve transitions. Locate stakes within 0.25 feet horizontally and establish the grade elevation to within 0.03 feet vertically.

650.3.5 Curb, Gutter, and Curb & Gutter

(1) Set construction stakes or marks at 50-foot intervals, maximum. Set and maintain stakes as necessary to achieve the required accuracy and to support the method of operations. Set additional construction stakes as necessary to establish location and grade of curb, gutter, and curb & gutter, including points of change in alignment grade, along intersecting radii, and at the radius points of intersecting road radii.

Locate stakes to within 0.02 feet horizontally and establish the grade elevation to within 0.01 feet vertically.

650.3.6 Pipe Culverts

(1) Set and maintain construction stakes or marks as necessary to achieve the required accuracy and to support the method of operations. Locate stakes for pipe culverts and appurtenant inlets and catch basins to within 0.25 feet horizontally and establish the grade elevation to within 0.03 feet vertically. If installing pipe culverts at existing drainage ditches, verify the existing ditch location, elevations, and skew for a minimum of 150 feet from pipe ends, and provide this information to the engineer at a mutually agreed upon date or 14 calendar days before ordering pipe culverts.

650.3.7 Structure Layout

(1) Set construction stakes or marks on a line offset from the structure centerline or on a reference line, whichever is appropriate, for both roadway and substructure units. Establish the plan horizontal and vertical positions to the required accuracy. Also, set and maintain stakes and marks as necessary to support the method of operations. Locate stakes and marks to within 0.02 feet of the true horizontal position, and establish the grade elevation to within 0.01 feet of true vertical position. The department, unless the contract specifies otherwise, will compute deck grades with contractor-supplied girder elevation data.

650.3.8 Concrete Pavement

(1) Set construction stakes or marks at 25-foot intervals. Set and maintain additional stakes as necessary to establish location and grade along intersecting road radii; and for auxiliary lanes, vertical curves, horizontal curves, and curve transitions according to the plans. Locate stakes to within 0.02 feet horizontally and establish elevations to within 0.01 feet vertically. Set and maintain sufficient additional stakes at each cross-section to achieve the required accuracy and to support the method of operations.

650.3.9 Concrete Barrier

(1) Set construction stakes or marks at 50-foot intervals, maximum. Set and maintain additional stakes as necessary to establish location and grade of concrete barrier including point of change in grade, along intersecting radii, and at the radius point of intersecting radii to achieve the required accuracy and to support the method of operations. Locate stakes to within 0.02 feet horizontally and establish the grade elevation to within 0.01 feet vertically.

650.3.10 Resurfacing Reference

(1) Set construction stakes for pulverized and re-laid pavement before beginning milling operations. Place construction stakes or pins for offsetting the roadway reference line at 100-foot intervals, minimum, or as the engineer directs.

(2) Place construction stakes or marks for all other types of resurfacing work at 300-foot intervals, minimum, or as the engineer directs.

(3) Set and maintain additional stakes as necessary to establish location and grade along intersecting road radii, auxiliary lanes, and curve transitions according to the plans.

650.3.11 Electrical Installations

(1) Set and maintain construction stakes or marks as necessary to achieve the required accuracy and to support the method of operations. Locate stakes to within 0.02 feet horizontally and to establish the grade elevation to within 0.01 feet vertically.

650.3.12 Supplemental Control

(1) Set and maintain construction marks as required to support the method of operations consistent with third-order, class I horizontal and third-order vertical accuracy. Check the department-provided horizontal and vertical control information and notify the engineer of any discrepancies. Provide marks to establish and maintain intermediate vertical and horizontal control for reference line alignment, side road alignments, radius points, bench level circuits, and offsetting the horizontal roadway alignment. These marks constitute the field control used to govern and execute the work.

(2) Document and provide to the engineer complete descriptions and reference ties of the control points, alignment points, and benchmarks to allow for quick reestablishment of the plan data at any time during construction and upon project completion. Document additional control on forms described as a part of the contractor staking packet in CMM 7.10.

650.3.13 Slope Stakes

(1) Verify the existing ground elevations as shown for all roadways on cross-section sheets for accuracy. Take and document a minimum of 5 shots per roadway section, one at the centerline or at an engineer-approved offset from the centerline and 2 at each side of the roadway. For the shots at the roadway sides, take one shot at the slope stake and one shot at the slope intercept. If the elevation at the slope intercept is off by more than 0.4 foot, notify the engineer.

(2) Set and maintain slope stakes on each side of the road at each cross-section location the plans show. Locate stakes to within 0.25 feet horizontally and establish elevations to within 0.1 feet vertically.

650.4 Measurement

(1) The department will measure the Construction Staking bid items for subgrade, base, concrete pavement, resurfacing reference, and slope stakes by the linear foot acceptably completed, measured along each roadway centerline. The department will not measure construction staking for base underlying concrete pavement.

(2) The department will measure Construction Staking Curb Gutter and Curb & Gutter by the linear foot acceptably completed, measured along the base of the curb face. The department will measure Construction Staking Concrete Barrier by the linear foot acceptably completed, measured along the base of the barrier. The department will not measure these bid items if abutting concrete pavement.

(3) The department will measure Construction Staking Storm Sewer as each individual inlet, catch basin, manhole, and endwall acceptably completed.

(4) The department will measure Construction Staking Pipe Culverts by each individual pipe culvert staked and acceptably completed.

(5) The department will measure Construction Staking Structure Layout as a single lump sum unit for each structure acceptably completed. The department will measure Construction Staking Electrical Installations as a single lump sum unit for all electrical installations acceptably completed on each project. The department will measure Construction Staking Supplemental Control as a single lump sum unit for all control marks acceptably completed on each project.

650.5 Payment

(1) The department will pay for measured quantities at the contract unit price under the following bid items:

ITEM NUMBER	DESCRIPTION	UNIT
650.4000	Construction Staking Storm Sewer	EACH
650.4500	Construction Staking Subgrade	LF
650.5000	Construction Staking Base	LF
650.5500	Construction Staking Curb Gutter and Curb & Gutter	LF
650.6000	Construction Staking Pipe Culverts	EACH
650.6500	Construction Staking Structure Layout (structure)	LS
650.7000	Construction Staking Concrete Pavement	LF
650.7500	Construction Staking Concrete Barrier	LF
650.8000	Construction Staking Resurfacing Reference	LF
650.8500	Construction Staking Electrical Installations (project)	LS
650.9910	Construction Staking Supplemental Control (project)	LS
650.9920	Construction Staking Slope Stakes	LF

(2) The department will not make final payment for any staking item until the contractor submits all survey notes and computations used to establish the required lines and grades to the engineer within 21 days of completing this work. The department will deduct from payments due the contractor for the additional costs specified in 105.6.

(3) Payment for all the Construction Staking bid items is full compensation for locating and setting all construction stakes; for relocating and resetting damaged or missing construction stakes.

(4) Payment for Construction Staking Supplemental Control also includes resetting damaged or missing preliminary construction stakes, and protecting and reestablishing the alignment of all roadways.

(5) Payment for Construction Staking Storm Sewer also includes setting construction stakes as necessary for storm sewer pipe associated with each inlet, catch basin, manhole or endwall staked.

(6) Payment for Construction Staking Pipe Culverts also includes setting construction stakes for appurtenant inlets and catch basins as necessary associated with each pipe culvert staked.