2017 Contract Administration Workshop
Surveying, Automated Machine Guidance and Grading
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Construction Surveying is performed by:

NCDOT Staff

Contract Surveying (Section 801)

CEI Survey Crews
Survey Preconstruction Meeting

AGENDA ITEMS

NCDOT Expectations

Review of Construction Layout Manual
  - Part of Contract Documents

Use of GPS

NCDOT Review of Contractor Layout
Survey Preconstruction Meeting

AGENDA ITEMS

Verification of Vertical and Horizontal Control

Survey Submittals - storm drain and utility submittals

Structure Layout – (Independent) Verification Needed

Supplemental Surveying
Surveying

Safety – The #1 Priority

Proficiency, accuracy and timeliness should never take precedence over safety of the crew and/or public.

Use caution with “One Man” Survey Parties

Most common hazard – moving equipment
Surveying

Required Submittals

A printout of horizontal verification, as well as coordinates, differences and error of closure.

A printout of vertical control verification, with benchmark location elevations, and differences from plan elevations.

Sketch of location of newly referenced horizontal control, with text printout of coordinates, method of reference and field notes associated with referencing control.
Surveying

Required Submittals

Description of newly established benchmarks with location, elevation and closed loop survey field notes.

The proposed method for recording information in field books to ensure clarity and adequacy.

All updated electronic and manuscript survey records on a monthly basis.
Surveying

Required Submittals

Two (2) copies of layout drawings for all utility construction systems.

Two (2) copies of layout drawings for all drainage systems.

Layout drawing for each structure and culvert.
Surveying

Required Submittals

Computations for buildups over beams, screed grades and overhang form elevations.

Sign S-Dimension information on an 11 ½ inch x 17 inch drawing depicting the theoretical finished section at each proposed overhead sign assembly location.

Coordinate data showing differences between supplied baseline coordinates and field obtained GPS coordinates, including report detailing preliminary input data.
Surveying

Required Submittals

Any proposed plan alteration to rectify a construction stakeout error, including design calculations, narrative and sealed drawings.

Validation of right-of-way marker locations.

Alignment of baseline for each borrow pit location.
Surveying

Required Submittals

Detailed sketch of proposed overhead and Type A and B ground mounted sign locations along with any obstructions that may interfere with installation

Digital Terrain Model (Location and Surveys)

AMG Work Plan
Surveying

Staking Control Points

Initial Survey Control – The foundation for all subsequent surveying

Contractor should easily verify Department’s control by performing a closed traverse within the specified accuracy and will preserve the accuracy in referencing the control

Submit to the Engineer a printout of the control verification, as well as coordinates, differences and error of closure.
Surveying

Orange Safety Fence

Provide construction stakes to establish the locations of the safety fence along the outside riparian buffer, wetland, water boundary or other boundaries.

Provide wooden stakes on 25 foot maximum intervals with flagging attached to delineate the interior boundaries of all jurisdictional areas. Interior boundaries of hand clearing areas shall be identified with a different colored flagging to distinguish it from mechanized clearing.
Surveying

Orange Safety Fence

Surveying

JURISDICTIONAL STREAM – RIPARIAN BUFFER ZONE*

* – REFER TO PERMIT DRAWINGS FOR JURISDICTIONAL BOUNDARIES AND BUFFER ZONE IMPACTS

PERMITTED CLEARING LIMITS

SAFETY FENCE

FLAGGING

ALLOWABLE IMPACTS ZONE 1

ALLOWABLE IMPACTS ZONE 2
Surveying

Pipe Stakes

The purpose of the drainage system is to effectively collect and distribute storm water.

Any potential drainage problems should be identified and recommendations made to the Engineer for correction.

It is the responsibility of the construction stakeout crew to ensure that the drainage systems detailed in the plans will function properly as staked.
Surveying

Pipe Stakes

Perform a field investigation of the proposed drainage system prior to calculating and staking the drainage system.

Consider the locations and elevations of all existing and proposed utilities.

A layout drawing of the drainage system must be submitted to the Engineer for review and approval following the Checklist for Drainage Layout.
Surveying

Pipe Stakes

Establish pipe lengths from the drainage structure locations and/or actual location of the slope intercept with existing streams, natural ground or proposed drainage ditches as measured during the field investigation and/or layout.

In order to ensure the clear zone recovery requirements are met, when staking crossline pipes notify the Engineer if the pipe length is less than the plan length.
Surveying

Minor Structure Stakes

During construction stakeout, the survey crew should identify potential drainage problems in the field and make recommendations for correction to the Engineer.

Verify the location of all drainage structures within sag vertical curves and reposition as necessary to assure the structure is located at the lowest point.

Super elevations at both the roadway and shoulder should be considered in establishing the lowest point.
Surveying

Minor Structure Stakes

Stake each drainage structure independently of each pipeline.

Each structure will require a reference line for alignment and grade, consisting of at least one hub on opposite sides of the drainage structure.
Surveying

Minor Structure Stakes

Prior to submitting a drainage system layout drawing, refer to the *Checklist for Drainage Layout Submittal* to verify that all of the required information is included.

Unless otherwise approved, calculate the entire network before submitting any portion of the network.
**Surveying**

**Major structure Stakes**

All major structures will be staked with reference lines which contain at least three (3) reference hubs on each side with tacks.

Reference hubs shall be checked for accuracy after sitting all winter.

If two structures are side by side, then the reference hubs for each bridge should be color coordinated to eliminate confusion.
Surveying

Major structure Stakes

*Bridge Stake Out*

Bridge stake out will contain two reference lines for each end bent, interior bent, and the long chord line.

Set a minimum of two (2) temporary benchmarks to remain in place throughout the entire bridge construction. One benchmark is to be used for substructure and one for superstructure.

On grade separation structures, a point of minimum vertical clearance may be shown on the general drawing.
Surveying

TYPICAL BRIDGE - TANGENT SURVEY LAYOUT

- Bridge Reference Points:
  - Marked with guard stakes and offsets for P.O.T.s on survey line.

- Survey Reference Points:
  - Marked with guard stakes and offsets for P.O.T.s on survey line.

Turn angles from bridge centerline to Bent Lines and measure and record distances from centerline of bridge to the reference points. Bridges should not be laid out using radial stakeout unless prior approval has been obtained.
Surveying

GPS

The Contractor may elect to utilize Global Positioning System (GPS) surveying, either static or kinematic.

Perform GPS surveys with same or higher order of accuracy as conventional surveys.
NCDOT projects utilize a localized coordinate system developed by the Location and Surveys Unit specifically for each individual project.

Using the Survey Control Sheet located in the plans, obtain the control information that the Location and Surveys Unit utilized in establishing the localized coordinate system, specifically the Rotation, Scaling, Translation and coordinates for the azimuth pairs.
Surveying

GPS

If no site calibration is provided in the plans, perform a site calibration and include the results in the required horizontal and vertical control verification submittal for approval.

Newly developed GPS procedures and techniques that do not conform to the Specifications in this section may be used if approved by the Engineer.

For additional guidance in performing GPS, see the GPS Survey Guidelines in the NCDOT Location and Surveys Manual.
Survey Equipment

GPS Rovers

Data-Collectors
   – New from Trimble later this year

Robotic Total Station
ABOVE ALL ELSE!

Be sure to perform an independent verification of the contract surveyor’s layout prior to construction
Automated Machine Guidance

Challenges

• Understanding of GPS capabilities
• GPS Equipment

Engineer’s and Inspector’s Perspective

How do I check grade?
Where are the stakes?
What is a calibration?
How do I run this data collector?
AMG Special Provision

Worked with Contracting Industry to develop Provision

Included on Major Earthwork Projects

Included on Design Build Projects

Included on Projects with New Alignments
AUTOMATED MACHINE GUIDANCE
(I-2-11)

General

This Special Provision contains requirements to be followed if the Contractor elects to use Global Positioning System (GPS) machine control grading and shall be used in conjunction with Section 801 of the Standard Specifications. The use of this technology is referenced as Automated Machine Guidance (AMG).

All equipment using AMG shall be able to generate end results that meet the Standard Specifications. Perform test sections for each type of work to be completed with AMG to demonstrate that the system has the capability to achieve acceptable results. If acceptable results can not be achieved, conform to the requirements for conventional stakeout.

The Contractor shall be responsible for all errors resulting from the use of AMG and shall correct deficiencies to the satisfaction of the Engineer at no cost to the Department.

Submittals

If the Contractor elects to use AMG, a Digital Terrain Model (DTM) of the design surface and all intermediate surfaces shall be developed and submitted to the Engineer for review.

At least 90 days prior to beginning grading operations, the Contractor shall submit to the Engineer an AMG work plan to include, but not limited to, proposed equipment, control software manufacturer and version, types of work to be completed using AMG, project site calibration report, repetitive calibration methods for construction equipment and rover units to be used for the duration of the project, and local GPS base station to be used for broadcasting differential correction data to rover units (this may include the NC Network RTK). All surveys must be tied to existing project control as established by NCDOT.

Inspection

The Engineer will perform quality assurance checks of all work associated with AMG. If it is determined that work is not being performed in a manner that will assure accurate results, the Engineer may require corrective action at no cost to the Department.

The Contractor shall provide the Engineer with one GPS rover unit for use during the duration of the contract. The rover will be loaded with the same model that is used with the AMG and have the same capability as rover units used by the Contractor. The rover will be kept in the possession of the Engineer and will be returned to the Contractor upon completion of the contract. Any maintenance or repairs required for the rover will be the responsibility of the Contractor. Formal training of at least 8 hours shall be provided to the Engineer by the Contractor on the use of the proposed AMG system.
If the Contractor elects to use GPS machine control grading it shall be used in conjunction with Section 801 of the Standard Specifications for Roads and Structures.

The use of this technology is referenced as Automated Machine Guidance (AMG).

All equipment using AMG shall be able to generate end results that meet the Standard Specifications.
Perform test sections for each type of work to be completed with AMG to demonstrate that the system has the capability to achieve acceptable results.

If acceptable results cannot be achieved, conform to the requirements for conventional stakeout.

The Contractor shall be responsible for all errors resulting from the use of AMG and shall correct deficiencies to the satisfaction of the Engineer at no cost to the Department.
If the Contractor elects to use AMG for fine grading and placement of base or other roadway materials, the GPS shall be supplemented with a laser or robotic total station.

Include details of the proposed system in the AMG work plan. In addition, the following requirements apply for the use of AMG for subgrade and base construction.
1. Provide control points at intervals along the project not to exceed 1000 feet. The horizontal position of these points shall be determined by static GPS sessions or by traverse connection from the original base line control points.
SUBGRADE AND BASE CONTROLS

2. Provide conventional survey grade stakes at 500’ intervals and at critical points such as, but not limited to, PCs, PTs, superelevation transition points, and other critical points as requested by the Engineer.

3. Provide hubs at the top of the finished subgrade at all hinge points on the cross section at 500 foot intervals. These hubs shall be established using conventional survey methods for use by the Engineer to check the accuracy of construction.
If the Contractor elects to use AMG, a Digital Terrain Model (DTM) of the design surface and all intermediate surfaces shall be developed and submitted to the Engineer for review.

At least 90 days prior to beginning grading operations, the Contractor shall submit to the Engineer an AMG work plan to include, but not limited to, proposed equipment, control software manufacturer and version, types of work to be completed using AMG, project site calibration report, repetitive calibration methods for construction equipment and rover units to be used for the duration of the project.
Grading - Earthwork

Photogrammetry

DTM

Cross-sections
Grading - Earthwork

The Use of Photogrammetry for Excavation Quantities

Memo to State Photogrammetric Engineer & State Location & Surveys Engineer with a date and location for the Earthwork Scoping Meeting

Some Issues: Clearing, Phased Construction & Detours, Borrow Pits, Field Surveys, etc.

Aerial Photography – A moment in time.
Grading - Earthwork

DTM and Cross-sections

Calculated by NCDOT Staff using Geopac or Computation sheets

Earthwork Computation Sheets in Plans

Request assistance from L&S with Models

Overpayments – Make sure you have documentation to confirm quantities!