7-18.1 General

Standard spec 650.3.3 allows the contractor to substitute GPS machine guidance for all or part of the subgrade staking work under the contract. The extents of each GPS machine guidance segment and each subgrade staking segment need to be described in the contractor's GPS work plan. It is the contractor's option whether they will use GPS machine guidance or conventional methods.

Not all projects are suitable for GPS use. Projects with a dense tree canopy, large vertical cuts, or limited survey control may not prove suitable. On these projects subgrade staking would continue to be performed using conventional methods.

7-18.2 Initial Coordination

The contractor needs to provide the GPS work plan as described in the specification to the engineer before the preconstruction conference so the engineer can evaluate the proposed plan. Attachment 1 shows an example GPS work plan. The design engineer, construction engineer, region survey staff, appropriate management, and contractor survey personnel should be present at the preconstruction meeting to discuss the following points regarding grading with machine guidance:

- GPS work plan
- Project and survey schedules
- Key personnel, roles and responsibilities
- Methods for handling changes in the model and related matters
- Handling of survey data and support
- 3-D models and their formats

The project engineer should be in close contact with the region survey staff throughout the course of the project.

7-18.3 3-D Model Development and Exchange

The contractor must develop and maintain the design model for use with the GPS machine guidance equipment, based on the initial survey information provided in the contractor staking packet, as discussed in CMM 7-10. The department recognizes that the contractor will need time to develop the model. To accommodate this, after the contract is awarded the contractor may request the contractor staking packet. The department will provide available information within 5 business days of receiving the request. If the contractor does not make the request to get survey information early, the department will provide survey information in the contractor staking packet at the preconstruction conference.

The contractor is responsible for ensuring that the model agrees with the contract plans. If a plan error is discovered, the contractor must notify the engineer. The department will make necessary plan revisions and updates to the existing surface DTM, but the contractor is still responsible for updating the model and sending the revised version back to the department in LandXML or other engineer-approved format.

The engineer should review the contractor’s proposed model and perform spot checks by projecting known points generated from the plan cross sections onto the proposed model, and generate an error report. The engineer is responsible for maintaining an archive of DTM revisions and dates. The archive should include the DTM files and the time period for which each was active on the project.

7-18.4 Site Control and Calibration

The department is responsible for providing control from the initial survey. The contractor is responsible for verifying, supplementing, and maintaining the project control. Site calibration, sometimes referred to as “localization”, for GPS machine guidance is a process that results in computation of parameters for transforming measured GPS coordinates into the coordinate system of the project control points. Good site calibration and checking are vital to the success of GPS machine control operations.

The GPS machine guidance specification requires that a minimum of 6 control points or 2 points per mile be used for site calibration and that the site calibration be checked daily at control points not used in the calibration. The horizontal and vertical coordinates of all control points must be documented and presented to the engineer. These points should be constructed or located outside the anticipated construction footprint, and they should be available 2 weeks before the preconstruction conference.

The control points used for site calibration should envelop the project and be well distributed around its

perimeter. Control points in close proximity to one another should be avoided. Long, narrow configurations of control points should be avoided. There should be control points near the corners of the project and approximately midway along its boundaries.

The number of site calibrations performed by the contractor should be limited. It is preferred that a single site calibration be used for the duration of the project, but there might be circumstances under which follow-up site calibrations are necessary. In these cases, independent construction checks should be made after each site calibration.

7-18.4.1 Construction Checks

The engineer should work with the region survey staff to develop a plan to perform construction checks. It is essential to provide some independent checks at project start-up to ensure contractor methods are meeting necessary tolerances. These checks should be performed using independent GPS equipment or conventional survey methods (e.g., total station or level), and should meet specified tolerances. The department reserves the right to do added checks as needed.

7-18.4.2 Daily Site Calibration Checks

Site calibration checks are the responsibility of the contractor, but should be reviewed with the region survey staff to verify they are within specified tolerances.

Horizontal and vertical tolerances are specified for site calibration checks but not for site calibration itself. Once the site calibration measurement process is complete, the RTK GPS software will report estimates for horizontal and vertical errors at each of the site calibration control points. The tolerances are 0.10 feet horizontal and 0.05 vertical for the site calibration checks. If any site calibration check exceeds specified tolerances, follow these steps:

1. The check should be re-measured at the same independent control point to ensure there is no problem with the check measurement.
2. A second and, perhaps, a third independent control point should be used to check the site calibration. If tolerances are met at these additional independent control points, then a problem is indicated with the first check control point.
3. If check tolerances are not met at two or more independent control points, then a problem is indicated with the site calibration, and the site calibration measurement and computation procedure should be repeated to ensure that there is no problem with the initial site calibration measurements. If site calibration problems persist, vendor-supplied manuals or guidance might also need to be consulted.
4. If the repeated site calibration measurements are in close agreement with the initial site calibration measurements, then a problem is indicated with one or more of the site calibration control points. The site calibration should then be performed while excluding the control point with the largest horizontal and / or vertical error estimate.
5. If a problem with a site calibration control point is identified in step 4, that control point should be replaced by another and the site calibration procedure and checking should be repeated. The above control point configuration guidelines should be followed in selecting replacement control points.

7-18.4.3 Final Subgrade Checks

On completion of the subgrade the contractor must perform 20 or more randomly selected subgrade checks per stage, per project, or per mainline roadway mile, whichever results in the most tests, against plan elevations. These points should be located at stations evenly divisible by 100 so it's easy to check against the plan. According to the definition of roadway in standard spec 101.3, a divided highway has two or more roadways.

Before conducting the final random checks the engineer may want to direct the contractor to make additional non-random checks in out-of-tolerance areas or areas that otherwise raise concern. Sideroads may warrant additional checks. The engineer should also be aware of critical points, and have the contractor perform additional checks at these locations. Critical points include the following:

- Beginning and end of the project
- Bridge clearances
- Ramp gore areas
- Above and below ground utility crossings
- Bridge approaches
- Intersections and side road matches
- Clearances over pipes

The specification requires the contractor to notify the engineer at least 2 business days before making the

random subgrade checks. It is very important for the engineer to be present during the subgrade checks, and to make note of each check in the field diary.

If more than 1 of any 5 consecutively tested random subgrade points differs by more than 0.10 feet from the plan elevation, the grade is not suitable, and the contractor must make corrections to the grade. Random subgrade checks should then be performed again until 4 out of 5 consecutively tested points are within 0.10 feet of plan elevation.

List of Attachments

Attachment 1 Sample GPS Work Plan