# CHAPTER 8

# EARTHWORK NOTES AND DOCUMENTATION

## 8.1 PURPOSE

To summarize accepted methods for recording cross section notes for final pay quantities, provide procedures for documenting various excavation items; channel, borrow, and subsoil excavation. To provide guidelines for verifying earthwork items, and to define FDOT radial survey requirements for construction surveys. It is not the intent of these procedures to supersede the requirements in the Survey Handbook, but to enhance the process for documentation of quantities for the submittal of the Final Estimates Package.

## 8.2 AUTHORITY

***Florida Statutes, Section 334.048***
***Board of Professional Surveyors and Mappers Rule Chapter 61G17-6.003***

## 8.3 REFERENCE

***Survey Handbook (SH) (Procedure Topic No. 550-030-101a)***

## 8.4 MINIMUM REQUIREMENTS FOR FINAL MEASURED EARTHWORK PAY ITEM NOTES

Cross-section notes are an important part of the Final Estimates field records for earthwork quantities. The following requirements are specifically written for final pay earthwork notes and are intended as minimum standards for any required note keeping. It is the responsibility of the Project Administrator (PA) to see that minimum standard requirements are met.

**8.4.1** Standard large bound field books (or approved electronic survey data recorders) shall be used to record your notes. The date, weather conditions and the names of the individuals making up the field crews should be recorded on each page where each days notes begin or a record stored within the data. (Identify pay items, original cross-sections, final cross-sections, etc. that define the purpose of the notes.)

**8.4.2** **Contractor's records are not acceptable for Florida Department of Transportation (FDOT) pay quantities**. (As an exception, Contractor survey notes may be used if obtained by a joint survey under the responsible charge by the Department or its representative.)

**8.4.3** Identify Center Line or Base Line (CL/BL) shots, and precede recording the shots left and right of CL/BL as they are being taken. For hand-written field books, the figures used should be plain and legible, and spaced so that figures are not written over one another. For examples, of sample lettering and standard note format see the ***Survey Handbook***. When recording data use a 2H or 3H pencil; never use a pencil soft enough to blur.

**8.4.4** Rod readings for earthwork notes (ground shots) are to be recorded to the nearest tenth (0.1) of a foot. The rod readings on paved surfaces will be recorded to the nearest hundredth (0.01) of a foot.

8.4.5 Check Levels, a complete set of levels from the first to the last bench mark on the job, turning through all existing bench marks, without adjusting H.I.'s or "correcting up" for any differences at individual benches. If the Check Levels are within third order accuracy, no additional check levels will need to be run.Third Order Accuracy requires the closure to be within 12.0 mm x square root of the distance in km (.05 feet x square root of the distance in miles).

**8.4.6** Project Bench Marks (BM) shall only be used after a complete ~~closed~~ set of check levels has been run. The Height of Instrument (HI) is established from shots made to the BMs. For hand-recorded notes, record the HI to the nearest hundredth (0.01) of a foot (or better) above the first cross-section to which it applies and at the top of the following pages until a different HI is established. Underscore each HI with double lines. Show BM location by description or station and offset in field notes and cross reference to field book and page to where BM elevations have been reestablished or verified. These cross-section level notes must carry the same closure tolerance as running bench levels. ~~The level lines run for bench levels on roadway jobs must be correct to Third Order Accuracy. This requires the closure to be within 12.0 mm x square root of the distance in km (.05 feet x square root of the distance in miles)~~

8.4.7 Temporary Bench Marks (T.B.M.) should be set only after the project check levels have been completed; and shall be accomplished by running a complete level circuit from one of the project bench marks to the T.B.M. and back or to another established project bench mark.

**8.4.8** For hand-recorded notes, when multiple HI's are required within only one cross section, it must be clearly indicated by brackets or other means, to which HI the different shots are referenced.

**8.4.9** Direct Rod Readings are not acceptable for use.

**8.4.10** The same baseline and stationing of cross sections must be used for both the original and final cross sections. Care must be exercised where match lines are required to insure that proper stationing on each baseline is reconciled and that proper ties are made. Stations at which cut or fill begin (daylight lines) must be identified in the notes.

**8.4.11** The maximum distance between cross sections shall be 100 feet for flat terrain, 50 feet for rolling terrain or closer where conditions warrant. In all cases, the breaks in terrain that will substantially affect the final quantities must be reflected in the notes.

**8.4.12** To determine the volume at any station or run of stations, each station must have an original terrain cross section (Existing Ground), final constructed cross section and the proposed plans template. Full cross-sections must be taken at all stations. Half sections are not acceptable for earthwork purposes.

## 8.5 MINIMUM FIELD RECORDS FOR PLAN QUANTITY PAY ITEMS

Payment for Regular Excavation, Lateral Ditch Excavation and Embankment made under the plan quantity concept are subject to the minimum standards as herein.

Field cross sections shall be required if the Department or the Contractor contends that the quantity is in error. If either party questions the plan quantity (in accordance with ***Section 9-3 of the Department's Standard Specifications for Road and Bridge Construction***), then perform the data collection according to the usual methods outlined herein.

The Project Administrator(PA) is required to verify a project's "plan terrain'' and ''final'' surfaces for conformity with the design plan representation through field survey, or by an alternate method approved by the District Final Estimates Manager(DFEM) or the District Construction Engineer (DCE). The following information shall be used in the determination of survey method, or to request a waiver of Department survey requirements.

## 8.6 ORIGINAL PLAN TERRAIN

Verify the method(s) used to derive the original cross sections (location survey, aerial photos, old as-built, etc.) with the Designer of Record. Also confirm the project's location and type (urban, rural, limited access, 3R, etc.)

Site inspection by the PA may be required to check for changed conditions such as commercial development, city or county projects, excessive erosion, or work performed by FDOT Maintenance. Other verification or Quick Checks such as spot elevation checks, slope stake verification, etc., may be required by the DFEM/DCE prior to waiving any

survey requirements. All field and Quick checks shall be recorded in a bound field book or in approved electronic data format.

The PA will submit the "Request for Waiver of Survey Requirements" to the DFEM/DCE for approval ***(See Figure 8-1)***. The DFEM/DCE will consider such things as type of work, monetary exposure, possible claims, and additional considerations before a waiver of survey is issued.

The PA shall notify the Contractor, by Certified Letter of the Department's findings regarding acceptance or rejection of the Original Ground line as shown in the plans and seek the Contractor's concurrence for actions taken (***See Figure 8-2*** & ***8-3***). Should the Contractor reject the actions taken, a second Certified Letter may be sent advising the contractor of the requirements as the Claimant under ***Section 9-3 of the Department's Standard Specifications*** (***See Figure 8-4***).

## 8.7 CROSS SECTIONS TO VERIFY PLAN TERRAIN

Cross sections to verify the plan terrain line, when required, must be taken before the clearing and grubbing operation to adequately address existing terrain conditions at full station locations shown in the plans.

When directed by the DFEM or the DCE, new construction projects will require complete original cross sections that will be taken at intervals as directed by the DFEM. Major widening projects may also require cross sections. The original ground line elevations are to be taken at break points shown in the plans and at other break points found to exist in the field within the Right of Way limits.

The Contractor shall be notified in writing if there could be substantial change in end-areas where the Department is taking cross sections, and DOT will provide him a copy of the survey notes along with any revisions to the plan terrain lines resulting from the Department's survey. If he wishes to dispute the Department's survey, he must acquire his own survey of the disputed area, certified by a Professional Land Surveyor, and at no expense to the Department. The contractor's own field survey must be completed before any clearing and grubbing operations (see ***Subarticle 9-3.2 of the Standard Specifications***).

If supplemental field cross sections show a significant difference, as defined in ***Subarticle 9-3.2.1 of the Standard Specifications***, quantity adjustments will be considered.

If a deviation exists between the plan terrain line and the pre-construction survey terrain line, the latter will replace the plan terrain line at the cross section stations.

The plans will be annotated with corrections to plan quantity (Areas/Volumes) regarding erroneous cross sections discovered by pre-construction survey. The closest cross section

on either end of the area surveyed will be struck through on the plans. A new quantity shall be calculated by the approved method for the area surveyed using the plan template and the terrain lines with the replacements mentioned earlier. The Contractor shall also be given this information as soon as possible, by dated transmittal letter with a copy to the DFEM. A terrain comparison can increase or decrease the quantities. Before allowing an adjustment, the difference in the increases and decreases (net result) must be checked against the limit set in ***Subarticle 9-3.2 of the Standard Specifications***. The contract's special provisions often change the amount of this limit.

## 8.8 AS-BUILT SURFACES FOR COMPLIANCE

The PA is required to document the project's As-Built surfaces for compliance with plans dimensions.

**8.8.1 Field Check -** The following field checks shall be used to require survey or to request waiver of survey.

(A) As soon as final dressing in a section of the project is done, Field "Quick Checks" such as spot surveys, slope or slope stake verification shall be performed at intervals or in areas deemed necessary by the DFEM/DCE.

(B) Standard bound field books or approved electronic data format shall be used to record your notes. The date, weather conditions, and the names of the individuals making up the field crews shall be recorded on the page where each days notes begin or a record stored within the data.

(C) The DFEM/DCE will consider such things as monetary exposure, possible claims, as well as supplemental information before a waiver of survey is issued.

(D) The PA will notify the Contractor of the Department's findings.

(E) If the field checks of the as-built cross sections reveal any substantial differences from the plan template, then it will be necessary to either: regrade such areas to bring them into conformance (this is done at the Contractor's expense) or reduce the pay quantities for the appropriate earthwork items within the areas not constructed to plan dimensions. Selection of which method to use is at the Department's discretion. The decision shall be based on the circumstances which exist on the particular project.

(F) Cross Sections of the As-Built Template where deductions for "Areas not Constructed to Plan Dimension" are necessary, a FULL CROSS SECTION

SURVEY **will** be taken at plan intervals or in areas designated by the DFEE/DCE.

(G) Plot the as-built sections by hand on the original plans or use a computer program to plot the as-built and plan template at the scale used in the plans.

(H) The plan quantity (Areas/Volumes) between these cross sections and extended to the closest cross section on either end of the area surveyed will be struck through on the plans. A new quantity must be calculated by the approved method for the area surveyed using the plan template and the As-Built lines with the replacements mentioned earlier. This information is given to the contractor through a dated transmittal letter with a copy to the DFEM. Remember that an As-Built comparison can only decrease the quantities. Before allowing an adjustment, the difference in the decreases (net result) must be checked to see if it exceeds the limit set in ***Subarticle 9-3.2 of the Standard Specifications***. The size of this limit is often changed by the contract's special provisions, so be sure to check.

(I) Deduction for the surveyed areas for the appropriate earthwork items shall be calculated by an approved method. The ***FDOT's Multiline Earthwork PC Program*** will develop the adjustments for plan quantity items; however, the PE may manually resolve these adjustments. If the earthwork volumes are not calculated manually, then the FDOT's Multiline Earthwork PC Program, or other software as approved by the DFEM, shall be used for all the FDOT's earthwork volume calculations, with the following exception:

(1) If another type of software other than the FDOT's Multiline Earthwork PC Program or other approved (by DFEM) software is used, then the program must produce the same electronic files and paper output reports containing the same information in the same format as those electronic files and paper output generated by the FDOT's Multiline Earthwork PC Program.

(2) Where any software has been used to calculate the earthwork volumes, the required Multiline compatible electronic files must be recorded on CD ROMs that include plots, and turned in with the final estimate package. They shall be included in the project computation book, stored in an envelope, bound as a page of the computation book and placed immediately behind the page recording the pay item they support.

(3) Should the engineer choose to develop the adjustments for plan quantity items manually, then cross sections for terrain comparison

and as-built template comparison shall be plotted along with the original plan template and original plan terrain on cross section sheets which are the same size and scale as the record set of plans for the project. Please note that the easiest way to do this manually may be to plot the cross sections on a full sized set of plans.

(J) No deduction will be made unless the dollar value of the deduction exceeds the limit set in ***Subarticle 9-3.4 of the Standard Specifications*** for the Contractor's failure to construct to plan dimensions. Any reduction for final cross section deficiencies in earthwork items is further limited to significant differences as defined in ***Subarticle 9-3.2 of the Standard Specification*** unless, in the opinion of the Engineer, a deliberate attempt has been made to take advantage of the tolerances to increase borrow excavation in fill sections or to decrease the required volume of roadway or lateral ditch excavation or embankment. In such cases, appropriate measurements shall be taken and reductions in pay quantities shall be applied. The grading tolerance, as defined in ***Subarticle 9-3.2*** *or* ***120-12 of the Standard Specifications***, will not be used or considered as a pay tolerance, nor shall the tolerance be construed as defining a revised authorized template.

**Note:** The above guidelines are not applicable to trench widening projects where the plan quantity for roadway excavation is based on the neat volume of the base trench. In this case, verification of the original terrain elevation is not required, but final cross sections will be required if the shoulder elevations change horizontally or vertically, providing the project has a borrow pay item. If revision to plan quantity for roadway excavation is required, the computations will be based on the theoretical change in volume only for changes that exceed the limits set forth in ***Standard Specification Subarticle 9-3.2.***

## 8.9 FIELD NOTES FOR BORROW EXCAVATION

These procedures relate specifically to field notes for borrow excavation.

**8.9.1 Final Cross Sections -** Final Cross Sections are required on all projects with Borrow Excavation if the shoulder elevations move out horizontally and/or vertically. A waiver of survey or alternate method may be approved by the DFEM or the DCE. Listed below are some examples where surveys may be eliminated.

### 8.9.2 Borrow Excavation Project Types

(A) Milling and resurfacing projects where shoulder elevation does not change.

(B) Projects that involve only earthwork around box culvert extensions.

(C) Projects that involve restoring eroded sections.

### 8.9.3 General

(A) Where vehicle load count is involved in reconciling quantities, make sure fluff plus shrinkage is considered. A suggested formula is: compacted fill volume (cross-sectional volume) x 1 plus shrinkage x 1 plus fluffage factor equals equivalent truck/vehicle measured volume. Example: 1 CY fill with 20% shrink and 20% fluff = 1.00 x 1.20 x1.20 = 1.44 Cubic Yards.

(B) Project flushed slopes that are constructed of borrow material and proposed for final payment are to be cross-sectioned, and any volume that is determined to be above the project template must be deducted.

(C) Borrow placed in areas beyond the project's subsoil lateral limits (unauthorized excavating) must have its volume determined and then deducted from the proposed borrow pay.

**Note:** For truck measured borrow requirements see ***Chapter 6 of this manual (for Tabulation Form, Daily Report of Truck- Measured Material)***. (***See Figure 6-5***)

## 8.10 FIELD NOTES FOR SUBSOIL EXCAVATION

The notes for subsoil excavation shall be given extra care and notes to explain the disposition of this material shall be freely used. The following special instructions and the sample field notes shall be regarded as the minimum standards:
(***See Figure 8-5*** through ***8-8***)

(A) The authorized limits of muck excavation, as staked in the field, **must be recorded in the earthwork notes for each pocket of muck excavation** and should conform to control slopes set up by the standard index, or as shown in the plans.

(B) The listing of the limits is generally made up from the plan depth and checked as they are staked in the field. If, during the excavation, the muck is found to be deeper than the plan depth, the notes shall be corrected by striking through the original limit and recording the new authorized limit. Such corrections should be dated and initialed.

(C) If subsoil excavation is required in an area where ditch excavation or the roadway template falls below the original terrain, the roadway template must be developed to

determine the authorized subsoil excavation. This condition shall be noted in the field notes.

(D) If extra depth muck excavation (depths greater than 5 feet) is encountered, a list of the controlling elevations shall be recorded. (***See Figures 8-9*** through ***8-11***).

(E) The maximum interval for subsoil cross sections shall be 50 feet. The beginning and ending of excavation shall always have a full cross section and should be identified with a note (Begin Cut or End Cut), or designated as a zero area.

(F) Partial sections must be extended to the match line to produce a complete cross section for each station.

(G) The earthwork notes for subsoil excavation shall always include a note for each pocket of excavation **explaining the disposition of the unauthorized excavated material**.

(H) Where subsoil excavation extends outside the plans lines or authorized by the PA (including allowable tolerances) and the space is backfilled with roadway or borrow excavation, the net fill, plus shrinkage allowance shall be deducted from additional authorized regular excavation or borrow excavation quantity, as applicable. **(*Subarticle 120-13 of the Standard Specifications*)**.

(I) When embankment or regular excavation is paid for under the Plan Quantity concept, original cross sections for subsoil excavation are considered to be identical to location or plan originals. Any roadway areas within the subsoil limit in which the plan originals are found to be out of tolerance, as specified in the ***Subarticle 9-3.2.1***, shall be recross-sectioned for all earthwork items affected. Otherwise location originals shall be used as originals for subsoil. Original sections shall not be "picked-off" of plan cross sections, and recorded in a field book.

(J) Station's pluses needed to obtain the maximum 50 feet interval or to obtain begin and end sections may be interpolated from the original terrain sections.

(K) The baseline (or centerline) used for location original cross-sections is the centerline of survey. When the centerline of construction, as used for final cross sections and control slope limits, is different from the location centerline, some method must be employed to make the two centerlines compatible with each other. The horizontal alignment shift may be done through the use of the ***FDOT's Multiline Earthwork PC Program***.

## 8.11 FIELD NOTES FOR CHANNEL EXCAVATION

This item does not accommodate itself to the Plan Quantity Concept since constant scouring and shoaling is normal in locations where this item is used.

(A) Pre-construction sections shall always be taken prior to beginning of excavation.

(B) Final sections are always required and must be plotted in conjunction with the template to determine the limits of final pay quantity.

(C) If shoaling occurs after final cross sectioning and prior to final acceptance of the job and the Engineer authorizes the shoaled material to remain in place, re-cross-sectioning must be done. The volume of any such material remaining within the limits of channel excavation shown in the plans shall be deducted from the measured quantity of Channel Excavation.

## 8.12 ELECTRONIC DATA COLLECTION ON CONSTRUCTION PROJECTS

### 8.12.1 Definitions:

***Digital Terrain Model (DTM)***: An irregular triangulation network that defines a surface.

***Electronic Field Book (EFB)***: FDOT's system for survey data collection and processing. This system has defined formats for unprocessed observations, processed observations, and analysis reports created during survey data processing.

***New Alignment***: A proposed plan alignment, which is different from the existing roadway alignment shown in the plans.

### 8.12.2 Requirements:

The methods described herein shall apply to surveys being performed on all Department contracts with automatic or semi-automatic total station equipment (radial survey). They are not intended to replace the methods for performing conventional cross section surveys as defined elsewhere in this manual, but are intended to supplement them.

**Note:** All survey data generated for construction must adhere to the Department's surveying standards.

In making the decision to use radial survey methods with total station equipment, the Consultant must assure the Department that the following field survey and data processing requirements can be met:

(A) Sufficient project control data (horizontal and vertical) exists or can be established to provide for all radial survey coverage.

(B) Perform radial survey that meets the Triangulated Irregular Network (TIN) criteria for generating a Digital Terrain Model (DTM).

(C) Software to compute an acceptable DTM from the radial survey data points and break line data point strings.

(D) Field check the DTM surface, using cross sections or profiles extracted from the DTM as compared to actual supplemental field survey.

(E) Compute cross sections from the DTM surfaces, perpendicular to defined alignments.

(F) Compute earthwork volumes by the method of average end areas using Department approved software and methods.

(G) Furnish all deliverables in a file format and medium that is compatible with Department software, as defined in these procedures or in the contract scope of services.

### 8.12.3 Project Control System:

Radial surveys must be referenced to the same project control system (baseline/centerline coordinates and benchmark datum) that was used for the Location and Design work. **This basic requirement is to ensure that all survey information for the project can be related to the same reference system.** This requirement can be met by occupying the existing control points that were established during the Location survey. Or, if additional control is needed, the existing control system may be extended by:

(A) Running a closed traverse and bench levels through the required point or points.

(B) Setting an unknown point, occupying it with the total station instrument and taking sufficient observations to define its position relative to the existing control system, as further described later.

(C) Using technology such as Global Positioning System (GPS) and bench levels to supplement existing survey control.

### 8.12.4 Calibration of Conventional Total Station equipment:

The surveyor must take every precaution to ensure that the total station equipment is in proper adjustment and is obtaining accurate field data. To identify systematic errors inherent in any angle-measuring device, an axis test of the instrument will be performed on a regular interval, at least once weekly.

An acceptable axis test consists of pointing at a fixed target three or more times in the Face 1 (direct) telescope orientation and recording the horizontal direction (H) and vertical direction (V) readings for each pointing. Then, transiting or “flopping” the telescope and pointing at the same target an equal number of times in the Face 2 (reverse) telescope orientation and recording those values. The values of the horizontal and vertical angle for each pointing at the target are used to perform the computations to determine if the instrument is in adjustment.

Each year and whenever the difference between the mean of the direct and the mean of the reverse readings depart from 180 degrees by more than 30 seconds, the instrument must be taken out of service and be adjusted for collimation error.

Readjustment of the instrument’s cross hairs and the level bubbles shall be done whenever their misadjustments affect the instrument reading by the amount of the least count, as specified for the Third Order Class II surveys. The total station instrument and retro-reflector prisms should be serviced on a regular basis and checked frequently on a calibration base line of known distance.

### 8.12.5 Establishing Position and Orientation of the Surveying Instrument:

When collecting field data by radial survey, there are two acceptable methods of establishing position and orientation of the instrument:

(A) Setup Over Known Control Point: The instrument is set up over an existing control point, or one that can be related to the baseline or centerline of the project by the geometry and elevations furnished. The (XYZ) coordinate of the point set up over must be known. The height of the instrument above the control point must be measured and recorded. When the above is done, the position of the instrument has been established.

(1) To establish orientation of the instrument, a back sight will be made by pointing to a target of a known height on a second control point with a known (XYZ) coordinate. The instrument’s horizontal circle will be “zeroed” while pointing to the back sight control point. A back sight

measurement of the horizontal direction, vertical direction, and distance (HVD) will be measured and recorded, including the target height. Position and orientation is now completed. Radial measurements (HVD) may be made and recorded for new survey points. All horizontal angles will be expressed as angles measured in the direct (Face 1) position.

(2) At the end of the field survey operations, the user shall again sight the original back sight control point and record the measurements, to ensure that the instrument was not disturbed during survey operations.

(B) Setup Over an Unknown Point: When the instrument must be set up in a location that does not have a prior known (XYZ) coordinate or is not tied to the control geometry and project bench mark datum, a semi-permanent monument should be set to perpetuate the location of the setup position. A bridge spike, hub and tack, iron rod or equivalent marker, which will last throughout the data gathering operations, will serve this purpose. When the instrument is set up, the height of the instrument above the set monument will be measured and recorded.

(1) To establish the position of, and orient the instrument setup over the unknown point, the setup must be tied by field measurements to two (2) points of known position. A back sight will be made to the first control point with a known (XYZ) coordinate. The horizontal measuring circle will be “zeroed” and HVD measurements will be made and recorded. A second control point with known coordinates will be selected and HVD measurements made and recorded. If available, a third control point with known coordinates may be selected and measured as a check on the position of the instrument. Target heights will also be recorded for all measurements.

(2) With the setup position properly established, radial measurements (HVD) to additional new survey points may then be made and recorded. All horizontal angular values will be expressed as angles measured in the direct (Face 1) position.

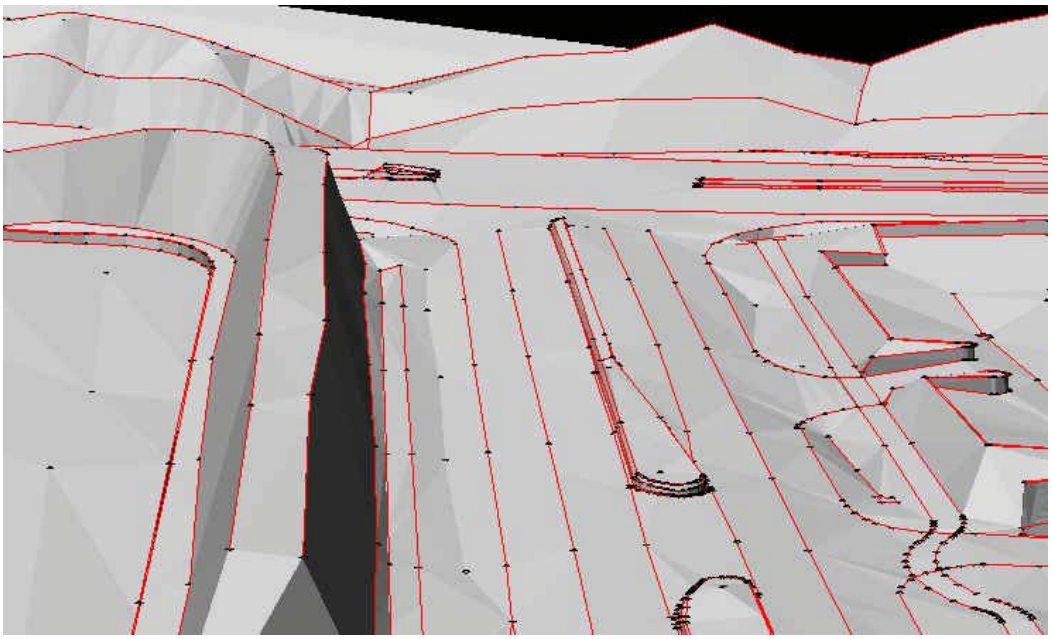
(3) At the end of the field measurements, the observer shall always sight the original back sight and take check measurements and record them. Again, this is to ensure that the instrument has not been disturbed during survey operations.

### 8.12.6 Field Observations (HVD) for DTM Surveys:

Radial survey procedures may be used to determine pre-construction surface elevations; and as the work of excavation or fill is accomplished, radial survey procedures may be used to determine final surface elevations. From DTM surfaces derived from radial survey methods, cross sections can be generated as needed. This makes the DTM a valuable method for quantity surveys, since cross sections can be generated at any interval along an alignment on any of the DTM surfaces.

(A) The important field consideration when surveying for DTMs is to collect data points that represent surface elevations on the ground at reasonable proximity to accurately represent the surface. It is also important to define breaklines along boundaries in the terrain where sharp or abrupt changes in surfaces occur. Break lines along the terrain "discontinuities" will be defined by the surveyor, by indicating the connection of points representing the break line profiles.

Illustration 1. Shows a terrain surface defined by Points and breaklines:



(B) It is a requirement of the Department that the field measurements (raw field data) be recorded and furnished in an acceptable format, as backup records for all DTM's.

(C) Most electronic data collectors (FDOT's EFB is an example) are capable of recording HVD data. If the consultant elects to use a data collection

system that only produces XYZ coordinates, the raw field data (HVD) must be recorded in a field book manually. Reduced data, (XYZ) coordinates, alone will not be acceptable.

(D) To assist in verifying the field notes and as an aid in checking the reduced data, the survey party shall prepare a sketch or layout of each setup and the area covered by observations. This may be done manually, or with the survey data reduction software. It shall show the setup point, the back sight point(s), and the identification data for the location of all field data taken from the setup position.

(E) Attached to these procedures are form examples, which are to be used to manually record field notes, unless the consultant is using a data collection system that will record and produce the same data in acceptable formats. (***See Figure 8-12*** through ***8-15***)

**8.12.7 Generating the DTM Surfaces:**

Surface-modeling techniques, such as using triangles to represent small continuous surface areas is known as the Triangulated Irregular Network (TIN). TIN has become the standard for terrain modeling for meeting engineering requirements. Each vertex of a triangle in the TIN is formed by a field measured data point, and is located by its (XYZ) coordinate. The TIN model is constructed by connecting these survey data points to their nearest neighboring points (in XY), forming a network (surface) of irregular triangles.

(A) It is important that the survey crew understand the TIN methodology and the assumptions made by the software when they are taking the survey data points for a DTM using the TIN method.

(B) Before the working cross sections are generated for earthwork computations, the DTM surfaces shall be field checked using randomly generated cross sections or profiles extracted from the model. These cross sections and profiles are then compared to actual ground shots taken to determine if the model matches the real-world terrain surface. This quality control check shall be performed before TIN data is used in quantities calculations.

**8.12.7 Cross Sections from DTM Surfaces:**

Once the DTM surface has been computed and field checked, cross sections may be computed at the specified interval along the centerline or baseline. If final quantities are to be compared to original plan quantities, the location of TIN extracted cross sections must be the same as the cross sections contained in the design plans.

(A) Field measured quantities, such as subsoil excavation, may be referenced to a construction-established baseline, as long as the original and final measurements are from the same reference.

(B) Design cross-sections, pre-construction cross-sections and final cross-sections must all be compared in order to determine final pay quantities. It is absolutely essential that all field data be referenced to the same alignment and station values.

### 8.12.8 Survey Deliverable Data:

Requirements necessitate the retention of surveying records and backup data to support the quantity computations. This requires that the consultant CEI or in-house project personnel deliver certain data in a format that can be retained, verified, and if necessary used to replicate the processed data at some future point in time.

(A) When radial survey is used, project personnel shall use the approved survey data formats authorized for use on FDOT surveys. ***FDOT's Multiline Earthwork PC Program or any other FDOT approved software*** should be used to calculate final pay earthwork volumes. If a consultant or CEI prefers to use any other software for radial surveying than ***that authorized for use by FDOT***, they must show the Department's District Location Surveyor (DLS) that an alternate system is able to produce the electronic files required for delivery to the Department as outlined later in this section. Prior to the work commencing, the consultant must receive an approval letter signed by the DLS stating that a proposed alternate system is able to produce the electronic files required by the Department.

(B) The consultant and/or FDOT project personnel shall deliver:

(1) The original field survey data files produced by the data collection system used to gather the data, regardless of format.

(2) The original field survey measurements in the approved file format for raw survey measurements at FDOT (FDOT .OBS format).

(3) A hard copy of the .OBS file(s) submitted, showing any changes not observed in the field. These changes must be prominently annotated in ink, and an explanation of each change must accompany as necessary.

(4) The reduced and processed field survey data in the Department's

.XYZ file format.

(5) The survey control used to reduce and process the original field survey data in the Department's .CTL file format.

(6) Copies of all output reports generated by the programs (both file and hard copy) used to reduce and process the field survey data.

**Note:** It is the responsibility of the DLS or the delegate to verify survey data processing results before being acceptable to the Department.

(C) At the completion of work, all files are to be delivered to the DLS or the delegate. Also, any additional reports and forms required by the DLS, such as a ***DTM CERTIFICATION FORM*** (if applicable), and a ***PROJECT CERTIFICATION LETTER*** must also be provided.

(D) All reports related to the project.

(E) All output files for interfacing to MultiLine, GEOPAK, etc. such as the cross sections in MultiLine .GEN file format, and alignment and other geometric data (including profiles) in GEOPAK Input file format.

(F) All graphics files of plan metric detail in both 2D and 3D Micro Station file format.

(G) All DTM TIN models represented as 3D Micro Station files.

(H) A project Journal file that describes:

(1) For each DTM, a description of the surfaces, DTM settings used, survey data used to define the surface(s). Also included in the Journal are the alignment names and scan / pattern lines used to cut cross sections, cross section file names with their usage/application, and contour settings.

(2) For each output report generated, describe the purpose of the report and the information needed to re-generate the report.

(3) For each output file, describe the purpose of the file and the information needed to re-generate the file.

(I) All electronic data is to be delivered on a clearly labeled CD-ROM, unless specified otherwise by the DLS. The label shall include the Financial Project Identification Number, State Roadway number(s), Project

Number(s), Consultant Identification (Names, addresses, etc.), contract number, and date the data was placed on CD-ROM.

(J) All data submitted to the Department shall be secured using the Department's Professionals Electronic Data Delivery System (PEDDS). PEDDS may be acquired at the following URL: http://www.dot.state.fl.us/ecso/support/applications/pedds/default.htm

(K) No project will be considered acceptable or complete until all deliverables are submitted and approved by the appropriate FDOT authority.

## LIST OF FIGURES FOLLOWING THIS CHAPTER