Chapter 7
Field Data Collectors and Coordinate Geometry Functions

7-1. Purpose

This chapter provides guidance on data collectors that are used to record topographic field data observed with total stations and RTK systems. Data collector features are described along with standard coordinate geometry (COGO) options. Some traditional route surveying parameters are also outlined at the end of the chapter.

7-2. Field Survey Notes--Manual and Electronic

Field survey notes can be collected either manually or electronically. Manual methods include field books or plane table sheets. Electronic methods include both internal and external data collectors interfaced with various survey instruments (total station, GPS receiver, or LIDAR). Electronic data collectors record, store, and transfer field data without the need to key in individual measurements, providing significant time savings in gathering and processing field data and eliminating reading and recording errors. However, not all supplemental feature data or detail sketches are easily encoded in a data collector. It is often better to draw detailed sketches of critical features in a traditional field survey book; or optionally on a digital notebook tablet. Sketches of features can also be supplemented with digital photos--video and digital cameras can be used to supplement the field sketch and provide a very good record of the site conditions for the CADD operator, design engineer, and user of the topographic map. Each District will have their own policy regarding how field notes are to be kept--manually and/or electronically. An important distinction is made when written field notes are not required, and the data collector is used exclusively as an "electronic field book." These electronic files are usually sufficient for submittal without identical hand entries from a field book. However, some Districts may require that a duplicate written field book be kept for electronically recorded data--for data safeguarding and legal issues. When duplicate field books are kept of electronically recorded data, the entries are compared to the files generated by the data collection processing. All field book data are written in the format set by each District. There is no Corps standard for field book data formats. Sample field book indexing and recording formats are shown in Chapter 12.

a. Four types of manual field book notes are kept in practice:

- sketches,
- tabulations,
- descriptions, and
- combinations of these.

The most common type is a combination form, but an experienced recorder selects the version best fitted to the job at hand. The location of a reference point may be difficult to identify without a sketch, but often a few lines of description are enough. Benchmarks are also described. In note keeping this axiom is always pertinent: when in doubt about the need for any information, include it and make a sketch. It is better to have too much data than not enough.

b. Topographic locations are numbered according to data record numbers (or feature codes), be they manually or electronically recorded. These feature codes depict what type of location and where locations were measured. This helps office personnel import digital field drawings into final design drawings. More important, blunders and mislabeled feature codes may be caught before costly design errors are made. The finished map and the sketch should be similar. Sketches are not required to be at any scale. The suggestions listed below will help eliminate some common mistakes in manually recording field notes in a survey book (or optionally on an equivalent digital tablet device):

- Letter the notebook owner's name and address on the cover and first inside page.
- Title, index, and cross-reference each new job or continuation of a previous one.
- Sign surname and initials in the lower right-hand corner of the right page on all original notes.
- Use a hard pencil or pen, legible and dark enough to copy.
- Begin a new day's work on a new page.
- Immediately after a measurement, always record it directly in the field book rather than on a sheet of scrap paper for copying it.
- Do not erase recorded data.
- Use sketches instead of tabulations when in doubt.
- Avoid crowding.

c. Some features are often too complex to be fully detailed in a data collector; thus, a field book sketch is required. Figure 7-1 is such an example of a sketch that depicts details for a steam utility system that would be impractical to input in a digital data collector. The general orientation of the object would be captured in the data collector, and the points referenced on the sketch. A note should be entered into the data collector referencing additional attribute data is provided in the field book (including page number).

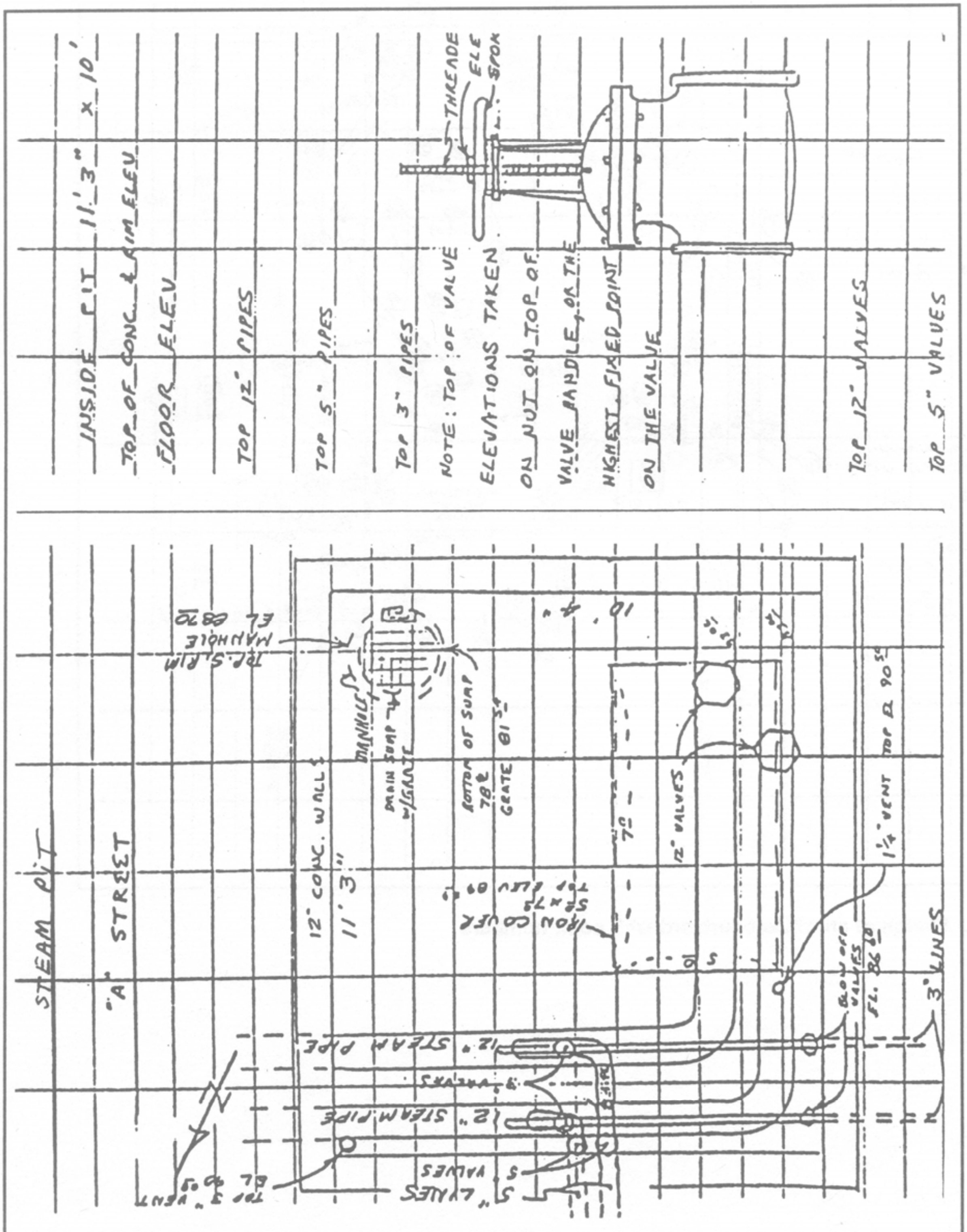


Figure 7-1. Sample from field book depicting utility details

7-3. Functional Requirements of a Generic Data Collector

A well-functioning and efficient data collector is vital to performing detail surveys using a total station or RTK system. Assumptions or oversights made at the time of equipment purchase can force a survey operation into equipment problems on the job for the economic life of the equipment. Listed below are some options to consider when purchasing a field data collector:

- Weatherproof, designed for rugged/durable field use.
- Nonvolatile memory ensures data safety.
- Allow the storage of at least 5,000 or more points, including full descriptor and attribute information.
- Full search and edit routines immediately on the spot.
- Optional screen view of mapped data points.
- Compatibility with a variety of electronic total stations, digital levels, and/or GPS systems.
- Formatting must be very flexible for manual entry, even for various CADD leveling tasks.
- Capability to use two files in the collector: one file for collection, the other file for processed data for stakeout tasks.
- Data collector must communicate with and remotely operate the total station.
- All the features of the total station should be usable with the data collector purchased.
- The data collector must be compatible with the software.
- The data collector must be compatible with the data dictionary.

In evaluating a data collector system for purchase, the following questions should be asked:

- Can I view and store coordinates in the electronic data collector in the field?
- Is the data collector environmentally rugged? What are the environmental limitations of the hardware?
- Can I upgrade the data collector to the latest software version easily and inexpensively?
- Can I create control jobs that can be accessed from any routine in the data collector?
- What data in the data collector will I be able to edit in the field and how will that affect my raw data?
- Will the data collector be compatible with all of the total stations I own?
- Do I have a choice of output formats in the data collector?
- What level of training and support is offered at the time of purchase, and what level can I expect after I have had the data collector long enough to know what questions to ask?
- What type of feature coding and attribute capability does the data collector have?
- Can I set up the parameters and configurations in the data collector to the way I like to survey?
- What numbers of electronic devices, total stations, etc., are supported in the basic configuration?
- What types of data are supported? (raw data, coordinate data point list, roadway alignment, archive data files, and descriptions)
- Can I perform separate tasks for collection of traverse points vs. topographic features or side shots?
- Supports State Plane Coordinate input?
- Memory capacity?
- Is the collection of raw data the same as indicated on the survey instrument? (PPM & Prism Constant)
- Is the unit capable of utilizing data from two different coordinate files at the same time?
- Supports auto mapping?

- Supports North and South Azimuth References?
- Supports user definable parameters? (Angle/distance tolerances, observation sequence for direct and reverse observations)
- Capable of producing stakeout reports, cut/fill, relative to design elevation?
- Generate location of next stakeout point from rodman's positions?
- Supports stakeout of a line?
- Downloading/uploading capability? Can it be done remotely via modem?
- Data collection software or data collector itself should output the following:
  - Point number
  - Coordinates
  - Elevations
  - Feature code

7-4. General Software Features on a Data Collector

Field data collectors are either self-contained within a total station or external units attached by cable or wireless (Bluetooth) connection to the survey instrument. Some of the more salient software features found on a data collector are outlined below, as taken from POB 2004b. Not all data collectors must contain all these software features to be acceptable--many of these features may not be required for standard Corps work. In addition, the more features that are included, the higher the cost of the data collector.

a. Cost. The average data collector software package will cost some $1,500 to $2,000; however software packages are available as low as $150 and over $3,000 at the high end. (These costs do not include the actual microprocessor hardware).

b. Computer. Some software packages will operate on a variety of operating systems while others are specific to a single system. The most common systems include CE.Net, CE, Microsoft, HP-48, and iPAQ. The newest systems have color display screens and will provide field-finish views of collected data. Screen displays should ideally include viewing of points, features, and associated attribute data entered during the survey.

c. Supported instruments. Data collector software may support only a specific brand of total station or can support (and connect with) a variety of electronic survey instruments, such as digital levels, static GPS, kinematic GPS, laser rangefinders, robotic total stations, etc. Obviously, software that encompasses all this versatility will cost more. The advantage of having a data collector that can perform many functions is obvious: the same instrument can be used with either a total station or GPS/RTK system.

d. Storage capacity. Most software can store almost an unlimited number of jobs and points, restricted only by the storage available in the data collector device.

e. Calculations. The software should be able to calculate coordinates from raw data observations, perform inverse computations, calculate intersections, perform traverse computations and adjustments, perform 2-point and 3-point resections (total stations), perform site calibrations (RTK), and perform area computations. Other desirable features would include a variety of stakeout options--to lines, curves, and slopes (including navigation to points), least-squares adjustments or regressions, volume and cut/fill computations, etc. Some of these COGO functions will be described later in this chapter.

f. Background images. The software should be able to import, orient, and display background images from a variety of file formats, such as MicroStation, AutoCAD, and ESRI, and display generic *.JPG, *.TIF, etc. type images.

7-5. Feature or Descriptor Codes for Topographic Field Data

Field codes or data collection codes are a means by which the surveyor controls the map compilation process. Feature codes for each shot are placed on the data collector. The code designations and sequencing will vary depending on the data collector and processing software. Typically, features are described in the data collector by means of some numeric or alphanumeric description. Strings of like features (e.g., curb lines, edges of roads, buildings) or polylines are identified by additional coding. Feature coding is an integral part of the field data acquisition phase. It defines characteristics of an object(s) and how they are represented on the final map--as points, lines, or areas. In addition, they can define the type of annotation, line weight, layer, or cell symbol to be placed on the map. Whether data are recorded by hand or electronically, one of the most critical survey operations is the recording of a code or description to properly identify the point during processing. For example, in a topographic or planimetric survey, identification of points which locate the position of curbs, gutters, centerlines, manholes, and other similar features are essential for their correct plotting and contour interpolation. Since the field crew can virtually produce the map from the field data, this eliminates the need for many field book sketches.

a. Feature code library. The coding scheme is designed so the computer can interpret the recorded data without ambiguity to create a virtually finished product. Normally a feature or descriptor code "library" is established for a given project. This library consists of the common object features that will be shot. During the survey, these feature/descriptor codes can be called up in the data collector after each shot, as a quality control check. If additional attribute information is needed on a point, this can be typed into the controller. These feature/descriptor codes associated with each topographic point shot are later downloaded to a CADD and/or GIS system. If additional attribute detail is provided, this information will stay with that point in the CADD/GIS system.

b. Typical descriptors used in a library. Currently, there is no established descriptor code standard for topographic features. Either numerical point codes or alphanumeric point feature codes can be entered into the data collector. Each District either has their own feature library standard, or accepts data in whatever format a contractor submits it in. Some projects are unique, and new descriptor codes are developed for that work. This variability may entail additional effort during subsequent inputs of datasets into CADD packages. The following is a partial list of alphabetic descriptor names for common features. These same features will have various descriptors in different Districts, as will be illustrated in subsequent lists. Whenever districts require specialized point codes, then the attribute file may be edited to include these changes.

Table 7-1. Typical Descriptors used in a Feature Library

1X2 STAKE	DOLPHIN	MONITORING	SPRINKLER
2X2 HUB/TACK	DOWN GUY	DEVICE	CONTROL VALVE
A/G FUEL TANK	DRAIN	NAIL	STEAM MH
A/G STEAM LINE	DRAIN PIT	NGS MON	STEAM PIT
A/G WATER VALVE	DRIVEWAY	O/H COMM	STEEL GUARD
AC@PCC JOINT	EDGE ROAD	O/H PIPE	POST
AIR RELIEF VALVE	EDGE ROAD	O/H POWER LINE	STEPS
AIRCRAFT TIE-DOWN	ELECTRICAL	ORNAMENTAL	STORM
ALUM MON	ELECTRICAL MH	PAD	STORM MH
ARCH CREST	ELECTRICAL	PAINT STRIPE	SWITCH BOX
ARCH END	OUTLET	PBM	TBM
ARCH START	ELECTRICAL	PHONE BOOTH	TELE @ BLDG
ARCH TOE	SPLICE	PICTURE POINT	TELE SPLICE BOX
ASPHALT	ELECTRICAL VAULT	PIER TOE	TELEPHONE MH
ASPHALT PATCH	END OF BRIDGE	PIER TOP	TELEPHONE POLE
B/L	EXPANSION JOINT	PILING	TEST WELL
BARBED WIRE	EXPOSED SEWER	PIPE	TOE
BENCHMARK	PIPE	PK NAIL	TOE CONC DRAIN
BLDG CORNER	FILED X	PORCH	TROUGH
BOLT	FILLER PIPE U/G	POWER @ BLDG	TOE/RIPRAP
BRASS CAP	TANK	POWER POLE	TOP
BREAKER BOX	FIRE ALARM	POWER	TOP CONC DRAIN
BREAKLINE	FIRE HYDRANT	POLE/TRANS	TROUGH
BREAKLINES	FLOODWALL	PVC PIEZOMETER	TOP OF RAIL
BRIDGES	FLOW DITCH	PVC SLOPE	TOP STRUCTURE
BUILDING LINE	FUEL	INDICATOR	TOP/RIPRAP
BUOY	FUEL PIT	QUARTER CORNER	TOPOGRAPHIC
C/L	FUEL TANK VENT	RAMP	TOWER LEG
C/L ROAD	PIPE	REBAR	TRAFFIC SIG
C/L ROAD	GAS	REBAR/CAP	CONTROL BOX
C/L RR TRACK	GAS LINE	REFERENCE POINT	TRANSFORMER
CABLE TV	GAS METER	RETAINING WALL	TREE LINE
CATCH BASIN	GAS PAINT MARK	RISER	U/G CABLE MARKER
CDHD	GAS VALVE	ROAD WORK	U/G COMM
CDHU	GEOTECH	ROCK	U/G COMM BOX
CHAIN LINK	GPS MON	RR SPIKE	U/G CONDUIT
CHISELED X	GRATED STORM MH	RWY LIGHT	U/G STREET
CLOSING CORNER	GROUND SHOT	SANITARY	LIGHTING BOX
COE MON	GROUNDING ROD	SANITARY	USGS MON
COMMUNICATION	GUY POLE	CLEANOUT	WATER
CONC MON	HAND DRILL HOLE	SANITARY LINE	WATER LINE
CONC. PATCH	HAZARDOUS	SANITARY MH	WATER METER
CONIFEROUS	WASTE VAULT	SECTION CORNER	WATER MH
CONTROL	HEADWALL	SHOULDER ROAD	WATER STANDPIPE
CROWN	HEATING	SIDEWALK	WATER VALVE
CULVERT	HOMESTEAD	SIGN	WE/WS
CURB	CORNER	SIXTEENTH	WELL HEAD
CURTAIN DRAIN	HYDRO	CORNER	WITNESS CORNER
CUT-OFF FENCE	LIGHT POLE	SLOPE	WOOD FENCE
POST	MEANDER CORNER	SLOPE BREAK	WOOD GUARD
DECIDUOUS	MON	SOUNDING	POST

c. Project specific descriptors. Individual projects will often have unique repeating features, necessitating additional feature codes. An example of a field feature coding scheme for a specific hydraulic design project in Tulsa District is shown below:

B = BEGIN	TB = TOP BANK
E = END	FL = FLOW LINE
BK = BREAK	H WALL = HEAD WALL
RIP = RR = RIP RAP	FEN = FENCE
ISL = ISLAND	RP = REFERENCE POINT
BEED = CHANNEL BED	G PT = GUARD RAIL POST
CHBS = CHECK BACKSIGHT	SC A = SCOUR AREA
CON = CONCRETE	BNK = BANK
CP = CONTROL POINT	

d. Creating unique descriptor codes. This is done in the software provided with or accompanying the data collector. Alphanumeric codes may also be used for a specific feature. The following process is excerpted from TDS 1999 and is typical of basic feature coding options that are used in most data collectors today.

TDS-HP48GX DESCRIPTOR CODE TABLES

One of the best ways of improving the productivity of data collecting is to speed up the process of keying in point descriptors. The Descriptor Code Table is provided for this purpose. Basically, the Descriptor Code Table is a text file in the TDS-48GX that contains a list of commonly-used point descriptors.

The descriptor table is a list of codes or abbreviations that are associated with a descriptor. These codes may be keyed into the descriptor field in place of the full descriptor. When one of these codes is found in a descriptor field, the TDS-48GX will replace the code with its associated descriptor. Once the TDS-48GX user has established a Code Table of commonly used descriptors, whenever the descriptor prompt appears in the TDS-48 program, a code may be keyed in. The TDS-48 will insert the complete descriptor from the code table in the place of the code in the Coordinate and Raw Data files.
The Code Table is actually a special text file in the TDS-48. It requires the unique name "DESCRIPT.TXT." The Code Table itself is composed of a series of lines of text. Each line of text consists of the code followed by a single space and the full descriptor. An example of a Code Table would appear as:

1	*POB*
02	*HUB*
CB	*CURB*
T4	*OAK TREE*
POB	*PT. OF BEGINNING*
F	*FENCE*
f	*FENCE*

Codes may be up to seven characters in length and may consist of any alphanumeric characters. Examples of these are: 02, CB, and T4. The code is case sensitive, which means that the "F" and "f" codes are not the same and could have different descriptors. If you want an upper or lower case "F" to be interpreted as FENCE you need to enter it twice (as above). The code and the descriptor are separated by one space, and the remainder of the line is the descriptor that is linked to this code. The descriptor may contain alphanumeric characters, spaces, punctuation or symbols; basically anything that can be typed into a descriptor from the keyboard.

During a survey, when the TDS-48 requests a descriptor (usually after the total station has taken a shot), you may key in the full descriptor such as CURB; or you may key in the corresponding code, such as CB, as a "shorthand" notation to indicate the CURB. In either case, the full descriptor CURB will be stored in the job file. If the data is being collected manually, the code may be keyed into the descriptor line of the Traverse/Sideshot Screen before the ***[TRAV]*** *or* ***[SIDES]*** *softkeys are pressed. As stated above, the TDS-48 will store the full descriptor from the table into the job file, not the code.*

Using Codes With Keyed In Descriptors And Combining Codes

Often you want to use a descriptor from the Code Table, but you would like to add additional characters to the descriptor from the keyboard. As an example, suppose you wanted to use the descriptors "NE 1/4 CORNER" and "SE 1/4 CORNER." Assume that the descriptor "1/4 CORNER" has been keyed into a Code Table under the code "15." To combine text and codes from the Code Table, use the "+" key in the following way: When the descriptor prompt appears in the display and you want the descriptor to read "NE 1/4 CORNER," key in "NE+15." The TDS-48 will combine the keyed-in descriptor "NE" with the descriptor associated with code 15 to create the complete descriptor "NE 1/4 CORNER."

Codes may also be concatenated with keyed in descriptors. For example, if you wanted a series of points with descriptors TOP OF CURB A1, TOP OF CURB A2, TOP OF CURB A3, etc., you would setup TOP OF CURB in a Descriptor Code Table with code 23, for example. Then in response to the descriptor prompt, key in 23+A1, 23+A2, 23+A3, etc.

Codes may also be concatenated with other codes. Assume you have code descriptor pairs for: T TREE, T1 PINE, T2 OAK and T3 MAPLE. The result of the following entries: T1+T; T2+T; T3+T; would be: PINE TREE; OAK TREE and MAPLE TREE. This technique may be used to concatenate up to three descriptor codes or text segments.

7-6. Descriptor Codes and Level Assignments for Various Topographic Features

The following listing contains an example of standardized coding for various features encountered on USACE civil and military projects. Both an alpha and numeric code are given. The four-digit "#Code" corresponds to the level number assignment, the first two digits representing the level (or first digit when only 3 digits are shown).

	Description	Alpha Code	# Code	Elevation	Main Feature/Level Designation
1	BUILDING	BLDG	401	Random	Buildings
2		BUILDING			
3	HOUSE	HOUSE	402	DNC	Buildings
4	TRAILER	TRAILER	403	DNC	Buildings
5	GARAGE	GARAGE	404	DNC	Buildings
6	SHED	SHED	405	Breakline	Buildings
7	CABIN	CABIN	411	DNC	Buildings
8	PORCH	PORCH	412	Exterior	Buildings
9	STEPS	STEPS	413	Breakline	Buildings
10	OVERHANG	OVERHANG	414	DNC	Buildings
11	CL ROAD	CLRD	601	Breakline	Centerline
12		ROADCL			
13		CLROAD			
14	CL BRIDGE	CLBDG	602	Breakline	Centerline
15		BRIDGECL			
16		CLBRIDGE			
17	CL RAILROAD	CLRR	603	Random	Centerline
18		CLRAILROAD			
19		RAILROADCL			
20	CL ABANDONED RAILROAD	CLARR	604	Breakline	Centerline
21	CL DITCH	DITCHCL	605	Breakline	Centerline
22		CLDITCH			
23	CL CREEK	CLCRK	606	Breakline	Centerline
24		CLD			
25		CREEKCL			
26		CLCREEK			
27	CENTERLINE	CENTLINE	607	Breakline	Centerline
28		CLINE			
29	CL SWALE	CLSWALE	608	Breakline	Centerline
30		CLSWL			
31	CL BERM	CLBERM	609	Breakline	Centerline
32	CL WALL	CLWALL	610	DNC	Centerline
33	CL STONE WALL	CLSTWALL	611	DNC	Centerline
34		STWALLCL			
35	CL DIKE	CLDIKE	612	Breakline	Centerline
36		DIKECL			
37	EDGE DRIVEWAY	DRIVEWAY	801	Breakline	Roads, Parking Lots, Walks, Railroads, and Trails
38		EDGEDRIVEWAY			
39	EDGE PAVEMENT	PVMTEDGE	802	Breakline	Roads, Parking Lots, Walks, Railroads, and Trails
40	EDGE ROAD	EDGEROAD	803	Breakline	Roads, Parking Lots, Walks, Railroads, and Trails
41		ROADEDGE			
42	EDGE SHOULDER	EDGESHOULDE R	804	Breakline	Roads, Parking Lots, Walks, Railroads, and Trails
43		SHOULDEREDG E			

44	EDGE SIDEWALK	ESW	805	Breakline	Roads, Parking Lots, Walks, Railroads, and Trails
45		ESWALK			
46		EWALK			
47		SW			
48	EDGE TRAIL	EDGETRAIL	806	Breakline	Roads, Parking Lots, Walks, Railroads, and Trails
49		TRAILEDGE			
50	BRIDGE CORNER	BRIDGECOR	807	Breakline	Roads, Parking Lots, Walks, Railroads, and Trails
51		CORBRIDGE			
52	PIER TOP	PIERTOP	808	DNC	Roads, Parking Lots, Walks, Railroads, and Trails
53		TOPPIER			
54	PIER TOE	PIERTOE	809	DNC	Roads, Parking Lots, Walks, Railroads, and Trails
55		TOEPIER			
56	RAILROAD SWITCH	RRSW	851	DNC	Roads, Parking Lots, Walks, Railroads, and Trails
57	CONCRETE EDGE	CONCEDGE	901	Breakline	Concrete Joint Layout
58		EDGECONC			
59	EXPANSION JOINT	CONCJOINT	902	Breakline	Concrete Joint Layout
60		EXPANJOINT			
61	CURB TOP BACK	BC	903	Breakline	Concrete Joint Layout
62		LBC			
63		CURBTB			
64		TBCURB			
65	CURB FRONT EDGE	CURBFE	904	Breakline	Concrete Joint Layout
66	CURB FLOW LINE	CURBFL	905	Breakline	Concrete Joint Layout
67	CURB/PAVEMENT	CURBPVMT	906	Breakline	Concrete Joint Layout
68	CURB-CUT	CURBCUT	907	Random	Concrete Joint Layout
69	CONCRETE	CONCRETE	1001	Random	Concrete Joint Elevations
70	HIGHWAY SIGN	HIGHWAYSIGN	1301	Random	Pavement Markings and Signs
71	SPEED SIGN	SPEEDSIGN	1302	Random	Pavement Markings and Signs
72	STOP SIGN	STOPSIGN	1303	Random	Pavement Markings and Signs
73	YIELD SIGN	YIELDSIGN	1304	Random	Pavement Markings and Signs
74	TURN SIGN	TURNSIGN	1305	Random	Pavement Markings and Signs
75	STOP AHEAD SIGN	STOPAHEADSIGN	1306	Random	Pavement Markings and Signs
76	STREET SIGN	STREETSIGN	1307	Random	Pavement Markings and Signs
77	CURVE SIGN	CURVESIGN	1308	Random	Pavement Markings and Signs
78	BRIDGE SIGN	BRIDGESIGN	1309	Random	Pavement Markings and Signs
79	MILE MARKER	MILEMARKER	1310	Random	Pavement Markings and Signs
80	REFLECTOR	REFLECTOR	1311	Random	Pavement Markings and Signs
81	SIGN	SIGN	1312	DNC	Pavement Markings and Signs
82	WEIGHT LIMIT SIGN	WEIGHTLIMITSIGN	1313	Random	Pavement Markings and Signs
83	RR X-ING SIGN	RRXINGSIGN	1317	Random	Pavement Markings and Signs
84	RR SIGN	RRSIGN	1318	Random	Pavement Markings and Signs
85	BILLBOARD	BBOARD	1319	DNC	Pavement Markings and Signs
86		BILLBRD			
87	DIST-TO-GO	DISTTOGO	1321	Random	Pavement Markings and Signs
88	PAINT STRIPE	PAINTSTRIPE	1322	Random	Pavement Markings and Signs
89	PARKING METER	PARK	1323	DNC	Pavement Markings and Signs
90	MAIL BOX U.S.	USMAILBOX	1394	DNC	Pavement Markings and Signs
91		MAILBOXUS			
92	RESIDENT SIGN	RESIDENTSIGN	1395	Random	Pavement Markings and Signs
93	MAIL BOX RESIDENTIAL	RESMAILBOX	1398	Random	Pavement Markings and Signs

94		MAILBOXRES			
95	FLAG POLE	FPOLE	1399	Random	Pavement Markings and Signs
96		FLAGPOLE			
97	WALL TOP EDGE	WALLTOPEDGE	1401	Breakline	Structures and Headwalls
98	WALL BOTTOM	BOTWALL	1402	Breakline	Structures and Headwalls
99		WALLBOT			
100	PUMP	PUMP	1403	Breakline	Structures and Headwalls
101	FLOODGATE	FLOODGATE	1404	Breakline	Structures and Headwalls
102	STEEL GUARD POST	STEELPOST	1470	Breakline	Structures and Headwalls
103	WOOD GUARD POST	WOODPOST	1471	Breakline	Structures and Headwalls
104	POST	POST	1472	Random	Structures and Headwalls
105	CORRUGATED STEEL-FLOW LINE	CMP	1601	DNC	Culverts
106	REINFORCED CONCRETE-FLOW LINE	RCP	1602	DNC	Culverts
107	PVC-FLOW LINE	PVCFL	1603	DNC	Culverts
108	TOP CULVERT-BASE FILL	TOPCULBASFIL	1604	DNC	Culverts
109	BOX-FLOW LINE	BOXFL	1605	DNC	Culverts
110	TOP OF PIPE CULVERT	TOPCULVERT	1606	Breakline	Culverts
111	RIPRAP	RIPRAP	1801	Random	Riprap
112	RIPRAP TOP	RRAPTOP	1802	Breakline	Riprap
113		TOPRRAP			
114	RIPRAP TOE	RRAPTOE	1803	Breakline	Riprap
115		TOERRAP			
116	WATER EDGE	WE	1901	Breakline	Water Features
117	THALWEG	THALWEG	1902	Breakline	Water Features
118	BED	BED	1903	Random	Water Features
119	TREE-DEC	CYPRESS TREE	2101	DNC	Vegetation
120		DOGWOOD			
121		DTREE			
122		MAPLE			
123		OAK			
124	TREE-CON	CTREE	2102	DNC	Vegetation
125		FERN			
126		PINE			
127		SPRUCE			
128	TREE	TREE	2103	DNC	Vegetation
129	TREE LINE	TL	2104	DNC	Vegetation
130	STUMP	STUMP	2105	DNC	Vegetation
131	GROUND IN TIMBER	INTREES	2106	Random	Vegetation
132	SHRUB	SHRUB	2107	Random	Vegetation
133	SHRUB LINE	SHRUBLINE	2108	Random	Vegetation
134	BRUSH	BRUSH	2109	Random	Vegetation
135	BRUSH LINE	BRUSHLINE	2110	Random	Vegetation
136	CULTIVATION	CULT	2111	Random	Vegetation
137	LAWN EDGE	LAWNEDGE	2112	Breakline	Vegetation
138		EDGELAWN			
139	BARBED WIRE FENCE	BWFENCE	2301	Random	Fences, Guard Rails
140		FENCEBW			
141	CHAIN LINK FENCE	CLFENCE	2302	Random	Fences, Guard Rails
142		FENCECL			
143	WOOD FENCE	WFC	2303	Random	Fences, Guard Rails
144	STOCK FENCE	STOCKFEN	2304	Random	Fences, Guard Rails
145		FENCESTK			
146	GATE EDGE	GATE	2305	Random	Fences, Guard Rails
147		GATEEDGE			

148		EDGEGATE			
149	FENCE CORNER	CORFENCE	2306	Random	Fences, Guard Rails
150		FENCECOR			
151	GUARDRAIL	GRAIL	2308	Random	Fences, Guard Rails
152	CATTLE GUARD	CATGUARD	2309	Random	Fences, Guard Rails
153	PROPERTY PIN	PPIN	2501	DNC	Boundary Lines / Cadastral-R/W
154		PROPPIN			
155	BLOCK CORNER	BLOCKCOR	2502	DNC	Boundary Lines / Cadastral-R/W
156	PLSS CORNER	SECCOR	2503	DNC	Boundary Lines / Cadastral-R/W
157	R/W-CAP	RWCAP	2509	DNC	Boundary Lines / Cadastral-R/W
158	R/W-MON	RWMON	2510	DNC	Boundary Lines / Cadastral-R/W
159	R/W-PIN	RWPIN	2511	DNC	Boundary Lines / Cadastral-R/W
160	R/W-REBAR	RWREBAR	2512	DNC	Boundary Lines / Cadastral-R/W
161	STATION MARKER	STAMARKER	2513	DNC	Boundary Lines / Cadastral-R/W
162	CONTROL HORIZ	HCON	2701	Breakline	Survey Control Points, Baselines
163	CONTROL VERT	BM	2702	DNC	Survey Control Points, Baselines
164		VCON			
165	CONTROL H/V	HVCON	2703	DNC	Survey Control Points, Baselines
166	GAUGE	GAUGE	2704	DNC	Survey Control Points, Baselines
167	CONTROL SECONDARY	SECCON	2705	DNC	Survey Control Points, Baselines
168		CONSEC			
169	BASELINE	BASELINE	2706	DNC	Survey Control Points, Baselines
170	PHOTO HORIZ	PHOTOH	2707	DNC	Survey Control Points, Baselines
171		HPHOTO			
172	PHOTO VERT	PHOTOV	2708	DNC	Survey Control Points, Baselines
173		VPHOTO			
174	PHOTO H/V	PHOTOHV	2709	DNC	Survey Control Points, Baselines
175		HVPHOTO			
176	BS STATION	BSSTATION	2710	DNC	Survey Control Points, Baselines
177	INST STATION	INSTSTATION	2711	DNC	Survey Control Points, Baselines
178	FS STATION	FSSTATION	2712	DNC	Survey Control Points, Baselines
179	CONTROL CHECK	CONCHECK	2713	DNC	Survey Control Points, Baselines
180	ELEVATION CHECK	ELEVCHECK	2714	DNC	Survey Control Points, Baselines
181	DUNE TOP	TOPDUNE	2903	Breakline	Breaklines
182		DUNETOP			
183	DUNE TOE	BOTDUNE	2904	Breakline	Breaklines
184		TOEDUNE			
185		DUNETOE			
186	BANK TOP	TB	2905	Breakline	Breaklines
187		BANKTOP			
188		TOPBANK			
189	BANK TOE	BB	2906	Breakline	Breaklines
190		BOTBANK			
191		TOEBANK			
192		BANKTOE			
193	CUT TOP	CUTTOP	2907	Breakline	Breaklines
194		TOPCUT			
195	CUT TOE	CUTTOE	2908	Breakline	Breaklines
196		TOECUT			
197		BOTCUT			
198	FILL TOP	TOPFILL	2909	Breakline	Breaklines
199		FILLTOP			
200	FILL TOE	BOTFILL	2910	Breakline	Breaklines
201		TOEFILL			
202		FILLTOE			
203	BREAK TOP	BREAKTOP	2911	Breakline	Breaklines
204		TOPBREAK			

205	BREAK TOE	BREAKTOE	2912	Breakline	Breaklines
206		TOEBREAK			
207	SWALE TOP	SWALETOP	2913	Breakline	Breaklines
208		TOPSWALE			
209	SWALE TOE	SWALETOE	2914	Breakline	Breaklines
210		TOESWALE			
211	RAILROAD BALLAST TOP	TRRBAL	2915	Breakline	Breaklines
212	RAILROAD BALLAST TOE	BRRB	2916	Breakline	Breaklines
213	BREAK LINE	BRK	2999	Breakline	Breaklines
214		BRKLINE			
215	GROUND	GND	3001	Random	Spot Elevation
216		NG			
217		SPOT			
218		SUR			
219		GROUND			
220	SLOPE	SLOPE	3002	Random	Spot Elevation
221		SLP			
222	GRAVEL	GRAVEL	3003	Random	Spot Elevation
223	SAND	SAND	3004	Random	Spot Elevation
224	LAWN	LAWN	3005	Random	Spot Elevation
225		GRASS			
226	PAVEMENT	PVMT	3006	Random	Spot Elevation
227		PAVEMENT			
228	ROCK	ROCK	3007	Random	Spot Elevation
229	SHOULDER	SHOULDER	3009	Random	Spot Elevation
230	BORE HOLE	BORE	3401	DNC	Bores, Holes, and Text
231		BOREHOLE			
232	TEST PIT	TPIT	3402	DNC	Bores, Holes, and Text
233		TESTPIT			
234	PERC TEST	PERCTEST	3403	DNC	Bores, Holes, and Text
235	STAND PIPE	STANDPIPE	3404	DNC	Bores, Holes, and Text
236	CDHD	CDHD	3405	DNC	Bores, Holes, and Text
237	CDHU	CDHU	3406	DNC	Bores, Holes, and Text
238	MONITORING DEVICE	MONDEVICE	3407	DNC	Bores, Holes, and Text
239	PVC PIEZOMETER	PVCPIEZ	3408	DNC	Bores, Holes, and Text
240	PVC SLOPE INDICATOR	PVCSLPIN	3409	DNC	Bores, Holes, and Text
241	TEST WELL	TESTWELL	3410	DNC	Bores, Holes, and Text
242	WELL HEAD	WELLHEAD	3411	DNC	Bores, Holes, and Text
243	CONC DRAIN TROUGH TOP	CONCDTTOP	3501	Breakline	Storm Sewerlines and Manholes
244		TOPCONCDT			
245	CONC DRAIN TROUGH TOE	CONCDTTOE	3502	Breakline	Storm Sewerlines and Manholes
246		TOECONCDT			
247	GRATED STORM MH	GRSTMH	3503	DNC	Storm Sewerlines and Manholes
248	STORM MH	SDRMH	3504	DNC	Storm Sewerlines and Manholes
249		STORMMH			
250		MHSTORM			
251	CATCH BASIN	CB	3505	Random	Storm Sewerlines and Manholes
252		EDGECB			
253	DRAIN PIT	DRAINPIT	3506	DNC	Storm Sewerlines and Manholes
254	CURTAIN DRAIN	CURTAINDRN	3509	DNC	Storm Sewerlines and Manholes
255	FLOW LINE IN STORM	FLISTORM	3510	DNC	Storm Sewerlines and Manholes
256	FLOW LINE OUT STORM	FLOSTORM	3511	DNC	Storm Sewerlines and Manholes
257	TOP OF PIPE STORM	TOPSTORM	3512	DNC	Storm Sewerlines and Manholes

258	SANITARY MH	SSMH	3701	DNC	Sanitary Sewerlines, and Manholes
259		SANMH			
260		MHSAN			
261	FLOW LINE IN SEWER	FLISEWER	3702	DNC	Sanitary Sewerlines, and Manholes
262	FLOW LINE OUT SEWER	FLOSEWER	3703	DNC	Sanitary Sewerlines, and Manholes
263	TOP OF PIPE SEWER	TOPSEWER	3704	DNC	Sanitary Sewerlines, and Manholes
264	SANITARY LINE	SSLINE	3706	DNC	Sanitary Sewerlines, and Manholes
265	CLEAN OUT	CLEANOUT	3707	DNC	Sanitary Sewerlines, and Manholes
266	LIFT STATION	LIFTSTA	3708	DNC	Sanitary Sewerlines, and Manholes
267	LEACH LINE	LEACHLINE	3709	DNC	Sanitary Sewerlines, and Manholes
268	SEPTIC TANK	SEPTICTANK	3710	DNC	Sanitary Sewerlines, and Manholes
269	DRYWELL	DRYWELL	3711	DNC	Sanitary Sewerlines, and Manholes
270	DRAIN FIELD	DRAINFIELD	3712	DNC	Sanitary Sewerlines, and Manholes
271	SANITARY SEWER FORCE MAIN	SSMAIN	3713	DNC	Sanitary Sewerlines, and Manholes
272	WATER VALVE	WATERVALVE	3901	DNC	Water Lines, Fire Hydrants, and Water Tanks
273	AIR RELIEF VALVE	AIRVALVE	3902	DNC	Water Lines, Fire Hydrants, and Water Tanks
274	RISER	RISER	3903	DNC	Water Lines, Fire Hydrants, and Water Tanks
275	WATER MH	WATERMH	3904	Random	Water Lines, Fire Hydrants, and Water Tanks
276		MHWATER			
277	WELL	WELL	3905	Random	Water Lines, Fire Hydrants, and Water Tanks
278	WATER LINE	WATERLINE	3906	Random	Water Lines, Fire Hydrants, and Water Tanks
279	WELL HOUSE	WELLHOUSE	3907	Random	Water Lines, Fire Hydrants, and Water Tanks
280	FIRE HYDRANT	FH	3908	Random	Water Lines, Fire Hydrants, and Water Tanks
281		HYD			
282	WATER METER	WATERMETER	3909	DNC	Water Lines, Fire Hydrants, and Water Tanks
283	END ABUTMENT	ENDABUT	3910	DNC	Water Lines, Fire Hydrants, and Water Tanks
284	WATER SERVICE	WATERSER	3911	DNC	Water Lines, Fire Hydrants, and Water Tanks
285	CURB STOP	CURBSTOP	3912	DNC	Water Lines, Fire Hydrants, and Water Tanks
286	SPRINKLER HEAD	SPKLR	3913	Random	Water Lines, Fire Hydrants, and Water Tanks
287	PUMP	WATERPUMP	3915	Random	Water Lines, Fire Hydrants, and Water Tanks
288	GAS VALVE	GASV	4102	DNC	Gaslines, Features, and Valves
289		GVALVE			
290		GASVALVE			
291	GAS TANK	GASTANK	4103	DNC	Gaslines, Features, and Valves
292	GAS METER	GASM	4104	DNC	Gaslines, Features, and Valves
293	GAS LINE	GASL	4105	DNC	Gaslines, Features, and Valves
294		GASLINE			
295	GAS MH	GASMH	4106	Breakline	Gaslines, Features, and Valves
296		MHGAS			
297	GAS WITNESS POST	GASWITPOST	4107	Random	Gaslines, Features, and Valves
298	FUEL PUMP	FUELPUMP	4109	DNC	Gaslines, Features, and Valves
299	FILLER PIPE U/G TANK	FILLPIPEUGTAN K	4110	Random	Gaslines, Features, and Valves
300	A/G FUEL TANK	AGFUELTANK	4111	Random	Gaslines, Features, and Valves

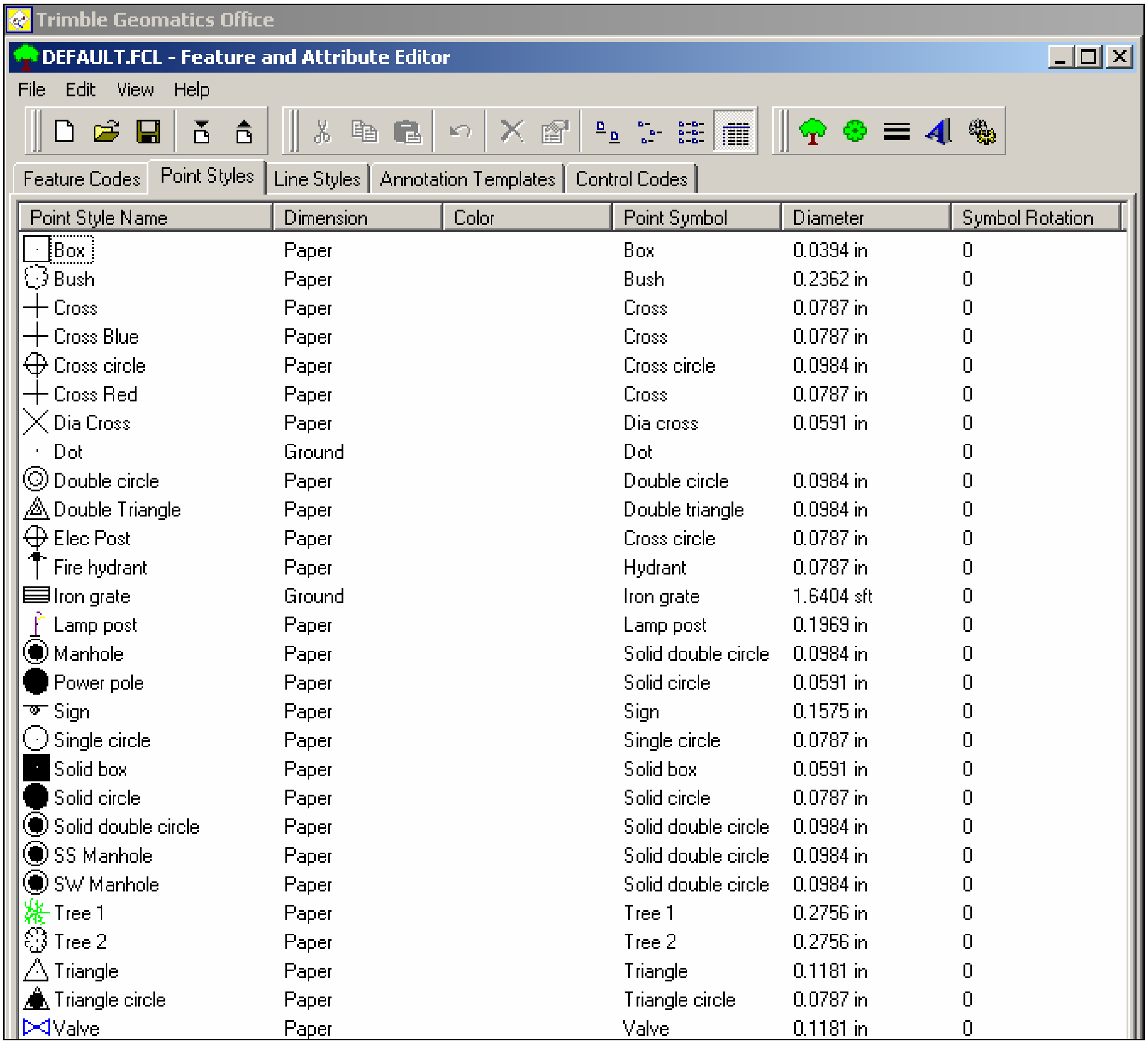
301	FUEL TANK PIPE VENT	FUELTANKPIPEVENT	4112	Random	Gaslines, Features, and Valves
302	FUEL PIT	FUELPIT	4113	DNC	Gaslines, Features, and Valves
303	POWER POLE	PPOLE	4301	DNC	Powerlines, Lights, and Telephone Poles
304	POWER DROP	PDROP	4302	DNC	Powerlines, Lights, and Telephone Poles
305	U/G POWER LINE	UGPOWER	4303	Random	Powerlines, Lights, and Telephone Poles
306		UNELEC			
307	O/H POWER LINE	OHE	4304	DNC	Powerlines, Lights, and Telephone Poles
308		OVEL			
309	LOW WIRE POWER	LOWWIREP	4305	Random	Powerlines, Lights, and Telephone Poles
310	LIGHT POLE	LP	4306	DNC	Powerlines, Lights, and Telephone Poles
311		LPOLE			
312	GUY POLE POWER	GUYPOLEELEC	4307	Random	Powerlines, Lights, and Telephone Poles
313	GUY ANCHOR POWER	GUYPOWER	4308	Random	Powerlines, Lights, and Telephone Poles
314	TRANSFORMER	TRANSFOR	4309	DNC	Powerlines, Lights, and Telephone Poles
315	ELECTRIC MH	ELECMH	4310	Random	Powerlines, Lights, and Telephone Poles
316		EMH			
317		MHELEC			
318	SERVICE POLE	SERVPOLE	4311	Random	Powerlines, Lights, and Telephone Poles
319	ELECTRIC METER	ELECMETER	4312	DNC	Powerlines, Lights, and Telephone Poles
320	POWER PED	POWERPED	4313	Random	Powerlines, Lights, and Telephone Poles
321	ELECTRIC DUCT	ELECDUCT	4314	DNC	Powerlines, Lights, and Telephone Poles
322	YARD LIGHT	YARDLIGHT	4315	DNC	Powerlines, Lights, and Telephone Poles
323	ELECTRIC JUNCTION BOX	EBOX	4316	DNC	Powerlines, Lights, and Telephone Poles
324		ELECBOX			
325	TOWER LEG	TOWERLEG	4317	Random	Powerlines, Lights, and Telephone Poles
326	TRAFFIC LIGHT POLE	TLP	4318	DNC	Powerlines, Lights, and Telephone Poles
327	TRAFFIC LIGHT SIGNAL BOX	TLSB	4319	DNC	Powerlines, Lights, and Telephone Poles
328	FIRE ALARM	FIREALARM	4320	DNC	Powerlines, Lights, and Telephone Poles
329	RAILROAD SIGNAL POST	RRSIGPOST	4321	Random	Powerlines, Lights, and Telephone Poles
330	RAILROAD SIGNAL BOX	RRSIGBOX	4322	Random	Powerlines, Lights, and Telephone Poles
331	RUNWAY LIGHT	RUNWAYLIGHT	4323	Random	Powerlines, Lights, and Telephone Poles
332	THRESHOLD LIGHT	THRESHLIGHT	4324	Random	Powerlines, Lights, and Telephone Poles
333	TELEPHONE POLE	TELEPOLE	4340	Random	Powerlines, Lights, and Telephone Poles
334	PHONE DROP	PHONEDROP	4341	Random	Powerlines, Lights, and Telephone Poles
335	U/G PHONE LINE	UGPHONE	4342	Random	Powerlines, Lights, and Telephone Poles
336		UNTEL			
337	O/H PHONE LINE	OVTEL	4343	DNC	Powerlines, Lights, and Telephone Poles
338		OHPHONE			
339	GUY POLE PHONE	GUYPOLEPHONE	4344	Random	Powerlines, Lights, and Telephone Poles
340	GUY ANCHOR PHONE	GUYPHONE	4345	Random	Powerlines, Lights, and Telephone Poles
341	TELEPHONE MH	TELMH	4346	DNC	Powerlines, Lights, and Telephone Poles
342	PHONE PED	PHONEPED	4347	DNC	Powerlines, Lights, and Telephone Poles
343	PHONE BOX	PHONEBOX	4348	DNC	Powerlines, Lights, and Telephone Poles
344	PHONE SUBSTATION	PHONESUB	4349	DNC	Powerlines, Lights, and Telephone Poles
345	PHONE BOOTH	TBOOTH	4350	DNC	Powerlines, Lights, and Telephone Poles
346	LOW WIRE PHONE	LWPHONE	4351	DNC	Powerlines, Lights, and Telephone Poles
347	REPEATER	REPEATER	4352	DNC	Powerlines, Lights, and Telephone Poles
348	U/G FIBER OPTIC	FIBERUG	4361	Random	Powerlines, Lights, and Telephone Poles
349		UGFIBER			
350	FIBER POST	FIBPOST	4362	Random	Powerlines, Lights, and Telephone Poles
351	U/G CABLE/FIBER MARKER	UGCAFBMKR	4363	Random	Powerlines, Lights, and Telephone Poles
352	U/G CABLE TV	TVUG	4371	Random	Powerlines, Lights, and Telephone Poles

353		UGTV			
354	O/H CABLE TV	OHTV	4372	Random	Powerlines, Lights, and Telephone Poles
355	TV PED	TVPED	4373	Random	Powerlines, Lights, and Telephone Poles
356	SATELLITE DISH	SATDISH	4374	DNC	Powerlines, Lights, and Telephone Poles
357	SATELLITE BOX	SATBOX	4375	DNC	Powerlines, Lights, and Telephone Poles
358	STEAM LINE	STEAMLINE	4501	DNC	Steamlines, Features, and Valves
359	STEAM LINE VALVE	SLVALVE	4502	DNC	Steamlines, Features, and Valves
360	STEAM MH	STEAMMH	4503	DNC	Steamlines, Features, and Valves
361		MHSTEAM			
362	STEAM PIT	STEAMPIT	4504	DNC	Steamlines, Features, and Valves
363	SOUNDING	SNDG	4901	Random	Soundings
364		SOUNDING			
365	BORROW PIT TOP	BORPITTOP	5001	Breakline	Channel Lines, Disposal Areas
366		TOPBORPIT			
367	BORROW PIT TOE	BORPITTOE	5002	Breakline	Channel Lines, Disposal Areas
368		TOEBORPIT			
369	SPOIL TOP	SPOILTOP	5003	Breakline	Channel Lines, Disposal Areas
370		TOPSPOIL			
371	SPOIL TOE	SPOILTOE	5004	Breakline	Channel Lines, Disposal Areas
372		TOESPOIL			
373	RED BUOY	REDBUOY	5201	DNC	Navigation Aides and Annotation
374		BUOYRED			
375	GREEN BUOY	GRNBUOY	5202	DNC	Navigation Aides and Annotation
376		BOUYGRN			
377	NO WAKE BUOY	NOWAKE	5203	DNC	Navigation Aides and Annotation
378	SWIMMING BUOY	SWIMBUOY	5204	DNC	Navigation Aides and Annotation
379	STUDY GAUGE	STGAUGE	5205	DNC	Navigation Aides and Annotation
380	NAVIGATION LIGHT	NAVLIGHT	5206	DNC	Navigation Aides and Annotation
381	BUOY	BUOY	5207	DNC	Navigation Aides and Annotation
382	DOLPHIN	DOLPHIN	5208	DNC	Navigation Aides and Annotation
383	PILING	PILING	5209	DNC	Navigation Aides and Annotation
384	LEVEE CL	CLLEVEE	5301	Breakline	Levees, Dikes, and Annotation
385		LEVEECL			
386	LEVEE CROWN	LEVEECRN	5302	Breakline	Levees, Dikes, and Annotation
387		CRNLEVEE			
388	LEVEE TOP	LEVEETOP	5303	Breakline	Levees, Dikes, and Annotation
389		TOPLEVEE			
390	LEVEE SLOPE	LEVEESLP	5304	Random	Levees, Dikes, and Annotation
391		SLPLEVEE			
392	LEVEE TOE	TOELEVEE	5305	Breakline	Levees, Dikes, and Annotation
393		LEVEETOE			
394		BOTLEVEE			
395	BERM CROWN	BERMCRWN	5306	Breakline	Levees, Dikes, and Annotation
396		CRWNBERM			
397	BERM TOP	TBERM	5307	Breakline	Levees, Dikes, and Annotation
398		TOPBERM			
399		BERMTOP			
400	BERM SLOPE	BERMSLP	5308	Random	Levees, Dikes, and Annotation
401		SLPBERM			
402	BERM TOE	BBERM	5309	Breakline	Levees, Dikes, and Annotation
403		TOEBERM			
404		BERMTOE			
405	DIKE CROWN	DIKECRWN	5311	Breakline	Levees, Dikes, and Annotation
406	DIKE TOP	DIKETOP	5312	Breakline	Levees, Dikes, and Annotation
407		TOPDIKE			
408	DIKE SLOPE	SLPDIKE	5313	Breakline	Levees, Dikes, and Annotation
409		DIKESLP			
410	DIKE TOE	DIKETOE	5314	Breakline	Levees, Dikes, and Annotation

411		TOEDIKE			
412	PIPELINE	PIPELINE	5401	DNC	Pipe Lines, Structures, and Bridges
413	O/H PIPE	OHPIPE	5402	DNC	Pipe Lines, Structures, and Bridges
414	PIPELINE SUPPORT	PIPESUPP	5403	DNC	Pipe Lines, Structures, and Bridges
415	ASPHALT REVETMENT EDGE	ASPHREVEDGE	5701	Breakline	Revetments and Annotation
416	ASPHALT REVETMENT	ASPHREV	5702	Breakline	Revetments and Annotation
417	CONCRETE REVETMENT EDGE	CONCREVEDGE	5703	Breakline	Revetments and Annotation
418	CONCRETE REVETMENT	CONCREV	5704	Breakline	Revetments and Annotation
419	CONCRETE MAT REVETMENT EDGE	CONCREVMATEDGE	5705	Breakline	Revetments and Annotation
420	CONCRETE MAT REVETMENT	CONCREVMAT	5706	Breakline	Revetments and Annotation
421	SEE FIELD BOOK NOTE	NOTE	6301	DNC	Unassigned

7-7. Feature and Attribute Libraries for Topographic Field Data

Most data collectors are now designed to hold detailed feature and attribute libraries. Attributes are subsets of a feature, describing standard detail about a common feature. For example, a CONCRETE_PIPE (Feature) may have selectable diameter attributes (24 IN, 36 IN, 48 IN, etc.). An unlimited number of attributes can be set up for a given common feature. The data collector software can be set up to prompt for selected attributes when a given feature (code) is shot. Unprompted attributes can optionally be assessed. Or, uncatalogued attributes can be added for a point. Feature libraries may be created on the data collector or on other PC software and uploaded to the data collector for use during survey operations. The following representative examples are taken from the Trimble Geomatics Office (TGO) Version 1.60, "Feature and Attribute Editor" default library--reference also Trimble Survey Controller Reference Manual (Trimble 2001). The feature and attribute library is created and edited in the TGO software and uploaded to the controller. Feature codes, point styles, line styles, etc. can be saved directly to a Trimble Survey Controller type data collector or to a generic ASCII file that could be uploaded to another data collector (e.g., a TDS-HP48GX). Some of the TGO default point styles are shown in Figure 7-2 below.



Point Style Name	Dimension	Color	Point Symbol	Diameter	Symbol Rotation
Box	Paper		Box	0.0394 in	0
Bush	Paper		Bush	0.2362 in	0
Cross	Paper		Cross	0.0787 in	0
Cross Blue	Paper		Cross	0.0787 in	0
Cross circle	Paper		Cross circle	0.0984 in	0
Cross Red	Paper		Cross	0.0787 in	0
Dia Cross	Paper		Dia cross	0.0591 in	0
Dot	Ground		Dot		0
Double circle	Paper		Double circle	0.0984 in	0
Double Triangle	Paper		Double triangle	0.0984 in	0
Elec Post	Paper		Cross circle	0.0787 in	0
Fire hydrant	Paper		Hydrant	0.0787 in	0
Iron grate	Ground		Iron grate	1.6404 sft	0
Lamp post	Paper		Lamp post	0.1969 in	0
Manhole	Paper		Solid double circle	0.0984 in	0
Power pole	Paper		Solid circle	0.0591 in	0
Sign	Paper		Sign	0.1575 in	0
Single circle	Paper		Single circle	0.0787 in	0
Solid box	Paper		Solid box	0.0591 in	0
Solid circle	Paper		Solid circle	0.0787 in	0
Solid double circle	Paper		Solid double circle	0.0984 in	0
SS Manhole	Paper		Solid double circle	0.0984 in	0
SW Manhole	Paper		Solid double circle	0.0984 in	0
Tree 1	Paper		Tree 1	0.2756 in	0
Tree 2	Paper		Tree 2	0.2756 in	0
Triangle	Paper		Triangle	0.1181 in	0
Triangle circle	Paper		Triangle circle	0.0787 in	0
Valve	Paper		Valve	0.1181 in	0

Figure 7-2 Example of Trimble Default Point Styles

Additional features are easily added to the library using a feature/attribute editor, such as that shown in Figure 7-3 below. Attributes can be added to existing or new features using software compatible with the data collector software. For example, the feature TREE in the TGO default library can be modified using the TGO software, and the modifications exported to the data collector, as shown below.

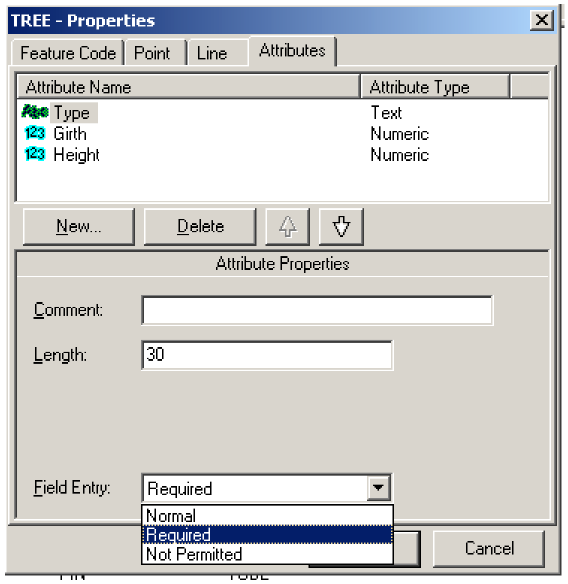


Figure 7-3. Example of Attribute Editor Options (Trimble)

The attributes for the feature TREE can be prompted for field entry, as shown in the pull down window. Numeric entries for GIRTH and HEIGHT can have default entries, minimum and maximum range, and decimal resolution. Any number of additional attributes can be added to this feature using this editor. When attributes are created, they should ideally conform to current USACE directed CADD/GIS standards.

7-8. Control Commands for Connecting Feature Line Strings

Topographic features that have the same feature code may be connected by a line string if that is the nature of the physical object. Examples of connected line strings would be shots taken along a CENTERLINE, BREAKLINE, CURB, EDGE OF SIDEWALK, BUILDING, etc. The individual feature codes input for these continuous objects do not represent the fact that they may be connected by a line string. A "Control Command" in the data collector before and after a string of individual point codes is used to indicate that a series of shots are connected. For example, a command code "CL" may be used to signify a series of shots along a CENTERLINE, with codes such as "CL START "and "CL END" on each end of the string.

a. Adding Control Commands to point codes provides many advantages over single point codes. Real-time field graphical depiction of features, utilities, and facilities is viewable on the controller screen, as opposed to a display of unconnected points. When the control-coded data is exported to a CADD or GIS platform, a significant amount of the mapping editing effort can be eliminated. In effect, adding Control Codes approaches a "field-finish" topographic mapping product, not unlike the "field-finish" drawing that resulted from a plane table survey years ago. Adding detailed Command Codes takes more care and time in the field; however, the advantages of cleaner editing will usually outweigh the lost time involved in the field.

b. Each data collector software vendor has unique Command Code formats. Users should ensure compatibility between the data collector software output and the CADD package that the final drawings will be developed on. Some formats are compatible with only a specific mapping processor. The feature codes tell how to group the points; the command codes tell how to connect the points. For example, TDS

ForeSight software has a *code table* that tells whether linework is required for a group of points and how it is to be plotted: e.g., symbol type, color, size, etc. In the code table you assign each feature code or group of points a specific symbol, a line type, and several other parameters. The code table is a function of the ForeSight program and is discussed in detail in its manual.

7-9. Field Coordinate Geometry Options

Coordinate Geometry (COGO) functions are software routines that perform standard field (and office) survey computations. These COGO routines range from simple ones like inverse computations, to more complex computations such as circular and spiral curve stakeouts or least squares adjustments. Each data collector software package will contain a varying number of these COGO routines. Depending on the type of work an agency performs, only a small number of these COGO features will actually be used in practice.

a. General. COGO (from COordinate GeOmetry) was initially developed by Charles L. Miller of M.I.T. in 1959. Since then, many improvements have been made, but the basic concept and vocabulary have remained the same. COGO is a problem oriented system that enables the user with limited computer experience to solve common surveying problems. The language is based on familiar surveying terminology, such as, Azimuth, Inverse, Bearing, etc. This terminology is used to define the problem and generate a solution. COGO may be used to solve problems such as curve alignments, point offsets, distance, and direction between two points, intersections, etc.

(1) The basis of the system is a series of commands used to manipulate or compute points defined by a point number, x-coordinate, and y-coordinate on a plane surface. These points are stored in what is referred to as the “coordinate table” and may be recalled by their point number in future computations.

(2) The mathematics used for the COGO computations are beyond the scope of this manual. There are many textbooks published that describe the mathematical procedures in detail--see listing at Appendix A-2. The Oregon DOT *Basic Surveying--Theory and Practice* manual (Oregon DOT 2000) is available on the Internet and describes many basic survey computations.

(3) There are many COGO packages on the market today. Several are available for an office PC environment on the Internet free of charge. However, COGO software compatible with a particular total station and data collector should be purchased as a package.

b. Requirements. A few general requirements for a COGO software package are as follows:

- The ability to utilize a combined scale factor in its computations. This will allow the user to calculate the ground distances when staking out a job, or reduce the measured distances to the reference vertical datum, and correct for the scale factor when the survey is to be tied to the SPCS.

- The ability to rotate and scale (transform) the survey points to fit existing control. When the surveyor uses field coordinates to perform the survey job, the survey can be transformed onto the SPCS by defining two points with their SPCS coordinates.

- Compass traverse adjustment is sufficient for the majority of traverses established by the USACE. The ability to perform a least squares adjustment may be advantageous.

- Must have the ability to work in bearings, north azimuth, or south azimuth.

- Allow the export of the coordinate table to an ASCII file.

- Allow the import of points from an ASCII, *.SHP, *.DGN, *.DFX, etc. file.

7-10. General COGO Computation Routines

Each COGO software package on the market has a variety of computational routines. Figure 7-4 illustrates a screen display from a TDS COGO software package used on field data collectors. Most software packages have fairly common COGO functions that are grouped into the categories listed below.

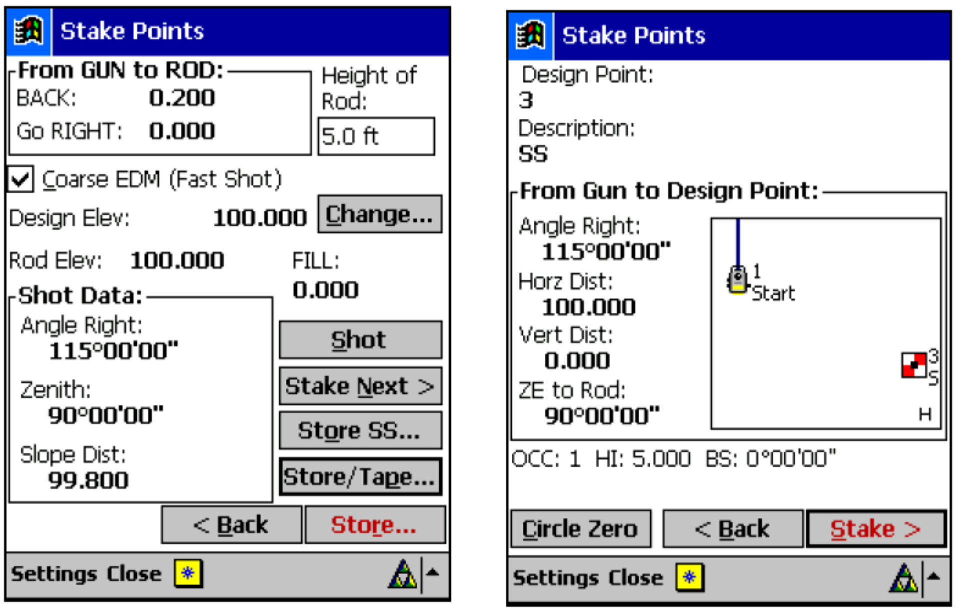


Figure 7-4. COGO screen displays for staking out a remote point (TDS COGO for Pocket PC)

Forward Computation Commands used to calculate the coordinates for a point, given the coordinates of a known point and the distance and direction to the unknown point.

(1) LOCATE/AZIMUTH: Computes a point given an azimuth and distance from a known point.

(2) LOCATE/BEARING: Computes a point given a bearing and distance from a known point.

(3) LOCATE/ANGLE: Computes a point given a backsight point, angle, and distance.

(4) LOCATE/LINE: Computes a POT (point on tangent) given tangent end points and a distance.

(5) LOCATE/DEFLECTION: Computes a point given a backsight, deflection angle, and a distance.

Inverse Computation Commands used to compute the distance and direction between two known points. Both the ground and grid distances should be given as output.

(1) INVERSE/AZIMUTH: Computes the distance and azimuth between two known points.

(2) INVERSE/BEARING: Computes the distance and bearing between two known points.

(3) TANGENT/OFFSET: Computes the distance offline and the distance down line given a known point and the ends of a known tangent.

Intersection Commands used to calculate the coordinates of an unoccupied point as the intersection of two vectors of defined direction and/or distance from two known points. Included would also be the various stakeout options--to given templates, slopes, offset alignments, etc.

(1) LINE/LINE INT: Computes the coordinates of the point of intersection of two lines whose end points are known.

(2) RANGE/RANGE INT: Computes the coordinates of the intersection of two arcs with known radii and centers. Two answers are possible, so the user must define the desired intersection.

(3) RANGE/AZIMUTH INT: Computes the coordinates of the intersection of a defined vector and an arc. Two answers are possible, so the user must define the desired intersection.

(4) AZIMUTH/AZIMUTH INT: Computes the coordinates of the intersection of vectors with known direction.

(5) FORESECTION: This is an Azimuth/Azimuth intersection, measured by turning angles from two known points.

Curve Commands allow the user to define curve parameters to use defined alignment in computations. Usually circular, transition, and vertical curves are included.

(1) ALIGNMENT: Given measured curve parameters, computes components of a curve such as:

- Arc length
- Long chord
- Radius
- Degree of curve
- Tangent length
- Center point coordinates
- External distance
- Mid ordinate
- Central angle
- Vertical curves

(2) STATION/OFFSET: Computes the coordinates of an unknown point, given a station and offset along the curve. The reverse function is also available to compute the station and offset of a known point relative to the curve alignment.

Traverse Adjustments. Traditional adjustments of traverses using either Compass Rule or Least Squares methods.

Leveling Routines. Input and adjust single-wire, three-wire, digital, or precise leveling.

Resection Computations. Two and Three-Point resection computations used for locating a total station relative to fixed points on a project.

Astronomic Computations. Sun shots or Polaris azimuth observation reductions.

Area Computation Commands which calculate the area of polygons and curve segments. The COGO package should calculate the area based on ground distances, not the reduced distances.

Volume Computations used for cut/fill or measurement and payment. Most COGO software uses Average End Area volume formulas. More sophisticated software will be able to perform surface-to-surface volume computations based on a generated DTM or TIN from observed topographic shots.

Coordinate Transformation Commands used to rotate, translate, scale, and best fit (warp) between coordinate systems, using either 3- or 7-point transformation routines.

Graphical Display of COGO Functions. Provide a graphical screen display of COGO calculations, such as stakeout, curves, etc.

The following paragraphs contain representative examples of some of the more commonly used COGO routines used in the field. The algorithms used in these COGO routines can be found in any of the surveying texts listed at Appendix A-2. These examples are taken from TDS HP-48GX software or the Trimble TSC software--COGO routines are all basically the same, regardless of the software vendor (e.g., 3-point resection algorithms are identical in output).

7-11. Total Station Resection Computations

Generally, total stations are set up over known control points and oriented in azimuth to another fixed point. Often the total station must be set up at a remote point in order to observe areas not visible from the established control points. This typically occurs on property surveys where multiple corners have been recovered but cannot be physically occupied with the instrument. In such a case, the instrument is set up at an unmarked point that can see two or more of the property corners plus affords good visibility to the survey area.

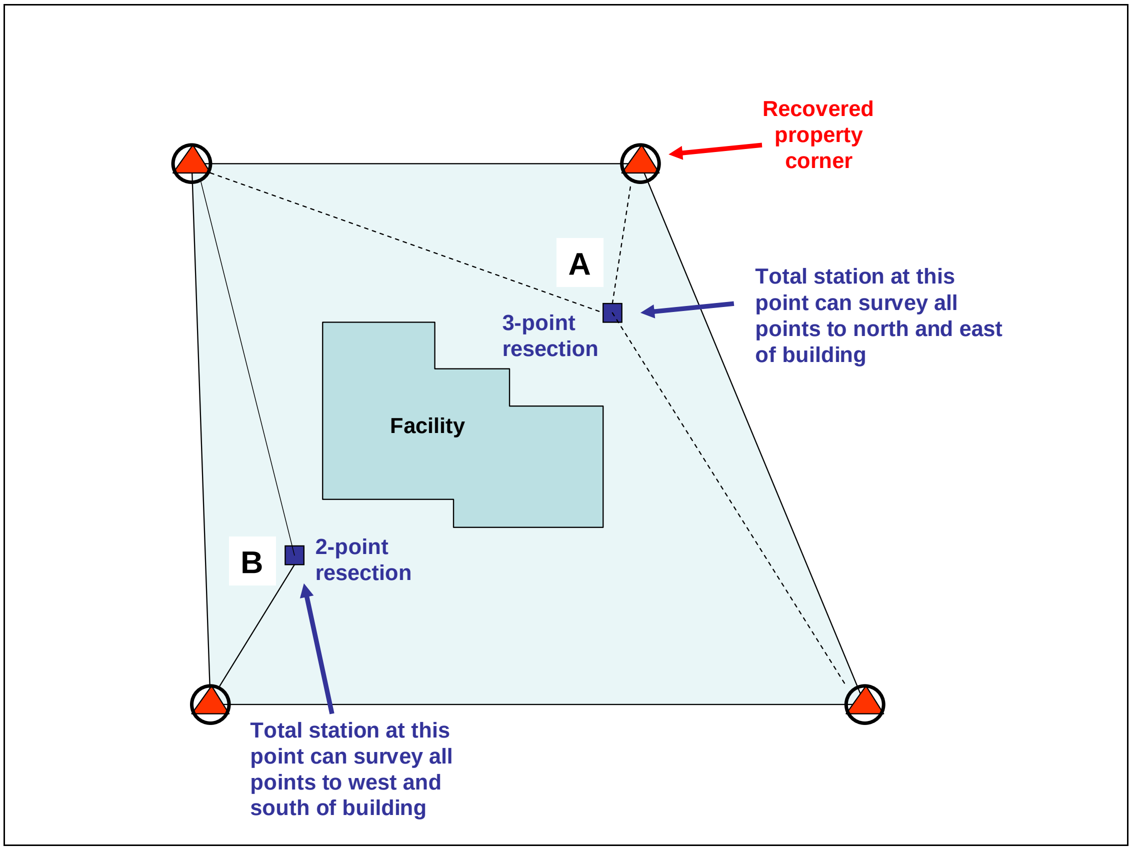


Figure 7-5. Two- and Three-point total station resections

As illustrated in Figure 7-5 above, the total station is set at points A and B in order to delineate facilities, utilities, and topography on this site. From these two points, the entire project site (including the building exterior walls) can be viewed. To position the instrument relative to the recovered property corners, either two- or three-point resections can be performed, as shown at points B and A respectively. The rodman places the prism pole at each corner and shots are taken and saved in the data collector. In practice, only a two-point resection would be performed at both points A and B since the total station can measure distances to both points and the angle between them; providing a redundant solution of the instrument's position. (Three-point resections require only observing of the two angles--three directions--between the three points for a solution--a practice once performed with traditional transits or theodolites). Some COGO software will perform a least-squares adjustment of the resected position when redundant observations are obtained--i.e., both directions and distances on a two-point resection or three directions plus one or more distances on a three-point resection. Likewise, an adjustment would be performed if four or more points were used in a resection. Options for 2D and 3D resection adjustments are available on commercial COGO packages.

The following Figure 7-6 is taken from Tripod Data System fieldwork software (TDS 1999). It illustrates a two-point resection on a HP 48 type data collector, which is similar to more current CE-based data collectors. In this example, the total station is set at point "50," and is backsighted on point "6" (assumed azimuth of 000 deg). A two-point resection is made between point "6" and point "1," as shown in the first table. The two field steps are shown on the following HP 48 menu screen displays. After the direction and distance to the second point is observed, pressing "SOLVE" on the HP 48 will initiate the resection computation. The solved X-Y-Z coordinates of the unknown point "50" will be displayed along with a comparison of the precision of the observation based on the redundancy in the solution.

Back Sight [BS]	Occu-pied Point [OC]	Fore-Sight [FS]	Height of Instru. [HI]	Height of Rod [HR]	Horizontal Angle (circular) [HA]	Zenith Angle [ZA]	Slope Dist. [SD]
6	50	6	5.42	6.0	0.0000	88.1347	162.19
6	50	1	5.42	6.0	74.1810	91.0713	498.91

This data is entered in the Two-Point Resection screen.

Path:	Press the direct access key [RESCT2] or [L]. As with all direct access keys, it can also be accessed from the Main Menu, then **[M] CO-GO menu**, then [L] Resect (2P).

Step 1: Enter the data for this example as shown in the screen below:

```
  Resection from 2 Pts
Option: >Direct only
First pt:    6
HI:5.420    HR:6.000
Circular:    0.0000
Zenith ang: 88.1347
Slope dist: 162.190
SOLVE                EXIT
```

<= Direct & Rev / Direct only

Step 2: Press [SOLVE] and the TDS-48 will go on to the second point. The next screen will appear. Fill it out as shown below:

```
  Resection 2nd Pt
Second pt:  1
            HR:6.000
Store pt:   50
Circular :  74.1810
Zenith ang: 91.0713
Slope dist: 498.910
SOLVE                EXIT
```

Figure 7-6. Screen displays from a HP 48 Two-Point Resection (Tripod Data Systems)

7-12. Line-Line Intersection Computations

Often the center of a rectangular object cannot be sighted but the corners can be cut in from one of more set ups. An example might be a steel tower structure where all four legs can be sighted from a single total station setup point--see Figure 7-7. The legs are shot with a prism at the base or at a constant elevation using a reflectorless total station. Given the coordinates of the four corners, the center of the object can be calculated. Most COGO routines can do this automatically and store the final coordinates of the object's center.

Figure 7-7. Steel tower structures requiring line-line intersections to compute center coordinates based on coordinates observed on each tower leg

Following is an excerpt from a TDS *.rw5 file showing multiple observations to four points. Initially the ground elevation of the approximate center of the tower is shot "FP3"--yielding a relative elevation of 101.18 ft as solved in the *.txt file from the data collector. Next, the four legs of a tower ("TL") are shot at a constant point about 60 ft above the ground--points FP5 thru FP8. The position of the center (Point 9 --"CTR TWR GROUND") is computed from the inversed intersection between the pairs of legs (shown as points 5 through 8 in the solved *.txt coordinate file). The ground elevation (101.18 ft) is manually input into the data collector to override the computed elevation at the elevated point on the tower that was actually shot.

```
SS,OP1,FP3,AR149.19000,ZE90.09150,SD86.790,--GROUND

SS,OP1,FP6,AR157.26250,ZE55.57200,SD97.338,--TL
SS,OP1,FP5,AR148.12250,ZE61.10000,SD113.340,--TL
SS,OP1,FP7,AR167.37450,ZE60.52150,SD112.328,--TL
SS,OP1,FP8,AR158.09550,ZE64.15150,SD126.306,--TL

SP,PN9,N 4909.8793,E 5036.6561,EL100.1800,--CTR TWR GROUND
```

TDS solved *.txt file output:

```
3, 4925.3608054400,  5044.2881496600,  100.1864730500,   GROUND

5, 4915.6088197900,  5052.3105890000,  160.0797345600,   TL
6, 4925.5170666700,  5030.9428381600,  159.9132991600,   TL
7, 4904.1569677500,  5021.0213152200,  160.0990367500,   TL
8, 4894.3940359500,  5042.3136274700,  160.2847694200,   TL

9, 4909.8792864900,  5036.6560961400,  100.1800000000,   CTR TWR GROUND
```