PART XII: TOPOGRAPHIC SURVEYS

12.1 Purpose and Scope

The purpose of performing topographic surveys is to map a site for the depiction of man-made and natural features that are on, above, or below the surface which will affect the design of the particular highway system. From this survey, planimetric maps, topographic maps, and a digital terrain model will be developed to show what existed on-site at the time of the survey. The project folder will contain sections for all surface topography (planimetric data), elevations, surface utility locations, and drainage, both surface and underground. The road design engineers will use the digital data for much of their design work. All files must utilize the same coordinate base. Hard copies of all maps must contain a statement similar to which follows, certifying map accuracy signed and sealed by the project surveyor.

I hereby certify that this map has been developed from survey data collected, and that accuracy standards are in accordance with the MDOT Design Survey Standards. This map correctly represents the existing conditions at the time the survey was completed.

The above statement can and should be modified to fit project conditions. No surveyor should certify to work not done under their control.

12.2 Vertical and Horizontal Control

Control points that will be used for topographic mapping shall have a standard of accuracy of 0.07 feet or below at the 95% confidence level.

Elevation data will be obtained as needed for project design, quantity computations and drainage studies. As a general rule, there should not be more than 66 feet between random observations to obtain elevations. The accumulated standard error for ground elevations should be no greater than 0.1 foot. All hard surfaced roads, curbs and sidewalks and water surface elevations shall be recorded to the nearest 0.01 foot. The relative error between adjacent elevations shall have an accumulated standard error of no more than 0.02 foot for hard surface measurements. If the total station method is used, instrument and target heights must be measured to the nearest 0.01 foot and recorded. Sights must be taken on targets on prisms. Distances for observations taken to determine hard surface elevations must not exceed 600 feet. No distances for any topographic data collection shall exceed 1200 feet.

When doing mapping field work, all horizontal and vertical control shall be checked into as random measurements with the designation recorded. The difference between mapping check coordinates and previously adjusted coordinates shall not exceed 0.05 foot in x, y, or z.

12.3 Feature Identification

All features within the site will be identified and their position located on the ground. Research of all pertinent documents will include as-built and design maps within MDOT, pertinent maps found within the municipal offices, and information extracted from legal research for lands within and adjacent to the site. Feature identification (description) should include, but shall not be limited to: tree species and size (trunk diameter measured 4.5 ft above the ground); culvert type, size and condition; material description (bit over concrete); building type and address (2 storey frame, house number); etc. Groups of trees, woods and brush should be classified as per Table 12.1.

Table 12.1
Classification Table for Trees, Woods and Brush

Classification	Clearing Size	Average Spacing of Trees (Center to Center)		
		Light	Medium	Heavy
1st Class	37" diameter or Larger	15' or more	10' to 15'	10' or less
2nd Class	19" to 36" diameter	20' or more	10' to 20'	10' or less
3rd Class	8" to 18" diameter	10' or more	3' to 10'	3' or less
4th Class	7" diameter or less and brush	One Half Covered	Two Thirds Covered	Completely Covered

12.3.1 Planimetrics

If the survey is being completed for MDOT design squads, all maps must utilize the most recent MDOT Design Division Cell Library. **No additional symbols will be used**. Symbols must be sized appropriately for the scale of the drawing. Points and lines are to be displayed according to MDOT specifications in Plans Preparation Guidelines. The map must be in digital form. Microstation drawings shall use the appropriate MDOT seed file. Tables 12.2 and 12.3 show the proper seed files for state plane coordinate projects. The digital file will also contain control, alignment and type, and property data. A hard copy of the planimetric map will be included in the portfolio. The map shall present the data in a clear and legible manner. Overlapping text, incorrectly drawn curves, crossing lines, etc., should be corrected prior to submission. Larger projects shall be plotted on multiple sheets at an appropriate scale.

If the survey is being completed for consultant design it is highly recommended that the project surveyor communicate with the project designer to obtain formats and data structures necessary to facilitate the software interface.

Structure surveys are often required, and shall conform to these standards with the following additions:Bridges, culverts, retaining walls and other structures require precise relative measurements. All structure dimensions are recorded to 0.01 foot. Bridge dimensions may be recorded on new field sketches or hand written on copies of construction plans. Elevation view sketches should be included and annotated appropriately. Specific information will be requested by the bridge unit. Photographs will be taken only if requested and labeled with control section, project number, data

Table 12.2
MDOT Seed Files: Metric
1983 Datum State Plane Coordinates

			North Zone	Central Zone	South Zone
3d Seed			SEEDZMN.DGN	SEEDZMC.DGN	SEEDZMS.DGN
2d Seed			SEEDMN.DGN	SEEDMC.DGN	SEEDMS.DGN
Global Origin		X	7,000,000	5,000,000	3,000,000
		Y	0	0	0
		Z	-715,827.883	-715,827.883	-715,827.883
Working Units	Master Units	MU	1	1	1
	Sub Units	SU	1000	1000	1000
	Positional Units	PU	3	3	3

Table 12.3
MDOT Seed Files: Feet
1983 Datum State Plane Coordinates

			North Zone	Central Zone	South Zone
3d Seed			SEEDZFN.DGN	SEEDZFC.DGN	SEEDZFS.DGN
2d Seed			SEEDFN.DGN	SEEDFC.DGN	SEEDFS.DGN
Global Origin		X	24,000,000	17,000,000	11,000,000
		Y	0	0	0
		Z	-2,147,483.648	-2,147,483.648	-2,147,483.648
Working Units	Master Units	MU	1	1	1
	Sub Units	SU	1000	1000	1000
	Positional Units	PU	1	1	1

and content. The project surveyor must insure that all required information is presented in a form easily accessed and understood by the designer.

Electronic field data shall include all topography around the structure to the limits described in the request for survey. The resulting terrain data for the approach design shall include the terrain beneath the bridge deck, but shall exclude the deck itself.

Each bridge survey must be packaged in a separate portfolio. If the survey is part of a larger road project, control and mapping data in the area of the bridge will be duplicated in the bridge survey portfolio.

12.3.2 Terrain Elevations

Historically, surveyors would identify terrain elevations by establishing a grid and observing the elevations at all of the grid nodes over the site. While the grid was convenient for developing contours over a large site, there were many terrain features, which would significantly affect the drawing of the contours, that did not occur at a grid node. Thus, these significant changes in the terrain were often located with respect to their location within the grid. This method of surveying had a lot of advantages when contours were drawn by hand. But, the advent of EDM mounted on theodolites and, particularly, the use of total stations, freed the surveyor from the rigidity of the grid structure.

Now, important terrain points are measured in three-dimensions using radial surveys from selected points on the site. With total stations and data capture systems like CAICE, the collection of these elevations is much more efficient. Contour are now generated by software. It is important to understand this process before collecting points out in the field.

The process of generating contours is very similar to the method used manually with the grid lines. Lines between these points are drawn forming a triangle. The resulting structure of a series of triangles connecting all points is called a Triangulated Irregular Network (TIN). The accuracy in which terrain can be modeled is a function of the size and shapes of the triangles since interpolation along the edges will be used to identify a particular contour, as an example.

Ideally, triangles should have short lengths or edges and good, fat angles. Fat angles increase the generic strength of the TIN model. Skinny triangles are inherently weaker and can lead to misinterpretation of the observed contours. The edges should also be short as possible. Once an edge to a triangle is formed, no other edge can cross it. Therefore, important terrain features may not be properly formed in the TIN model because they become blocked by the longer edges.

Break lines can be defined as terrain points where there exists a significant change in slope on the ground. These can occur either naturally or artificially through activities of people. Break lines should be measured at a density that will prevent the formation of triangle edges across the break-line features. As a general rule, observations should be spaced no longer than about 120 feet.

Some areas, such as around bridges, the distance between terrain points will be much smaller. It is very important to identify any vertical faces with elevations at both the top and bottom of the features.

When requested, the surveyor shall produce a digital terrain model (DTM) of the project site. Break lines and high/low points shall be used to make the model an accurate representation of the shape of the ground. Building interiors and bridge decks shall be excluded from the DTM. The surveyor shall examine the model for accuracy and completeness. A contour map of the site will be produced from this model. The project surveyor shall certify the accuracy of the contour map. The map should show the alignment or horizontal control as a reference.

When terrain elevations are obtained to supplement photogrammetric mapping, both the ground survey and the photo mapping must use the same horizontal and vertical control. A digital terrain model and contour map must be produced as described in this manual.

12.4 Drainage

When required, surface and underground drainage information is assembled by the project surveyor. The surveyor shall contact the local officials to obtain plans of any drains crossing the project and to inquire about any known drainage problems within the project area. The surveyor shall report any observed drainage problems.

The composition, size and invert elevation of each pipe at each drainage structure is required for design of improvements in critical areas. The construction type and condition of each structure and connecting pipe shall be fully described. Connections between manholes and catch basins must be determined.

The location of all structures and drainage pipes are shown on the planimetric map. It may be necessary to prepare separate plots to show underground storm drain systems. Plans and maps obtained from local officials are to be included with the notes. Reports from these officials regarding drainage problems and the surveyor's observations will be documented in a separate drainage report.

12.5 Public and Private Utilities

Public safety and good design practice requires that the design engineer know the location of utilities in the project area. A listing of companies with utilities in the area, and utility plans, will be requested by MDOT designers early in the project.

The project surveyor must know before starting the survey whether the designer requires all utilities to be located or just those visible above the ground. All utilities shall be related to the coordinate system of the project and shown on the topographic map. The surveyor shall provide a list of utilities with installations located in the project area, noting address, phone number and contact person for each. Structures, like a manhole, will be identified along with the associated information germane to that feature. For example, if the structure was a manhole, is it important to know 'where do the pipes go'?

12.5.1 Surface

The surveyor must locate and identify all visible utilities. A station and offset list of such surface manifestations must be included in the final submittal.

12.5.2 Underground

If exact locations of underground utilities are required, the survey must be coordinated with location efforts by the owner of the utility. When sanitary sewer information is necessary, the composition, size, and invert elevation of each pipe at each manhole will be critical. It may be necessary to prepare separate plots to show connectivity. Plots of underground utilities may be combined if not too cluttered.

12.6 Deliverables

Data required to be submitted for topographic mapping:

Hard copy format data:

Planimetric map,

- Contour map if required,
- Utility plans,
- Utility company listing,
- Underground utility data if required,
- Drainage issues reported by local authorities or residents,
- Plans and maps obtained from local agencies,
- Station and offset list of utility features

Digital format data:

Planimetric map and, if required, contours,
Digital terrain model (DTM),

- Utility company listing,
- Surveyors drainage report.