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NEW YORK STATE DEPARTMENT OF TRANSPORTATION

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The attached revised Section 5.04 of the Highway Design Manual supersedes the 10/6/89 version distributed as EI 89-25.

This section, entitled Terrain Data Requirements for Design, has been updated to emphasize the use of digital terrain models (DTMs) in lieu of directly measured contours and cross sections when appropriate for project needs. In addition, the combined use of survey and photogrammetric data to meet project requirements is discussed.

This document continues to be based on current design requirements and equipment capabilities. As these requirements change or other circumstances warrant, this section will be updated.

5.04 TERRAIN DATA REQUIREMENTS FOR DESIGN

5.04.01 General

When required, terrain data for design may consist of planimetric mapping with or without digital terrain models (DTM), or cross sections. The terrain data product is dependent on the type of project and the area where it is located. The data can be collected by either photogrammetry or field survey; or a combination of the two.

This section is written to provide a guideline as to the type of terrain data to request and the most cost effective method of collecting the data for a given type of project. In preparing this section the following factors were considered:

- Size and scope of typical projects
- Time generally required to move from data collection to the start of design
- Estimated costs of data collection
- Level of accuracy needed for elevation data.

Following these guidelines the PROJECT DESIGNER is responsible for identifying the appropriate terrain data requirements (type of data, accuracy required, area of coverage, etc.). The PROJECT DESIGNER in conjunction with the regional SURVEY SUPERVISOR is responsible for requesting the terrain data needs in a timely manner. The regional SURVEY SUPERVISOR is responsible for selecting the method of data collection. In making these selections, these guidelines along with other factors specific to the project and site should be followed.

Extensive terrain data acquisition normally should not be included in design consultant agreements as this is usually the most expensive method and delays the start of actual design. Following these guidelines, the primary terrain data should be acquired either through the Regional Survey Unit or the Mapping Services Bureau.

5.04.02 Method of Data Collection

Photogrammetry and field survey can provide terrain data in the form of planimetric mapping, DTMs, or directly measured cross sections. Directly measured cross section points are individually measured by photogrammetry or field survey as opposed to being interpolated from a DTM surface. In general, field survey can achieve greater accuracy than photogrammetry. However photogrammetry is sufficiently accurate for most applications and is generally less expensive for all but very small projects. Thus, because of the cost effectiveness of photogrammetry, it should be used whenever appropriate.

For mapping, photogrammetry can provide an accurate, comprehensive, digital product at less cost than field survey. However, if a project is short, has dense foliage, or requires only mapping of limited features, field survey may be the

logical choice. Also, field work will be required for most projects to compile property lines, right-of-way information, and some utility, culvert, tree, building and sign data unavailable through aerial photography.

Photogrammetric DTMs and photogrammetric cross sections are also very economical when compared to field surveyed data. However, two factors must be considered. First, photogrammetric DTM points and directly measured cross section points on hard surfaces have an elevation standard deviation of ±0.2 feet. If higher vertical accuracy than ±0.2 feet is required for any areas of a project, the vertical data must be field surveyed in these areas. Second, dense foliage or other site conditions may obstruct the view from the air. If the ground is not visible from the air, the vertical data must be field surveyed. If the higher vertical accuracy requirements or obstructed views occur only in limited areas, photogrammetric data can be supplemented with field surveyed elevations. Typically, high vertical accuracy will be needed on the highway pavement areas only. This situation is best solved by using a combination of survey data and photogrammetric data. Surveyed DTM data can easily be combined with photogrammetric DTM data to meet the accuracy requirements at a reasonable cost. It is recommended that field survey data be collected prior to photogrammetric stereocompilation to assure the accuracy and cost effectiveness of the DTM. See the attached chart (Figure 1) and the Project Type for specific guidelines as to when photogrammetry, survey, or a combination of both should be used.

5.04.03 Terrain Data Products

Discussed here are the various products which may be requested. While these requests will typically originate from Design, they should also serve the requirements of Construction. It is the PROJECT DESIGNER'S responsibility to ensure that the terrain data requested by Design meets the needs of Construction whenever practical. The SURVEY SUPERVISOR is responsible for asking the PROJECT DESIGNER if Construction needs have been met. This is particularly important for the vertical data, whether DTMs or cross sections. The vertical data used for Design should be adequate for Construction so that Construction does not routinely need to collect preconstruction cross sections.

Mapping used for design development and right-of-way (ROW) is generally provided at 1"=40' scale or 1"=50' scale. If vertical data is required, it is provided as a DTM or directly measured cross sections. 1"=20' scale mapping can be provided for highly complex projects or bridge sites.

DTMs have taken the place of contours and are an optional (and usually preferred) substitute for directly measured cross sections. They allow considerably more flexibility for the designer and potential follow-up use by Construction. Using the DTM approach, earthwork quantities for construction volume payment purposes can be calculated based on the final design centerline. With the DTM data, cross sections for stakeout

purposes can be generated at any desired interval and with any desired station numbering.

DTMs should be requested if the project will be designed using the CADD system's automated design software, cross sections along multiple alignments are required for Design, or if Construction needs cross section data. If the design is to be accomplished manually or using CADRE and only one set of cross sections is required for Design, and Construction does not need centerline cross section data, then directly measured cross sections should be requested rather than a DTM.

Directly measured cross sections are generally provided at 50' or 100' intervals (with plus stations) along a defined baseline, geometric centerline or the visual centerline closely represented by tangent segments. Design cross sections which also are to be used by Construction for volume payment will be generated along a (preliminary) geometric centerline, or visual centerline, not a baseline. If baseline cross sections are required for Design, and centerline cross sections are required for Construction, then a DTM should be requested.

All photogrammetric plan mapping is compiled digitally in 2D files for the Department's CADD system. Photogrammetric DTMs are compiled digitally in 3D and are provided in a format suitable for use with the Department's CADD system and automated design software. Photogrammetric cross sections are also in digital form and can be used with the Department's CADD system or the UNISYS A-15 system. More detailed information on photogrammetry products and how to request them is available in the Catalog of Photogrammetric Services.

Field surveyed data can be obtained using data collectors that are formatted to be compatible to the Department's computer design systems. This electronic recording survey method should be used whenever possible to efficiently complete the mapping process. However, practices vary from region to region and the regional Survey Supervisor should be contacted for information on the products available.

5.04.04 Terrain Data by Project Type

Categorized below are the amount and type of terrain data that will generally be required and the method of data collection for each project type. Some projects may have varying requirements, however, which may necessitate a different combination of products in some areas. In addition to the following description, also refer to the attached chart. (Figure 1)

I. BRIDGE PROJECTS

A project where the primary objective is to replace, rehabilitate, or remove an existing bridge, or to repair the deck of an existing bridge. Incidental highway work limited to that work on the approaches necessary to transition between the bridge and the untouched highway.

A. Bridge Replacement/New Bridge

These projects consist of work wherein an existing bridge is fully or substantially removed and is replaced at the same site or at an adjacent location by a substitute bridge. Included are superstructure replacements, even though some or all of the existing substructure elements are retained.

1. Terrain Data Required

Large scale mapping with vertical data portrayed by DTMs or directly measured cross sections will generally be required for projects of this type. 1"=20' mapping is generally required for the bridge projects. It can be prepared for use at 1"=20' or generated by the designer by enlarging 1"=40' or 1"=50' mapping on NYSDOT's CADD system. The mapping and DTM coverage that is requested for these projects should be limited in area, but include areas of necessary approach work and upstream and downstream areas.

Map Scale: 1"=20' (or 1"=40' or 1"=50' which can be converted to 1"=20')

DTM: Digital terrain model data will be collected instead of direct contour and cross section compilation. Contours and cross sections can then be computer generated from the DTM. Either DTM or directly measured cross section data can be requested, but not both.

Cross Sections: Stationing at 50' intervals (with plus stations). Cross sections can also be taken perpendicular to the stream flow.

2. Method of Collection

For bridge projects with mapping requirements of over 15 acres, photogrammetry should be used. For those projects requiring mapping for under 15 acres photogrammetry and/or survey may be used depending upon the level of mapping detail required. Photogrammetric methods can also be used for bridge projects which have terrain characteristics that make field survey difficult. Field survey will be needed to obtain supplemental data for bridge projects, such as underwater and under-structure data which cannot be obtained from the aerial photography, or where vertical accuracy requirements are critical.

If DTMs are to be produced, they should be collected photogrammetrically for projects requiring data for over 15 acres. However, the DTM must be supplemented

by field surveyed data where vertical accuracy is critical. Photogrammetry or field survey may be used for those projects requiring data for under 15 acres depending upon the terrain, foliage conditions, and accuracy required.

For directly measured highway cross sections, field survey should be used due to the accuracy generally required for bridge projects and the foliage conditions usually present. For hydraulic sections, field survey should also be used due to foliage conditions and the need for underwater elevations. Photogrammetry can be used if the cross sections are extensive or in difficult terrain. In such cases photogrammetric cross sections should be compiled and supplemented by field surveyed cross sections where vertical accuracy requirements are critical.

B. Bridge Rehabilitation

These projects consist of work that is intended to return an existing bridge to a condition of adequate support or to a condition adequate for placement of an additional stage of construction (bridge protective systems or resurfacing). Work could include complete deck removal and replacement.

1. Terrain Data Required

Bridge rehabilitation projects will generally not require any terrain data unless necessary for major rehabilitation or hydraulic studies. When terrain data is necessary, the same terrain guidelines used for Bridge Replacement/New Bridge should be applied.

2. Method of Collection

When terrain data is necessary, refer to the Bridge Replacement/New Bridge guidelines.

II. HIGHWAY PROJECTS

A project whose primary objective is to construct a new highway, or to reconstruct, or restore and preserve, an existing highway. These projects could include bridge work of any type that is incidental to the primary objective.

A. Reconstruction/New Construction

These projects consist of work wherein an existing highway is replaced essentially on existing alignment including rebuilding of the highway to include geometric improvements. Bridge replacement/rehabilitation may be included as required to complete the project. Projects generally involve extensive earthwork, extensive

rebuilding of subgrade and drainage systems and relocation of utilities.

OR

Work wherein a new highway or interchange is constructed.

1. Terrain Data Required

Large scale mapping with vertical data portrayed by DTMs will generally be required for projects of this type. The mapping coverage requested for these projects should be for a band width that is sufficient to prepare the plan of the project in accordance with the approximate alignment and ROW requirements.

Map scale: 1"=40', 1"=50'
or
1"=20'(highly complex projects)

DTM: Digital terrain model data will be collected instead of direct contour and cross section compilation. Contours and cross sections can then be computer generated from the DTM.

2. Method of Collection

For these Reconstruction and New Construction projects, due to their size and the amount of data to be collected, photogrammetry should always be used for data collection. Field surveyed data must be used to supplement the photogrammetry data if high accuracy is needed in critical areas.

B. Major R & P Projects

These projects consist of work to reconstruct a highway, generally along existing alignment, including addition or widening of shoulders, geometric improvements by minor lane widening or minor adjustment of vertical/horizontal alignment, or provision of turning lanes at intersections. Projects may also include drainage improvements, slope work, and/or replacement of signs and signals, guiderails, and other roadside appurtenances. Bridge work would include deck repairs/replacement, joint repairs, minimal replacement of structural elements or repairs to abutments, piers, wingwalls, etc. as necessary. Roadway subgrades would not generally be reconstructed and earthwork would not be extensive.

1. Terrain Data Required

Large scale mapping with vertical data portrayed by DTMs or directly measured cross sections will generally be required for projects of this type.

The projects in this category will usually involve significant ROW acquisition. The typical mapping band for projects which involve ROW work is 300'-400'. For projects which do not involve ROW changes, a mapping band as narrow as 200' may be adequate. Additional coverage may also be provided along intersecting side roads and streams. DTMs or directly measured cross sections can be provided and combined with field survey data in critical areas.

Map Scale: 1"=40', 1"=50'
or
1"=20'(highly complex projects)

DTM: Digital terrain model data will be collected instead of direct contours and cross section compilation. Contours and cross sections can then be computer generated from the DTM. Either DTM or directly measured cross section data can be requested, but not both.

Cross Sections: Stationing at 50' intervals for urban and developed areas.

Stationing at 100' intervals for rural areas. If cross sections are to be used by Construction then 50' stationing should be used and the alignment centerline should be reviewed with Construction.

2. Method of Collection

For major R & P projects over 1/4 mile long photogrammetry should be used for mapping with or without DTMs, or directly measured cross sections. For those projects under 1/4 mile long photogrammetry or field survey may be used depending on how comprehensive the terrain data requirements are. Field surveyed data must be used to supplement the photogrammetry data if high accuracy is needed in critical areas.

C. Minor R & P Projects

These projects consist of work to resurface a highway including shoulder stabilization/widening, minor widening for turning movements, and spot subgrade replacement. Projects may also include minor amounts of drainage improvements, slope work and/or replacement of signs, signals, guiderails, and other roadside appurtenances. Bridge work could include deck repairs/replacement, joint repair, minimal replacement of structural elements or repairs to abutments, piers, wingwalls, etc., as necessary.

1. Terrain Data Required

Large scale planimetric mapping will generally be required for these minor R & P projects. DTMs will not be required. Full project cross sections will generally not be required. However, some cross sections for limited areas may be needed. For simple resurfacing projects mapping will not be required. Since projects in this category generally do not involve additional ROW acquisition, the mapping band requested should typically be quite narrow. The band should generally be less than 400' with 200' being adequate for most projects. Some features such as vegetation may be required in only selected areas. Another option is skeletal coverage consisting of very limited data such as pavement and shoulder edges.

Map Scale: 1"=40' or 1"=50'

DTM: Not required

Cross Sections: Generally not required

2. Method of Collection

For minor R & P projects over 1/2 mile long, if full band mapping is needed it should be acquired by photogrammetric methods. For those projects under 1/2 mile long photogrammetry or field survey may be used, depending upon the complexity of the mapping. If only skeletal coverage consisting of very limited data such as pavement and shoulder edges is needed then photogrammetric methods should be used only for projects over 2 miles. Field survey should be used for skeletal coverage of projects under 2 miles.

If cross sections are required for limited areas photogrammetry or field survey can be used. If only high accuracy pavement elevations are needed then field survey must be used. If more extensive cross section data is required photogrammetry should be used.

D. Resurfacing Projects

These projects consist of work to resurface a highway and may include replacement of signs, guiderails and other roadside appurtenances. Bridge resurfacing may also be included.

1. Terrain Data Required

Simple resurfacing projects will normally not require any projectwide mapping since plans will not generally be part of the contract. However, limited

data may be required such as pavement elevations where superelevation adjustments are anticipated.

2. Method of Collection

If very limited data is required for small areas, field survey should be used.

III. PLANNING STUDIES

These projects consist of major projects requiring highway corridor selection, and extensive planning studies involving areawide transportation study.

1. Terrain Data Required

Small scale mapping with or without a DTM will be provided for these projects only when existing mapping (1:24,000 topographic quad sheets, existing 1"=200' scale mapping, or 1:9600 planimetric mapping), or new photographic enlargements are not acceptable for the project. Because of the extremely high cost of 1"=200' mapping, special care should be taken to confine the requested mapping to as small an area as possible.

Map Scale: 1"=200'

DTM: Digital terrain model data will be collected instead of direct contours. Contours can then be computer generated from the DTM.

Cross Sections: Not required

2. Method of Collection

Due to the size and the amount of data to be collected, photogrammetric methods will be used to produce all mapping needed for planning.

FIGURE 1

PRIMARY METHOD OF TERRAIN DATA COLLECTION

This chart is a summary of Design Manual Section 5.04 Terrain Data Requirements for Design. The chart cannot be applied in proper context without reading Section 5.04.

PROJECT TYPE	PLAN MAPPING	DTM	CROSS SECTIONS
MAJOR PROJECTS (New Contruction)	P	P (1)	NA
BRIDGE SITE PROJECTS			
> 15 acres	P	P (1)	S
< 15 acres	P/S (2)	P/S (2)	S
MAJOR R&P PROJECTS			
> 1/4 mile	P	P (1)	P (1)
< 1/4 mile	P/S (2)	P/S (2)	P/S (2)
MINOR R&P PROJECTS			
Full Band Coverage (3)			
> 1/2 mile	P	NA	P (1)
< 1/2 mile	P/S (2)	NA	P/S (2)
Skeletal Coverage (3)			
> 2 miles	P	NA	P
< 2 miles	S	NA	S
Resurfacing Only	NA	NA	S (4)
PLANNING STUDIES	P	P	NA

P = Photogrammetry
S = Field Survey

(1) Survey elevations must be used to supplement photogrammetry elevations is high vertical accuracy is needed in critical areas.

(2) Photogrammetry, survey or a combination of both can be selected depending upon the level of mapping detail or amount of cross section or DTM data required.

(3) For Minor R&P Projects, full coverage consists of collecting data for up to a 400' wide band; skeletal coverage consists of very limited data, such as pavement and shoulder edges.

(4) Surveyed cross sections will be collected only where superelevation adjustments are anticipated.