# DESIGN ELEMENTS

# SECTION 400

## 401 GEOMETRY

### 401.01 BASIC STANDARDS

Basic geometric design standards are contained in the Department's "Highway Design Manual" (HDM) and AASHTO'S "A Policy on Geometric Design of Highways and Streets." A copy of the HDM will be given to the Consulting Engineer at the Assignment Meeting. The Department will specify the applicable design document and the classification to be used for each highway section. If non-classified state roads or local roads are included in the design, the Department will advise the Consulting Engineer of the standards to be applied.

The design criteria outlined in the HDM should be considered minimum desirable values. Design conditions should be as high as are commensurate with field conditions. Should condition warrant the application of a sub-standard design feature, a description of the proposed design feature, a description of the proposed design, the standard design and the reasons for recommending the proposed design should be included in the Preliminary Design Report.

### 401.02 HORIZONTAL GEOMETRY

Maximum curvature should be commensurate with design speed. Continuous use of maximum curvatures should be avoided. Curvature less than 0° - 30' should be avoided. Broken back curves and compound curves should be avoided. If compound curves are necessary, the ratio of the curves should not exceed the allowable minimum. The tangent distance between reversals of curvature should be long enough to allow for proper super-elevation transition. Lengths of climbing lanes and tapers should be clearly indicated on the plans.

### 401.03 VERTICAL GEOMERTY

Maximum grades should be commensurate with design speed. In order to obtain satisfactory drainage, the minimum gradient recommended is 0.5%. Proposed grades flatter than 0.5% should be discussed with the Project Engineer. Angle points in the profile grade line should be avoided. Available sight distance and corresponding safe speed should be indicated for vertical curves. Climbing lane warrants should be derived from the

applicable design standards. Sag vertical curves in cut sections should be avoided. Flat grades and sag vertical curves should be avoided on bridge decks because water pockets may result, causing sand accumulation, deterioration and scaling of the bridge deck.

### 401.04 COMBINATION OF HORIZONTAL AND VERTICAL GEOMETRY

The horizontal and vertical geometry should be balanced and blend into the existing terrain. A change in horizontal geometry should not be hidden by a crest vertical curve. Adequate passing distance should be included in the design, where applicable. The geometry should consider earthwork quantities and earthwork balance. Headlight glare from opposing roadways should be considered. When determining minimum vertical clearances, the ultimate condition should be considered on an expandable roadway.

When lane drops are necessary, adequate continuous sight distance throughout the lane drop should be provided. The vicinity of the lane drop should be free of horizontal and crest vertical curves. It is preferable to drop the right lane. Dropping a lane in an interchange area should be avoided. Adequate distance for advance signing should be available. The full shoulder width should be provided throughout the transition.

### 401.05 INTERCHANGES

Configurations which would result in unfamiliar traffic operations should be avoided, such as left-hand exits and entrances, lane drops in the interchange area, partial interchanges and split interchanges. The distance between interchanges should consider signing and weaving. Interchange configurations should be compatible with the design traffic volumes and favor the heavier movements. Lane continuity should be provided through interchanges, and weaving sections and operational lanes should be avoided.

The gore area should be designed with a flat cross slope to allow for recovery of errant vehicles, designed for impact attenuators where necessary and graded to reduce runoff of water through the gore area. Infield areas should be clear of fixed objects, graded to allow errant vehicles adequate distance to stop or recover and graded to minimize guide railing requirements on both diverging roadways. Exits from mainline curves to the left should be avoided because the ramp could be misconstrued to be the mainline. Storage length of acceleration and deceleration lanes should be in accordance with the appropriate standards. The angle of intersection between a ramp and local road should not be less

than 60°. "Second" curves to provide a 90° angle of intersection on diamond ramps should be avoided.

### 401.06 AT-GRADE INTERSECTIONS

Turning movement volumes at intersecting roads should be evaluated to determine requirements for signalization, turning lanes, approach width and lane arrangement. Turning radii should accommodate the design vehicle. Intersection sight distance should be commensurate with design speed. Profiles should be designed to give preference to the through street. Right angle intersections are desirable. Steep grades at intersections, angle points at the curbline, angles of intersection less than 60° and tapering roadway widths through intersections should be avoided whenever possible.

### 401.07 MEDIAN

In keeping with the concept that each roadway of an expressway is to be designed independently, thus achieving a separated roadway design, the typical sections for expressways will usually not indicate a median width. In instances where an expressway design is of the "Divided Highway" type, the median width and treatment shall be indicated. Where a change in width of median is required, the transitions shall be made smoothly. The change shall generally be made on a horizontal curve and without the use of reversed curvature in alignment of pavement or curbs. Where the transition must be made on a tangent, it is preferable to have it occur on the crest of grade to make the change in alignment less conspicuous.

### 401.08 CUT AND FILL SLOPES

The height of fill is the vertical distance measured from the toe of slope to the junction of the line of the slope and the grade of the edge of the shoulder. Fill slopes shall be as flat as feasible to reduce the need for guide rail. Excess earth material should be used for this purpose.

When it becomes apparent that the proposed improvement will require the use of borrow material, the Designer will review the topography of the project and determine if widening of the earth cut sections or decreasing the angle of slopes or a combination of both can be accomplished economically to produce the additional fill material.

If this can be accomplished without detriment to proposed or future planning, roadside development, or adversely affect wetlands, the original template for cross sections shall be revised where advisable to make available additional excavation to decrease the borrow item. In instances where flattening the slopes would project the slope limits beyond the standard or available right-of-way width, the Department will determine if the additional impact is warranted.

### 401.09 SIDE SLOPE TRANSITIONS

For safety and aesthetic reasons, it shall be the practice to provide adequate lengths for transitioning from one rate of slope to another in fills and also at the approaches to earth cuts. The actual rate of transition will vary according to the site conditions controlling at each individual location, i.e., the contour of the natural ground, drainage, appearance, ease of maintenance, right-of-way and other considerations. As a basic guideline, it is recommended that the rate of one point of slope be used every 20 m. For example, in transitioning from 1:2 to 1:6 in fill, successive 20 m sections shall have side slopes as follows: 1:2, 1:3, 1:4, 1:5 and 1:6. These rates of slope must be clearly indicated on the cross sections throughout the length of the transition.

### 401.10 SUPERELEVATION

The superelevation rates contained in the HDM are based on design speed and degree of curvature. Engineering judgment shall be used in determining the speed from which to calculate superelevation rates for ramps, turning roadways, climbing lanes, frontage roads, local roads and any other road sections which are not part of the main line. On climbing lanes, the rate of superelevation should be that required for the vehicle speed, decreasing in rate as the higher part of the grade is approached. Superelevation of local roads will be determined at the Town Roads Meeting.

## 401.11 DRIVER EXPECTANCY

The most fundamental elements of the driver communications system begin with, and to a large extent are determined by, the natural features which exist around the roadway. Variations in weather conditions, the existence of construction and maintenance operations, and a lack of continuity or consistency in basic design alter the environmental situation. The information reaching the driver from these many varied sources must blend into a comprehensive picture of the conditions which exist ahead; otherwise, the possibility for driver confusion and indecision exists.

The driver assimilates the many cues necessary for driving and establishes a course of action which must be taken in the near future. This decision-making process is repeated on a continuous basis as the driver is provided new information. The following items should be reviewed by the designer as they relate to establishing driver behavior patterns:

1. The aesthetic treatment of the median and roadside has been designed to be harmonious with general topography and vegetation in the area consistent with current safety and operating policies.
2. When the driver's view ahead is limited, the upcoming roadway alignment does not conflict with the alignment suggested by natural terrain features.
3. Has consideration been given animal movements, falling rocks, unusual drainage patterns, and other natural environmental elements which could constitute a hazard to the driver.
4. Signing delineation, vegetation and other means have been used to clarify design inconsistencies.
5. Pavement striping and reflectors in combination with either fixed illumination or post-mounted delineators have been included to provide reasonably adequate delineation of major roadways under a variety of adverse weather conditions.
6. Pavement surface contours have been prepared and appropriate consideration has been given to vertical alignment, cross slope and pavement surface to provide proper drainage. Special attention has been given to especially flat grades, curve transitions, and similar situations where drainage of the standard pavement cross section may be inadequate under heavy rainfall conditions.
7. The alignment on bridges and roadways approaching bridges does not increase the hazard of ice on the structure.

8. All intersections have been located to provide greater than the minimum sight distance for approaching traffic.

9. Consideration has been given to adding lanes for turning traffic at intersections to reduce delay and accident potential.

10. Intersection channelization has been designed to ensure a high degree of operational safety.

11. Design standards greater than minimum, particularly with regard to sight distance to the roadway features, have been utilized to improve the communication of the roadway with the driver.

12. Interchange design has been simplified to provide better driver understanding and to permit effective directional signing.

13. The relatively high potential for wrong-way movements at interchanges has been recognized and considered in the design process.

14. Access and egress have been designed to afford the driver maximum visibility at merging and diverging areas.

15. A variable median width has been designed to afford the driver maximum visibility at merging and diverging areas.

16. Adequate transition and clarifying information has been provided the driver well in advance of the point where a new and different roadway design is encountered.

17. Additional sight distance is provided at points where adequate transitions cannot be provided between two sections of different cross section design. (Warning signs are not always effective in alerting the driver to this situation.)

## 402 ROADWAY

### 402.01 GRADE LISTS

After the final grade has been established, it shall be accurately depicted on the profile sheets. The rate of tangent grades shall be shown to the nearest 0.001%. The station and elevation, to the nearest 0.001 m, shall be shown for each P.V.C. and P.V.T. The length of each vertical curve shall be shown. From the grades shown on the profile sheets, grade lists shall be prepared. These lists shall show the finished roadway grade at the point of grade application at each 20 m station, the elevations and stations of all P.V.C.s and P.V.T.s, grade controls, rates of grade, etc. Where superelevation is required, the elevation differential from the control grade shall be shown for each edge of a travel lane. The grade list shall include the superelevation to the nearest 0.005 m where

applicable.

### 402.02 PLOTTING TEMPLATES ON CROSS SECTIONS

The cross section of the proposed highway shall be drawn on the applicable section of the original ground line, showing clearly the upper limit of fill material and lower limit of excavation and related side slopes. The proposed grade elevation to the nearest 0.001 m at each 20 m station shall be shown above the point of application, together with the superelevation, in meters, where applicable. Proposed drainage design shall be shown. Limits of unsuitable material should be defined on the cross sections.

### 402.03 PLOTTING SLOPE LINES

Limits of earth excavation or fill activity shall be determined from the cross section sheets and plotted accurately on the plan sheets. These lines shall indicate either the top of the slopes in cut or the toe of the slopes in fill and shall be labeled “Approximate Slope Limits.”

The limits of toe of slope (Fill) shall be indicated by the symbol (F) and the limits of top of slope (Cut) shall be indicated by the symbol (C) at the extremities of the slope limits on each sheet. Both letters shall be noted where there is a change from cut to fill or vice versa.

Example:

(F)_____ (F)

(C)_____ (C)

(F)_____(F) (C) _____ (C)

In cases where the toe of slope (Fill) is contiguous with the top of slope of a side ditch, the symbol (F) shall be used because it is the intent to show the relationship of the slope line to the roadway.

## 402.04 PAVEMENTS AND SUBBASE

The subbase design depth at any location will be determined in the Roadway Soils and Foundations Report and approved by the Department. The limits and depths of subbase shall be shown on the bottom of the profile sheets in straight line diagram format. Care shall be exercised that no ground water be trapped where transitioning from one subbase depth to another. Abrupt changes in subbase depth shall be avoided by using transitions. Foundation under-drains or other means should be provided for draining the subbase in cut sections.

## 402.05 SIDEWALKS

Sidewalks disturbed by construction shall be replaced in-kind unless otherwise directed by the Department. Existing curbing disturbed by construction shall also be replaced in-kind. New sidewalks and curbing and/or an upgrade of existing facilities shall be included only where called for by agreement between the Department and the Municipality concerned.

## 402.06 MEDIAN OPENINGS

Median openings shall not be provided unless specifically directed by the Department.

## 402.07 DRIVEWAYS

Whenever possible, driveway grades shall be no greater than the grade of the existing driveway that is being replaced. If the grade must be increased, the maximum desirable grade shall be 12% for residential properties and 8% for commercial and industrial properties. Grades in excess of the above must be brought to the attention of the Project Engineer.

In order to assure a clear understanding of the intended driveway construction, the plans and profiles shall be supplemented by a standard sheet, a typical section or a special detail. The typical section or detail shall be of a scale and sufficiently detailed so that there will be no misunderstanding by construction personnel or claim of misrepresentation by the Contractor.

## 402.08 SIDEWALK RAMPS

Sidewalk ramps shall be designed in accordance with the HDM and current Americans with Disabilities Act (ADA) guidelines.

Sidewalk ramps shall be constructed at all pedestrian crosswalks in all new designs and at pedestrian crosswalk locations where an existing curb or walk is to be disturbed by construction. Pedestrian crosswalks shall be defined as that portion of a highway (includes streets and roads) ordinarily included within the prolongation or connections of lateral lines of sidewalks at intersections, or any portion of a highway distinctly indicated as a crossing for pedestrians by lines or other markings on the surface, except such prolonged or connecting lines from an alley across a street.

Drainage design in the vicinity of sidewalk ramps shall be considered an integral part of the design of these ramps. No drainage structures shall be placed within the limits of a sidewalk ramp.

Regardless of the type of pavement of adjacent sidewalk, all sidewalk ramps shall be constructed of Portland cement concrete.

## 402.09 FENCING

Fencing along a controlled access highway is a means of preventing unwanted and hazardous intrusion from outside of the right-of-way line into the vicinity of moving traffic. Where drivers move at high speeds with expectation of complete protection from all forms of roadside interference, fencing should be installed to ensure safety of traffic movement for one or more of the following:

1. To keep animals off the highway
2. To keep children or pedestrians off the highway
3. To prevent vehicles and people from entering or leaving the highway at unauthorized places
4. To prevent stones or other objects from being dropped or thrown from highway overpasses onto vehicles passing underneath

To accomplish the above, continuous chain link fencing shall generally be provided on either the right-of-way or access-control lines. Engineering judgment should dictate exceptions in areas of precipitous slopes or natural barriers where fencing may not be required to effectively preserve access control, or others such as noise barriers where the

noise barrier itself provides a physical barrier. The fence shall be 1.8 m high in areas having a high concentration of children such as schools, churches and playgrounds. A 1.5 m fence shall be used in areas adjacent to housing developments, single family homes, parks, reservoirs, commercial and industrial properties, etc. During design, consideration shall be given to impending development to preclude replacement a short time later. Additionally, protective fencing shall be provided on all pedestrian bridges and should be in compliance with the "Bridge Design Manual" for all other structures.

### 402.10 CONCRETE STEPS

Concrete steps shall be designed in accordance with the HDM and ADA guidelines.

### 402.11 OBJECT MARKERS

Object Markers shall be installed near off-the-road drainage structures, at Type II guide rail end anchors and to otherwise identify minor roadside objects. Two object markers shall be required at all culvert endwalls where such endwalls are not covered by any type of guide railing.

### 402.12 NOISE BARRIER WALLS

The type of Noise Barrier Walls used on a project shall be at the Contractor's option, providing the weight of a masonry wall on a bridge does not preclude its use.

Currently, the Department has standard drawings for wood, metal, and masonry Noise Barrier Walls. All are considered applicable where structures are not involved.

The Consulting Engineer is responsible for all modifications to the design of the applicable standard walls as may be required to ensure their suitability for use as a structure mounted Noise Barrier Wall and for the design of the connection of the wall to the structure. All of the approved types of Noise Barrier Walls, except masonry, are to be included as alternatives when a structure mounted Noise Barrier Wall is required.

## 403 STRUCTURES

The design of structures should be accomplished in a professional manner with due consideration for the aesthetics of the structure, the economy of design relative to the initial construction and long-term maintenance cost, but mostly with consideration for the safety of

the public using the structure and those in the vicinity of the structure. It is the Department's opinion that good design produces good looking structures and that gingerbread and other non-natural aesthetic treatment is expensive, and at best only produces short-term aesthetics.

The design of all bridges, box culverts, and retaining walls shall be in accordance with the latest edition of the Connecticut Department of Transportation's "Bridge Design Manual" and in accordance with the criteria noted in the report of the Assignment Meeting. The design and details of all structures and structure components, for projects negotiated after July 1, 1998, shall conform to the requirements set forth in the latest edition of the AASHTO LRFD Bridge Design Specification. In addition to the requirements of the AASHTO LRFD Design Code, all bridges shall also be analyzed for two Department operating vehicles. Approval for any deviation from these policies must be requested and obtained from the Department before proceeding with the design.

The Consultant shall perform an independent design check of all critical structure components. This should include but not be limited to all abutments, piers, walls, girders, splices, cross frames, connections, bearings, etc. This shall consist of a totally independent design, complete with a stand alone set of computations. The result of the independent design shall be compared against the original design and modifications made to the final design as deemed appropriate. The final design computations submitted to the Department must include a statement that they reflect the required independent design check.

The following list outlines the design process and describes the various submissions that may be required. These submissions are presented in more detail in the "Bridge Design Manual" and in Chapter 300 of this manual. The list should not be considered all inclusive.

- Environmental Review of the site
- Hydrology Study*
- Preliminary Hydraulic Study (including any temporary facility as required)*
- Structure Type Study

- Rehabilitation Study Report
- Scour Analysis (draft/final) Report*
- Railroad Clearance Diagram **
- Structure Layout for Design (SL/D) plans and Soils and Foundation Report
- Final Hydraulic Study *
- Final Plans for Review
- Incorporation of Review Comments
- Final Submission

* For structures crossing a waterway
** For structures over a railroad

## 403.01 LIGHTING ON STRUCTURES

On State highways, the Department will designate those structures that are to be lighted during the review of SL/D plans, and will determine the basic lighting requirements, specifically the light intensities, and types and location of luminaires. The location and details of light standard anchorages and conduits will be provided to the Consulting Engineer for insertion into the structure plans. Special Provisions for the pertinent items will be furnished by the Department. The Consulting Engineer shall maintain close liaison with the Department concerning details of the required lighting.

On local streets, the Consulting Engineer is responsible for contacting the City or the Utility Company representing the City to determine lighting needs and incorporating these requirements into the contract documents.

## 403.02 SIGNING ON STRUCTURES

The Department will designate those structures on which signing will be required during the review of the SL/D plans. The Department will determine the type and location of the sign structures. This data will be submitted to the Consulting Engineer to be used in the design of the anchorages. Details of the anchorages are to be shown on the structure plans.

Sign supports located on parapets and wingwalls are subject to large loads being developed by the signs and appurtenances. It is, therefore, required that the designer investigate these loads and design the superstructure slab, parapet and/or wingwall accordingly.

If the design agreement requires the Consulting Engineer to design the lighting or signing, then the Consulting Engineer should include the required structure appurtenances in his SL/D plans.

## 403.03 PEDESTRIAN STRUCTURES

Pedestrian structures shall be designed in accordance with current AASHTO guidelines for such structures and the “Bridge Design Manual.” This material will be made available to the Consulting Engineer upon request.

Specific attention will be given to ensure accessibility to the structure.

## 403.04 HIGHWAY GRADE SEPARATIONS

The minimum vertical and horizontal clearance shall be in conformance with the "Bridge Design Manual," the "Highway Design Manual," and/or AASHTO's "A Policy on Geometric Design of Highways and Streets" whichever governs, as determined by the Department for individual structures.

## 403.05 SCOUR ANALYSIS

A preliminary screening for scour classification shall be performed on all structures over waterways or in the floodplain, which are being totally replaced, are undergoing major bridge work or whose decks are being repaired. Major bridge work includes substructure widening, deck replacement and superstructure replacement. A preliminary screening classification is already on record in the Department's bridge inspection files for some bridges.

The screening shall be performed in accordance with Hydraulic Engineering Circular No. 18 (HEC-18) or a successor document.

## 403.06 NAVIGABLE WATERS

If requested by the Department, the Consulting Engineer shall determine the navigability of the stream being crossed. This will be accomplished by first contacting the Department to see if a previous determination of the stream has been made. If no such determination has been made, the Consulting Engineer, in writing, shall request the navigable determination.

If requested by the Department, the Consulting Engineer shall prepare hydraulic data as described in Section 404 (Hydraulics & Drainage) and shall also prepare plans in accordance with the requirements of Chapter 800 (Permits).

Warning lights required for navigation shall be designed in accordance with the requirements of the U.S. Coast Guard.

## 403.07 RAILROAD STRUCTURES

The minimum vertical clearance for a structure over a railroad track is limited by Section 13b-251 of the Connecticut General Statutes. See the "Bridge Design Manual" for detailed information.

The Consulting Engineer shall arrange a field meeting with representatives of the railroad involved, and Department of Transportation personnel to investigate the site, determine controls, and establish clearances. This meeting should be held early in the Preliminary Design phase.

Following the initial meeting with the railroad, the Consulting Engineer shall develop railroad clearance diagrams and an "Approval of Railroad Clearance" form for the railroad's approval.

To minimize any possible problems before the construction contract is awarded, the Consulting Engineer shall arrange a railroad field review meeting at the Final Design for Review Submission. At this time, plans and specifications including limitation of the Contractor's operations must be available. The meeting shall be attended by the Department's Design and Railroad Liaison Engineers, and representatives of the Railroad including engineering operations and electrical section.

The Consulting Engineer is to inform the Bridge Liaison Engineer prior to the scheduling of such a meeting.

### 403.08 SOILS

The subsurface exploration program for structures must essentially be completed prior to the SL/D submission so that the boring logs can be included. Reference is made to Section 405 (Soils and Foundations) for more detailed instructions.

### 403.09 UTILITIES

During the SL/D review, a structural utility meeting will be held to determine what utilities will be incorporated into the structure design. The Consulting Engineer shall be responsible for coordinating and incorporating such utilities into the structure.

### 403.10 POST DESIGN RESPONSIBILITIES

The Consulting Engineer is responsible for various post design activities as detailed in the “Bridge Design Manual.”

These include the following:

- Contractor inquiries both during the bidding process and during construction
- Changes to the contract documents both by Addendum and by Construction Order
- Review of Shop Plans
- Review of Working Drawings

## 404 HYDRAULICS AND DRAINAGE

The requirements for hydraulics and drainage facilities are specified in the Department's “Drainage Manual” (DM). In addition, guidelines and procedures outlined in current FHWA hydraulic circulars shall be followed. The section in the DM entitled “Checklist for the Review of Drainage Design” should be referred to in developing the hydraulic/drainage design. The checklist should be included in the drainage report and annotated by the Consulting Engineer indicating issues that are applicable and incorporated into the design. This will expedite the review process.

If a project involves crossing a watercourse, then the Department will coordinate with the DEP Fisheries Division to determine if fish passage is a concern. If a project involves fish passage, then coordination with the Fish Biologist should be maintained as the project develops to ensure Fisheries requirements/concerns are addressed.

All hydraulics and/or drainage computer programs which are to be used shall be submitted to the Department for approval. Documentation should be provided to verify that the computer program proposed by the Consulting Engineer will generate the same data requested in the DM. It is essential that an early approval be obtained, prior to their use, in order to preclude delays in the design of projects.

## 404.01 HYDRAULICS

A hydraulic analysis is involved when the waterway opening conveys a watershed area greater than ***1.0 square mile***. If the Consulting Engineer's assignment includes hydraulic engineering services, the Consulting Engineer shall retain the services of a professional engineer whose qualifications to perform hydraulic analyses have been approved by the Department. A resume should be submitted for review and an interview may be requested of the candidate by the Department.

In order to expedite reviews of hydraulic computations, the output data disks of the computer model are to be submitted with the Hydraulic Report. These disks are to be the 3-1/2" size.

### HYDROLOGIC STUDY

The design discharge shall be calculated and submitted for approval prior to the start of the hydraulic study for determining the waterway opening. All pertinent backup data shall be submitted to facilitate the review process. This work shall conform to the latest edition of the Department's "Drainage Manual."

### PRELIMINARY HYDRAULIC STUDY

A Hydraulic Study is required if the structure requires work within the floodplain of a watercourse or stream with a watershed area exceeding ***1.0 square mile.*** All work within the floodplain must meet the requirements noted later in this Section under Environmental Permits, along with the criteria outlined in the DM. If a floodway is established, every effort should be made to avoid encroachment into it. Certain activities, such as the construction of bridge piers within the floodway, may be acceptable provided there is no increase in the "with floodway" water surface profile for the base flood or the ten year flood.

Prior to the preparation of a Structure Type Study, a Preliminary Hydraulic Study must be prepared and submitted for review and approval. If Stream Channel Encroachment Lines are established, they should be shown on the plans.

### SCOUR ANALYSIS

The potential for scour at bridges over waterways must be evaluated and submitted to the Department for review and approval. For this purpose, the FHWA document entitled

"Evaluating Scour at Bridges" (HEC-18) or successor documents shall be used. Substructures which may be for bridges over waterways shall be designed to safely support the structure subjected to the design scour. Substructures subjected to scour shall be designed with pile foundations, foundations on rock, foundations located below the maximum estimated scour depth, or any other means approved by the Department, provided adequate scour protection is maintained. The preferred foundation types are pile foundations and foundations on rock.

## SUBMISSIONS FOR DESIGN OF BRIDGES AND BOX CULVERTS

The following list outlines the hydraulic design process and describes the submissions required for the design of bridges and box culverts. It should not be regarded as complete. The following items, where applicable, should be submitted to the Department in the order listed:

1. Environmental review of the site
2. Hydrologic study
3. Preliminary Hydraulic Study (including any temporary facility as required)
4. Scour analysis (draft/final)
5. Structure Type Studies or Rehabilitation Study Report
6. Structure Layout for Design (SL/D) plans and Soils and Foundation Report
7. Final Hydraulic Study
8. Final Plans For Review

## ENVIRONMENTAL PERMITS

All work within the floodplain of a watercourse or stream with a watershed exceeding one square mile must meet the requirements of Sections 13a-94, 22a-344 and 25-68b through 25-68h of the General Statutes of Connecticut, and be approved by the Department of Environmental Protection. If Stream Channel Encroachment Lines exist within the project limits, any encroachment or obstruction riverward of these lines established by DEP under Section 22a-344 of the General Statutes requires a permit.

The permit process, for certification and approval, may involve a significant time frame, depending on the nature of the project and the impact to the regulatory areas. Therefore, early coordination with DEP, Natural Resources Division, is recommended to ensure that the development of the project is consistent with the requirements of these permits and that certification from DEP can be acquired within the project schedule.

An activity within a regulated area, as described in the General Statutes, may not require a full hydraulic analysis (i.e. discharging into a regulated area) but may require Floodplain Management Certification. The application entitled "Guidelines and Procedures in the Environmental Permit Application Package," as prepared by the Department of Environmental Protection, should be followed. Chapter 800, (Environmental Permits) outlines the various permitting processes in greater detail.

**404.02 DRAINAGE**

All roadway reconstruction projects require drainage computations. Computations should include: gutter flow analysis, storm sewer design and hydraulic gradeline. Topographic mapping should be included with the drainage computations with the watershed delineation clearly defined to each inlet. The hydraulic gradeline analysis should consider all friction, entrance, junction, exit and bend losses and follow the procedure outlined in Hydraulic Engineering Circular No. 22 (HEC-22) entitled "Urban Drainage Design Manual." Cross culverts conveying a drainage area less than ***1 square mile*** shall be designed using an abbreviated method, as outlined in the DM.

All roadway drainage should be brought to a suitable outlet. The storm system should be shown to its outlet or to its hydraulic control. Computations should be provided to verify that the proposed drainage will not adversely impact the existing downstream storm system or property owner. Existing drainage rights should be shown on the plan. If upgrading of pipe downstream of the project is necessary, then additional rights may need to be acquired.

**DRAINAGE PATTERNS/DIVERSIONS**

Existing and proposed drainage patterns of pipes, ditches and swales should be shown on the plans. In cases where drainage is diverted from one watershed area to another, guidelines in the DM should be followed.

## WATERCOURSES AND CULVERTS CONVEYING WATERCOURSES

Watercourses, perennial or intermittent, should be shown and labeled on the plans. This will define appropriate drainage rights that may be required as well as define the design discharge outlined in the DM. If it is uncertain whether a culvert crossing conveys a watercourse, then a site visit can be conducted by the Consulting Engineer to establish the appropriate design parameters.

## CONDITION SURVEY

Existing drainage systems that are scheduled to remain in use should be investigated for general condition and hydraulic adequacy. A visual inspection should be performed for all pipes and drainage structures within the project limits that are to remain in use. This information should be documented and included as part of the drainage and/or hydraulic computations.

The condition survey should be performed early in the design process to determine whether the existing pipes/culverts warrant replacement. The condition of existing ditches that are to remain in use should be field inspected and analyzed to verify their stability.

The condition of the outlet at the discharge points should be investigated to ensure no erosion or sediment problems exist. If outlet protection is required, it should be incorporated into the project.

## TEMPORARY DRAINAGE

The need for temporary drainage should be addressed as part of the Maintenance and Protection of Traffic. Temporary drainage calculations should be prepared in accordance with the current criteria outlined in the DM.

## ENVIRONMENTAL PERMITS

(See Hydraulics Section 404.01)

## 404.03 DRAINAGE DESIGN SUBMISSIONS

The following list summarizes typical drainage design elements that should be included in the design reports and/or on the plans as the design develops. This summary is not necessarily complete; depending on the nature and complexity of a project, additional information may be required. It does, however, establish the fundamental

drainage/hydraulic elements required to complete a drainage review.

## PRELIMINARY DESIGN

The following issues should be presented in the Preliminary Design Report:

1. An overview contour map for the project showing watershed areas for cross culverts
2. Major culvert crossings
3. Fish passage
4. Diversions
5. Drainage design criteria to be used
6. Permit requirements
7. Detention designs
8. Any unusual designs such as pumping stations

## FINAL DESIGN

The Consulting Engineer is encouraged to provide the Preliminary Drainage Design as a separate submission. It may, however, be included in the Semi-Final Submission depending on the complexity of the project. The Consulting engineer should obtain concurrence from the Project Engineer on the intended action early in final design. The Preliminary or Draft Drainage **report** should include the following elements:

1. Disposition of Preliminary Design comments
2. Topographic mapping
3. Drainage computations
4. Culvert computations
5. Condition Survey plans
6. Drainage checklist

The drainage (or semi-final) **plans** should show the following information:

1. Storm system shown and analyzed to its outlet
2. Disposition of pipe
3. Diversions
4. Drainage rights
5. Outlet protection

The Final Plans for Review Submission should include the following documents and/or incorporate the following issues:

1. Final Drainage report and design computations
2. Disposition of previous comments
3. Intersection grading plans
4. All drainage facilities shown on cross sections with its baseline station identified
5. In areas where cross culverts are being extended, a profile of the natural ground to show how the inverts will tie into the existing topography
6. Temporary drainage

## 405 SOILS AND FOUNDATIONS

### 405.01 GENERAL

The Consulting Engineer shall prepare soils and foundations engineering studies and analyses as may be required for the proper design of the project including pavement and structures. The Consulting Engineer shall be responsible for the procurement of the necessary data and information to aid in accomplishing such studies and analyses.

The Consulting Engineer shall have an engineer who will supervise the soils and foundations engineering work, said person may already be on the Consulting Engineer's staff in such a capacity, or in their employ, or be a consultant specifically retained to do this work. As stipulated in the Agreement, this person shall be qualified in soils and foundations engineering and must be acceptable to the Department.

Depending upon the nature and scope of the project, it may be necessary to prosecute the soils and foundations engineering work in two separate phases; a Pilot Program in the preliminary design and a more in-depth investigation in the final design. The complexity of the project will generally determine the degree of soils and foundations engineering work to be accomplished in a particular design phase. The degree, type and necessity of such work, and the manner in which it is to be performed, shall be subject to the prior approval of the Department.

Detailed information relative to procedures for accomplishing the various phases or

aspects of soils and foundations engineering work is contained in “Soils and Foundations Guide for Design by Consulting Engineers.”

The Consulting Engineer is reminded that field activities associated with obtaining soils data are subject to environmental regulations administered by federal and state agencies. Permits may be required if exploratory work is to be performed in regulated areas. The Consulting Engineer should coordinate permitting requirements with the Project Engineer.

### 405.02 SOILS AND FOUNDATIONS ENGINEERING LIAISON

The Consulting Engineer’s personnel or consultant, approved by the Department to be responsible for the soils and foundations work, shall maintain adequate liaison with the Department. Such liaison activities will involve matters relating to procedure, special design considerations and any other technical aspects which may require mutual resolution for the successful and scheduled completion of various phases of design.

Communication with the Department through normal channels, or other means, such as office and field conferences, will be necessary. The frequency and depth of these liaison contacts will be governed by the complexity of the project relative to soils and foundations features.

### 405.03 DATA FOR SOILS AND FOUNDATIONS ENGINEERING STUDIES AND DESIGN

The Department will make available to the Consulting Engineer any subsurface information, soil testing results, engineering studies and evaluations, etc., which are in its possession, and which may be applicable to the project.

In the absence of such data, or in the event the available data is insufficient to generate proper studies for completion of project designs, the Consulting Engineer will be required to procure the necessary data and/or augment available data.

Subject to the approval of the Department, the Consulting Engineer shall plan, arrange for and inspect whatever field, laboratory and office work of a soils and foundations nature is necessary to complete the required roadway and structure designs appropriate to the particular phase of the project design. The Department may limit, reduce, or expand any field or laboratory programs proposed by the Consulting Engineer

for procurement of the necessary data for soils and foundations engineering studies and analyses. All data and information shall be procured by currently accepted methods and practices in the field of soils and foundations engineering, unless otherwise indicated or stipulated by the Department.

### 405.04 ENGINEERING STUDIES AND DESIGN

The Consulting Engineer shall submit to the Department copies of all types of field subsurface information procured, laboratory test results, computations, etc., made in formulating and achieving specific soils and foundations recommendations for the design of the roadways and structures. Such supportive material or documents shall be submitted, prior to, or concurrently with, the various project design submissions, unless otherwise indicated by the Department.

### 405.05 SOILS AND FOUNDATIONS ENGINEERING REPORTS

The Consulting Engineer shall prepare and submit to the Department, engineering reports covering the soils and foundations features of the work necessary to support the presented designs for the various submissions required for the roadways and structures on the project.

Such reports shall be prepared by or supervised by the Consulting Engineer's approved designated soils engineer. In any case, these reports shall be signed by the approved individual.

These reports will be reviewed by the Department in arriving at its acceptance, modification or rejection of various soils and foundations aspects of the project designs as submitted.

## 406 TRAFFIC

### 406.01 SIGNALS

Signals should be designed in accordance with all current Federal and State Standards and/or guidelines including but not limited to the MUTCD, the Department's "Manual of Traffic Control Signal Design," "Standard Specifications for Roads, Bridges

and Incidental Construction," "Guidelines for Highway Design," State Traffic Commission Regulations, the requirements of the Americans with Disabilities Act, and the requirements of the Department of Transportation's Office of Rights of Way.

## PRELIMINARY DESIGN PHASE

The **preliminary design** plans for traffic signals should reflect the drafting guidelines contained in the Department's "Manual of Traffic Control Signal Design." Accompanying the PD design submission should be the following:

1. Peak-hour turning traffic volumes for each intersection in a flow diagram format
2. Intersection capacity analysis results using the methodology described in the Transportation Research Board's Special Report 209 entitled "Highway Capacity Manual" (HCM) for each intersection and peak-hour analyzed
3. For each peak hour analyzed, queue analysis for each lane group approaching the signalized intersections in the project
4. Design statement addressing all pedestrian crossings and indicating the consultant's intended signal design for each location. Statement as a minimum, should address design considerations which will be affected by capacity, accident history, and field conditions. Statement shall also address the type of signal system planned and why, if applicable, as well as the duration and number of timing plans needed.

## FINAL DESIGN PHASE

The **semi-final design** plans should reflect the comments of the PD phase and continue to follow the Department's "Manual of Traffic Control Signal Design" and include a complete electrical design. Accompanying the semi-final design submission should be the following:

1. Traffic Control Signal Plans
2. Project specifications and special provisions needed to construct the traffic signal work
3. Span pole calculations
4. Intersectional signing and pavement marking plans if applicable
5. Time space diagrams and complete coordination and programming information for each proposed timing plan for each signal to be interconnected
6. Appropriate standard detail sheets and special details necessary to construct project

7. Completed unmetered service request forms for each location
8. Traffic signal item detailed estimate sheet
9. Communications/interconnect plan for those signals to be interconnected

The **Final Plans for Review** Submission should reflect the comments of the semi-final design phase and incorporate ongoing coordination with utility companies and town entities when appropriate. Those items originally accompanying the semi-final submission which require revision as a result of the semi-final review should be resubmitted at this time.

The **Final Design Plans** submission should reflect the comments of the Final Plans for Review phase and include the following:

1. All traffic related plans, specifications and estimates included in the complete contract document submission
2. A record copy of the traffic control signal plans plotted on mylar having the seal of a Connecticut licensed professional engineer affixed
3. Intersection signing and pavement marking plan (if required) plotted on mylar having the seal of a Connecticut licensed professional engineer affixed
4. For signal systems, a record copy of the communications/interconnect plan plotted on mylar

The **Post Final Submission** should include a 3 1/2" diskette(s) containing the CADD file(s) for the signal plans, the intersection signing and marking plans, and the detailed estimate sheet of traffic items. This is in addition to the submission of complete contract plans in electronic format (See Section 304.05).

### 406.02 SIGNING

A preliminary signing pattern (1:2500 scale plans) shall be included with the Preliminary Design submission.

Signing required for the maintenance and protection of traffic will be submitted with the Semi-Final Design submission.

Final signing plans, specifications and estimates should be included with the Final Plans For Review submission. Any required "Manual on Uniform Traffic Control Devices" (MUTCD) project signing occurring outside the project limits shall be included with the design of the project.

### 406.03 PAVEMENT MARKINGS

Pavement Marking plans, specifications and estimates shall be included with the Semi-Final Design Submission and prepared in accordance with the drafting guidelines in the "Manual of Traffic Control Signal Design."

### 406.04 ILLUMINATION

If illumination is part of the Consulting Engineer's assignment, it shall be designed in accordance with current federal and state standards, including "FHWA Roadway Lighting Handbook," "AASHTO Guide for Roadway Lighting," the Department's standard specifications, and the "National Electrical Code."

The Preliminary Design submission should address whether to install illumination, limits of illumination, preliminary illumination concept (conventional roadside, median, utility pole, high mast arm, etc.), and a determination of who will own, maintain and pay energy costs.

The Semi-Final submission should include plans showing illumination layout, design criteria, legend, notes and the electrical layout. The submission should also include miscellaneous detail sheets, lighting and electrical calculations, and proposed special provisions.

The Final Plans For Review submission should reflect all corrections and completion of the semi-final submission, plus pay items, quantities, cost estimate, and Utility Company correspondence. Illumination/Electrical information must be properly coordinated with all highway, bridge, drainage, signing, and signal designs. Highway and bridge plans shall reflect illumination/electrical appurtenances as required.

The Final Design submission shall incorporate all previous Department comments and be in a format described elsewhere in this manual.

### 406.05 MAINTENANCE AND PROTECTION OF TRAFFIC

This item includes all necessary plans, specifications, temporary signals, construction signing, temporary pavement markings and temporary illumination as required. The geometry for all detours should be compatible with the approaching highway and shall equal or exceed the requirements of Part VI of the MUTCD. The Department will provide the Consultant with a "Limitation of Operations" chart which will dictate the number

of lanes required on all expressways. Liquidated damages will also be provided for construction violations relative to the “Limitations of Operations” chart.

The Consultant and the Department shall discuss the optimum method for maintaining traffic during construction. On complex projects, a 1:2500 scale concept plan and descriptive narrative for the Maintenance and Protection of Traffic should be included with the Preliminary Design submission. A fully developed 1:2500 scale Maintenance and Protection of Traffic plan, 1:500 scale detour plans, and special provisions for Maintenance and Protection of Traffic and Prosecution and Progress should be included with the Semi-Final Design Submission.

If any traffic appurtenances are designed by the Department, final plans, specifications and estimates will be forwarded to the Consulting Engineer for incorporation into the project.

## 407 ROADSIDE DEVELOPMENT

The Consulting Engineer shall consider aesthetics during the development of the plans for the project. Particular emphasis shall be given to screening the highway from unsightly areas such as junkyards and scrap metal processing facilities. Among the acceptable methods of accomplishing this screening are the placing of the highway in cut and the construction of earth berms.

Normally, the preparation of planting plans will not be included in the Consulting Engineer’s assignment.

The roadside development shall be designed in accordance with the “Highway Design Manual” and applicable Department Policy Statements.

The Department has prepared guidelines for projects involving the Merritt Parkway. A document titled “Merritt Parkway Guidelines for General Maintenance and Transportation Improvements” is available from the Department.

## 408 SURVEY

If survey is included in the assignment, the Consulting Engineer shall complete the survey assignment in accordance with the Department's current "Location Survey Manual" or as directed by the Project Engineer.

### 408.01 PROGRESS SUBMISSIONS

**A) Project Control:** All control shall be reviewed and approved by the Department prior to the submission of the base map data.

Horizontal submission shall include:

1. Control sketch of traverse network
2. Copy of traverse adjustment computations
3. Raw horizontal and angular field measurements

Vertical submission shall include:

1. All original computations for level run and sketch of level run
2. Original computations concerning adjustments, copy of field notes, etc.
3. Copy of computations concerning the adjustment of bench levels

**B) Cursory review of Mapping and Digital files:** The Consulting Engineer will provide one set of paper prints and electronic media (coordinate media type with your Project Engineer) for review by the Department following the approval of control survey.

**C) Final review of Mapping and Digital files:** The Consulting Engineer will provide one set of paper prints and electronic media (coordinate media type with your Project Engineer) for review and approval prior to certification.

**D) Final Submission**

1. Certified Mylars
2. Final Digital Files

### 408.02 CHANGES IN FIELD CONDITIONS

Regardless of the survey responsibility, the Consulting Engineer shall make periodic visits to the project site during all stages of design to detect changed field conditions. If survey is in the assignment, the Consulting Engineer shall perform or arrange for additional surveys needed to modify and correct the plans. If the Department performed the survey, the Consulting Engineer should notify the

Department of the observed changes and request updated survey files.

The design plans must be adjusted as required to ensure that the plan and design details are those best suited to the latest existing field conditions.

## 409 RIGHTS OF WAY

The Department will be responsible for acquiring the necessary property, easements and rights for the project. The Consulting Engineer, with the approval of the Project Engineer, shall establish taking lines, non-access lines, easements and rights in accordance with the Department's "Policy and Procedures for Property maps," a copy of which can be obtained from your Project Engineer.

The acquisition of right of way is a time consuming process; therefore, property requirements should be defined as early in the Final Design Phase as possible. As a minimum, all property requirements should be shown on the Semi-Final Design Submission so that property maps can be prepared immediately thereafter.

### 409.01 TITLE SEARCH

The Department will perform a title search on the affected properties after the Preliminary Design Review Meeting. A Design/R.O.W. meeting will be scheduled by the Project Engineer to identify properties requiring title search. The Consulting Engineer will provide a mylar base survey plan with the proposed baseline shown and a table summarizing the properties affected and the type of search required. A sample spread sheet, referred to as a schedule of owners, is available from your Project Engineer.

The completed title search will be forwarded to the Consulting Engineer. The current owner's names, property lines, easements and rights shall be transferred to the base survey plan. Property line dimensions should not be shown on the base survey.

### 409.02 13A-57 MAPPING

State Statute Section 13a-57 allows the Department to file layout plans with municipalities to "freeze" all zone changes within the project corridor. The procedures for filing layout plans is available from your Project Engineer. Layout plans are not required for all projects. The need for 13A-57 mapping will be established at the Assignment Meeting.

### 409.03 PROPERTY MAPS

Property maps must be prepared for all properties affected by land takes or easements, in accordance with the Department's "Policies and Procedures for Property Maps. (As Revised or Amended).

The Consulting Engineer shall review the affected sites in the field to determine if the survey mapping agrees with the current field conditions. Any changes should be reflected on the current ground survey file(s) as noted in Section 408 prior to the preparation of the property maps.

When the project design has progressed to the point where property impacts are defined and generally finalized (i.e. design 50%-75% complete) the consultant is to submit draft property acquisition maps for review and approval. Each map should be accompanied by a current plan view drawing (and cross sections if appropriate) for reference purposes.

When the draft map has been approved, the Consultant will be directed to submit a reproducible, unsigned property map for use in negotiations with the property owner. Any subsequent revisions to a property map, whether initiated by the consultant or the Department, shall be so noted in the Revision block of the property map.

Upon completion of negotiations with the property owner, the Department will request from the Consultant a "fixed line photographic" matte mylar (.003 inch thickness minimum) stamped with indelible red ink by the producer and subsequently "signed and sealed" by the registered land surveyor having prepared the map.

All rights and easements noted on the property maps shall be shown on the design plans in accordance with the "Policies and Procedures for Property Maps." The Consulting Engineer is responsible for the proper conversion of english and metric dimensions and for consistency between the final property maps and the final contract drawings. The configuration and controls of all taking lines and defined easements must appear on the final contract drawings exactly as shown on the property map.