DESIGN

PLANS AND SPECIFICATIONS

I. A General Overview of Design

- A. What is the highway design process?
  1. Highway design is a process that may begin with a conceptual idea (or scope of work) on how to best improve a road. It is a response to a highway problem. The end result is an accurate description of the work to be done which is noted in a set of drawings.
  2. Design is an evolving process which ends with plans, specifications and estimate.
  3. The primary objective or function of design is to develop a set of drawings that will be used for:
     1. Estimating
     2. Contract Bidding
     3. Construction
  4. Plans, specifications and estimate are sent to Final Plan Review Bureau. This package is commonly referred to as the "PS&E Package."
     Highway construction contract in NYSDOT is unit price contract.
     - Each element of work is designed as a pay item.
     - The total bid is obtained by summation of the amounts, in dollars, for all items scheduled in the proposal.
     - Contracts are always let on a competitive-bid basis.
     - The contract is awarded to the lowest responsible bidder.
  5. NYSDOT Contract Letting Process
     1. Typical Schedule of a Project
        - ° PS&E
        - ° Advertising
        - ° Amendments
        - ° Letting
        - ° Award

II. Contract Documents

1. Advertisement for Proposal
2. Contractor's Proposal
3. The Agreement
4. Standard Specifications
5. The Plans & Selected Standard Sheets
6. Amendments
7. Schedule for Participation by Disadvantaged Business Enterprise Participation Goal

III. Plan Content

Plans delineate the extent and nature of the work to be done and specifications tell the contractor how it is to be accomplished.

A. Order of Sheets (HDM 21.02.02)
   - Necessary to group sheets in logical order
   - FHPM 6-3-3-1

B. Title Sheet (HDM 21.02.03)
   - Prepared on Standard Form HC 47-1
   - Signatures - Approval Block
   - Location Map
     (Use of Dept. Quadrangle vs. custom map)
     (Scale, north arrow)
   - Location Description
   - List of Standard Sheets (Main Office adds)
     (Role of Std. Sheets)

C. Index (HDM 21.02.04)
   - List of sheets in the plans
   - Spaces reserved for added sheets, field change sheets, revised sheets

D. Legend, General Notes (HDM 21.02.07)
   - Using General Notes disk file
   - CADD Legend Sheet

E. Typical Sections (HDM 21.02.05)
   - Subject of Training Topic #6
   - Ref. Hwy. Design Manual Chapters 2 and 3
   - Shows <u>Typical</u> features of roadway and roadside which are shown transverse to the roadway; (widths of lanes, thickness of courses, cross slopes, offsets to barriers and swales, etcetera.)

F. Summary of Quantities (HDM 21.02.06)
   - Ordinarily prepared by Main Office from engineer's estimate computer print-outs.
   - Shows item number, description, unit of payment and quantity.

G. Plan and Profile - 200' Scale (HDM 21.02.08)
   - Ref. Hwy. Design Manual Chapter 5
   - Plan shows contract and F.A. project limits, centerline stationing and major political and topographic features. Profile shows design elevations of roadways, design grades, vertical curve information.

H. "MPT" Plans (HDM 21.02.09)
   - Ref. Hwy. Design Manual Chapter. 16
   - General Notes for MPT from disk file.
   - Recommended Construction Phasing
   - MPT Schemes not covered by the MUTCD, Part 302.

I. Table and Plan of Highway Maintenance Jurisdiction (HDM 21.02.10)

- Ref. Hwy. Design Manual Chapter 15
- Highway; Curb and Sidewalks; Traffic Signals; Snow Removal; Recharge Basins; Service Roads; Side Streets
- Authority; Section of Highway Law

J. Miscellaneous Tables (HDM 21.02.11)
- Base Line Ties and Benchmarks
- Drainage Table
- Disposal of Buildings
- Fencing
- Driveways
- Guide Rail, Median Barriers
- Curb
- Sidewalk, Pedestrian Ramps
- Utility Work (by whom)
- Saw cuts

K. Miscellaneous Details (HDM 21.02.12)
- Not to be confused with Typical Sections.
- Curbing, resurfacing transitions, pavement repairs, plating, driveways, guide rail, etc.
- Regional Guide Sheets for drainage.

L. Plan and Profile -- 50 Scale (HDM 21.02.15)
- Scale can vary: 1:500, 1:250, etc. 40', 20', etc.
- Roadway Plan: Pavement geometry and type of work; curbs, driveways, sidewalks, guide rail*. etc.
- Drainage, Grading and Utilities Plan:
  drainage pipe and structures, guide rail*, contours, utilities (existing and proposed), etc.
- Landscape Development Plan
- Profile: Show existing subsurface lines, cross street locations, etc.

M. Special Plans (HDM 21.02.16 & 17)
- Sign Removal
- Signing (incl. Sign Text Data, Sign Structure Details, Sign Location Details)
- Pavement Markings (incl. typical marking details, gore details, etc.). Include, whether or not Contractor is to do them.
- Traffic Signal (incl. Traffic Signal Detail Sheets, Microprocessor Sheets, etc.)
- Roadway Lighting
- INFORM System

N. Structure Details (HDM 21.02.19 & 20)
- Box Culverts (Ref. HDM Chapter. 20)
- Retaining Walls
- Noise Barrier Walls

O. Bridge Plans (HDM 21.02.21)

- Usually prepared by Consultants or M.O. Structures
- Always at end of plans.

IV. Standard Specifications

A. 1995 Standard Specifications
- Sec. 100 (General Provisions)
- Secs. 200 thru 600 (pay item list at rear of each Section)
  Main Parts of each Section:
  - ° Description
  - ° Materials
  - ° Construction Details
  - ° Method of Measurement
  - ° Basis of Payment
- Sec. 700 (relationship to secs. 200 thru 600)
- Addenda Number 1
- M.O. Proposal Notes which revise Standard Specs

B. Standard Contract Pay Item Book
(example: .6m [24"] Cl. IV Concrete Pipe)

C. ASTM, AASHTO, Approved Lists, etc.

V. Special Specifications

A. Addenda File
- Changes Report
- A, D, PIN only, etc.
- Special Specifications Coordinator

B. Main Office (Albany) Special Specifications
- 15 prefix: Facilities Design
- 16 prefix: Structures
- 17 prefix: Soils
- 18 prefix: Materials
- 19 prefix: Experimental

C. Regional Special Specifications
- General Approval (Special Services)
- One-Time-Only (Designer)
- Main Parts:
  - ° Description
  - ° Materials
  - ° Construction Details
  - ° Method of Measurement
  - ° Basis of Payment
- Item number determination
- Tips and Procedures: Ref. Design Memo 88 (3)

DESIGN CRITERIA/STANDARDS

I. The dictionary defines the word standard as "something considered by an authority or by general consent as a basis of comparison; an approved model." Also, "anything, as rule or principle, that is used as a basis for judgement." With respect to highway design and construction, the standards which apply depend upon the type of project that you are working on. These standard are continually updated to reflect advances made in technology and as more is learned about highway through studies, experience, etc. Most of the project we work on will fit into one of the following three categories of standards:

1. <u>AASHTO Standards</u>

   These are generally the standards contained in Chapter 2 of the Highway Design Manual (HDM) and the American Association of State Highway and Transportation Officials' (AASHTO) publication "A policy on Geometric Design of Highways and Streets," sometimes referred to as the green book. In the Design Manual, applicable standards are determined based upon Design Class, which is a function of the twenty year forecast one-way design hour volume as obtained from the Planning Group. The design Class is determined using the design hour volume combined with the character of the area involved, either Urban or Rural. These standards are applicable to most new construction and reconstruction projects. The majority of these projects are generally Federally funded.

2. <u>R Standards</u>

   Many of the projects that we work on involve the reconditioning and preservation (R&P) of existing facilities. R&P type projects in the past have been developed to AASHTO standards requiring large dollar commitments and thus less miles of improvements for the available funds. On the other hand, just resurfacing can increase the number of miles improved, but has led to increased accident experience due to resultant higher speeds. In order to achieve improvement to as many miles of roadway as practicable, the NYSDOT has developed the idea of R standards (Resurfacing, Restoration and Rehabilitation). At this time, these standards are applicable only to non-freeway, 100% State funded projects.

   Certain elements of work should be included in every 3R type project. In addition, accident experience is investigated and analyzed. Improvements up to the 3R standard for other elements of work are only included in the project if an accident problem is demonstrated. Generally, but not in all cases, the standards that apply to these different items of work are less stringent than AASHTO and Design Manual standards.

3. Parkway Standards

The Parkways were originally designed in the 1920's and 1930's, when operating speeds were lower than today. These roadways were not meant for high speed traffic and were designed mainly based upon aesthetics. The NYSDOT Main Office realized that it would be extremely difficult and cost prohibitive to apply AASHTO and Design Manual standard to parkways. Consequently, they have recently developed a separate set of standards (not yet adopted) for the Parkway system. In addition, a separate set of R&P (3R) standards is being developed for the Parkway system. Some common problems encountered with the Parkway system, to be aware of are: low bridge clearances, lane widths, horizontal and vertical curvature, trees (fixed objects) within clear zone, different types of guide rail (wood post, rustic rail), signs (smaller letter height, painted posts and panel backs, etc.). It is important to note that some of, and/or certain sections of Parkways are listed on the National Register of Historic Places. The Landscape Architecture Unit is often helpful when you are developing a project for a Parkway.

II. Highway Features Which Should Meet Standards

A. Lane Widths
AASHTO Standards -- 3.6 m (Typ. 12')
3R and Parkway Standards -- 3.3 m & 3.0 m permitted (11' and 10')

B. Shoulder Widths
AASHTO Standards -- 3.0 m Rt., 1.8 m Lt.(10' Rt. 6' Lt.)
3R Standards - .6 m - 1.8 m (2' - 6')
Parkway Standards -- 2.4 m adequate 1.2 m Lt. (8' Rt. 4' Lt.)
3.0 m Rt.desirable (10' Rt.)

C. Maximum Grades
AASHTO Standards -- 4-5% mainline
7% service roads
3R Standards -- Does not specify. It is very difficult to improve on 3R projects.
Parkway Standards -- 4-5% (AASHTO Max. + 1%)

D. Max. Curvature
AASHTO Standards -- 4.5° Urban (English)
3° Rural (English)
3R Standards -- only curves with high accident rates should be redesigned.
Parkway Standards -- AASHTO Standards are applicable.

E. Stopping Sight Distance

AASHTO Standards -- 210 m desirable (650')

3R Standards -- if stopping sight distance is adequate for 20 mph or less below design speed no mitigation is required.

Parkway Standards -- AASHTO Standards are applicable.

F. Design Speed

AASHTO Standards -- 100 km/h mainline -- urban (60 mph)
60 km/h service roads -- urban (40 mph)
110 km/h -- rural (70 mph)

3R Standards -- 85th percentile speed or reg. Speed limit + 10 km/h (5 mph)

Parkway Standards -- do not maintain design speeds. Assume AASHTO Standards apply.

G. Clear Area Fixed Objects

AASHTO Standards -- generally 9 m (30')

3R Standards -- determined on a project by project basis.

Parkway Standards -- generally 9 m (30') but 6 m (20') permitted if an accident analysis is done.

H. Cross Slopes, Superelevation

AASHTO Standards -- Max. bank -- 4% slope, urban (1/2" per ft.)
6% slope, rural (3/4" per ft.)

3R Standards -- normal cross slopes vary from 1.5% slope (3/16" per ft.) to 3% slope (3/8" per ft.)

Parking Lanes -- 6% slope (3/4" per ft.)

Shoulders -- 2% slope to 8% slope (1/4" per ft. to 1" per ft.)

Parkway Standards -- no special provisions for cross slopes or superelevation on parkways. Assume AASHTO standards apply.

I. Control of Access Requirements

AASHTO Standards -- Interstate projects must have full control of access. Primary and Secondary projects may or may not.

3R Standards -- generally not control of access.

Parkway Standards -- generally controlled access.

J. Bridge Clearances

AASHTO Standards -- 4.3 m min. (14' min.) 4.6 m desirable (15')

3R Standards -- 4.3 m min.(14' min.) 4.6 m desireable (15')

Parkway Standards -- 4.0 m (13') [travel lanes] 3.3 m (10'-6") [shoulders]

ROADSIDE DESIGN

The desired width will be a function of the design speed, traffic volume, roadside slopes, and the curvature of the roadway. It must be stressed that accidents will occur, regardless of the clear zone width. The selected clear zone width is a compromise, based on engineering judgement, between what can practically be built and the degree of protection afforded by motorists. For both new and existing facilities, selection of appropriate design clear zone widths is to be made by an engineer experienced in roadside design issues.

Several terms need to be specifically defined to understand the process for selecting design clear zone widths for new and reconstructed facilities.

1. **Basic Recovery Width**, BRW. This is a numeric value representing the basic width of recovery area that should be provided for given traffic volumes, design speeds, and slopes ranging from 1:3 cut slopes to 1:4 embankment slopes. Slopes in this range are considered recoverable since a driver may be able to recover control of an errant vehicle and return to the roadway. (Smooth cut slopes steeper than 1:3 may generally be included as part of the clear zone, provided there are smooth slope transitions between the roadway and the slope. This remains an area requiring the use of good judgement.) The BRW values will generally, but not always, provide adequate width for recovery of errant vehicles.

2. **Non-Recoverable Slope**. If an embankment slope is steeper than 1:4, it is unlikely that a driver will be able to regain control of an errant vehicle and return to the roadway. The vehicle will instead continue down to the bottom of the slope. Fill slopes steeper than 1:4 are therefore termed non-recoverable. If such a slope is smooth, not steeper than 1:3, and does not contain any obstacles, it may be considered traversable. To minimize the potential for destabilization of the vehicle, all slope intersections should be rounded as noted in Chapter 3. Traversable, but non-recoverable slopes may be present in the clear zone, but may not be credited towards meeting the Basic Recovery Width needs. On new or reconstructed interstate highways, slopes steeper than 1:4 should be avoided.

3. Curve Corrected Recovery Width, CCRW. This width takes into account the effects of horizontal curvature. It is obtained by multiplying the Basic Recovery Width by the appropriate horizontal curve correction factor, K and should particularly be applied when the curve is at the bottom of a long downgrade or obscured by a crest vertical curve and there is an increased possibility of a driver being “surprised” by the curve.

Clear Zones

Under ideal conditions, a vehicle that inadvertently left the roadway would encounter an extensive, firm, flat, hazard-free area that would permit the driver to safely return to the roadway. Limitations on the availability of right-of-way and the cost of cutting and filling require that the width of the hazard-free area be limited to values that will generally, but not always, provide adequate distance for recovery. This area, from which all surfaces have been cleared and the surface has been graded to permit (but not guarantee) reasonable safe re-entry to the highway or provide adequate distance for stopping, is termed the "clear zone". When conditions are not ideal, it may not be reasonable to provide a good or even an adequate clear zone and the guidance presented in the selection steps at the end of this section should be followed.

The clear zone is the total roadside border width starting at the edge of the traveled way, available for safe use by errant vehicles. This width will usually include a shoulder and a recoverable slope and may include a traversable but non-recoverable slope and a clear run-out width. A traversable slope (or area) as defined herein, is one which a vehicle may cross without becoming destabilized and without incurring severe damage to the vehicle or injury to the occupants. Where auxiliary lanes are present, the outside edge of the clear zone will extend to the further of 1) the width determined for the through travel lane measured from the edge of that lane or 2) the width determined for the prevailing operating speed on the auxiliary lane measured from the edge of the auxiliary lane. For high speed deceleration lanes, the auxiliary lane's operating speed should be assumed to be the same as the main line's until the end of the gore area.

Some hazards will not significantly slow a vehicle but might result in objects entering the passenger compartment. Mailboxes (Section 10.5.1) and rails on fences (Section 10.5.2) are examples. Fire hydrants are generally not serious hazards since they are usually designed with breakaway features to prevent damage to the water main in the event the hydrant is struck. Standpipes and non-breakaway hydrants should be treated as potential hazards.

The designer should recognize that even barriers installed to deflect vehicles away from fixed objects may be hazards in themselves. Preference should therefore be given to eliminating or relocating the fixed object or potential hazard rather than placing guide rail in front of it.

Treatment Options

The designer should consider, in sequence, the five categories of treatment options available to address hazards within the design clear zone distance. Ranked in order of safety with the most desirable listed first, these options are A) Removal, B) Relocation, C) Modification D) Shielding and E) Delineation.

VERTICAL CLEARANCES

A. Highway Grade Separations:

1. For all bridges that receive a rehabilitation where the structural deck is not being fully replaced, or for bridge deck repair projects, a minimum 4.3 m clearance is allowed. For all cases described in this subsection, an additional 0.15 m of clearance should be provided to allow for future resurfacing; however justification as a non-standard feature is required only if the actual clearance is less than the 4.9 m or 4.3 m minimum specified values.

2. For bridges over roads and streets not on the National Highway System all new and replacement bridges shall provide 4.3 m minimum clearance above the pavement and useable shoulders of the lower roadway. To allow for future resurfacing an additional 0.15 m clearance should be provided. Bridge rehabilitations shall also provide a minimum of 4.3 m vertical clearance, unless a lesser height is approved by the Regional Director and the clearance is posted accordingly.

B. Pedestrian Bridges: For bridges that carry exclusively pedestrian and/or bicycle traffic over highways, the minimum vertical clearance above the lower roadway shall meet the requirements of A. plus an additional 0.3 m clearance.

C. Railroad Grade Separations: Minimum vertical clearances above operating mainline railroad tracks shall generally be 6.71 m. On occasion, some additional clearance may be justified. For tracks other than mainline and where clearance is restricted by other bridges, a minimum less than 6.71 m may be allowed.

DRAFTING:

Line Weights:

Proposed is heavier than existing

Dimension lines are solid, lighter lines

Min. letter hgt. -- 3.2 mm (1/8")

Width-- 2.7 mm

SUPERELEVATION:

V = Car Speed (MPH) **R** = Curve Radius (Meters)

$e + f = \frac{.067V^2}{R}$ **e** = Superelevation (banking)

<u>Max: 6% Rural</u> <u>4% Urban</u> **f** = Friction Factor (tires to pavement)

Normal crown is <u>1/4"/ft</u>. scope or <u>2%</u> metric pavement <u>sloped</u> to remove <u>water</u> from pavement

Rollover maximum: 4% lane to lane; 8% lane to shoulder

Highway Design: <u>Most Important</u>:

(Any sudden change to the driver introduces an element of danger)

Ditches: Ditch profile usually equals or is steeper than road profile.

GUIDE RAIL:

<u>Type</u> is based upon <u>deflection dist</u> = distance to object protected from back of rail.

<u>Length</u> is based upon point of NEED:

Calculated using 15° (10° interstate) from back of object.

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1.) What is elev. of point B?

140'

2.) What is distance from point A to point B?

250'

3.) What is the elev. change from B to C?

60'

4.) What is grade from B to C?

$\dfrac{\text{DIFF ELEV}}{\text{DIST.}} = \dfrac{60'}{600'} =$ **.10 1/1 OR 10%**

5.) What is the average grade from A to B?

$\dfrac{40'}{250} =$ **.16 1/1 or 16%**

COMPUTING ASPHALT:

Special conversion factors vary by Region.

(1) Figure square yards of pavement x depth in inches x .055 +/-
(2) Figure cubic yards of asphalt x 1.95
METRIC:
(3) Metric Ton = Meters 2 of pavement x $\frac{\text{depth(mm)}}{\text{25 mm}}$ x .059 +/-

COMPUTING FLOW: FROM DRAINAGE AREA:

Rational Formula = Q = CIA

C = Run-off Factor → .2 Pervious Gravel w/Grass
→ .9 Concrete, Asphalt, Roofs

I = Rainfall Intensity - depends on:

Location, <u>Storm Frequency</u> Required Usually 2 to 8 inches/hour

A = Drainage Area in Acres

Storm Frequency is also called return period

2 year storm is $\frac{100}{2}$ = 50% chance of happening in any year

50 year storm is $\frac{100}{2}$ = 2% chance of happening in any year

EARTHWORK COMPUTATION

1. Using cross sections total earthwork between two cross sections is average area X distance between cross section.

Ex. <u>Metric</u>

X section at 1+500 centerline has an area of cut of $64m^2$ at 1+515 centerline. The area is $16m^2$. How much earthwork is there?

$\underline{64+16} \times 15 = 600m^3$

Area 1 + 000 3m x 3.2m = $9.6m^2$

Area 1 + 050 3.4m x 3.2m = $10.9m^2$

Trench & Culvert Excavation = $\frac{9.6 + 10.9}{2} \times 50 = 512.5m^3$

How much select granular fill is needed to fill 0.3m over top of pipe. (Don't forget to subtract out pipe volume). A_1 = 3.2m x 2.3m = A_2 = $7.36m^2$

Vol = (7.36 + 7.36 x 50) - (TT $(1)^2$ x 50) = 368 - 157 = $211m^3$