

HIGHWAY DESIGN MANUAL

CHAPTER 3 - TYPICAL SECTIONS (Limited Revisions)

Revision 44

July 9, 2004

CHANGES TO CHAPTER 3

Pages

Change

3-26

Corrected typographical error in Section 3.2.5. In the second paragraph, first line, replaced “lateral” with “horizontal”.

**CHAPTER 3
TYPICAL SECTIONS**

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CHAPTER 3 TYPICAL SECTIONS

3.1 INTRODUCTION

Typical sections describe the physical shape and relationship of the various highway elements that are present at or proposed for a normal or typical interval along a highway. This chapter defines and describes the elements and presents guidance on details of their design. It also discusses how the individual elements may be brought together to form typical sections for the different classifications of highways.

The chapter begins by defining, in Section 3.1.1, the elements that make up typical sections and follows, in 3.1.2, with a description of the two highway classification systems used in this chapter. Section 3.2 presents discussions of the individual elements as they relate to new construction. Section 3.3 focuses on some of these elements as they relate to resurfacing, restoration and rehabilitation work on existing facilities. Section 3.4 provides guidance on drawing layout, conventions, notes and general presentation of typical sections for construction contracts. It also includes example drawings. Section 3.5 provides references for the many documents that provide supplementary information relevant to the preparation of typical sections.

3.1.1 Element Terminology and Definitions

Tables 3-1 and 3-2 present definitions of elements that may be included in the typical sections of new or reconstructed projects. Different arrangements of elements will be used depending on the functional classification of the highway. Figure 3-1 illustrates a typical arrangement for a limited access highway. Figure 3-2 illustrates an arrangement of elements for urban streets. (Two tables and two figures are provided for ease of illustration rather than to indicate exclusive use of the elements in one section or another.) The older a highway is, the more likely it is to differ from the sections shown.

3.1.2 Classification of Highways

Two classification systems are used in this chapter. One, the Federal Aid System functional classification of highways, is used in the definition of the various critical design elements. Chapter 2 provides the guidance on critical design elements for new and reconstructed highways, including Resurfacing, Restoration and Rehabilitation (3R) projects on Interstates and Freeways. Chapter 7 of this manual provides additional requirements, standards and guidance for both freeway 3R and non-freeway 3R projects. The second classification system is only used herein for hot mix asphalt pavement selection and thickness guidance (Section 3.2.4.5) and is the system used in the *Highway Sufficiency Rating Manual*.

Table 3-1 General Terminology (Limited Access and Other Highways)

<p>1 Clear Area-The total roadside border area, starting at the edge of traveled way and extending to the first hazardous obstacle.</p> <p>2 Cut (Back) Slope-A slope formed by excavation.</p> <p>3 Ditch Control Edge-The edge of traveled way nearest to a ditch. Serves as the vertical control for depth.</p> <p>4 Ditch Depth-Vertical distance from the ditch control edge to the invert of ditch in cut sections.</p> <p>5 A. Ditch (Side) (Fore) Slope-The area between the shoulder break and the ditch invert. B. Ditch Back Slope-A desirable 3 m wide, 1:4 slope between the ditch invert and the cut slope, used to enhance traversability.</p> <p>6 Ditch Width-The width of the ditch invert or bottom.</p> <p>7 Edge Drain-An underdrain located beneath the edge of pavement. See Sections 3.2.4.4, 3.2.9.3, and 3.3.5 and Chapter 9, section 9.3.9.</p> <p>8 Embankment-A road-carrying raised structure typically composed of soil and rock materials placed and compacted under controlled conditions between embankment foundation and subgrade surface.</p> <p>9 Embankment Foundation-Surface upon which embankment is constructed after all preparatory work is done.</p> <p>10 Embankment (Fill) Slope-A slope formed by an embankment.</p> <p>11 Existing Ground-Location of ground or embankment surface at present. (Compare with Original Ground)</p> <p>12 Guide Rail-Redirecting barrier installed adjacent to shoulder if adequate clear zone not available. May also be used for access control. (See Chapter 10.)</p> <p>13 Highway-Whole strip of land bounded by ROW lines.</p> <p>14 Median-Portion of road separating opposite direction traffic.</p> <p>15 Median Barrier-Barrier system used in median and designed to be impacted on either side. (See Chapter 10.)</p> <p>16 Mowing Strip-Optional asphalt strip that may be provided under guide rail or behind a curb to inhibit plant growth.</p> <p>17 Original Ground-Ground surface prior to any highway construction.</p> <p>18 Right of Way or ROW-General term denoting land, property, or interest therein, usually in a strip, acquired for or devoted to a highway.</p>	<p>19 Right of Way Fence-Fence designed to discourage trespassing onto limited access highways and to distinguish Department Right-of Way. Generally runs as close as possible to the ROW line while maintaining a straight alignment. (See Section 10.5.2)</p> <p>20 Right of Way Line-Line denoting ROW lateral limit.</p> <p>21 Roadbed-The portion of the highway prepared to provide foundation support for the shoulders and pavement structure. The pavement structure begins at the bottom of the subbase course.</p> <p>22 Road Section-Portion of highway included between top of slope in cut and bottom of slope in fill.</p> <p>23 Roadway-Portion of highway included between outside edges of paved shoulders (see §3.2.5 for different definition in Vehicle and Traffic Law). Divided highways have two or more roadways.</p> <p>24 Shoulder - Portion of the roadway contiguous with the traveled way primarily for accommodation of stopped vehicles for emergency use. (Also, preferred location for bicycle traffic using roadway.) Provides lateral support for traveled way courses. Unless stated otherwise, the term 'shoulder' is generally taken to mean the paved width. A. Paved (Stabilized) Width-Portion of the graded width contiguous with the traveled way and paved or stabilized to provide a better all-weather support than offered by the untreated subbase course. B. Graded Width - The area between the edge of traveled way and the shoulder break.</p> <p>25 Shoulder Break-Point of intersection of the shoulder slope plane and the embankment or ditch slope plane.</p> <p>26 Shoulder Joint-In Portland cement concrete pavements, the joint between the shoulder slab and the traveled way slabs.</p> <p>27 Subbase Course-Compacted layers of well-graded sand and gravel placed as a foundation for pavement layers above it.</p> <p>28 Subgrade Surface-The surface of the subgrade. (Subgrade-roadbed section upon which the subbase course is placed.)</p> <p>29 Traveled Way-Portion of roadway for movement of vehicles, exclusive of shoulders. (Through Traveled Way-Portion of the roadway for movement of vehicles, exclusive of shoulders and auxiliary lanes.)</p>
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Figure 3-1 Typical Elements of Limited Access Highways

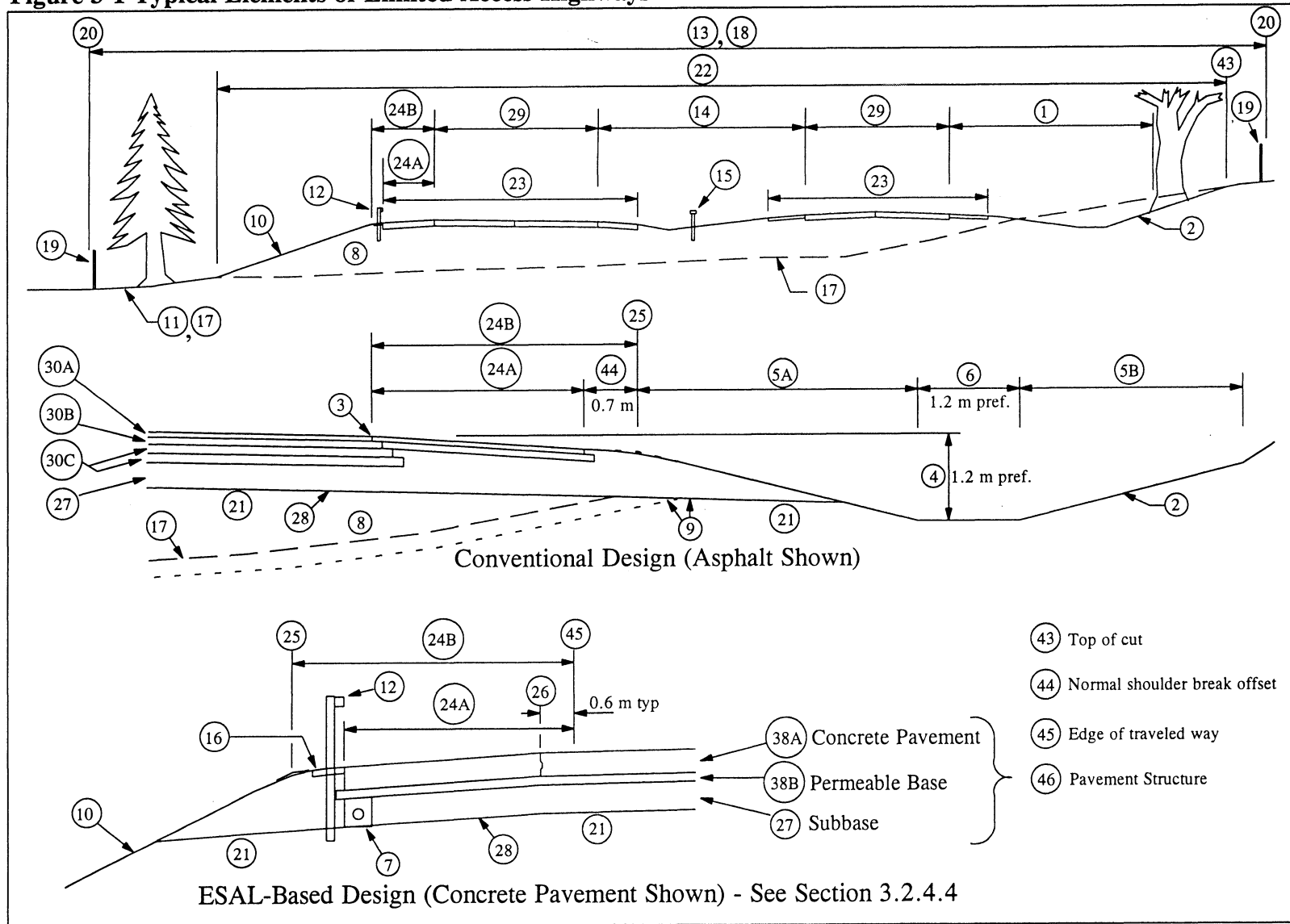


Table 3-2 General Terminology (Urban Streets and Other Highways)

<p>30 Asphalt (Hot Mix*),HMA-A pavement material consisting of an aggregate and bituminous mixture. A. Top Course-Asphalt layer placed as riding surface. Generally, finest gradation except for shim course. B. Binder Course-Asphalt layer placed below top course. Gradation is intermediate between base and top. C. Base Course-Large aggregate asphalt layer placed as structural base for overlying asphalt layers. D. Permeable Base-Asphalt layer with limited fine aggregate, typically placed at bottom of asphalt section where needed to provide drainage and support. Satisfies requirement of ESAL-based design for a 100 mm drain layer below HMA pavements.</p> <p>31 Centerline-A theoretical line representing the plan location of the center of roughly symmetrical roadway sections. Compare with Horizontal Control Line.</p> <p>32 Curb-A narrow, raised element placed at the edge of pavement to control drainage and driveway access, reduce maintenance and right-of-way requirements, and separate pedestrian and vehicular traffic. May be mountable or serve as barriers.</p> <p>33 Gutter-A broad (up to 1 m), shallow ditch section placed at the edge of the paved area and designed primarily to collect and carry surface water into a drainage system.</p> <p>34 Horizontal Control Line or HCL-Control for horizontal alignment.</p>	<p>35 Parking Lane-A lane provided in some commercial and residential areas for parking vehicles. (Refer also to Chapter 18 for bicycle lanes.)</p> <p>36 Pavement Course-A distinct layer of a given type of hot mix asphalt. (See Term 30.)</p> <p>37 Point of Rotation (of superelevated section)-The POR is the "hinge" point on the pavement surface (usually the TGL) about which the adjoining lanes rotate up or down during superelevation transitions.</p> <p>38 A. Portland Cement Concrete (PCC) Pavement-Also referred to as Rigid Pavement. B. Cement Treated Permeable Base-A coarse aggregate drainage layer stabilized with cement. (ESAL-based designs require use of 100 mm layer of cement or asphalt treated permeable base below PCC pavement.)</p> <p>39 Sidewalk-A paved surface along the side of a street, but separated from vehicular traffic, for the use of pedestrians.</p> <p>40 Snow Storage Area-Area between sidewalk and back of curb or gutter, or in some situations, edge of shoulder. Where no sidewalk is present, area begins at back of curb, gutter or edge of shoulder and may extend to ROW line.</p> <p>41 Theoretical Grade Line (TGL)-Control for vertical alignment.</p> <p>42 Topsoil-Surface soil layer placed to support grass growth.</p>
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*NOTE: Current practice should be to use the term Hot Mix Asphalt (HMA) in preference to terms formerly used, such as Asphalt Cement Concrete (ACC), Bituminous Concrete, Blacktop, Macadam, etc.

3.2 ELEMENTS OF THE TYPICAL SECTION

The discussion of the typical section elements is organized sequentially starting with the horizontal control line and working out to the Right-of-way line. For the dimensions or minimum widths of critical design elements for new and reconstructed highways and for 3R projects on interstates and freeways, reference should be made to Chapter 2. Although not called out for each element, there are separate corresponding standards for non-freeway resurfacing, restoration and rehabilitation (3R) projects found in Chapter 7.

3.2.1 Control Lines

Collectively, the control lines determine the location of the typical section in space. There are three components to this spatial control.

The "horizontal control line", or HCL, is the control for the horizontal alignment. The stationing for the roadway is measured along this line. In situations where the HCL is located in the middle of the traveled way, between lanes, the term "centerline" is used. When a centerline is shown as the horizontal control, it is not necessary to also call it the HCL.

The "theoretical grade line", or TGL, is the control for the vertical alignment. The roadway profile is measured along this line. The TGL is usually located on the theoretical pavement surface at the HCL.

The "point of rotation", or POR, is the point on the pavement surface about which adjoining lanes rotate up or down during superelevation transitions. The POR will usually be located at the same lane edge as the TGL. The location of the POR only needs to be indicated on sections when it is different from the location of the TGL.

"Baselines" are not shown on typical sections, but should be shown on alignment plans. (See Chapter 21, Section 21.2.) Baselines are established as straight line segments between known fixed points, generally within the right-of-way. They are located for the convenience of the surveyors and provide the initial control for all of the preliminary survey work and subsurface exploration.

3.2.2 Lane Widths

A highway lane is the portion of the traveled way dedicated to the sole use of a single line of vehicles. Lane width is a "critical design element" discussed in Chapter 2. Refer to that chapter for design widths to be used for travel lanes on new and reconstructed highways and 3R projects on interstates and freeways. (The guidance for non-freeway 3R projects is provided in Chapter 7.)

3.2.3 Cross Slope and Superelevation of Lanes

Pavement cross slope and superelevation of lanes are two of the critical design elements covered in Chapter 2. That chapter presents the minimum and maximum values that should be used for the various functional classifications of highways. The normal cross slope is 2% for travel lanes, 4% for parking lanes and 6% for shoulders. Generally, a 'normal crown section' is considered to be one in which the travel lanes slope at 2% away from the point of rotation. Chapter 2 also presents Tables 2-9, 2-10 and 2-11 which, in addition to providing the radius/design speed/superelevation correlations that shall be used, give the minimum runoff lengths for superelevation transitions. (Note again the existence of separate non-freeway 3R standards. See Chapter 7, Section 7.3.)

3.2.4 Pavement Sections

A typical section drawing shall indicate the type of pavement materials to be used and the required thicknesses of the various layers. These are two separate operations. The structural thickness requirements will be either conventionally determined (Section 3.2.4.3) or be by ESAL-based design (Section 3.2.4.4). In general, pavement material type will be either Portland Cement Concrete (PCC) or Hot Mix Asphalt (HMA). Within HMA, however, the material may be either 'SUPERPAVE' asphalt or, for most of 1999, 'conventional' Marshall Mix asphalt. In some instances, the placement requirements for the SUPERPAVE courses will require slight increases in the thicknesses used in conventional designs. SUPERPAVE guidance is contained in Section 3.2.4.5. Guidance on conventional asphalt item selection is contained in Appendix A.

In normal, full-scale production work, HMA must be compacted by either static or vibratory rollers. In some instances, it is possible that vibratory compaction could lead to damage of particularly sensitive structures. Particular concern should be given to urban areas where there are old utility pipes under the pavement and/or vulnerable buildings nearby. The action of the vibratory compactor may also have a detrimental effect on some underlying soil conditions, particularly if the soil is fine grained and the groundwater elevation is close to the surface. The Regional Geotechnical Engineer and/or the Regional Materials Engineer should be consulted to determine if either problem should be anticipated. If either Engineer judges that vibration sensitivity is likely to be a problem, a Special Note should be inserted in the proposal, stating "***Vibratory compaction is prohibited at certain locations within this project. Check the Plans for specific locations.***" The Engineer may (also) judge that vibratory compaction may be a problem at certain locations. In this case, a Special Note should (also) be included in the Proposal stating that "***Areas that may have vibration sensitivity problems are indicated on the Plans. The use of vibratory compaction in these areas shall be strictly at the Contractor's risk.***" The Plans and, when practical, the proposal should be specific as to the areas where the Special Notes will apply. Refer to the subsection on 'Neighborhood Sensitivity' (under Section 3.2.4.5) and to the subsection on 'Field Compaction Procedures' (under Section 3.2.4.5 B) for a discussion of compaction monitoring procedures in potentially vibration sensitive areas.

To verify that PCC pavements have been placed with a smooth, comfortably rideable surface, a profilograph may be used to measure the cumulative roughness of the finished concrete. On all mainline concrete pavements 1 km or more in length, the designer should specify that the

profilograph be used to measure the pavement and that the contractor be paid in accordance with the Special Specifications for profilographed pavements. These Items, 15502.0401M - Cement Concrete Pavement, Reinforced, Class C Profilographed and 15502.0601M - Cement Concrete Pavement, Unreinforced, Class C Profilographed, correlate the amount of payment with the degree of smoothness obtained. Item 15502.04M - Profilograph should be specified to require the contractor to provide a profilograph for the Engineer's use at a lump sum price.

3.2.4.1 Selection of Pavement Type

Each significant pavement-related project should be carefully evaluated to determine the most appropriate type of pavement for new or reconstruction projects or, as discussed in Section 3.3, the most appropriate rehabilitation treatment for existing pavements. The current emphasis is to examine life cycle cost rather than first cost. Only a general overview of the process is presented below. The selection process is outlined in greater detail in Engineering Instruction 92-015 *Project Level Pavement Selection Process*.

The first step in the selection process is to define one or more suitable treatment options. For new or reconstructed pavements, preliminary designs must be prepared for both PCC and HMA alternatives. Sections 3.2.4.2, 4.3 and 4.4 discuss the procedure for determining suitable new and reconstructed section compositions. For existing pavements, some of the other treatment options are discussed under Section 3.3.

The second step in the process is to compare the suitable options by performing a Life-Cycle Cost Analysis (LCCA). Guidance on performing LCCA's is presented in Volume II of the *Pavement Rehabilitation Manual*.

The third step for new or reconstructed pavements is to prepare a Pavement Type Selection Analysis to document in the project files the reasoning behind the selection. Guidance on preparing this documentation is contained in Volume II of the *Pavement Rehabilitation Manual* and EI 92-015.

3.2.4.2 Selection of Thickness Design Procedure

Pavement thickness design procedures are classified herein as conventional (Section 3.2.4.3) or as ESAL-based (see Section 3.2.4.4). Values for conventional design thicknesses are presented in Table 3-3 and details are discussed in Section 3.2.4.3. In October of 1994, the Department issued the revised *New York State Thickness Design Manual for New and Reconstructed Pavements*, also known for convenience sake as the *Pavement Thickness Design Manual* or PTDM. This document describes the design for thicker, longer-lasting pavements and is the design guidance for new construction and full width reconstruction projects. Projects over 1.5 km in length, exclusive of bridges, should be designed in accordance with the PTDM ESAL-based design procedures discussed in Section 3.2.4.4. The two suitable options are full-width (outside of shoulder to outside of shoulder), full-depth sections of either HMA or PCC. New pavement projects less than 1.5 km in length may be exempted by the Regional Design Engineer and may be designed in accordance with the conventional design procedures presented in Section 3.2.4.3.

Widening projects should use pavement sections that are compatible with the existing pavement design. Typically, this means that the total thickness of binder and top will be the same (preferably) or slightly greater. The same applies to the base and to the subbase layers. Furthermore, it is critically important that the effectiveness and continuity of any existing drainage layers be maintained or enhanced. The goal is to develop a widened section that will have the same response to frost, traffic loads and other effects as the existing section.

3.2.4.3 Conventional Pavement Design

Conventional pavement design should be based on both the total amount of traffic and the amount of truck traffic. Conventional concrete slabs should typically be unreinforced and 6 m long on new facilities and 6.096 or 6 m on existing facilities. Designers working with older roads should be aware that some concrete pavements were built with 60 and even 100 foot long slabs. When placed adjacent to existing slabs, joints should generally be made, at a minimum, at the same locations as the existing joints. The first two slabs following the departure bridge approach slab should be reinforced. Table 3-3 gives the pavement depths that should be used for given traffic volumes.

For the Interstate system, the following are minimum requirements for conventional pavement design.

- 1) The depth of PCC pavement for all Interstate mainlines shall be 225 mm.
- 2) If HMA pavement is selected, heavy truck traffic shall be assumed for the pavement design.
- 3) The interchange ramp pavements should generally be built of HMA with a minimum thickness of 140 mm. The ramp pavement thicknesses should also satisfy the values shown in Table 3-3. When arriving at pavement thicknesses for ramps, consideration should be given to heavy truck destination points in the immediate vicinity, such as truck terminals or refueling areas, and the pavement thickness increased accordingly.
- 4) PCC pavement may be used on high speed ramps (80 km/h or greater) to preserve continuity with a PCC paved mainline.
- 5) The joint between PCC mainlines and HMA ramps should be at the first transverse joint beyond the separation of mainline and ramp pavements. The change in pavement type should be at right angles to the ramp.

Table 3-3 Conventional Pavement Thickness Guide

Design Hour One-way Traffic	Subbase Course (all Pavements)	Portland Cement Concrete Pavement	Traffic Makeup	Hot Mix Asphalt Pavement	
				Base Course	Top* Courses
Over 500 Vehicles	300 mm	225 mm	Heavy [†]	200 mm	65 mm**
		225 mm	Normal [‡]	150 mm	
300 to 500	300 mm	225 mm	Heavy [†]	150 mm	65 mm**
		200 mm	Normal [‡]	100 mm	
200 to 300	300 mm	Not Applicable	All	75 mm	65 mm**
Under 200 Vehicles	300 mm	Not Applicable	All	75 mm	25 or 40 mm

*This includes the thickness of both Binder and Top courses.

**Where Heavy Duty or Rut Avoidance mixes are used (see Appendix), lift thickness limits will yield a minimum combined thickness of 80 mm. SUPERPAVE materials require a minimum combined thickness of 80 mm (or 90 mm if ESALs exceed 3 million).

† Heavy traffic is defined as being made up of more than 10% trucks and assumes at least half of the trucks are at or near the legal maximum weight.

‡ Normal traffic is defined as being made up of less than 10% trucks and assumes at least half are at or below the legal maximum weight.

3.2.4.4 ESAL-Based Pavement Design

The key input variable in the ESAL-based design process is the anticipated amount of heavy truck traffic. The truck traffic is measured and converted to a number of 80 kN Equivalent Single Axle Loads (ESALs). Appendix A of the PTDM introduces this aspect of traffic prediction.

For flexible (HMA) pavements, a second key input variable is the load carrying capability of the materials below the pavement. This element is termed the Soil Resilient Modulus (M_r). This modulus is dependent on the characteristics of the underlying soil. The value of the modulus for given locations may be obtained from the Regional Geotechnical Engineer.

Using the input variables and the tables in the PTDM, the designer obtains either the concrete slab thickness and length, dowel bar diameter, and tie bar length and number for a PCC option, or, for an HMA option, the overall asphalt thickness exclusive of the permeable base. Subsequent sections in this chapter provide guidance on determining the thickness of the individual layers that make up the overall asphalt thickness. As with conventional PCC design, the first two concrete slabs following the departure bridge approach slab should be reinforced.

Several features of new and reconstructed ESAL-based pavement sections that were not standard prior to 1993 are 1) the 100 mm permeable base layer, 2) the use of edge drain systems along both edges of pavement, and 3) full depth shoulders (same pavement section as mainline). The PTDM introduced another significant change to Portland Cement Concrete Pavements by relocating the joint between shoulders and travel lanes to be 0.6 m outside of the travel lane.

3.2.4.5 Hot Mix Asphalt Selection Guidelines

Beginning in 1999, the normal asphalt mixes for projects should be SUPERPAVE items. The use of Marshall mix items on a given project should have the approval of the Regional Materials Engineer. Any projects using conventional asphalt mixes should have material selection done in conformance with Appendix A.

As indicated in Tables 3-6 and 3-7, selection criteria for binder and top courses should be based on the Functional Classification as defined in the *Highway Sufficiency Rating* manual (see Table 3-4, below), the Equivalent Single Axle Loads (ESALs) and, in some cases, the Average Annual Daily Traffic (AADT). The PTDM's recommended parameters for determining ESALs are intended for structure selection and are generally overly conservative for mix design. Mix design ESALs should not be overestimated for the following reasons:

1. the aggregate properties and binder specified may be restrictive and costly, and
2. the pavement's anticipated service life may not be obtained if the predicted traffic is not present to provide reworking and compaction of the asphalt.

Therefore, when calculating ESALs for SUPERPAVE mix design, the following parameters should be used in the "simple" method for compound traffic growth as described in the PTDM.

<u>Criteria</u>	<u>Input Parameter</u>
Design Life	20 years
Percent of Trucks in Design Lane	1 lane = 100, 2 lanes = 85, 3 lanes = 70, 4 lanes = 60
Compound Truck Weight Growth Rate	0.5%
Compound Truck Volume Growth Rate	2%

When the difference between the calculated design ESALs and the next lower ESAL design level is less than 10% of the lower ESAL mix design level, consideration should be given to using the lower design level. The Regional Materials Engineer should be consulted in these situations. (For example: Calculated ESALs are 10.3 million. Choose the <10 million design level instead of the <30 million level.)

Table 3-4 Functional Classification Code Descriptions (*Highway Sufficiency Rating*)

URBAN		RURAL	
Principal Arterial Interstate	11	Principal Arterial Interstate	01
Principal Arterial Expressway	12	Principal Arterial Other	02
Principal Arterial Other	14	Minor Arterial	06
Minor Arterial	16	Major Collector	07
Collector	17	Minor Collector	08
Local	19	Local	09

The selection and specification of asphalt for SUPERPAVE projects is dependent on numerous factors. Those factors are discussed below. Selection of items should be in accordance with the tables. Note that this discussion applies to mainline production paving. Shoulders and Truing and Leveling are discussed in Sections 3.2.4.5 H, I and J.

Location / Exposure - The Performance Graded Binder (PGB) used to bind the aggregate together shall be based on the environment that the binder will be subjected to. These effects can be taken into account by looking at geographic location as a substitute for temperature range. The designer will have to provide a special note in the proposal (see Section 3.2.4.5 D, Special Note Development) indicating which PGB shall be used in which locations.

Grade Bumping - Special deterioration conditions, such as wheelpath rutting, shoving or corrugations, may occur where the pavement is subjected to higher than normal loads. Problems occur where traffic is heavy (20 year ESALs exceed 10 million), the grade exceeds 4%, or where traffic is regularly accelerating or decelerating, such as at intersections. Table 3-5, Performance Graded Binder Selection, defines which PGB is to be used as the "bumped grade" when 1) the traffic level is greater than 10 million ESALs based on a 20 year design life or 2) the traffic level is greater than 3 million ESALs and the roadway segment contains (a) grades in excess of 4.0% or (b) intersections that have traffic control signals (3 light signal).

Repetitive Stress - ESAL-based pavement design is based on the premise that pavement damage is directly related to the heaviest load that the pavement is subjected to. ESAL-based design adjusts for this factor by estimating the total number of equivalent single axle loads that the pavement will be subjected to over its design life. The equivalencies are discussed in the PTDM. Basically, many light loads, such as those produced by passenger vehicles, are needed to produce the same distress as is produced by one heavy load. At the other extreme, one very heavy load will cause the same distress as numerous heavy loads. With ESAL-based designs, the pavement thickness is increased as a function of the ESALs. With SUPERPAVE, the asphalt binder and mix selection itself will also be a function of the heavy loads. See the beginning of this section for a discussion of the differences in determining ESALs for pavement structure and for mix selection.

Friction - Pavement friction is dependent upon the coarse aggregate in the top course and, in time, the volume of traffic (AADT) passing over it. In areas where high traffic volumes are anticipated, aggregates having the appropriate resistance to polishing must be used. Different friction aggregate requirements are specified in certain locations in the state or where the pavement is considered to be high volume.

Functional Classification - The functional classification of a highway, whether it is a U11 - Urban Principal Arterial Interstate, an R06 - Rural Minor Arterial, or other, is also factored into the selection process, even though the classification typically will not reflect pavement wear and distress as directly as will the ESAL count and the AADT. The full list of classifications, based on the system used in the Department's *Highway Sufficiency Rating Manual*, is presented in Table 3-4.

Neighborhood Sensitivity - A key means of obtaining long-lasting pavements is to ensure that the material is thoroughly compacted. By carefully selecting the gradation and using appropriate compactive effort, a dense pavement can be obtained. However, this compactive effort may be so

high that it could potentially damage sensitive structures, such as weak, old masonry structures that are in close proximity to the work. Where any of the neighborhood structures are potentially subject to damage from vibratory compaction, asphalt specifications with a lower compactive effort requirement (Section 3.2.4.5 B) should be used and notes should be included on the plans and Special Notes in the proposal indicating that vibration either 1) shall not or 2) should not be used during compaction of the asphalt in that area. Refer to Section 3.2.4 for sample Notes.

Monitoring Considerations - As mentioned above, a primary concern in monitoring the quality of the product is assuring that the appropriate compaction has been achieved. On large jobs, it is reasonable to use a direct method, such as coring, to verify the density. On smaller jobs, it is reasonable to use indirect methods, such as nuclear density gauge readings to evaluate density. Since the method of monitoring the density is part of the specification for the item, the designer needs to include this decision in selecting which item to specify. Smaller jobs will be considered as those where less than 5000 Mg (metric tons) of each course is placed in a single location.

A. Gradation Considerations

Binder Course - The choices in maximum aggregate size for the binder course are 19.0 mm and 25.0 mm. The larger 25.0 mm size should be used for pavements with an estimated 20 year ESAL count of over 3 million. Larger aggregate sizes require greater lift thicknesses to ensure thorough compaction.

Top Course - In some regions, particularly the southern tier, sources of good quarry aggregate are limited and reliance is placed on gravel deposits which may contain unsound material. To help remove the unsound material and create angular faces, gravel should be crushed and screened. As a result of this process, the overall size of the aggregate available for use in asphalt pavements is reduced. To accommodate this, the Regional Materials Engineer may approve the use of a top course mix with a maximum nominal aggregate size of only 9.5 mm, rather than the preferred 12.5 mm. Designers of projects in affected areas should be aware of this issue and make sure that the Regional Materials Engineer has been consulted to determine the appropriate gradation to specify.

B. Interpreting Item Numbers

An item number, such as 18403.376131 may be interpreted as follows.

Responsible Organization - The first two digits indicate the organization that developed or issued the item number. In the example above, the 18 designates that the Special Specification was developed by, or on behalf of, the Materials Bureau. Refer to Chapter 21, Section 21.3.1 for a full listing of the designations.

General Item Number - The three digits to the left of the decimal place. In the example above, 403 designates Hot Mix Asphalt.

Nominal Maximum Size - The two digits to the right of the decimal indicates the nominal maximum aggregate size in millimeters. In the example, the 37 indicates that the dimension of the nominal maximum aggregate is 37.5 mm, which is a base course mix. Top course mixes include 9.5 mm and 12.5 mm, and the binder course mixes include 19.0 mm and 25.0 mm. The 9.5 mm mix should only be used when recommended by the Regional Materials Engineer. Use of the 19.0 mm binder mix should only be considered when the computed ESALs are < 3.0 million, in which case it's use is preferred.

Field Compaction Procedures - The third digit after the decimal indicates the compaction monitoring requirements to be utilized in the field. A 5 indicates the highest level of compaction monitoring which requires the Contractor to take daily cores of the each day's new pavement. A 5 should always be specified on full and partial access controlled pavements.

The 6 in the example above indicates that pavement density monitoring is performed using a density monitoring device, such as a nuclear density gauge. For correlation to density testing, pavement cores are taken from the test section with additional cores taken at the discretion of the EIC. The cores are used to determine if a quality adjustment factor (QAF) will be applied. A 6 should be specified for all pavements where a 5 or 7 is not appropriate.

A 7 indicates that pavement density will be monitored using a density monitoring device, without coring, and that the Target Density will be established by 'peaking out' the density monitoring device during the compaction of the test section. ('Peaking out' occurs when the gauges detect no significant increase in density in spite of continued efforts to compact the test section.) All devices that will be used for subsequent monitoring of the production compaction must be calibrated during the compaction of the test section. A 7 should always be used 1) in areas where the Regional Materials or Geotechnical Engineer judges that there may be a vibration sensitivity problem and the possibility of damaging homes, historic sites, etc. due to excessive vibration during compaction, or 2) when less than 5000 Mg (Metric Tons) of each course will be placed in a single location. If a 7 is specified due to vibration concerns, notes should be provided on the plans indicating where vibration should not be used. In addition, a Special Note should be provided in the Proposal indicating that the test section should be compacted without vibration and that given areas, or the entire project, are not to receive vibration during compaction.

Friction Aggregate - The fourth digit after the decimal place is either a 1 or a 2, indicating the type of friction aggregate to be used. A 1 should be specified on all roadways, regardless of traffic volume, in Dutchess, Orange, Rockland, Putnam, Westchester, Nassau, and Suffolk counties and the City of New York and in all other counties on roadways with a design year two-way AADT \$ 8000 for 2 or 3 lanes or \$ 13000 for more than 3 lanes. A 2 should be specified on roadways (in counties not specified above) with a design year two-way AADT < 8000 for 2 or 3 lanes or < 13000 for more than 3 lanes.

Quality Units - The fifth digit after the decimal place has been reserved for quality payment adjustments, which are applicable to all hot mix asphalt mixtures paid for by the ton. A 0 is reserved for the Specified Contract Item. In preparing typical sections and calling out items, the designer should only use a 0 in this position. The contract, however, should have individual items for each quality adjustment factor specified for that project by the Materials Engineer. A 1 indicates a quality payment adjustment for Plant Production, and will be included in all

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contracts that include Hot Mix Asphalt Items paid for by the ton. A 2 indicates a quality payment adjustment for Pavement Density, which will be included in high level compaction projects. Some adjustment factor items will be used less frequently. In the example above, for instance, the 3 indicates a quality payment adjustment for Longitudinal Joint Density. A 4 indicates a quality payment adjustment for Pavement Smoothness. Quality payment adjustment for other pavement properties may also apply in the future.

Revision Number - The sixth digit after the decimal place is used to display the revision number. The 1 in the example indicates that it is the first version of the specification.

C. Performance Graded Binder Selection

Currently, it is necessary to select, and indicate on the first typical section in the plans that calls out asphalt items, the specific performance graded binder to be used. While guidance on the selection is provided below, designers should confirm all choices with the Regional Materials Engineer before finalizing the binder selection.

Table 3-5 indicates the performance graded binder (PGB) that should be specified for each "temperature zone".

Table 3-5 Performance Graded Binder Selection

Location by County	Location by Latitude	Dominant Performance Grade and (Spec Number)	PGB Grade Bumping ¹	
Jefferson, Lewis, St. Lawrence, Franklin, Clinton, Essex, and the northern sections of Herkimer, Oswego, Hamilton, Warren, and Washington Counties	> 43°-30'	58 -34 ² (702-5834)	---	
All Other Counties	# 43°-30' and \$ 41°-30'	58 -28 (702-5828)	64 -28 (702-6428)	
Orange, Putnam, Rockland, Westchester, Nassau, Suffolk Counties and City of New York	< 41°-30'	64 -22 (702-6422)	70 -22 (702-7022)	76 -22 ³ (702-7622)

1. These grades should be used if 1)the traffic level is greater than 10 million ESALs based on a 20 year design life or if 2)the traffic level is greater than 3 million ESALs and the roadway segment contains (a) grades in excess of 4.0% or (b) intersections that have traffic control signals (3 light signal). See beginning of Section 3.2.4.5 for discussion of ESAL counts.
2. A 58 -28 may be used when a single course overlay is being placed.
3. The use of a PG 76-22 requires the approval of the Regional Materials Engineer.

D. Special Note Development

The specification of the binder grade and the mixture’s design level of “80 kN ESALs” must be conveyed to the Contractor in the form of a Special Note in the proposal. The note should read as follows:

“The Contractor should be aware that this is a performance-related specification in which the Contractor is responsible for compacting the pavement within a specified density range. The Contractor must be prepared to select, operate, and control the paving and compaction equipment, to monitor the results, and to make necessary adjustments (without direction from the Engineer) to achieve the specified density results. Written instructions for determining pavement density and core locations are available from the Regional Materials Engineer or the Director, Materials Bureau.

The Performance Graded Binder used in the production of SUPERPAVE Hot Mix Asphalt mixtures shall be a PG [XX-XX] as defined by AASHTO Provisional Standard MP1 - Standard Specification for Performance Graded Asphalt Binder. [YYYY] The mixture designs must be developed in accordance with the criteria specified in the SUPERPAVE Hot Mix Asphalt Items that are appropriate for an “Estimated Traffic” level of [ZZZ] “Million 80 kN ESALs”. Under no circumstances shall the Performance Graded Binder content in the hot mix asphalt be less than 5.6% for a 9.5 mm design, 5.0 % for a 12.5 mm design, 4.3% for a 19.0 mm design, or 4.0% for a 25 mm design.”

The bracketed portions of the Special Note may be substituted as follows:

<u>First Bracket [XX-XX]</u>	<u>Second Bracket [YYYY]</u>
[58-34]	[]
[58-28]	[A PG 58-34 or PG 64-28 may be substituted for the PG 58-28 at the Contractor's discretion.]
[64-28]	[]
[64-22]	[A PG 64-28, 70-22 or 76 -22 may be substituted for the PG 64-22 at the Contractor's discretion.]
[70-22]	[]
[76-22]	[]

Third Bracket [ZZZ] Use [<0.3], [<1], [<3], [<10], [<30], [<100], or [\$100] as appropriate. (The “Estimated Traffic” level for Parkways shall be “<3.0 Million 80 kN ESALs”).

Note: The first and second bracket (PG grade) are dependent upon each other, however **the third bracket** (ESAL level) **is independent** of the first and second brackets.

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Selecting the total thickness of the asphalt section (how much base, binder and top) will depend on the requirements discussed earlier for either conventional asphalt design (Section 3.2.4.3) or ESAL-based design (Section 3.2.4.4). For some low volume roads, the minimum course thicknesses may actually govern. Selection of the specific SUPERPAVE asphalt item type will involve four decision steps as laid out moving from left to right in Tables 3-6 and 3-7. The decisions are as follows.

1. What is the project's Functional Classification?
2. If it has a Principal Arterial classification, does it have either Full or Partial Control of Access, or not?
3. What is the project's location, 20 year ESAL count, and AADT/lanes relationship? For the tables, the City of New York, and the surrounding counties of Dutchess, Nassau, Orange, Putnam, Rockland, Suffolk and Westchester are referred to as 'downstate'. All other areas are referred to as 'upstate'. 'High volume' refers to 2 or 3 lane highways with design year two-way AADTs over 8000, or for more than three lanes, with two-way AADTs over 13,000. Low volume refers to highways with lower volumes for the specified number of lanes.
4. Does the project involve less than 5000 Mg of each lift or is it in proximity to areas where vibratory compaction may be a problem?

Within each section of tables 3-6 and 3-7, the subdivision of choices places the preferred, longer-lasting pavement option first.

F. Specialty Top Course Mixes

Information regarding Superpave Ice Retardant Top Course and Type 10FX Open-Graded Surface Course may be found in Appendix A.

Table 3-6 Pavement Selection for Principal Arterials

Functional Classification	Full/Partial Control of Access	Downstate ¹ OR High Volume	Over 5000 Mg AND NOT vibratory sensitive	Mix Type
U11 - Urban Principal Arterial Interstate	Yes	18403.ZZ51QR (Top and Binder) 18403.3761QR (Base)		
U12 - Urban Principal Arterial Expressway		Yes	Yes	18403.XX61QR
U14 - Urban Principal Arterial	No		18403.XX71QR	
Other	No		Yes	18403.XX62QR
R01 - Rural Principal Arterial Interstate		No	No	18403.XX72QR
R02 - Rural Principal Arterial				
Other				

1. The City of New York, and the surrounding counties of Dutchess, Nassau, Orange, Putnam, Rockland, Suffolk and Westchester are referred to as 'downstate'. All other areas are referred to as 'upstate'. 'High volume' refers to 2 or 3 lane highways with design year two-way AADTs over 8000, or for more than three lanes, with two-way AADTs over 13,000. Low volume refers to highways with lower volumes for the specified number of lanes.
2. ZZ aggregate size may be 25.0 mm for binder, 12.5 mm or 9.5 mm for top. Note that 9.5 mm top requires concurrence of Regional Materials Engineer.
3. XX aggregate sizes may be 37.5 mm for base, 25.0 mm or 19.0 mm for binder, 12.5 or 9.5 mm for top. Note that 25.0 mm aggregate size for binder is required when the 20 year ESAL projection is greater than 3×10^6 . The 19.0 mm aggregate size binder is preferred for ESAL projections less than 3×10^6 . Note also that 9.5 mm aggregate size for top requires concurrence of the Regional Materials Engineer.
4. Q has been reserved for Quality Payment Adjustments.
5. R has been reserved for Revision Number.

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Table 3-7 Pavement Selection for General Highways

Functional Classification	Downstate ¹ OR High Volume	Over 5000 Mg AND NOT vibratory sensitive	Mix Type
U16 - Urban Minor Arterial	Yes	Yes	18403.XX61QR
U17 - Urban Collector		No	18403.XX71QR
U19 - Urban Local			
R06 - Rural Minor Arterial	No	Yes	18403.XX62QR
R07 - Rural Major Collector		No	18403.XX72QR
R08 - Rural Minor Collector			
R09 - Rural Local			

1. The City of New York, and the surrounding counties of Dutchess, Nassau, Orange, Putnam, Rockland, Suffolk and Westchester are referred to as 'downstate'. All other areas are referred to as 'upstate'. 'High volume' refers to 2 or 3 lane highways with design year two-way AADTs over 8000, or for more than three lanes, with two-way AADTs over 13,000. Low volume refers to highways with lower volumes for the specified number of lanes.
2. XX aggregate sizes may be 37.5 mm for base, 25.0 mm or 19.0 mm for binder, 12.5 mm or 9.5 mm for top. Note that 25.0 mm aggregate size for binder is required when 20 year ESAL projection is greater than 3×10^6 , but 19.0 mm is preferred for lower projections. Note also that 9.5 mm aggregate size for top requires concurrence of Regional Materials Engineer.
3. Q has been reserved for Quality Payment Adjustments.
4. R has been reserved for Revision Number.

G. Lift Thickness Limitations

In general, minimum lift thicknesses are constrained by the maximum size of the aggregate that is to be compacted. Maximum lift thicknesses are set to ensure that the full thickness of the lift is adequately compacted. If the required course thickness (structural requirements in Sections 3.2.4.3 and 3.2.4.4) of a given item exceeds the maximum permissible lift thickness, then multiple lifts are to be used to obtain the required course thickness. The following table lists the minimum and maximum lift thicknesses for the various nominal maximum aggregate sizes.

Table 3-8 Limits on Permissible Lift Thicknesses

Maximum Nominal Aggregate Size (mm)	Minimum Lift Thickness (mm)	Maximum Lift Thickness (mm)
37.5	75	125
25.0	50	75
19.0	40	75
12.5	40	50
9.5	40	50

H. Designed Pavement Shoulders

Design of the shoulder section is discussed in Section 3.2.5 and elsewhere. With respect to materials, any shoulders requiring base or binder should use the same base and binder items as the mainline pavement. The specifications for those items allowed reduced frequency of testing for their use in shoulders. For the shoulder surface course, either an Item 18403.1282QR or 18403.9582QR may be used for all Functional Classifications. These items do not require friction aggregate. These mixtures must be used with the appropriate matching main-line top course (i.e., use the 12.5 mm nominal shoulder mixture with a 12.5 mm mainline mixture). The thicknesses of shoulder top courses shall be identical to those of the mainline.

I. Optional Flexible Shoulders

Note that, as of the date of this revision, efforts are under way to provide guidance on thickness designed shoulders that will essentially end the specifying of Optional Flexible Shoulders. In the meantime, if Optional Flexible Shoulders are specified, Item 18303.0182QR should be used. This will permit the Contractor the option of selecting from up to five alternative flexible shoulder systems. On a given project, the designer should insert a Special Note in the proposal if any of the options are to be precluded. No friction aggregate requirements exist for this Item.

J. Truing and Leveling

Item 18403.2182QR is the SUPERPAVE Truing and Leveling item, which should be used to establish the proper cross-slope and grade. Selection of the appropriate mixture should be left to the discretion of the project Engineer-In-Charge depending on the thickness needed for the truing and leveling course. No friction aggregate requirements exist for this item and it may be used for all Functional Classifications.

3.2.4.6 Subgrade Considerations

Regardless of the design procedure used, the pavement structure should be supported on a properly prepared subgrade. Chapter 9 - Soils and Foundations contains detailed information on the many issues and options available. The PTDM also has a brief discussion. Only a generalized introduction is presented below.

Once the alignment has been determined, the Regional Geotechnical Engineer will determine the amount of subsurface testing and investigation that is required and will subsequently identify the need for any special subgrade preparation procedures such as preloading, surcharging or undercutting for placement of select granular subgrade, and, if so, the required depth of cut, the type and thickness of fills, and any special sequencing requirements. The Standard Specifications, Section 203-Excavation and Embankment, cover materials and placement requirements. In general, where embankment fill is required, suitable material is used to bring the embankment up to subgrade surface. Suitable material is generally defined as any inorganic soil, blasted or broken rock and similar materials of natural or man made origin, or mixtures thereof. In the subgrade area, usually defined as the 0.6 m zone below the subgrade surface, particles greater than 150 mm in maximum dimension are not permitted.

In situations where the Regional Geotechnical Engineer has determined that the existing soils in the subgrade area are potentially susceptible to frost heave and/or offer poor foundation support, placement of a layer of Select Granular Subgrade under the subbase course may be specified. When used as a frost layer, the thickness is normally limited to 600 mm, but may be up to 900 mm, or occasionally more, when used for subgrade stabilization. The specific type of treatment and its geometry will be determined by the geotechnical engineer to suit the actual conditions encountered. One likely set of placement details is shown for illustrative purposes in Figure 3-3. Note that drainage is usually provided at the low point of the select granular subgrade.

The use of edge drains is standard for ESAL-based designs. An edge drain consists of two functioning components: the pipe and the underdrain filter material. The standard construction sequence should consist of 1) excavation of a 300 mm wide trench, 2) placement and grading of 100 mm of underdrain filter material, 3) positioning of the pipe, and 4) placement and compaction of additional underdrain filter material up to the working surface. Refer to Figure 3-6. The lateral position of the drain is intended to prevent it from being damaged when guide rail posts are driven.

The depth of the pipe should provide positive drainage for the permeable base and subbase, yet be high enough to permit the outlet pipe and the underdrain filter material to daylight above the finished invert of the roadside ditches. The preferred depth for the bottom of the edge drain trench is 300 mm below the bottom of subbase, with the pipe invert being placed 200 mm below the bottom of the subbase. In some situations, particularly on older, lower volume roads, the roadside ditch invert may not be deep enough to permit positive drainage of edge drains placed at the preferred depth. In those instances, the designer may raise the edge drain pipe inverts as high 100 mm above the bottom of the subbase. If that depth still presents problems with positive drainage, consult the Regional Geotechnical Engineer.

It is desirable to have one consistent depth for the edge drains throughout a given project. However, the benefits of deeper edge drains should not be routinely abandoned for the sake of consistency.

If the areas where edge drain depth presents a problem are limited to discrete portions of the project, the designer should give serious consideration to specifying the preferred depth for most of the project and providing special details for those portions of the project where a shallower edge drain depth will be required.

The typical slope of the outlet pipe should parallel the subgrade surface to permit excavation of a consistent (to the limit of the subgrade surface) depth trench for pipe placement. Where closed drainage systems are being used and it will be feasible to stub into field inlets, etc., the Geotechnical Engineer should be consulted for the appropriate depth and location of the edge drain.

Similarly, for conventionally designed pavements, the Regional Geotechnical Engineer should be consulted as to the appropriate extent and location of edge drains. In general, edge drains are standard practice on rubblized sections and should be provided at sag vertical curves and along the low side of superelevated sections on new and reconstructed conventionally designed pavements. For further discussion and details, refer to Chapter 9.

In both conventional and ESAL-based sections, a Subbase Course, Item 304.XX, typically 300 mm thick, is constructed on the subgrade surface prior to placing the pavement items. Under the full depth portions of the pavement sections for both conventional and ESAL-based designs, the subgrade surface should parallel the top surface. In ESAL-based designs, the slope of the subgrade should parallel the slope of the shoulder out to daylight.

In conventional designs, the slope of the subgrade should change under normal shoulders to a 2% slope that should be carried either to daylight or to an edge drain section. The change in slope should occur at a point 0.3 m outside the edge of slab when a concrete pavement is used or at the outside edge of the bottom base course when asphalt pavement is used. Starting at the edge of traveled way, a 50 mm step-out should be allowed for each lift of asphalt that is 50 mm or less in thickness and a 100 mm step-out should be allowed for each lift of asphalt that is over 50 mm in thickness. Under heavy duty shoulders (see Section 3.2.5), the subgrade surface should parallel the top surface and should change to a 2% slope outside of the bottom lift of asphalt base course as described above. Under the shoulders, longitudinally, the transition of the subgrade surface from normal to heavy duty slopes and from heavy duty back to normal slopes should occur over distances of 10 m. For an illustration of the recommended subgrade surface slope changes, refer to Figure 3-4, Conventional Edge of Traveled Way Details.

Figure 3-3 Placement of Select Granular Subgrade

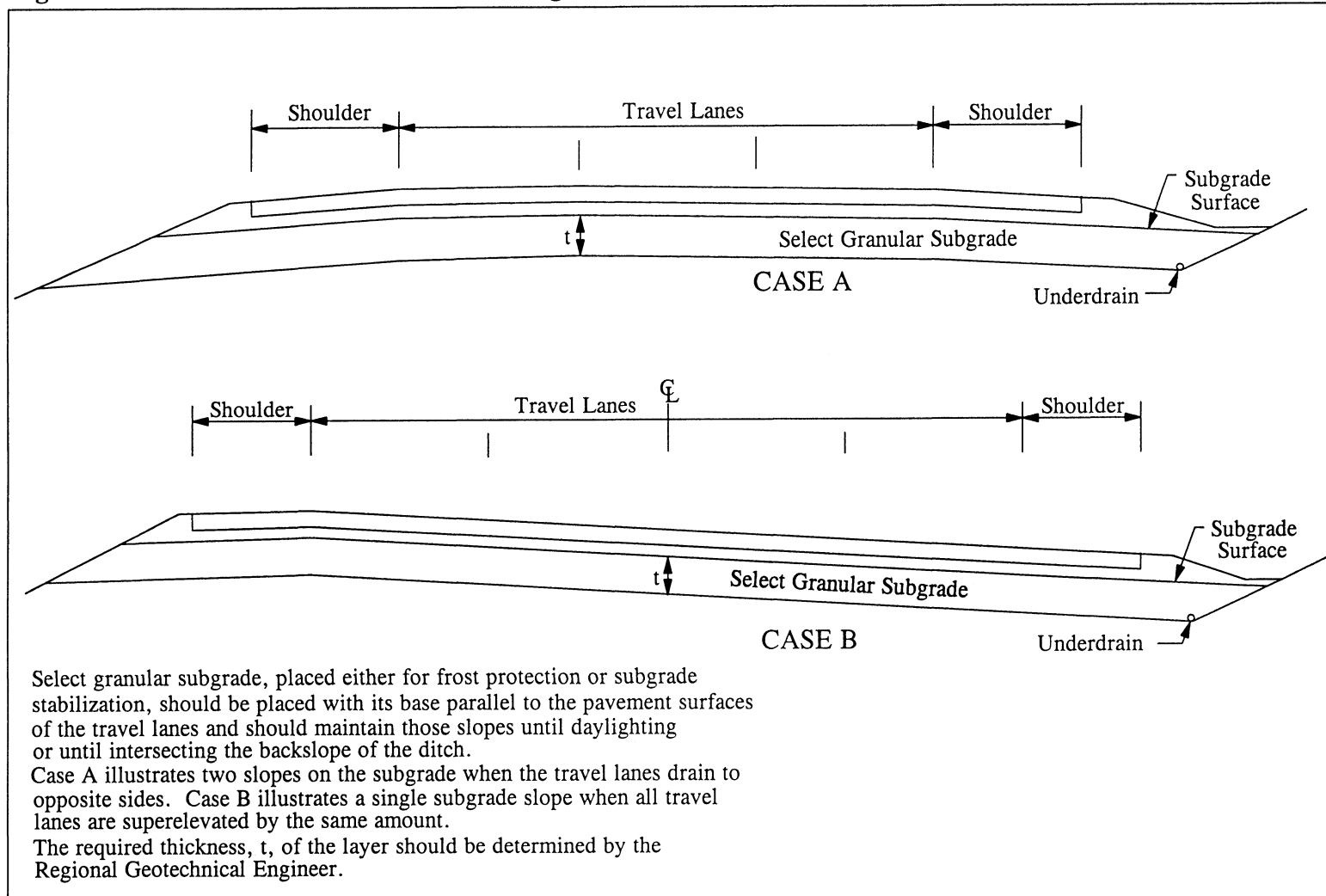
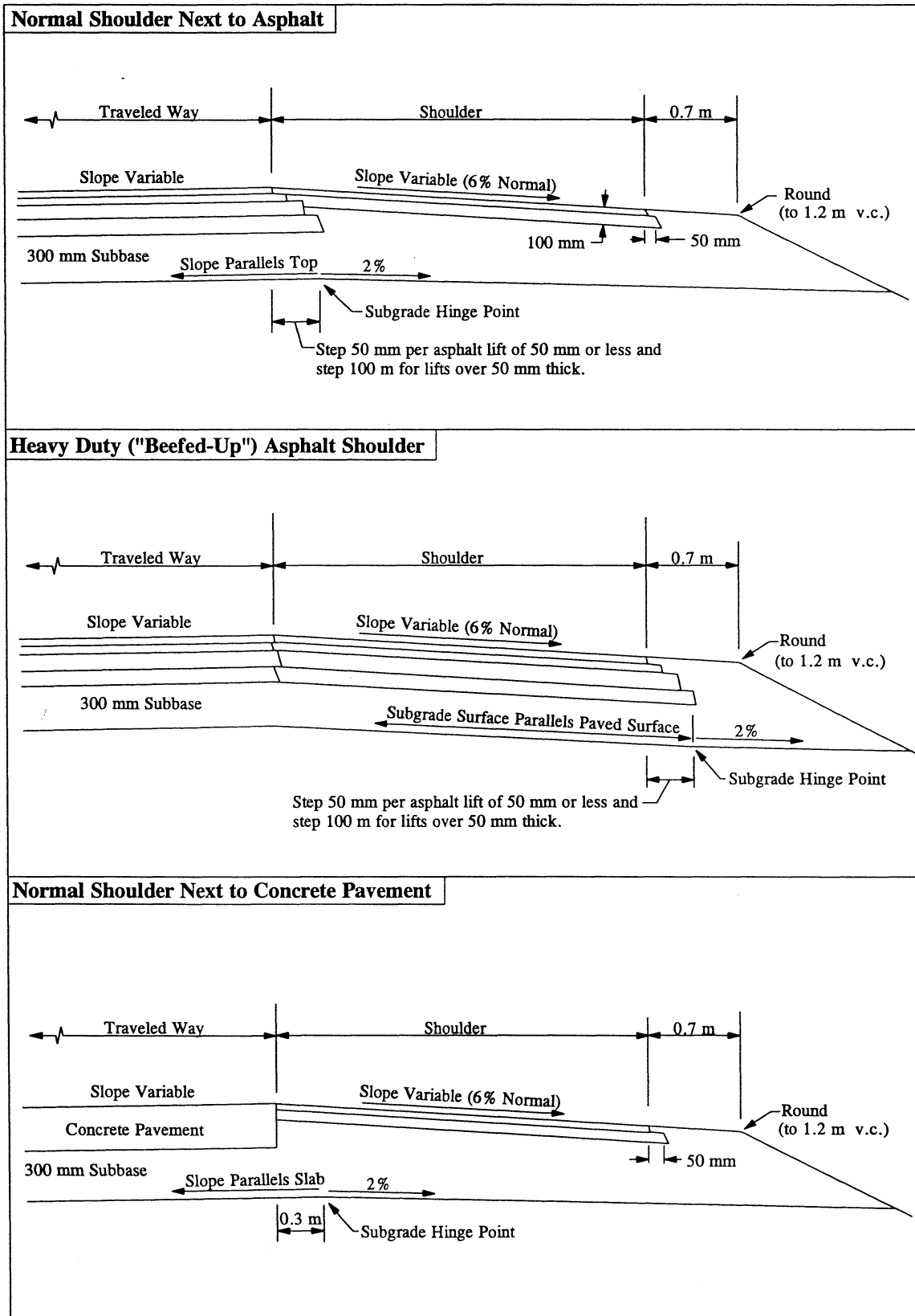


Figure 3-4 Conventional Edge of Traveled Way Details



3.2.5 Shoulders

In traditional NYSDOT usage, shoulders are considered to be a part of the roadway. Note, however, that the Vehicle and Traffic Law definition of roadway excludes the shoulders.

Shoulder width and horizontal clearance are two of the critical design elements defined in Chapter 2 and for which minimum requirements are provided. (Note again, the separate standards for 3R projects in Chapter 7.) Additional width and markings may be required to accommodate bicycle traffic. The typical sections are to indicate the widths of the shoulders. Where there will be several changes in width within the project area, a table should be included in the plans showing the station limits for the various widths. When a consistent width shoulder cannot be provided, such as on some 3R projects with restricted right-of-way, the maximum and minimum widths should be indicated on the section along with the word “varies”. Where highways cross railways at grade and on skews $\geq 30^\circ$, shoulders that may be used as bikeways should be locally widened to permit bicyclists to cross the rails at right angles. Refer to Chapter 18 for other bicycle facility guidance and for guidance on pedestrian use of shoulders. If an HMA shoulder is a designated bikeway or heavily used by bicyclists, the nominal maximum aggregate size of the top course should not exceed 12.5 mm, as coarser surfaces, while safe for bicycling, may be rough enough to lead bicyclists to choose to use the traveled way instead.

In some residential areas, particularly where no ditches or only shallow ditches are required, rutting problems may develop at the edge of the shoulder. Refer to Section 3.3.5 for a discussion of some of the measures that may be taken to address this problem.

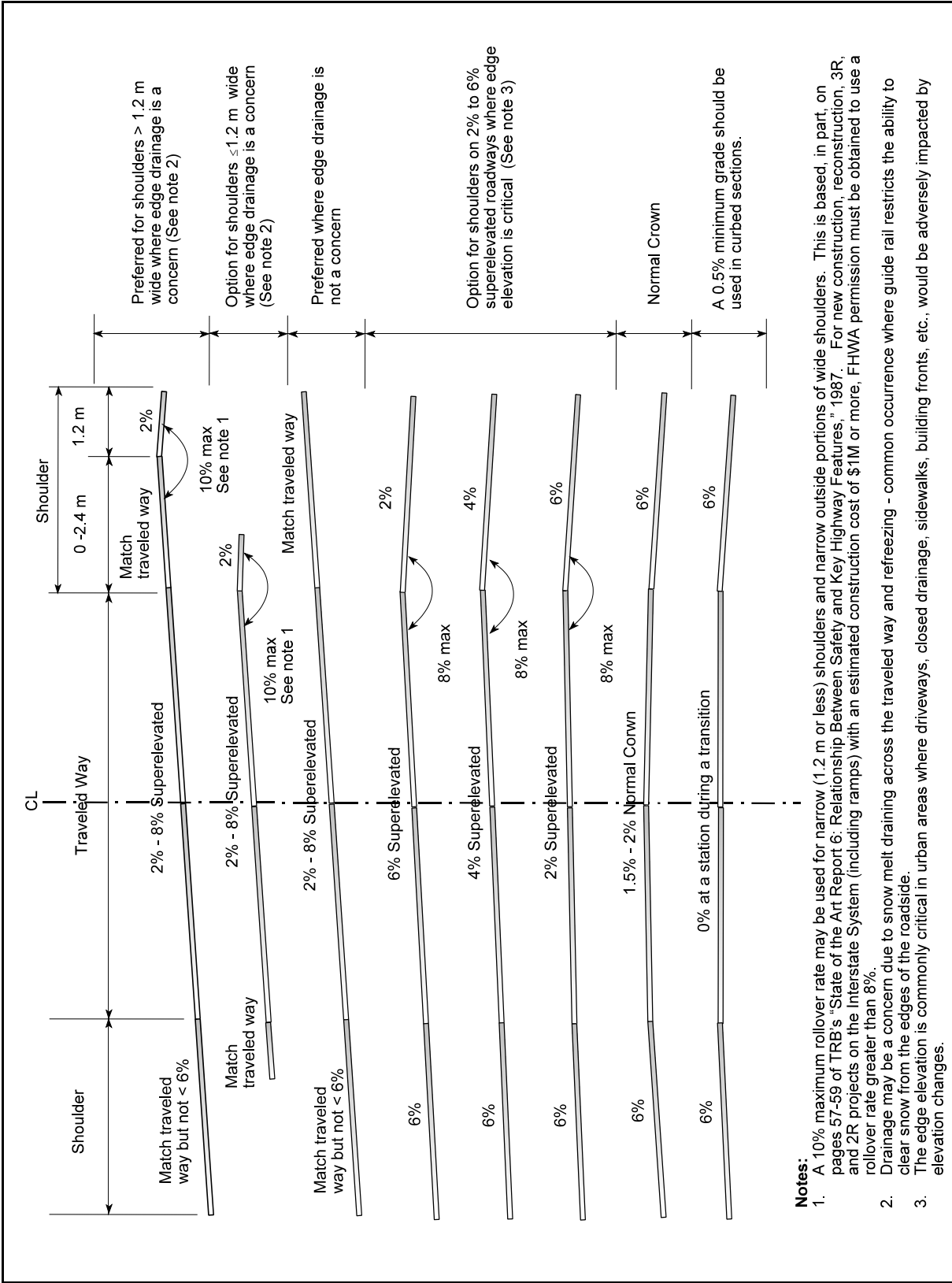
3.2.5.1 Shoulder Cross Slopes and Rollover Limitations

The normal cross slope for shoulders on a normal section or the low side of a banked curve should be 6%. When the lane is superelevated beyond 6%, however, the cross-slope of the low side shoulder should be increased to match that of the adjacent lane.

Rollover, the change in cross slope between two adjacent highway lanes or between a highway lane and its adjacent shoulder, is a critical design element. Chapter 2 lists the design criteria limit for rollover (algebraic difference in grades) between the traveled way and the shoulder. For all classifications of new and reconstructed facilities, the maximum rollover rate is 10% for narrow (1.2 m or less) shoulders and 8% for wide (greater than 1.2 m) shoulders. Cross slope breaks within the shoulder are not to exceed an algebraic difference of 10% where the breaks occur 1.2 m or less from the outside edge of shoulder and 8% where they occur greater than 1.2 m from the outside edge of shoulder. Where the traveled way is superelevated at 6% or less, an 8% maximum rollover rate is preferred for narrow shoulder widths. This means that where the traveled way is banked at 6%, a 1.2 m wide high-side shoulder should desirably be sloped no more than 2% away from the traveled way, and in no case more than 4% away from the traveled way.

For illustrations of requirements and guidance on the preferred shoulder slopes, refer to Figure 3-5 Recommended Rollover Combinations. Normally, the rollovers will occur 1.2 m from the edge of shoulder, but may also occur at the edges of the traveled way for HMA pavements and 0.6 m outside the right edge of the traveled way of new rigid pavements. For projects on the NHS, rollover rates over 8% are to be justified as nonstandard features per Chapter 2, Section 2.8 of this manual and approved in accordance with the Design Related Approval Matrix.

Figure 3-5 Recommended Rollover Combinations



3.2.5.2 Shoulder Thicknesses

[NOTE: The Department recently made the decision to use shoulder thickness designs that are based on the expected amount of heavy traffic that the shoulders would be subjected to over their target design life. The specific guidance should be issued within a few months of the issuance of this revision. Designers are advised to use that Engineering Instruction for shoulder thickness design once it has been issued.]

The 1994 PTDM (*New York State Thickness Design Manual for New and Reconstructed Pavements*, revision of October, 1994) issued the new shoulder thickness design policy for ESAL-based designs: full-depth tied PCC shoulders for rigid pavements and full-depth HMA shoulders for flexible pavements.

On conventionally designed shoulders, the normal thickness will be a minimum of 100 mm. The designer may specify Item 303.01, Optional Flexible Shoulder or may specify an equal or thicker section that is appropriate for the situation. Item 303.01 provides the contractor with several different options of courses and thicknesses to choose from to obtain the 100 mm minimum total thickness. Note that the Type I Optional Flexible Shoulder, which is only required to include 25 mm of top over 75 mm of bituminous stabilized course, should not be used where there is a likelihood that milled-in rumble strips (§ 3.2.5.4) will be added in the future.

Conventionally designed shoulders, including those on retrofit projects, must address the need for subgrade drainage. The Regional Geotechnical Engineer should be consulted for specific recommendations.

There are some locations where conventionally designed shoulders will typically be subjected to more than normal traffic. To prevent premature damage to the shoulders, these locations should be provided with more durable shoulders. The usual approach is to specify that the shoulder be constructed with the same section or a section equivalent to that used in the traveled way. This thicker than normal, heavy duty shoulder, often referred to as a "beefed-up" shoulder, should be used for shoulders on the inside of curves for ramps, intersections and turning lanes, and for shoulders opposite the leg of 'T' intersections.

Heavy duty shoulders for ramps and intersections with safety widenings (see Chapter 5, Section 5.10.5.5 D) should begin 6.0 m before the P.C. and terminate 3.0 m beyond the P.T. Where safety widening is not provided at an intersection, the heavy duty shoulder should begin 15.0 m in advance of the P.C. and end 3.0 m beyond the P.T.

Where right-turning movement AADTs exceed 2500 and the shoulder is likely to be illegally utilized, the heavy duty shoulder should begin 50 m in advance of the P.C. for the shoulder. Under adverse geometric conditions, where large design vehicles will have difficulty negotiating curves or corners without encroaching onto the shoulders, the designer should use truck templates to determine whether the heavy duty shoulder should be extended beyond the limits given above.

Bus traffic on shoulders, particularly starting and stopping, can cause rutting and/or rolling of HMA pavements. Where frequent bus traffic on the shoulders is anticipated, heavy duty sections should

be provided. Concrete stopping pads should be considered at designated transit stops. Local bus companies or transit authorities should be consulted to assess current and projected areas of need.

For a variety of reasons, shoulders on high volume highways should be designed for large volumes of traffic. These reasons include:

- ! Temporary detouring due to accidents, maintenance or construction,
- ! Legal or illegal use of shoulders as travel lanes during periods of high congestion, and
- ! Planned conversion of the shoulder to a travel lane.

For the above reasons, full depth pavement shoulders should generally be provided on reconstruction projects when the design year AADT exceeds 15,000 vehicles per lane per day. Consideration should also be given to providing full depth shoulders on high volume 3R projects when the inclusion of that work would not result in relatively large cost increases. Note that Revision 1 of the PTDM requires full depth shoulders for new and full width pavement reconstruction projects.

3.2.5.3 Shoulder Breaks

On all new or reconstructed highways, the nominal shoulder break should be a minimum of 0.7 m outside the edge of paved shoulder (to provide for present or future guide rail placement and to provide lateral support to the shoulder pavement). The shoulder break surface shall be rounded to a nominal 1.2 m vertical curve for aesthetics, ease of mowing, reduction of eddying that might promote snow drifting, and, most importantly, so that errant vehicles will be less likely to become airborne. Refer to Figures 3-6 for Typical Shoulder Details for ESAL-Based Asphalt Pavement Design and 3-7 for Typical Shoulder Details for ESAL-Based Concrete Pavement.

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Figure 3-6 Typical Shoulder Details for ESAL-based Asphalt Pavement Design

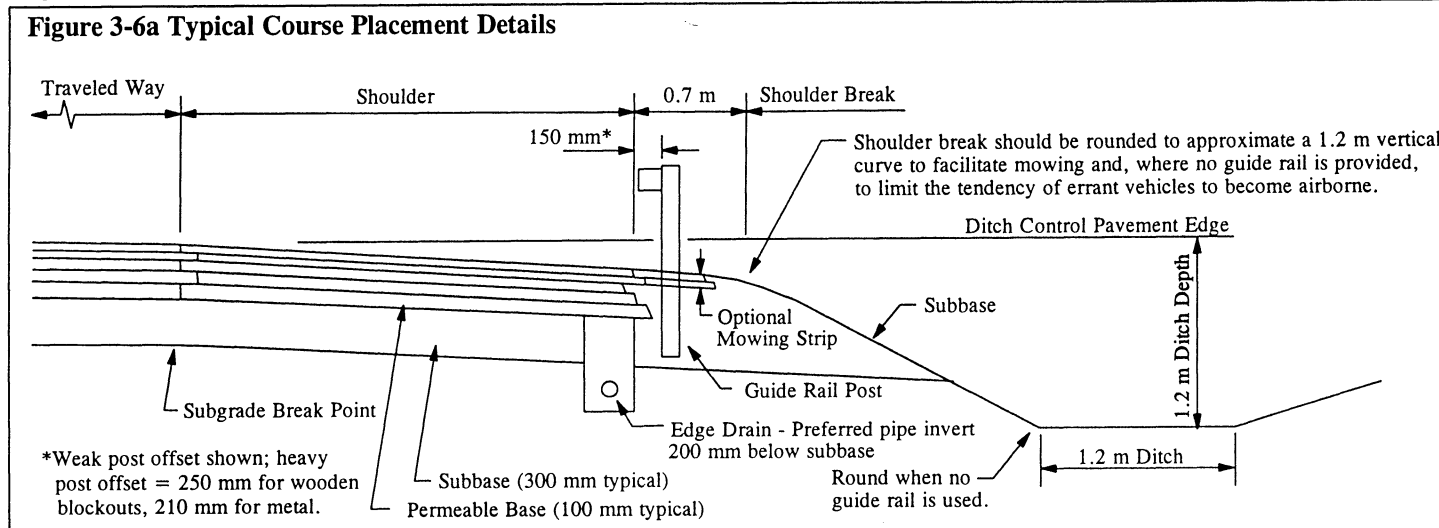


Figure 3-6b Typical Edge Drain and Outlet Detail

NOTE: When ditch depths are 1.2 m or less, foreslopes are 1:5 or flatter, pavement sections are thick and shoulder slopes are steep, the edge drain depth and outlet cross slope should be checked to ensure that outlet will be above ditch invert.

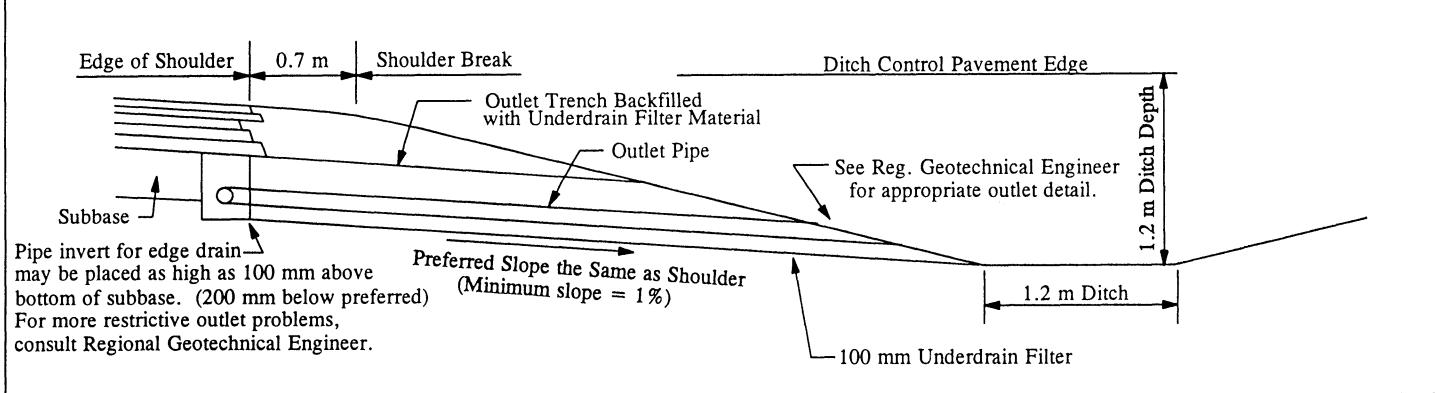


Figure 3-7 Typical Shoulder Details for ESAL-based Concrete Pavement Design

Figure 3-7A Concrete Shoulder with Guide Rail

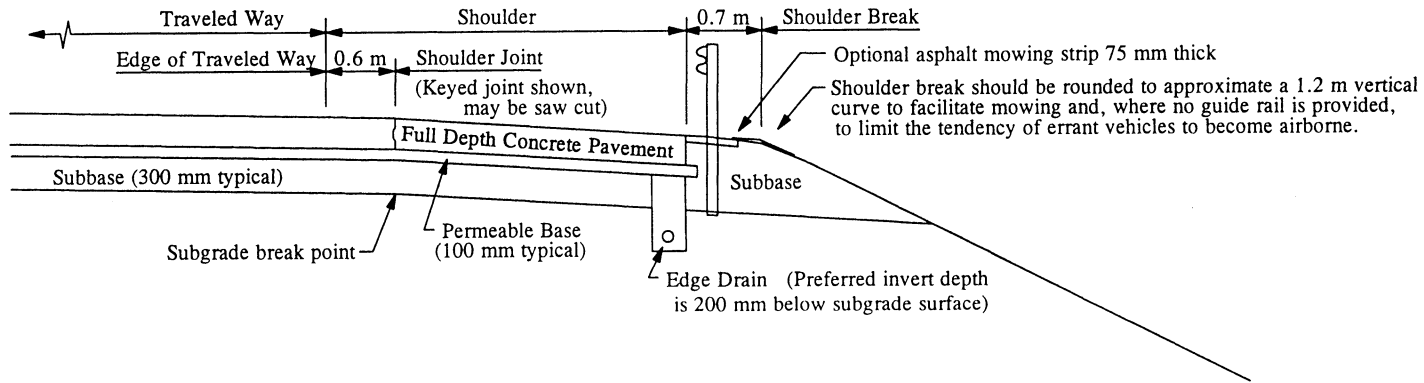
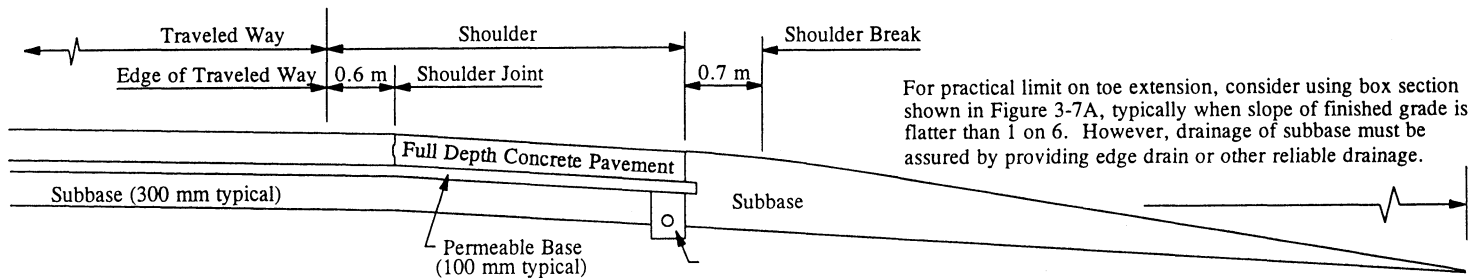


Figure 3-7B Concrete Shoulder without Guide Rail



Edge Drain - When outlet limitations make it impractical to place at preferred depth (see above), invert may be placed as high as 100 mm above subgrade surface. For more restrictive outlet problems, consult Regional Geotechnical Engineer.

NOTE: Thickness of concrete slab to be determined in accordance with the guidance found in The New York State Thickness Design Manual for New and Reconstructed Pavements.

3.2.5.4 Delineation of Shoulders

The boundaries of travel lanes warrant clear delineation. Much of the guidance on the necessary delineation is found in the NYS *Manual of Uniform Traffic Control Devices*, in the booklet *Pavement Marking Policy* issued in June 1987 by the Technical Services Division and in EI 87-30 *Pavement Marking Policy* issued in August, 1987. While the above delineation is important, it is generally not necessary to show it on the typical sections.

On highways with full or partial control-of-access, it will generally be appropriate for additional delineation to be provided by Audible Roadway Delineators (ARDs), which are also called safety shoulder rumble strips (SAFE-STRIPS). Safety shoulder rumble strips are very effective in reducing Drift-Off-Road (DOR) accidents. The Department is promoting their expanded use on limited access highways. In certain situations, consideration should also be given to using SAFE-STRIPS on highways other than those with some control of access. These situations would include: 1) limited stretches of highway or specific locations with a proven history of DOR accidents, 2) in advance of bridges where the shoulder substantially narrows, 3) at gore areas, and 4) as short warning strips on the outside of curves that follow long tangents.

It should be noted, however, that shoulder rumble strips can be a major interference for bicycle traffic and may cause bicyclists to spend more time in the traveled way. Therefore, where the nominal shoulder width is 1.2 m or less and bicycle traffic is permitted, shoulder rumble strips should not be used. On routes where bicycle traffic is permitted and the nominal shoulder width is 1.8 m, the decision to provide shoulder rumble strips should be reviewed by the Regional Traffic Engineer and the Regional Bicycle and Pedestrian Coordinator. On designated bicycle routes having shoulders with a nominal width of 1.8 m, if the decision is made to provide SAFE-STRIPS, the positioning and width of the strip should be such as to leave a nominal width of 1.2 m for bicycle traffic. The preferred means of accomplishing this is to use the milled-in geometry (400 mm width, see below and Figure 3-8A) at a 200 mm offset from the edge of traveled way. With wider shoulders, the shoulder is typically wide enough to accommodate both bicyclists and standard shoulder rumble strip arrangements, in which case the strip may act as a safety buffer between motorized vehicles in travel lanes and bicyclists on the shoulder.

One type of shoulder rumble strip, Milled-In Audible Roadway Delineators (MIARDs) may be ground into existing asphalt shoulders. They may also be ground into green concrete and cured concrete shoulders, but the effort and cost are substantially greater. Details of the MIARDs configuration are shown in Figure 3-8A. The broad depression permits some wheel drop and thereby produces a distinct vibration as well as a loud noise. Its effectiveness for large-tired, loud vehicles makes it the preferred type of safety shoulder rumble strip for most applications, particularly when a significant proportion of the traffic is large trucks.

A second, less-favored type of safety shoulder rumble strip is the Rolled-In Audible Roadway Delineator (RIARD), which is formed by compacting hot asphalt shoulders with a smooth drum steel roller to which 2.5 NPS pipe halves have been welded. The strips produce a noise when driven over at high speeds, but less than that produced by MIARDs and with much less vibration. Rolled-in strips are significantly less effective than the preferred milled-in type and may also encounter more constructibility and quality control problems, so their use should be limited. As use of denser, leaner

SUPERPAVE mixes becomes prevalent, increased difficulty is anticipated with the rolling-in operations. Because of the lower noise levels produced, RIARDs may be considered for use in well populated areas or in locations with little truck or bus traffic. Details are shown in Figure 3-8B.

There are two types of formed-in ARDs, which are made by forming impressions into freshly placed concrete. One type, Formed-In Corrugated Audible Roadway Delineators (FICARDs) consists of wide patches of corrugations approximately 600 mm by 600 mm. The other type, Formed-In Narrow Audible Roadway Delineators (FINARDs), are only about 180 mm wide by 400 mm long and approximate the shape of the MIARDs. The size and the spacing of formed-in impressions may be varied to suit the situation. Details are shown in Figures 3-8C and 3-8D.

When shoulder rumble strips are to be used on highways where access is not limited, adjustments may need to be made for the entrances. Of particular concern are cases where the traffic speed and volume of the mainline are high and there are driveways to adjoining property. It is undesirable to cause traffic exiting from a high speed, high volume highway to slow down in the traveled way before turning off of the highway as this may lead to rear end or sideswipe collisions. If deceleration lanes are not provided, it would be desirable to permit use of full width shoulders for deceleration. If rumble strips were run continuously across the entrance, or if only a short break were provided, drivers might be reluctant to use the shoulder to decelerate due to its bumpiness. The designer should use judgement in deciding how to apply rumble strips in the vicinity of entrances, taking into account the following factors.

- a) Mainline volume and speed - the higher these are, the less impediment there should be to using the shoulder for deceleration.
- b) Shoulder width - if the shoulder is not wide enough or appropriate to use as a deceleration lane, alteration of the rumble strip location may not be appropriate either.
- c) Exiting volume - if the exiting volume is low, such as for an individual residence, the nuisance will be limited to a few times a day. Where exiting volume is very low, such as for field entrances that may only be used a few times a year, no interruption in the rumble strips should be made. For high volume exits without deceleration lanes, such as for local roads or some businesses, the combined effects of the nuisance to drivers, the noise generated, and the potential damage to the rumble strips may warrant alteration of the strip location.

When it is judged that provision should be made to facilitate the shoulder's use for deceleration, the line of rumble strips should be set back on the shoulder to permit vehicles to straddle the rumble strips while slowing down. For instance, on a 2.4 m shoulder, the strip should be aligned in the middle of the shoulder for a distance of approximately 100 m prior to the actual exit. The setback should be achieved abruptly, preferably by terminating the line of rumble strips next to the traveled way and resuming it next to that point but in the middle of the shoulder. A continuous line should not be tapered over to the new offset as this could confuse night time drivers as to the location of the edge of the road and has had a poor appearance where it has been done.

The same strategy should be considered for deceleration lanes serving median cross-overs on divided highways. If the median deceleration lane is wide enough to accommodate a vehicle outside of the shoulder rumble strip, then the preferred location for the strip should be adjacent to the traveled way. If there is not adequate room for both, then either 1) consideration should be given

TYPICAL SECTIONS

to the possibility of widening the median deceleration lane or 2) the preferred location for the strip should be in the middle of the lane, with offset details as described above. (See Figure 3-8E.)

Further information concerning general policy, descriptions, installation criteria, specifications, layout and construction methods is presented in the Department's SAFE-STRIPS Policy developed by, and available from, the Traffic Engineering and Safety Division (EI 97-013). Because of their proven benefits (refer to NCHRP *Synthesis Report #191*), Safety Shoulder Rumble Strips should be a routine, standard design item on shoulders of rural limited access highways and other selected highways as described in the SAFE-STRIPS Policy. Generally, a site specific benefit-cost analysis will not be necessary to specify the use of SAFE-STRIPS.

Figure 3-8 Typical Shoulder Rumble Strip Details

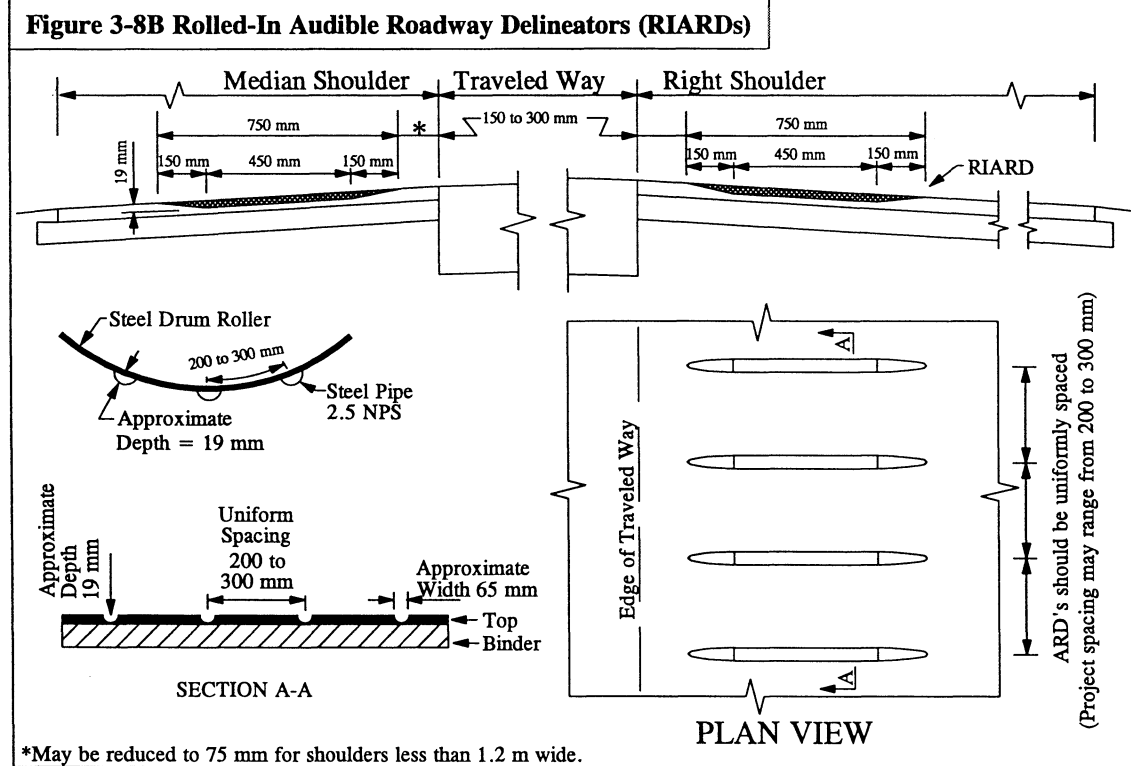
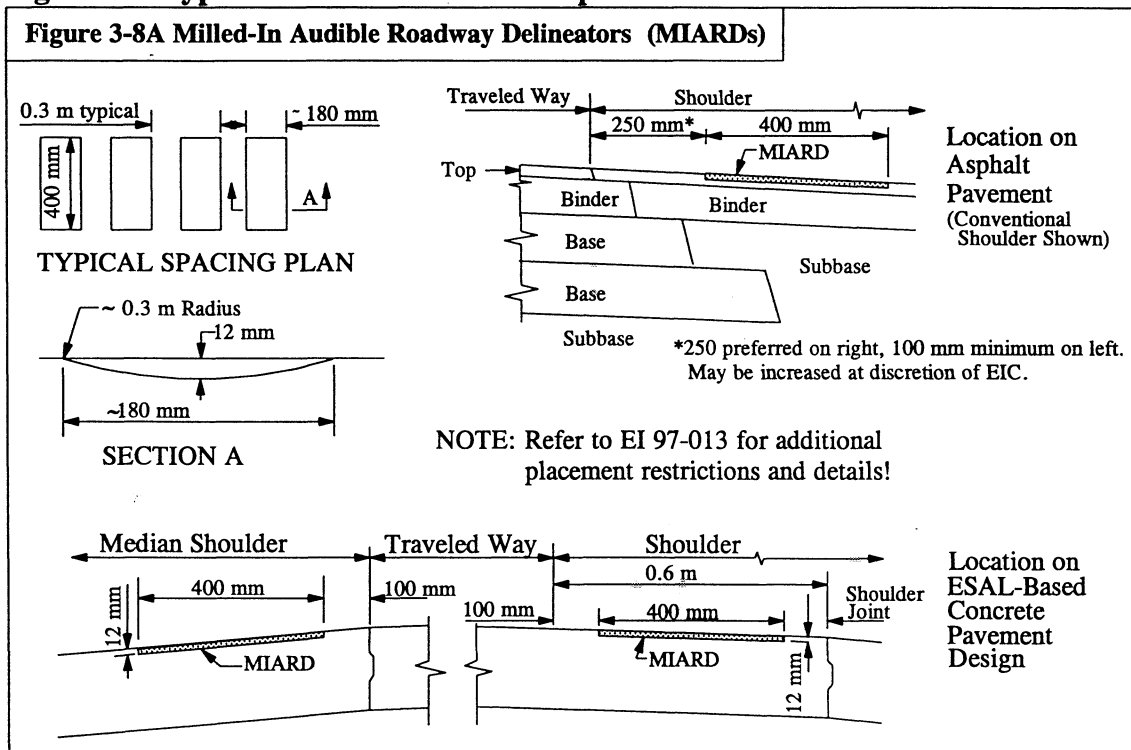


Figure 3-8 Typical Shoulder Rumble Strip Details

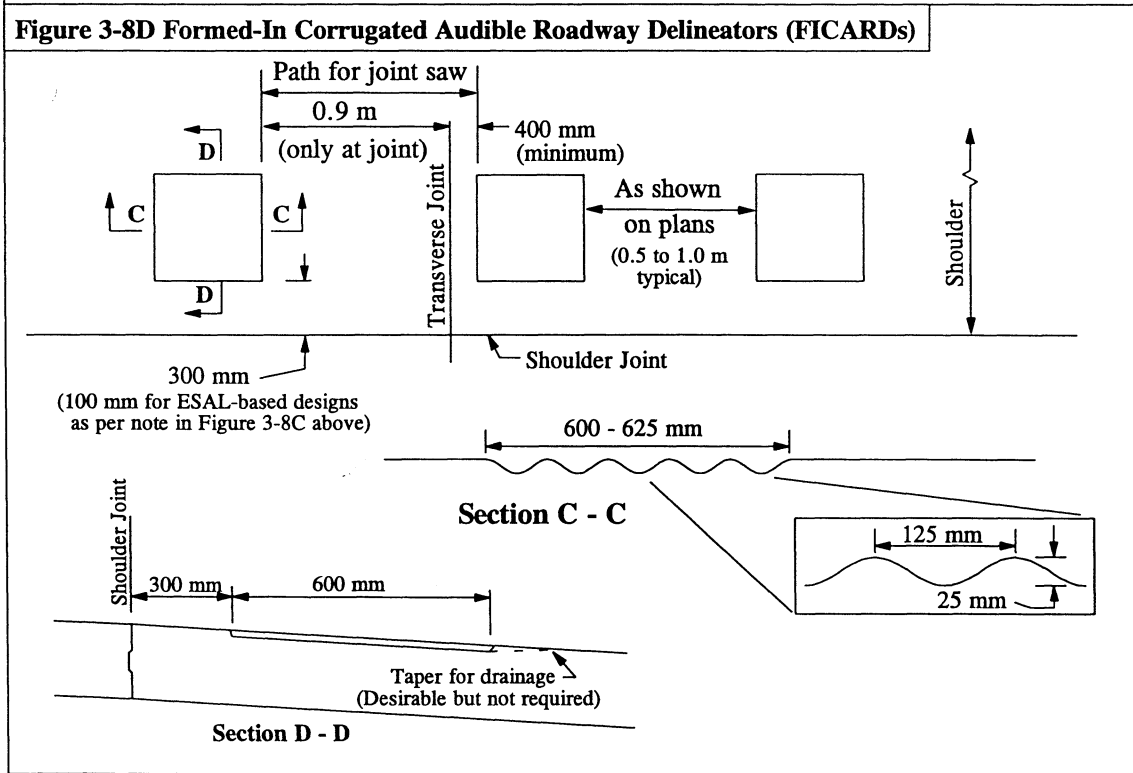
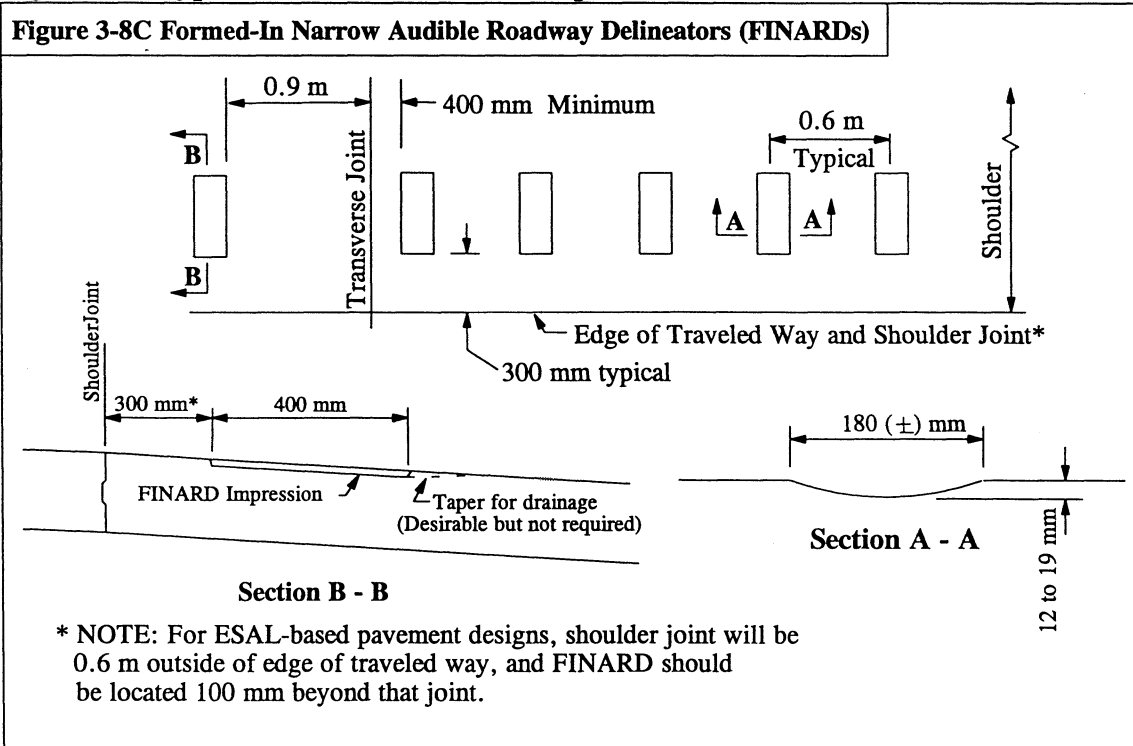
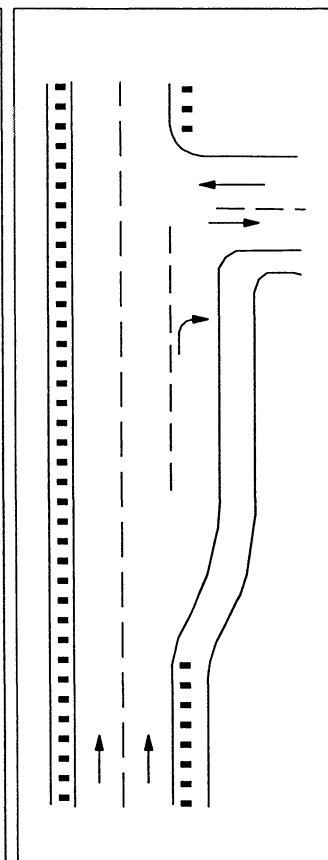
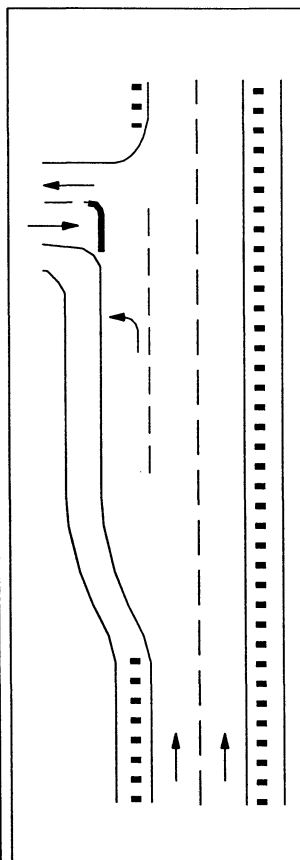
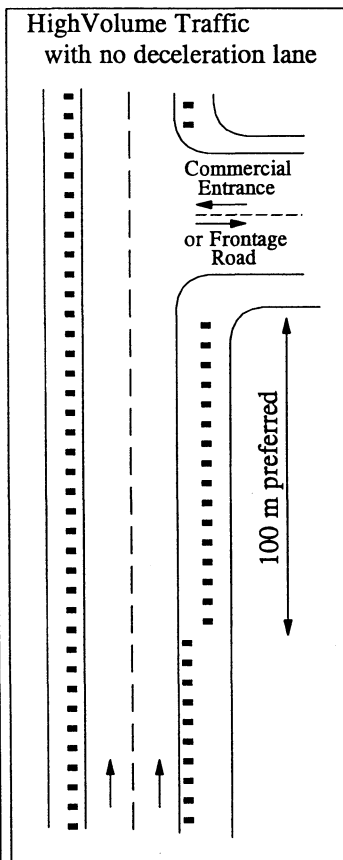
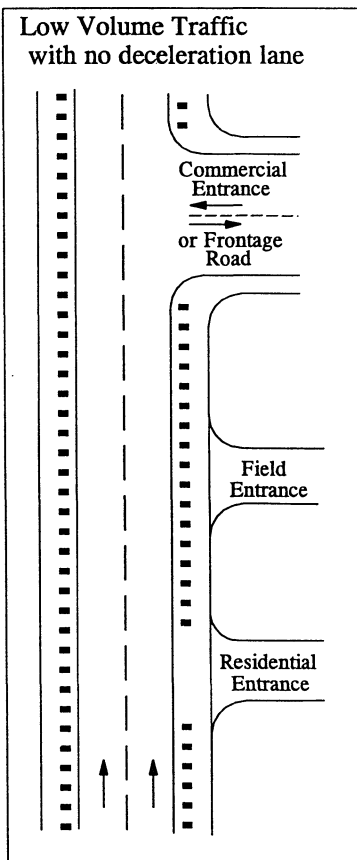
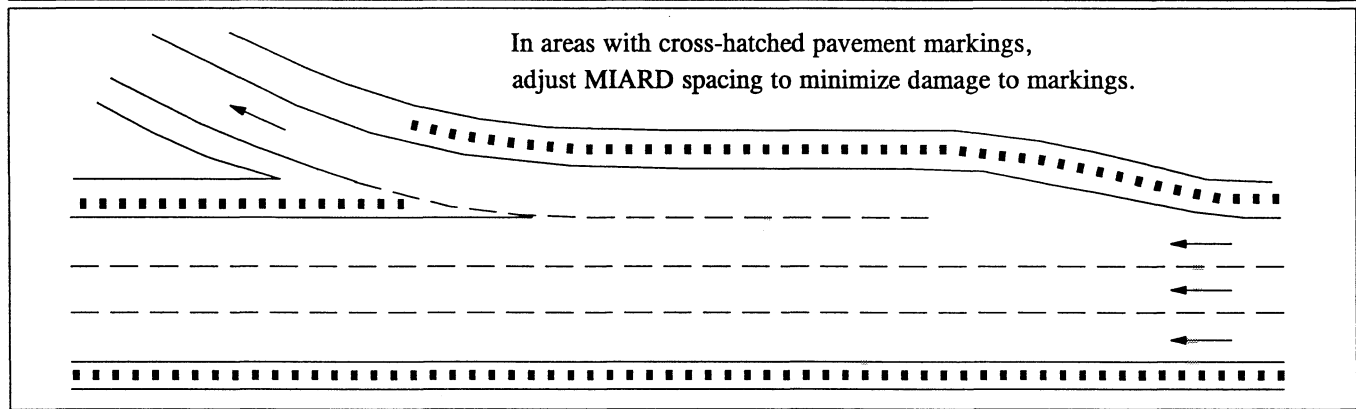
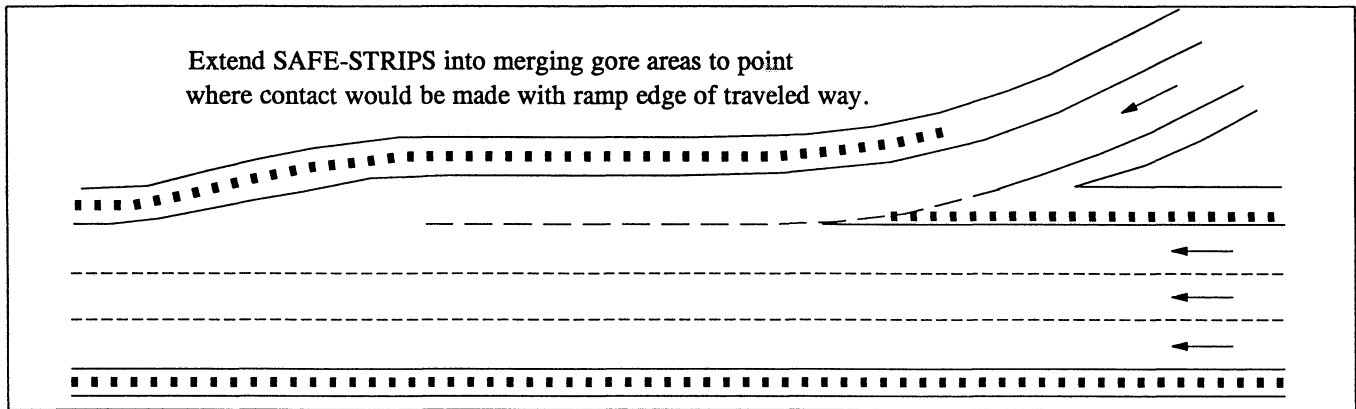


Fig 3-8E Recommended SAFE-STRIP Termination and Initiation Points



3.2.6 Clear Zone Widths

Chapter 2 defines and provides minimum requirements for lateral clearance. Lateral clearance may be thought of as the distance from the edge of traveled way to any element, curbs excluded, that may affect driver operation. Elements that are perceived as potential hazards may affect driver operation even though the elements are not actually hazardous. The clear zone may be thought of as the distance from the edge of traveled way to an actual obstacle or potential hazard, excluding features such as breakaway signs and non-hazardous elements. Chapter 10 provides a detailed description of the clear zone concept and the process of determining an appropriate design clear zone width. A partial summary of the process follows.

For a given design speed, traffic volume, and embankment slope, a basic recovery width is recommended. This is the amount of obstacle-free distance that should be provided adjacent to a tangent section to permit the average driver to recover control of an errant vehicle. Additional distance may be appropriate on the outside of curves. Where fill slopes of between 1:4 and 1:3 (non-recoverable, but traversable) are closer to the traveled way than the required basic recovery width, additional cleared width, flatter than 1:6, should be provided at the base of the slopes since the non-recoverable slope can not be credited towards satisfying the width requirements. This additional cleared width is termed the clear runout width. To provide space for the average vehicles, the minimum clear runout width should be not less than 2.5 m and desirably should be equal to or exceed the amount by which the non-recoverable slope extends into the minimum recovery width.

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 may consist of a shoulder, a recoverable slope, a non-recoverable (but traversable) slope, and a clear runout width. Note that clear zone concerns should be addressed in medians as well as at roadside areas to the right of traffic.

When it is appropriate to show the limits from within which fixed objects and other potential hazards are to be removed, the typical sections should indicate the design clear zone width or, where traversable non-recoverable slopes extend into that width, the minimum clear runout width needed at the base of the slope. As indicated in Section 3.4 DRAWINGS, if there are numerous variations in the widths, a separate table should be provided.

Where conditions make it impractical to provide an appropriate and reasonable clear zone width, a barrier system should normally be provided as discussed in Chapter 10. (A width is appropriate if it provides enough clear area for conditions. A width is not reasonable if it must be made excessively wide to include broad non-recoverable slopes.)

3.2.7 Barriers

Chapter 10 describes the various barrier systems and provides guidance on selection. Where required, the typical sections should schematically indicate the presence of a barrier and show its position. The normal position of any weak post barrier will provide a minimum distance of 150 mm between the edge of (paved) shoulder and the front of the post. For the heavy post, blocked out W-beam guide rail, the minimum distance between the edge of shoulder and the post should be 250 mm for the currently approved wooden blockouts. For the previously accepted metal blockouts (now considered outmoded) the distance was 210 mm.

As an optional maintenance measure, not related to safety, a 75 mm thick (minimum) layer of asphalt pavement mowing strip may be placed beneath the rails to prevent the growth of vegetation. Where used, it is recommended that the optional mowing strip extend 0.6 m from the edge of paved shoulder for weak post systems and 0.7 m for heavy post, blocked out systems. See Section 3.2.9.4 B and Chapter 10, Section 10.2.3.5 for further discussion of Optional Mowing Strips.

Refer to Chapter 10, Section 10.2.3.5 for guidance on the need for extra length posts when posts must be placed close to steep slopes.

Where concrete barriers are used, they should be placed as far from the edge of traveled way as possible up to a maximum of 3.0 m, measured at the base, or 3.6 m, where that is the minimum required shoulder width. The intent is to maximize the available recovery area while limiting the likelihood of higher angle impacts that wide separations are more likely to permit. On the inside of curves, exceptions to the maximum offset distances are permitted to the extent necessary to avoid a horizontal sight distance problem. The entire area between the traveled way and the base of the concrete barrier should be paved to at least the thickness of the adjoining shoulder.

The position and type of median barriers should be indicated on the typical sections. Barriers should be indicated on the general plans using appropriate symbology. The extent (longitudinal location, limits, lengths, etc.) of the various types (pay items) of roadside and median barriers (including post lengths, post spacings and anchorage units) should be indicated on separate drawings (usually on the Miscellaneous Tables) as tables of guide rail and/or median barrier.

Recently issued Engineering Instructions on the use of new guide rail terminals passing NCHRP 350 require that, if the conventional w-beam or box beam terminals are used, they must usually be extended to burial in a backslope or to near the back of the clear zone. This requirement will necessitate that the designed end location for these terminals also be included on the project plans.

3.2.8 Medians

A median is the portion of a divided highway separating the traveled way for traffic in opposite directions. Medians are highly desirable on highways carrying opposing high-speed, high-volume traffic on four or more lanes. The use of uneven medians may be an economical alternative where the topography would necessitate large volumes of earthwork to permit the travel lanes for opposite directions to be placed at the same level. The design of medians should satisfy the clear zone or barrier requirements identified in Chapter 10. In general, medians should be as wide as practical. Refer to Figure 3-9 for Typical Wide Medians. Wider medians tend to reduce the frequency of severe accidents, provide for future lane additions, and lessen headlight glare problems. All transitions in median width should be effected gracefully to preclude any appearance of distorted or forced alignment. When feasible, these transitions should be accomplished along horizontal curves. Drainage systems should be designed for wide medians, while narrow medians may either drain across the pavement or, where curbed medians are used, drain into a drainage system at the edge of the median. Any ditches used in median clear zones should satisfy the traversability, hardware and depth design criteria identified in Chapter 10 and Section 3.2.14.

The guidance for selecting the appropriate width and type of median will vary depending upon the highway functional classification, the availability of right-of-way, the traffic volume and speed, environmental considerations, the presence of pedestrians, the degree of control desired over left-turning traffic, and in some cases, the desired type of barriers in the median and the desired width of the median shoulders. In developed areas, and on roads with lower functional classifications, the availability of right-of-way and the economic justification may not be sufficient to permit the use of medians. Where two-lane highways are to be built and expansion to four lane divided highways is anticipated, every effort should be made to obtain all of the necessary real estate at one time. Various narrow median alternatives are illustrated in Figure 3-10 Typical Narrow Medians. Median design considerations for various highway functional classifications are briefly discussed in the following sections. For a more thorough discussion, refer to the respective functional classifications in AASHTO's *A Policy on Geometric Design of Highways and Streets, 1994*, and to Chapter 18 for pedestrian factors.

Figure 3-9 Typical Wide Medians

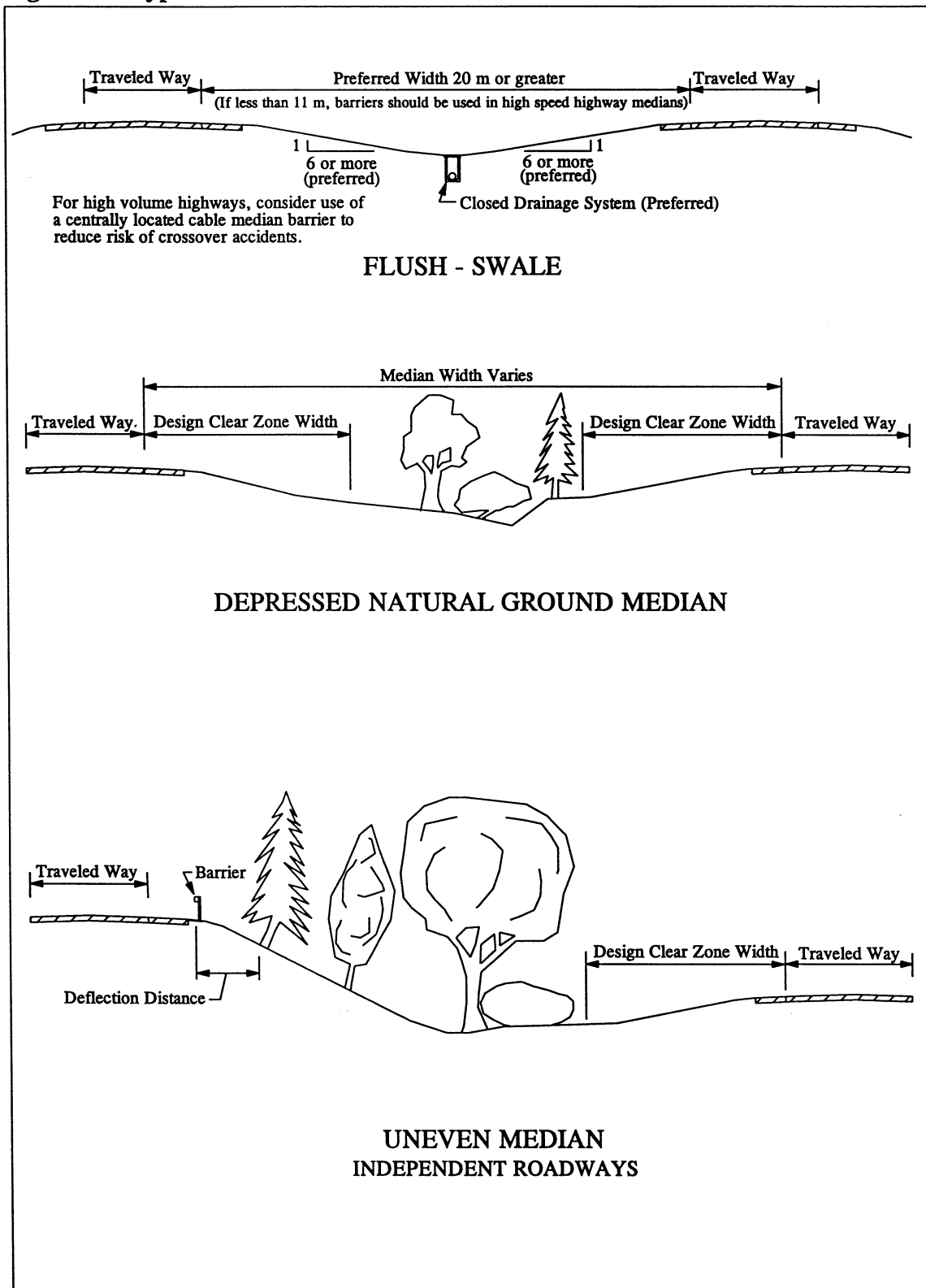
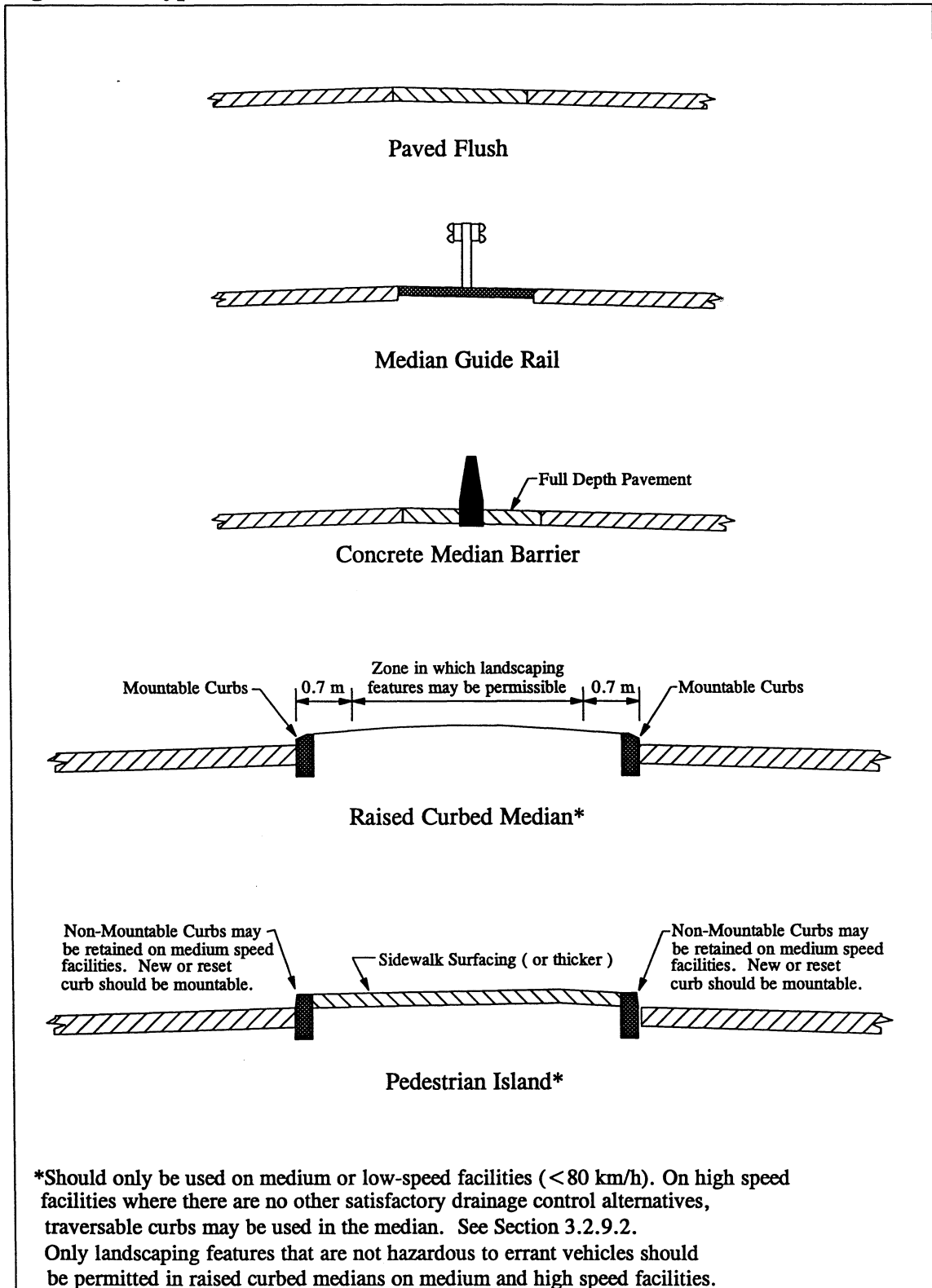


Figure 3-10 Typical Narrow Medians



3.2.8.1 Medians for High Speed Facilities (Interstates and Freeways)

The wider a cleared median is, the lower the cross-over accident rates tend to be. Up to a width of about 20 m, the increased width will generally produce increases in safety benefits. Therefore, where right-of-way conditions permit, it is desirable for high speed facilities to be provided with clear medians at least 20 m wide. Extra width should be allowed where lane additions are contemplated. Note that Chapter 2 provides minimum design criteria of an 11 m wide median for rural interstates and freeways and 3.0 m median for mountainous or urban interstates and freeways. Where a median width of at least 11 m can not reasonably be provided, refer to Chapter 10 for warrants and guidance on the need for and use of barriers in the median. Curbing is not to be used on interstates and freeways except as noted in Chapter 10 for bridge approaches and, where necessary for drainage control, use of a 100 mm traversable curb, as described in Section 3.2.9.1, is permissible.

For traffic safety, gently depressed (1:6 or flatter), wide medians are preferred with the full width cleared of obstacles. Where wider natural ground medians are selected and trees or other obstacles are present, fully developed clear zones should be provided in the median for each traffic direction or, if clear zone development is not practical, appropriate barrier systems are to be provided. When evaluating the practicality of developing adequate clear area, it should be remembered that barriers themselves constitute a potential hazard. Refer to Chapter 10 for guidance on median barrier arrangements. Refer to Chapter 5 for details of permanent median cross-over designs.

Temporary median cross-overs are sometimes required to fully divert traffic off of a bridge that is to be worked on. Following completion of the work, these cross-overs are to be substantially retained for possible future reuse. To permit them to be retained, the embankments shall either utilize traversable slopes or be adequately shielded in accordance with the guidance in Chapter 10. All asphalt courses should be removed from the temporary cross-over and, after scarifying the surface, replaced with an equivalent depth of topsoil (or more if necessary) and seeded to produce a satisfactory growth of grass. In all cases, the permanent expressway shoulders shall be finished so as to preserve the continuity of their appearance and texture. Any exceptions to this policy shall be noted and explained in the Design Approval Documents (DAD).

3.2.8.2 Medians for Arterials and Collectors

New arterials with four or more lanes should be divided by medians. Reconstruction of undivided multi-lane arterials or expansion of two lane arterials to multi-lane facilities should preferably include an appropriate median, particularly for high speed, high volume rural arterials. Medians can be adapted to serve a wide variety of functions on arterials and collectors. Medians may be used to 1) increase the separation between opposing traffic, 2) facilitate the operational efficiency and safety of left-turning movements, 3) limit left turn movements, 4) prohibit left turn movements, 5) provide physical barriers to reduce the frequency of accidental cross-overs, and 6) simplify pedestrian crossings by providing a refuge for non-motorized traffic, when deemed appropriate and ADA-compliant features are provided. The designer (scoper) should consult with the Regional Traffic Engineer and, for existing facilities, perform an accident analysis (see the Traffic and Safety

Division's *Safety Investigation Procedure Manual*), to determine what functional objectives should be considered for the medians. Where raised medians are warranted, the designer should refer to Chapter IX, 'At-Grade Intersections' of AASHTO's *A Policy on Geometric Design of Highways and Streets, 1994* for details of the median openings and intersection geometries.

A. Flush Medians with No or Minimal Turn Demands

In areas where there are no driveways or roads to cause left turn movements, a flush paved median of any width equal to or greater than 1.2 m (minimum for divided rural arterial stated in Chapter 2) is permissible and the increased separation of opposing traffic will be desirable as a benefit to safety. However, if there is some turn demand, the use of a flush paved median with a width of 1.2 m is permissible, but widths of between 1.2 m and 2.7 m are to be avoided (especially where ROW is available for 3.0 m medians) as the narrower widths may be inadequate for safe storage of turning vehicles.

B. Two-Way Left Turn Lanes

The provision of a flush median as a two-way left turn lane may be justified in areas where there is a need for mid-block left turn movements and either accident analysis or projected turning movements from the through lanes across opposing traffic indicate a significant operational or safety problem. Chapter 2 provides the design criteria for the median widths. The minimum width of a median with left turn lanes on a rural arterial is 3.6 m. The desirable width of a continuous two-way left turn lane (TWLTL) median on an urban arterial is 4.8 m, while the minimum width that should be considered is 3.3 m. For urban collectors, where speeds will typically be lower and ROW generally more restricted, the desired width is 3.3 m, while the minimum is 3.0 m. If narrower lanes are used, accidents are to be expected due to rear-end collisions with the turning vehicle, side-swipes when drivers in the through lane shy away from the turning vehicle, or rear-end collisions when through traffic brakes for the turning vehicle.

The need to accommodate significant amounts of crossing pedestrian traffic should be taken as a strong indication not to use continuous TWLTLs.

Regardless of whether or not they are used for turn lanes, it is desirable for the surface of flush paved medians to be clearly marked, either by the use of thermoplastic and epoxy reflectorized pavement markings or by color contrasting with the surface of the adjoining travel lanes. The *NYS Manual of Uniform Traffic Control Devices* provides guidance on appropriate pavement marking and signage. For color contrasting, asphalt pavement may be used adjacent to cement concrete pavement or, in special circumstances, white synthetic binder pavement (see *Standard Specifications* Section 638) may be used adjacent to asphalt pavement. Because of the high cost and the logistical problems of the extensive preparations necessary for placing the white synthetic binder, its use is generally limited to instances of strong municipal preference. Generally, it may be used where there is a need for a TWLTL, where aesthetics are a consideration, and where the location is in a commercial district. The compacted thickness should typically be 20 mm. The item should

not be used where mid-block turns are prohibited. The delineation effectiveness of the item is not good under wet or night-time conditions.

C. Raised Medians with Left Turn Bays

Where higher traffic volumes, sight restrictions, rates of left turning traffic and possibly traffic speeds indicate that a problem may be expected due to the left turning movements, or the accident analysis indicates that there is a problem, consideration should be given to limiting the locations in the median from which left turn movements can be made.

The preferred method of separation to restrict the location of turning movements on medium and low speed highways (80 km/h or greater is considered high speed) would be the use of turning bays in 1) a depressed median, 2) a raised curbed median, or 3) where there are few turning locations, a flush median with barriers. It is desirable for the left turn lanes to have a 1% cross slope towards the direction of the turn. Where the curbed median option is selected, mountable curbs are normally used, although non-mountable curbs are permissible on low speed (60 km/h or less) roads. Barriers are not the preferred choice where there are frequent turning bays because of the hazard presented by the frequent ends of the barriers and/or the cost of providing end treatments to make the barriers crashworthy. Raised medians should be separated from the travel lane by a curb offset of approximately 0.6 m.

Curbed medians should be removed from any existing medium speed facilities where the accident analysis indicates that there is a significant history of accidents related or attributable to the curbs.

Where it is necessary to have pedestrians use medians as refuge areas, non-mountable curbing is to be used on low speed facilities (60 km/h or less) while 150 mm mountable curbing is preferred for medium speed (between 60 and 80 km/h) facilities. In the latter instance, it may be appropriate to provide some form of protective barrier for the pedestrians. In either case, curbed pedestrian islands are to have curb ramps or flush pass-throughs. Flush pass-throughs should be narrow enough to prevent use by cars. In general, the minimum height of curbing at pedestrian refuges should be 100 mm, while 150 mm is preferred.

In the absence of pedestrians, mountable bullnoses should be considered at the ends of raised medians. At locations where the ends of islands are likely to be struck by snowplows, (not only potentially seriously damaging, but also potentially dangerous) the leading end of the island should be flared away from the traveled way and depressed to permit the plow to ride up onto the curb. Refer to Chapter 5 for additional guidance on the design of intersections and median openings.

Curbed medians are to be avoided on high speed arterials, particularly when speeds exceed 90 km/h. Where traffic volumes are low, but the speeds are 80 or 90 km/h, and it is desired to prevent some turning movements while permitting others, a raised median with mountable curbs (preferably 100 mm) and turning bays may be considered, but only when

there is no other acceptable alternative and when justified in the design approval document as a non-conforming feature. In the same situation, except with high traffic volumes, preference should be given to using barriers in the median to permit turning only at intersections. Because of the destabilization hazard posed to high speed traffic by curbing, any use of mountable curbed medians in this case requires thorough documentation of the justification in the design approval document. The preferred treatments to restrict left turns between the intersections to a few openings, would be the use of 1) flush paved medians or 2) depressed, flush or gently bermed grassed medians with, for any of these cases, appropriate types of median barriers and end treatments, or, 3) for the unpaved cases, sufficient separation width.

Curbed medians should be removed from any existing medium or high speed facilities where the accident analysis indicates that the curbs contributed significantly to the accident history. Refer to Chapter 10 for guidance on the need for and use of barriers in medians.

D. Medians for Prohibiting Turns

In some instances, the projected traffic volumes and turning movements, or the number of accidents may be great enough to justify designing a median that prohibits left turning movements. As noted above, raised curbed medians should be avoided on high speed facilities in favor of flush paved medians with barriers, although other unpaved median options, such as those discussed above, are satisfactory. For low and medium speed facilities, the prohibition of left turns between the intersections should generally be done with the use of a depressed grassed median or a raised median with mountable curbs. While a non-mountable curb may be used on low speed roads, use of a non-mountable curb on medium speed facilities should be documented as a non-conforming feature.

Frequently, municipalities desire to provide landscape development for depressed or raised medians. While this can be done without creating safety hazards, several cautions should be observed. Raised medians should be avoided on high speed facilities. Trees that will grow to diameters in excess of 100 mm shall not be planted in the median clear zone, even on low speed facilities. Mounded beds should not be used on high speed facilities. The location of any landscape features in medians should not interfere with sight distance requirements for either the mainline or at intersections. High maintenance landscaping should be discouraged on high volume, higher speed facilities as the maintenance work will be hazardous to both landscaping workers and traffic. The designer should consult with the Regional Landscape Architect whenever median planting is considered.

E. Medians with Continuous Traffic Barriers

Under adverse conditions of high speed and traffic volume, the actual or anticipated incidence of inadvertent cross-median accidents may justify the use of traffic barriers to limit the potential for errant vehicles to cross over into opposing traffic. In this instance, preference should be given to the use of paved flush medians with a barrier or barriers in the median. Openings in the barriers should be avoided due to the cost and potential hazard

posed by the required terminals. Chapter 10 contains guidance on the use of appropriate barriers in medians. In unusual circumstances, it may also be possible (and would be preferable) to satisfactorily alleviate the cross-over problem by widening the medians sufficiently to permit use of an unpaved median to separate the opposing traffic. When this is done, the guidance for design of wide medians in Section 10.2.4.2 should be followed.

3.2.8.3 Medians for Local Roads and Streets

Medians in local urban streets and rural roads are primarily placed as landscaped islands for aesthetic purposes. The location of any landscape features in medians should not interfere with sight distance requirements. Traffic efficiency and safety may benefit, if the medians are properly designed. The design of medians for local roads and streets should generally follow the guidance on medians for arterials and collectors. Dividing local streets by the use of uneven medians may be an economical alternative where hillside developments would require large volumes of earthwork to place both travel lanes at the same level.

3.2.9 **Curbs**

Curbs may be useful for drainage control, access (driveway) control, delineation, aesthetics, orderly roadside development, and visual separation of vehicular areas from pedestrian areas. There are few clear-cut warrants governing the use or avoidance of curbing, except for limitations in medium and high speed situations. Refer to Chapter 10, Section 10.2.2.4 for detailed restrictions on curb use and curb-guide rail combinations.

3.2.9.1 Types of Curbs

In terms of function, the four general types of curbs are non-mountable (barrier), mountable (150 mm and 100 mm), and traversable. Presently accepted types are shown on the item 609 series Standard Sheets. The standard sheets also show the different types of construction and installation details. Some of these are discussed briefly in Section 3.2.9.5.

- a. Non-mountable, or barrier, curbs generally provide a 150 mm high exposed face with a steep-faced design to discourage operators from driving off of the pavement. Non-mountable curbs have very little redirective capacity and should be considered as having no significant capacity to redirect medium and high speed errant vehicles. The 150 mm high barrier curbs are indicated on the Standard Sheets as the B150 series.
- b. The Department uses several types of mountable curbs. These may be grouped as 150 mm high mountable (M150 series on Standard Sheets) and the 100 mm high mountable (M100 series). The mountable curbs have faces that are more gently inclined than the non-mountable (barrier) curbs so that vehicles can safely mount them at a crawl speed. The 100 mm high curb presents less of a potential hazard to vehicular traffic than does the 150 mm high curb. The 150 mm provides better visibility and delineation and will accommodate a greater puddle depth. (Note that resulting storm puddle should not infringe on more than half of a travel lane. See Chapter 8, Section 8.7.4.4 C.)
- c. The traversable curb has a nominal width of 300 mm with a 1:3 slope across the top and no vertical reveal on the traffic side. It is intended to permit delineation and drainage control while minimizing the potential destabilization hazard to errant vehicles. The absence of a vertical reveal also minimizes the potential for tripping (and thereby rolling) vehicles that are skidding laterally. The 100 mm high traversable curb is shown on the Standard Sheets as the T100 series.
- d. In some developed areas, curbs may be integrally combined with a gutter shape to provide enhanced hydraulic capacity for the drainage system and/or accentuated delineation of the edge of the shoulder. Combination curb-gutters are cast-in-place, with either a mountable or non-mountable curb portion. The thickness of the gutter base should be a minimum of 150 mm and may be increased to match the lift arrangement of the pavement structure. It should be noted that longitudinal joints within the shoulder or curb offset area constitute a hazard to bicyclists. A relatively small vertical offset parallel to the bicycle wheels can cause a fall. For this reason, the use of curb-gutters is to be avoided along routes where the

shoulders are regularly used by bicyclists, unless there is no other acceptable alternative. Where a curb-gutter is to be used adjacent to a designated bicycle lane, the separation between the joint and the traveled way should be a minimum of 1.2 m.

- e. Asphalt curbs are a considerably less expensive alternative to other curb types. However, they are much more susceptible to damage and should generally not be used where they are likely to be hit by snow plows, other heavy equipment or frequent errant vehicles.

3.2.9.2 Limitations on Curb Use

Refer to Chapter 10, Section 10.2.2.4, for detailed restrictions on curb use and curb-guide rail combinations.

3.2.9.3 Potential Uses of Curb

Where curb use is not limited by Section 10.2.2.4, curbs may be utilized for the reasons discussed below.

A. Erosion Control

The Department is committed to controlling adverse environmental effects of erosion from its right-of-way. One of the leading potential problem areas is embankment slopes. Particular attention should be given to embankments that are steeper than 1:4, higher than 5.0 m, constructed of erodible soils, and that drain to streams, lakes, wetlands and other bodies of water. The designer should consult with the Regional Geotechnical Engineer, the Regional Landscape Architect, and Regional Maintenance to develop a consensus on the need for a traversable or 100 mm mountable curb at the edge of shoulder to form part of the erosion control system. The use of curbing on high speed facilities should only be considered as a last resort after all other feasible options have been explored.

B. Closed Drainage Systems

If it has been determined that use of a closed drainage system is appropriate, curbing, combination curb-gutters, or gutters (Sect. 3.2.10) may be needed to channel runoff into the system. Refer to Chapter 8 for details of drainage system design. On high fills with full shoulders and guide rail, the selected curb may, and often will, be asphalt. Because asphalt curb is so easily damaged by snow plows, it may be advantageous to place it outside the line of the guide rail as part of an optional mowing strip. Where asphalt curb will be exposed to snow plow hits, it should be continuously backed up with appropriate fill.

Where curb is required for drainage control, the type, selection and placement should be in conformance with Chapter 10, Section 10.2.2.4.

TYPICAL SECTIONS

Typically, where curbs or gutters are used, it is necessary to provide an edge or underdrain system since the subbase cannot drain to daylight. The recommended placements of the underdrain pipe are shown in Figure 3-11 Typical Curb and Edge Drain Placement. The pipe is located under the pavement immediately on the traffic side of the curb (or gutter) to minimize interference between the curb and the drain and to avoid an area of weak support where curbing is carried across driveways (vehicles could push curb down into drain system). Any back-up concrete for curb setting should be low slump to avoid fouling the drain system.

C. Access Control

The Department's *Policy and Standards for Entrances to State Highways* should be consulted for any access control requirements and guidance. The specific type of curbing used should be in conformance with the guidance provided in Chapter 10, Section 10.2.2.4, unless specified otherwise in the entrances policy.

D. Sidewalk Separation

Refer to Chapter 18 for sidewalk warrants. Where sidewalks are warranted on low speed highways, predominantly in developed areas, curbs may be desirable to delineate and help separate vehicular from pedestrian traffic. Note that curbing, even non-mountable curbing, has very little redirective capacity and therefore should not be considered as an effective barrier for the protection of pedestrians. Its presence is meant to discourage the mingling of vehicular and pedestrian traffic. Note, also, that as traffic speeds increase, the potential hazard posed by curbing also increases. While curbing may offer a sense of protection to pedestrians on sidewalks or median islands/refuge areas, it is potentially hazardous and its use, particularly on medium and high speed highways, should be in accordance with Section 10.2.2.4.

E. Access for Persons with Disabilities

The Department is required to provide access for persons with disabilities whenever our projects result in the construction or alteration of pedestrian facilities. These requirements are discussed in Chapter 18. As typical examples of the work required, curb ramps should be provided at sidewalk crossings on projects where:

1. Curbs, gutters or sidewalks are being installed,
2. Traffic signals (including pedestrian) are being installed
3. Roadway resurfacing where there are sidewalks, or
4. Pavement markings are being placed at crosswalks.

In addition, designers should consult with the Regional Landscape Architect to ensure designs are consistent with the requirements found in the *Americans with Disabilities Act Accessibility Guidelines for Buildings and Facilities*.

Figure 3-11 Typical Curb and Edge Drain Placement

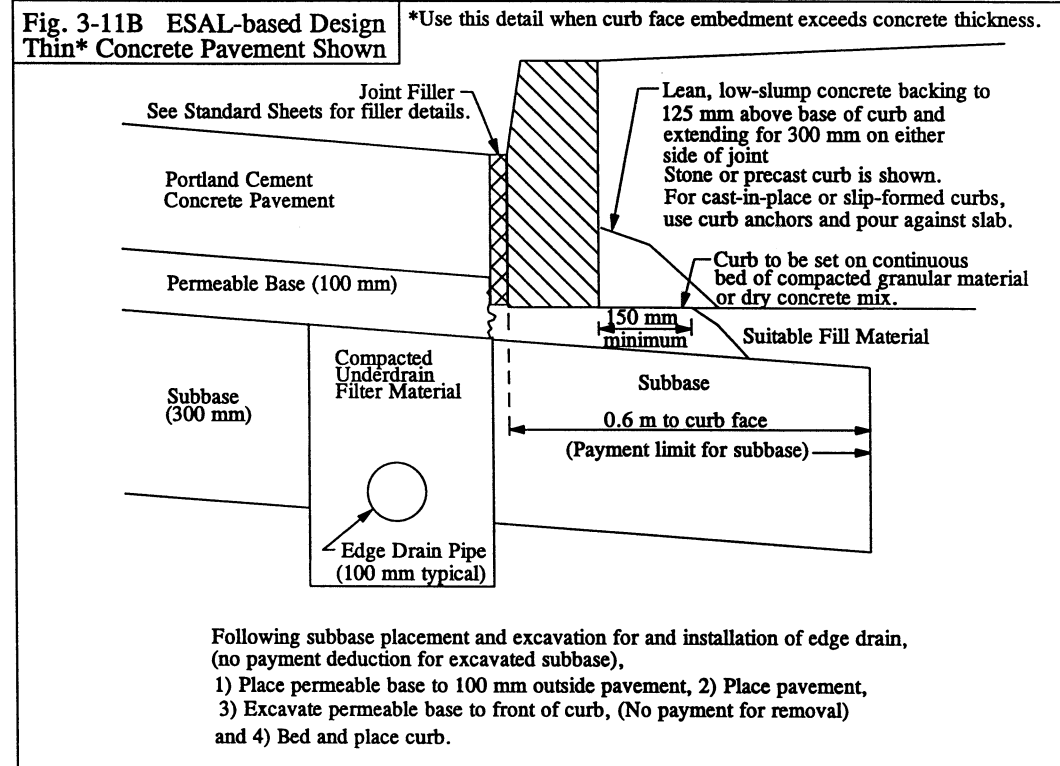
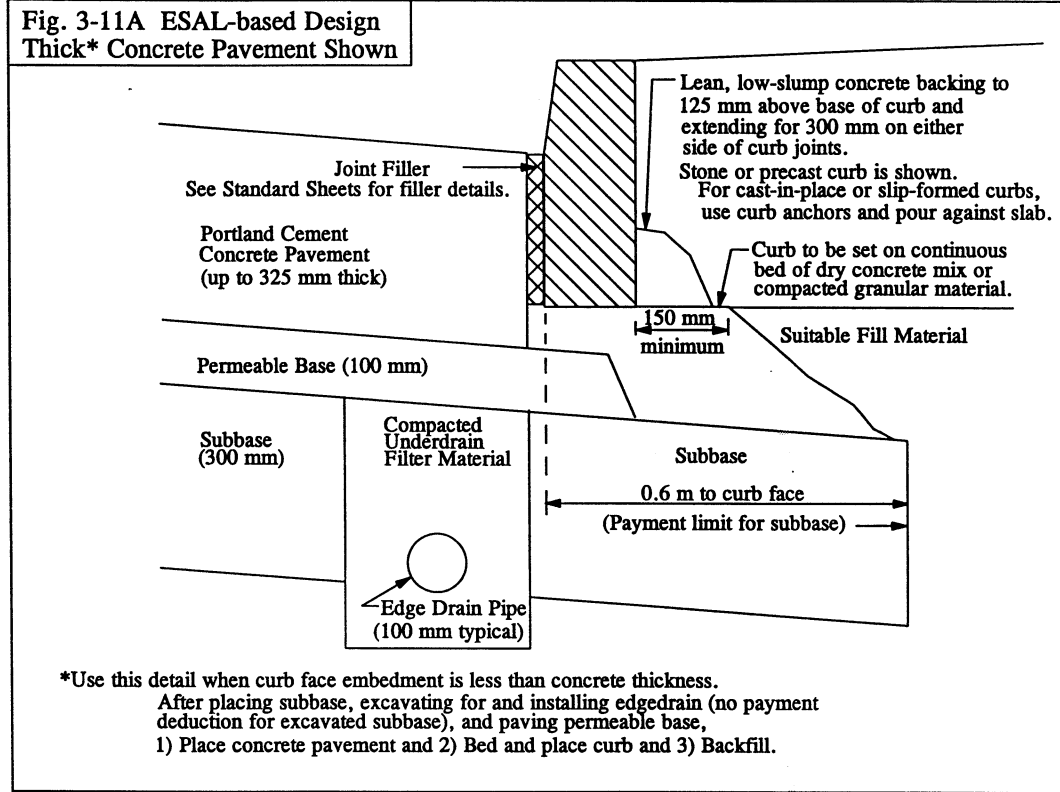
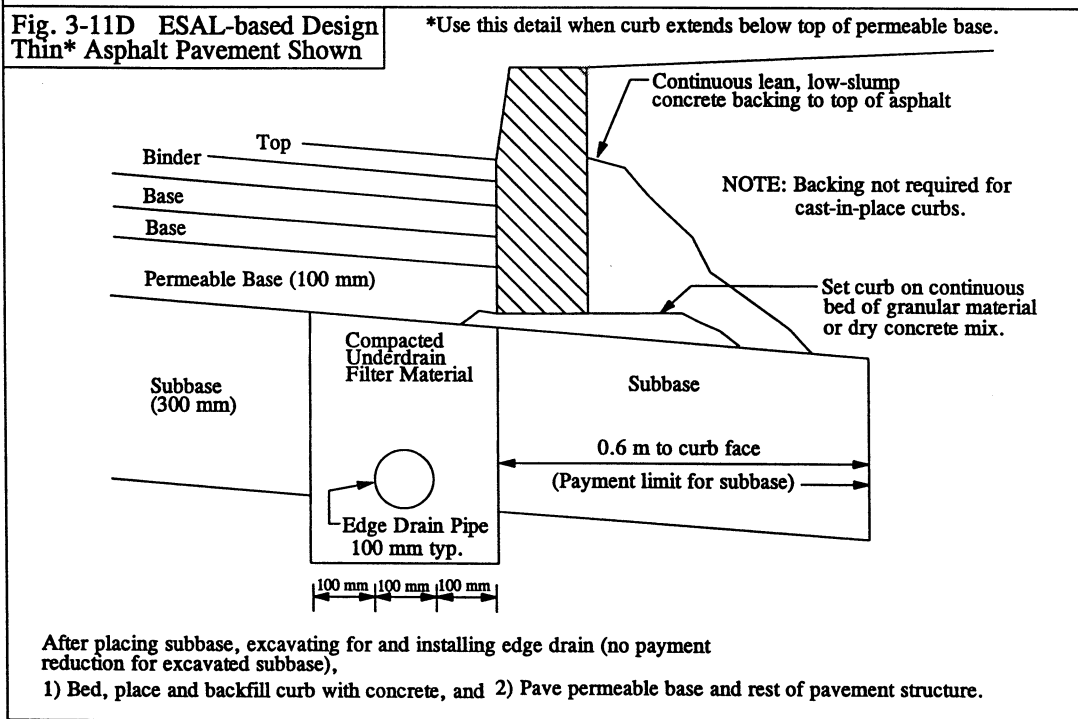
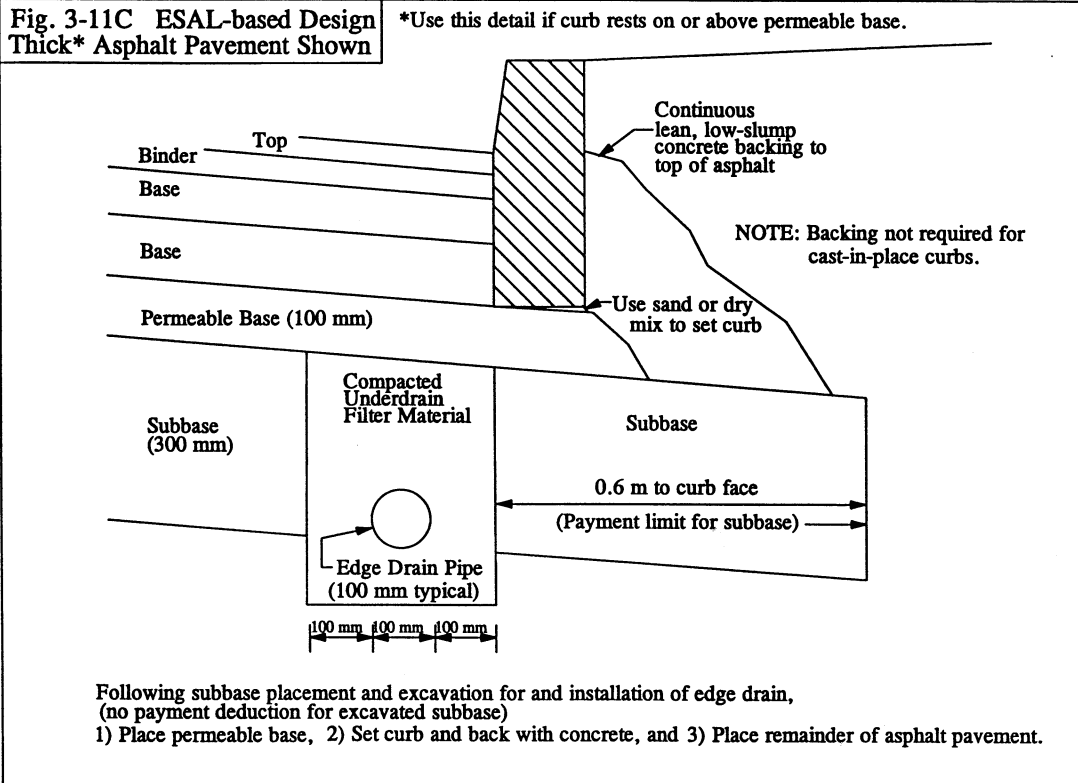


Figure 3-11 Typical Curb and Edge Drain Placement (continued)



3.2.9.4 Curb Alignment and Typical Section Details

A. Offsets

Barrier curbs and 150 mm mountable curbs introduced intermittently (after gaps exceeding 100 m) along streets should be offset 0.6 m from the edge of traveled way; where continuous, (as along a median or interrupted only by driveways and side streets), barrier curbs should be offset at least 0.3 m, and preferably 0.6 m. The intent is to minimize driver shying responses where curbs start.

On medium and low speed highways, although a 0.3 m or 0.6 m offset is preferred, 100 mm mountable curbs do not need to be offset, but the full width of the curb should be outside of the designed width of the traveled way. On all new and reconstructed high speed highways, any mountable or traversable curb that is required should be located no closer to the traveled way than the outside of the shoulder. Any exceptions should be explained in the Design Approval Document (DAD).

B. Mowing Strips

When curbing is placed in such a manner that the Department's machines will need to mow behind it, a 0.6 m wide, 75 mm thick (minimum) asphalt mowing strip may be placed immediately behind the curb to reduce the possibility of the mowing machines dropping off of the curb. Factors that should be considered include proximity to the traveled way, volume and speed of traffic, whether the curb is mountable or non-mountable, and aesthetics.

C. Snow Plowing Considerations

Both curbs and trucks may be badly damaged when snowplows strike curbs. To minimize this problem, curb ends should be introduced with either a vertical taper (preferred) or gentle lateral tapers. The problem with a lateral taper is that when a snow plow is being used to clear the shoulders, even a gradual lateral taper struck by a plow traveling at 50 km/h (30 mph) is still a significant impact that can damage the equipment and contribute to driver fatigue. The preferred termination detail (actually the initiation end with respect to direction of snow plowing) is shown on the Standard Sheets and calls for ramping the curb up on a constant 1 on 12 slope. Alternatively, where guide rail is present and there is a reason to extend the curb behind the rail, such as for drainage to a grate or combination inlet, the curb may be tapered in at an angle not to exceed 15E.

3.2.9.5 Curb Material Selection and Installation Details

Curbs may be asphalt, cast-in-place concrete, slip-formed concrete, precast concrete or stone, which includes bluestone, sandstone and granite. The costs vary widely as does durability. Installation considerations also influence selection.

Asphalt curbing is typically the least expensive option, but its poor mechanical durability limits the locations where it can be used to areas where it is unlikely to be hit by snow plows or errant traffic. Its durability in locations exposed to snow plowing may be marginally improved by earth backing since the ground will have fairly good strength when frozen.

Cast-in-place concrete is appropriate for unusual geometries or at sites where limited quantities of curb are to be installed, particularly if concrete will be needed for concurrent work. The drawbacks to cast-in-place concrete curbs are that they usually cost more than slip-formed or precast and that their forming and curing are time-consuming steps that may interfere with traffic. This may be a key concern for business or private driveways.

Slip-formed concrete is most appropriate where long, uninterrupted runs of curb are required. The curing time may be a concern for traffic control plans. Where either cast-in-place or slip-formed curbs are to be placed adjacent to new concrete pavements, the pavement should be placed first, with curb anchors embedded in the pavement. When curbs are to be added next to existing concrete pavements, curb anchors should be grouted into holes drilled into the existing pavement slab. Where curb is to be used adjacent to new asphalt pavement, the curb should be placed first.

Precast concrete curb may be installed quickly and, after installation costs are figured in, has a cost similar to stone curbing, but is less durable. Curved sections may be readily shop-cast. Because the effective section lengths are shorter than for the slip-formed or cast-in-place curbs, backing should be placed behind the curb to provide lateral support to resist overturning when asphalt lifts are compacted against it. The Standard Sheets provide details of the recommended backing alternatives. Where pre-cast or stone curbs are placed adjacent to concrete pavements, the space between the curb and the pavement must be filled and sealed to limit the infiltration of water. Details are shown on the Standard Sheets.

Stone curbs, and particularly granite, tend to be the most durable and may frequently be reset. This reduces their life-cycle cost. Because of their high initial cost, however, stone or granite curb, (except on bridges) should only be specified as the exclusive choice when it is the prevailing local practice or an existing standard, and its use is requested in writing by the municipality. If municipal specifications exist, they should be submitted to the Design Quality Assurance Bureau's (DQAB) Specifications and Standards Section for a review of the compatibility with NYSDOT specifications. When granite is the preferred curb, but sufficient justification is not available to specify it exclusively, Optional Curb (see below) should be specified. The Standard Sheets provide details of the backing alternatives recommended for stone curbs. Because the sectional width of stone curbs, and hence their resistance to overturning, is less than the sectional width of other types of curb, the amount of backing recommended is greater.

When it is appropriate to specify a particular material type, the designer should use item 609.02xx for granite curb, 609.08xx for precast concrete curb, and 609.04xx for cast-in-place. Whenever there is no need to specify a particular material, Special Specification 15609.123x should be used to give the Contractor the choice of furnishing granite or precast concrete curb. Item 609.09x may be used to give the Contractor the additional choice of furnishing cast-in-place curb. The Special Specification for items 15609.123x was issued by Engineering Instruction 96-034.

3.2.10 **Gutters**

Gutters may be used at the outside edge of the shoulder or parking lane to collect runoff where ditches or curbs would not be appropriate. Approved gutter sections are shown on the Standard Sheets for 609 series items. The flattened and widened sections should be used at driveways. At driveways that are below the level of the road, the gutter may need to be further modified so that "bottoming" of vehicles may be avoided. Driveway profiles may be checked by the "vehicle template" method described in Section 3.2.11.4 and Figure 3-12 to determine if bottoming is likely. (For an introductory discussion of geometries of low ground clearance trucks, refer to TRR1356, Transportation Research Record 1356 - Operational Effects of Geometrics and Geometric Design.) Regardless of the profile modifications, a 65 mm channel depth should be maintained in the gutter.

Generally, the inboard slope of the gutter section may be counted towards the width of the shoulder or the parking lane if the difference between that slope and the pavement slope is less than 8%.

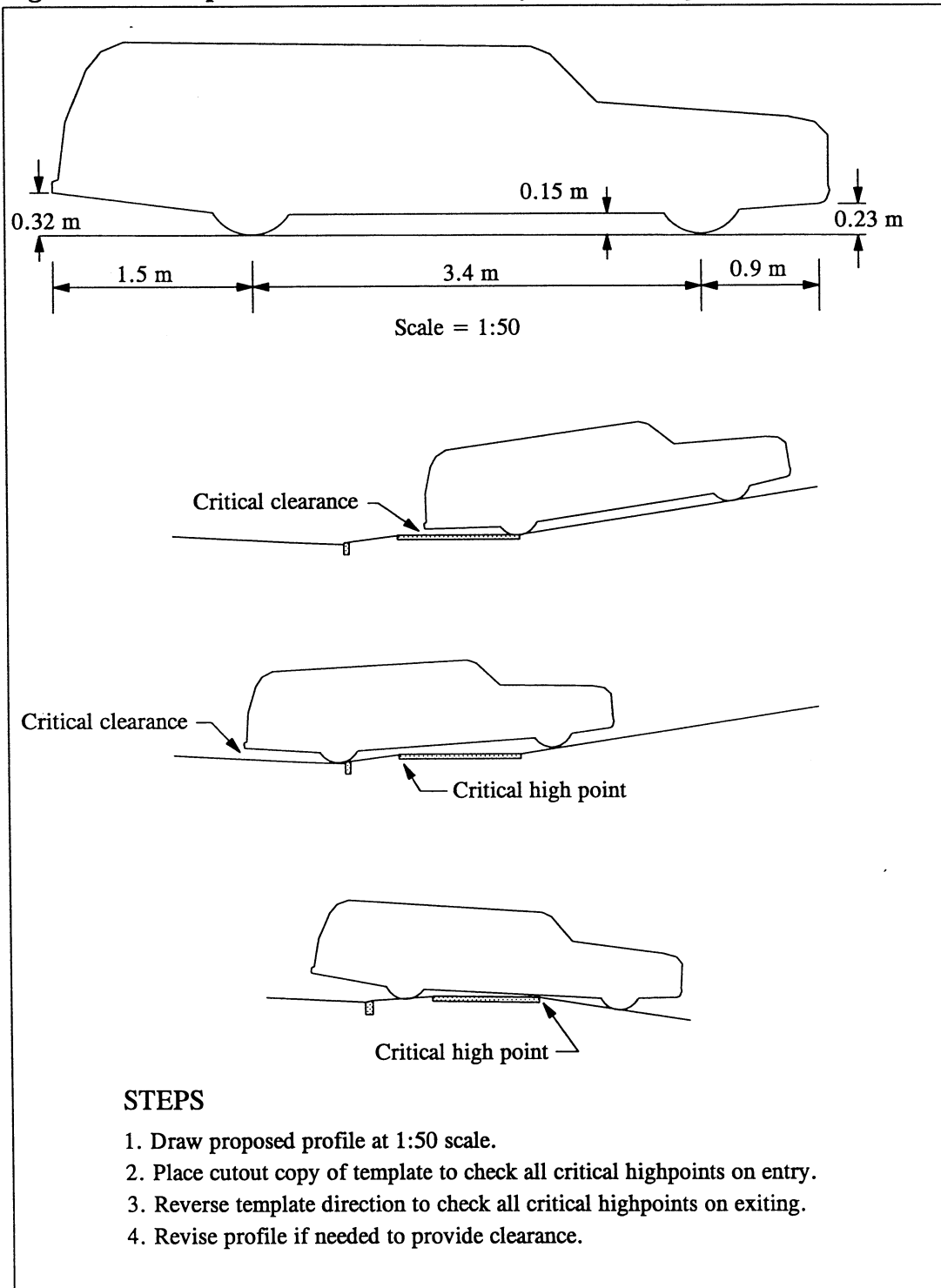
Gutter sections should not be used immediately adjacent to the traveled way. Where an accessible route crosses a gutter, the gutter needs to meet ADAAG requirements.

Chapter 8 or the Regional Hydraulics Engineer may be consulted on the design of grate inlets to be used in conjunction with gutters.

The Regional Geotechnical Engineer should be consulted as to the need for underdrains in conjunction with the gutter and their location.

3.2.11 **Sidewalks**

Refer to Chapter 18 for a detailed discussion of sidewalks, their warrants and placement within the Right-of-Way. The purpose of sidewalks is to provide pedestrians with a safe, accessible and convenient alternative to walking along the shoulder or in the traveled lanes. Sidewalks should be considered wherever significant pedestrian traffic is anticipated, and where sidewalks are essential for access.

Figure 3-12 Template Method for Driveway Profile Design

3.2.11.1 Setbacks

Refer to Chapter 18 for detailed guidance on sidewalk placement within the Right-of-Way. Sidewalks should be set back as far as practicable from the roadway. The desirable setback is 2.5 m or more. Sidewalks in commercial areas may start at the curb, due to the demand for space and the need for curbside access in parking zones. When the sidewalk is adjacent to the curb line, the usable sidewalk width is measured from the back of the curb and the width should be increased to account for car door openings, sign posts, street hardware, etc. The desirable minimum setback in residential areas should be 1.25 m. A 1.0 m minimum setback is also beneficial on urban highways. Set back sidewalks (formerly referred to as ribbon walks) provide added safety to pedestrians by virtue of the separation from vehicular traffic.

The space between the curb and the sidewalk is also beneficial as a storage area for snow, removal of which is particularly difficult in built-up areas. Snow that is plowed on to sidewalks may pose problems both due to the need to rehandle it when sidewalks are cleared and because pedestrians may choose to walk in the roadway if the sidewalks are impassable. It is therefore desirable for the width of the snow storage area to be adequate to hold the amount of snow that will accumulate during most winters. The required storage volume will vary with the number of lanes being plowed and the snowfall. The desirable width of the snow storage area should be calculated as the product of the 90th percentile seasonal snowfall depth (obtained from Figure 3-13) and 20% (actually, $20\%/m = 6\%/ft$) of the distance from the centerline to the curb (or outside of plowed area). An upper limit of 4.0 m may be applied to this product.

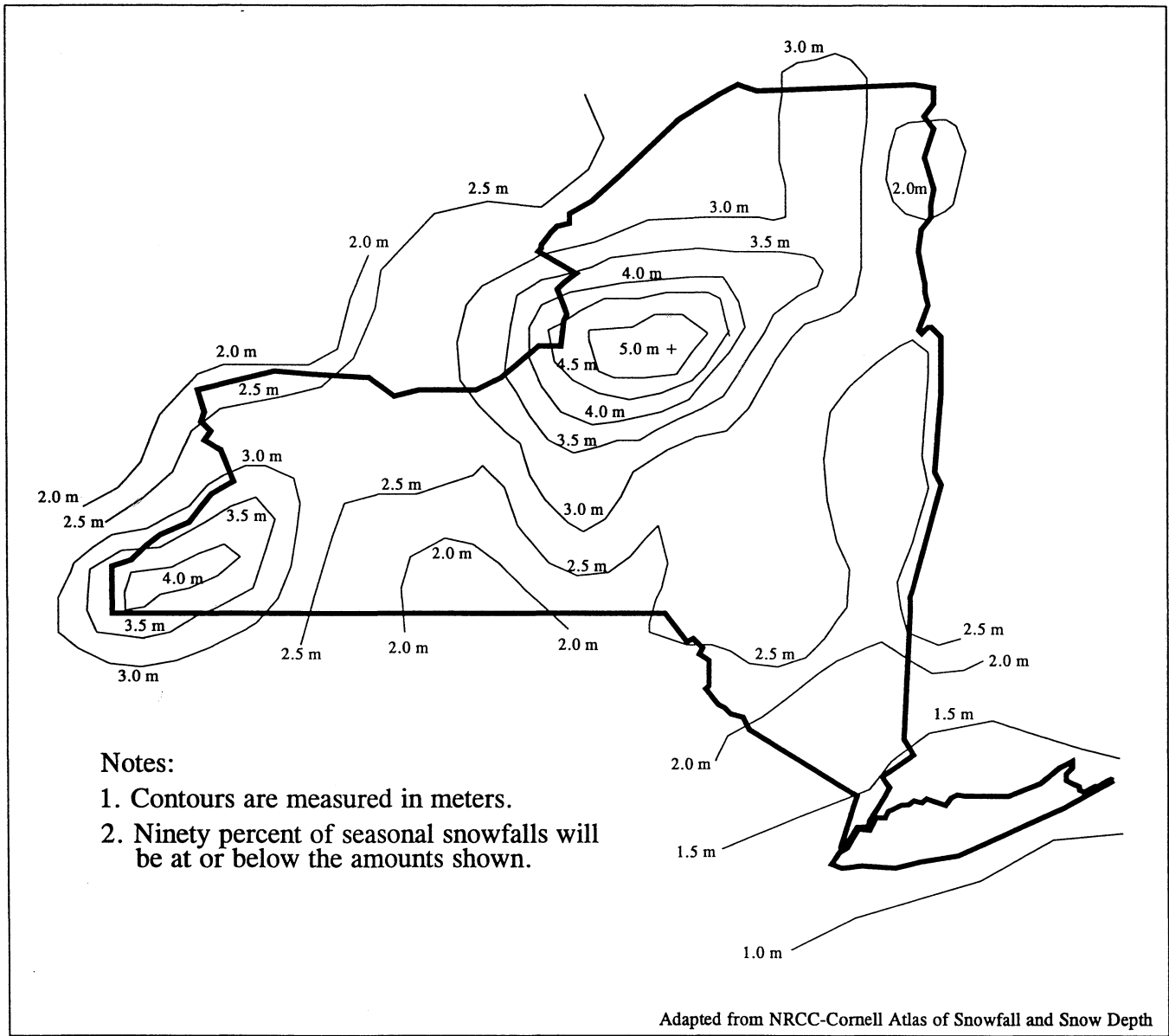
EXAMPLE:

Given: Ninetieth Percentile Seasonal Snowfall = 2.5 m
Single direction traffic includes one 3.0 m travel lane and
a 3.0 m parking lane.

Solution: Desirable Width of Snow Storage Area =
 $2.5 \times 0.2 \times (3.0 + 3.0) = 3.0 \text{ m}$

While it may not be possible to provide the desirable snow storage widths in areas that are already developed, sidewalk location plans for new developments should provide the desirable snow storage widths if possible. The minimum width for residential areas should be 1.25 m. In commercial areas, the full width between the curb and the buildings will generally be paved. However, if possible, it is preferable that this width include the snow storage width appropriate for a residential area and a usable sidewalk width of at least 1.525 m.

Figure 3-13 Nintieth Percentile Seasonal Snowfall Contours



3.2.11.2 Geometry

The normal concrete thickness for sidewalks is 100 mm, which should be increased to a minimum of 150 mm at driveway crossings. The minimum width for new sidewalks should be 1.525 m. Where sidewalks are contiguous with the curb, the width may be measured from the back of the curb, but it is highly desirable for the minimum design width to be increased by 0.6 m to allow space for car door openings, sign posts, traffic poles, street hardware, etc. Refer to Chapter 18 for further guidance on sidewalk warrants, widths, cross slopes, accessible design requirements, etc.

To provide drainage, sidewalks should be sloped. The normal and preferred slope is a cross-slope of 2% towards the road. However, on uncurbed fill sections, the slope may be 2% away from the road. No sidewalk cross slope should exceed 5%. Reduced or flat cross-slopes may be used if the sidewalk profile has a longitudinal grade.

All sidewalks must, to the extent feasible, provide a continuous passage for persons with disabilities. The cross slope of a continuous passage must be no steeper than 2%. The remaining portions of the sidewalk width should not exceed a 5% cross-slope. Additional information regarding requirements for findings of infeasibility and other information pertaining to the accessibility standards for facilities serving persons with disabilities may be found in Chapter 18.

3.2.11.3 Alternate Materials

Various materials have been used for sidewalk pavements. The normal choice is concrete reinforced with wire fabric. Asphalt sidewalks are typically installed as short term alternatives. The asphalt thickness should be 65 mm. At driveways, the thickness of asphalt sidewalks should be a minimum of 150 mm, and not less than the thickness of the driveways.

Various brick, precast, and special pavers may be used for aesthetic or historical reasons. The determination of any such need should be made in consultation with the Regional Landscape Architect.

3.2.11.4 Access - Sidewalks and Driveways

The Department is committed to providing access to persons with disabilities when our projects physically affect access to public and private property. Where sidewalks cross curb lines, curb ramps should be provided. Typical examples are shown on Standard Sheets for 608 series items. Curb ramps should be installed as appropriate on projects where 1) curbs, sidewalks or curb-and-gutters are to be constructed, 2) pedestrian traffic signals are to be installed, 3) roadway resurfacing is to be done and there are sidewalks present and 4) the pavement is to be marked for pedestrian crosswalks. Care should be taken to ensure that projects do not reduce accessibility, for persons with disabilities, to adjacent residences or facilities. Modifications to alignment and profile should be thoroughly examined early in the design process as they can have major impacts on accessibility. Refer to Chapter 18 for additional guidance.

Unless the Department has acquired access control for a given highway (ROW purchased "Without Access"), access must be maintained to adjoining private property. If guide rail is to be erected, openings must be provided for existing private walkways if no driveway is evident. To avoid placing openings in undesirable locations, consideration should be given to relocating the walkway. If a driveway and a walkway are evident, an opening only needs to be provided for the driveway (***provided it meets accessibility standards or provides better accessibility than the sidewalk does***) and consideration should be given to relocating the walkway. A break for both may be considered under special circumstances, such as to accommodate the needs of persons with disabilities. If no drive or walkway is evident, it is not necessary to break the run of guide rail, even if it runs across the entire frontage. Note that any proposed change in access should be presented at project public hearings or informational meetings.

Figure 3-13, Template Method for Driveway Profile Design, presents a graphical method for checking to see that the position of the sidewalk at driveway crossings will not cause problems with passenger vehicle access.

For additional information, refer to the Department's "Policy and Standards for Entrances to State Highways."

3.2.12 Shoulder Breaks

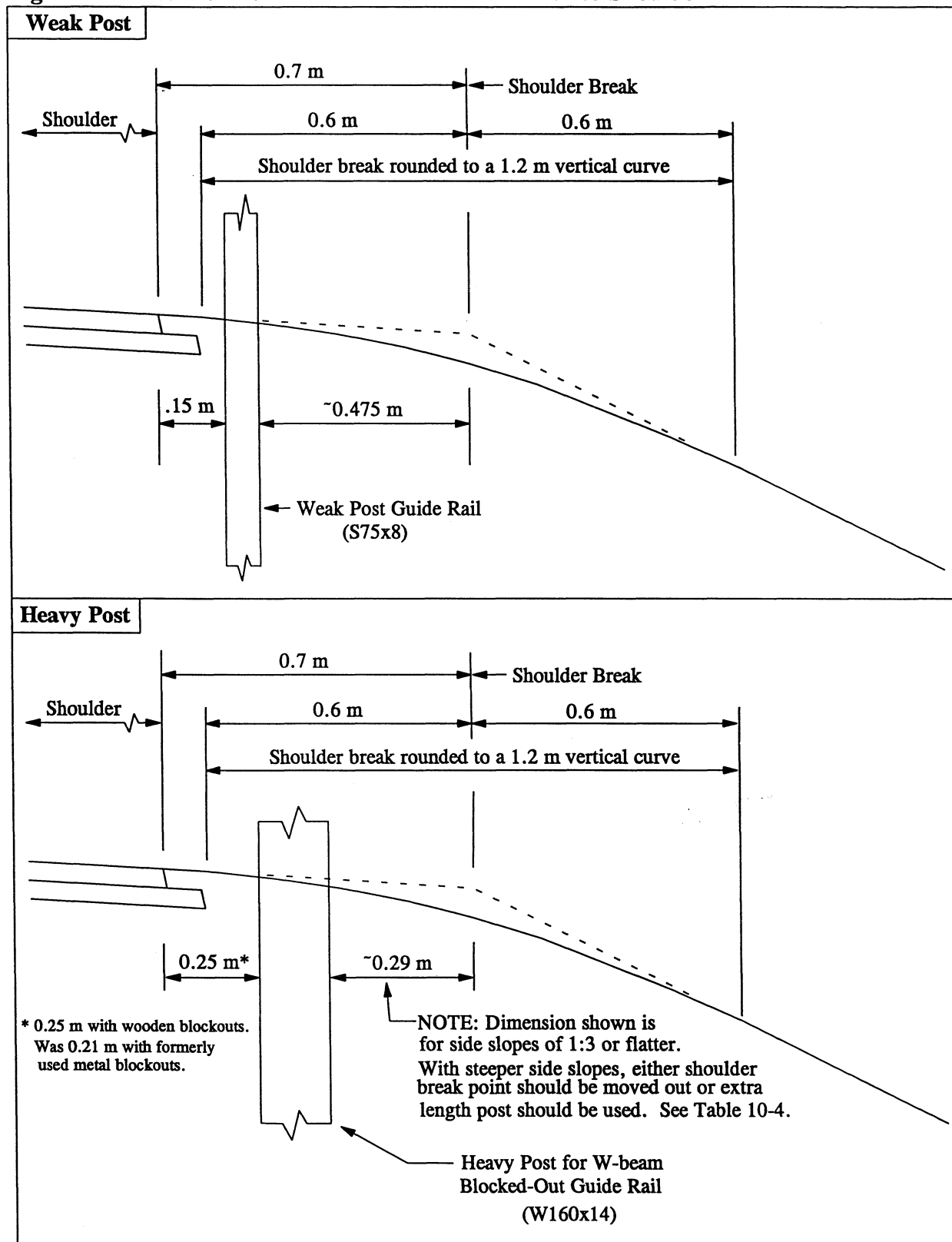
The intersection of the shoulder slope and the embankment slope should normally occur at a point 0.7 m outside the edge of the paved shoulder. The width of the paved shoulder does not include any asphalt mowing strip that may be included under guide rails. To reduce the chances of an errant vehicle becoming airborne, and to facilitate mowing, the shoulder breaks should be rounded to approximate a 1.2 m vertical curve. Refer to Figure 3-14 for an illustration of the preferred geometry and the normal positioning of weak and heavy posts for guide rail relative to the shoulder break.

The shoulder break should not be moved in unless necessitated by ROW limitations. If the shoulder break is moved in, there may be a loss of lateral support to the edge of the paved area and an unacceptable reduction in the usable width available for bicyclists and pedestrians. Another serious concern is the potential loss of lateral soil support for the guide rail posts. If the guide rail is put in close to a steep embankment slope and there is less than adequate soil support, the rail system is likely to deflect more than expected and, in the extreme case, may fail to redirect an errant vehicle. To avoid this problem, extra long posts, as discussed in Section 10.2.3.5, may be used to get extra lateral support at depth. Section 10.2.3.5 defines when the extra length posts should be used based on the offset from the back of the post to the shoulder break. The offset limits vary with the angle of the embankment slope. If the slope is steeper than 1:3, for instance, the regular length heavy post blocked out guide rail can not be used at the normal offset from the shoulder break. The extra length posts would have to be specified and the normal deflections for a given post spacing would have to be multiplied by 1.3. Particular attention should be paid to the problem of lateral support of guide rail posts on widening projects where it would otherwise be convenient to steepen the side slopes and reduce the shoulder break offset.

The shoulder break may be located farther out in situations where a wider embankment is desired, such as for a future lane addition, where there is significant bicycle traffic on the shoulder, or where it is desired to spoil excess fill within the ROW. The designer should consider the impact of these widenings on all of the drainage systems that will be affected.

The Standard Sheets for the 606 series items indicate that the roadway section may need to be widened at transitions from cable to box beam guide railing. An area no steeper than 1:6 must extend out 3.7 m from the normal face line of the guide rail so that errant vehicles will be less likely to be destabilized on impact in the guide rail transition area.

Figure 3-14 Normal Positions of Guide Rail Relative to Shoulder Break



3.2.13 **Embankment (Fill) Slopes**

A primary objective when designing side slopes should be to provide slopes which are vehicle traversable to the extent that the driver may regain control and bring the vehicle to a safe stop. If it is not possible to provide traversable slopes due to excessive embankment heights, right-of-way limitations, the close proximity of roadside hazards, and/or other considerations, guide railing should be placed at the outside edge of the shoulder in accordance with current warrants. See Chapter 10 for a discussion of recoverable, non-recoverable and traversable slopes and the warrants for barriers to shield slopes.

3.2.13.1 Slope and Height Relationships

Flatter slopes improve safety and maintainability. For existing facilities, suitable excavated material should be used for flattening side slopes, whenever practical, rather than being disposed of off-site. Table 3-9 presents the desirable maximum slopes for different embankment heights and operating speeds. To the extent practical, one consistent side slope should be used for each discrete embankment.

Table 3-9 Maximum Desirable Side Slopes

Embankment Height [†] (meters)	Highway Design Speeds (km/h)			
	70 km/h or less	90 km/h or less	110 km/h or less	Over 110 km/h and Interstates [‡]
1.0	1:4	1:6	1:6	1:6
1.5	1:4	1:5	1:6	1:6
2.0	1:3	1:4	1:6	1:6
2.5	1:3	1:3	1:5	1:6
3.0	*	1:3	1:4	1:6
3.5	*	1:3	1:4	1:5
4.0	*	*	1:3	1:5
5.0	*	*	1:3	1:4
6.0	*	*	*	‡
7.0	*	*	*	‡

[†] Vertical measure from shoulder break to toe of slope.

* Slopes of 1:3 or flatter are preferred. Slopes steeper than 1:3 may be used, provided the slope stability of embankment and its foundation are deemed adequate by the Regional Geotechnical Engineer, but guide rail will normally be required. Fill slopes of 1:2 or steeper, with heights in excess of 1.5 m require a suitable barrier. Refer to the end of Section 10.2.1 for guidance on retention of existing steep slopes less than 1.5 m in height.

[‡] Fill slopes steeper than 1:4 are not to be specified in the clear zone of new or reconstructed freeways and interstate highways and side slopes of 1:6 or flatter, are desirable. When conditions require the use or retention of fill slopes steeper than 1:4, but 1:3 or flatter, the designer should explain the rationale in the Design Approval Document and either design an appropriate Clear Recovery Area at the base of the slope or provide a suitable barrier system above the slope. Existing fill slopes that are steeper than 1:3 should be shielded or, preferably, flattened to at least 1:3 slopes (preferably 1:4 or flatter).

3.2.13.2 Embankment Zones

Under certain circumstances, it may be desirable to dispose of specific types of highway construction debris within the limits of the project and inside of the highway embankment itself. The conditions under which this option may be used are specified in detail in the Standard Specifications and in Chapter 9, Section 9.3.14. The zones are illustrated in Figure 9-6. The following discussion of the subject is provided solely for general information purposes. The referenced publications should be consulted for authoritative guidance and review requirements.

The portion of the embankment that is critical to the support of the roadway is the zone encompassed by lines projecting down and out 45E from the points at which the subgrade surface daylight. The portion of the fill section outside of this critical zone is referred to as the embankment side slope area as illustrated in Figure 100-1 of the Standard Specifications. As specified in section 203-3.10, the side slope area may be used for the disposal of oversized particles. At the designer's discretion, but in consultation with the Regional Geotechnical Engineer, a note may be added to the typical section indicating that between given stations, uncontaminated construction debris may be placed in the side slope area, provided it is covered by not less than 0.6 m of soil. This practice should be avoided on sections where widening may be anticipated. Logs should not exceed 250 mm in diameter and preference should be given to chipping stumps and logs. Woody matter should not be nested in one area.

In addition to the side slope area, a zone designated as Area A on the 203 series Standard Sheets may be indicated on the typical sections for projects needing disposal areas for unsuitable material, such as peat and muck. Even if it is not indicated on the plans, the Standard Specifications permit the Contractor to use this Area A for disposal as designated and approved by the Engineer-in-Charge. Area A is limited to the portion of the cross-section lying above a 1:2 slope starting at the shoulder break. Care must be taken, however, to ensure that the subbase is still carried to daylight to permit drainage of the subgrade. Normal compaction and lift thickness requirements need not apply to material placed in a zone designated as an Area A. Where widening may be anticipated, placement of material that will remain unsuitable is discouraged. Refer to Chapter 9 for illustration and additional discussion.

3.2.13.3 Toe Rounding

All slopes that will be part of the clear zone should be liberally rounded at their intersection with existing ground. This rounding is important to facilitate mowing and traversal by errant vehicles. The rounding of slope intersections which are parallel to the road should approximate a 4 m vertical curve.

Where drainage must be accommodated in a lined ditch at the juncture of the fill slope and a lateral slope, preference should be given to using a broadly rounded (10 m minimum radius on high speed facilities) ditch lined with Stone Filling. The surface of the Stone Filling should be placed flush with the planes of the highway embankment and of the lateral slope to facilitate traversal. Refer to Section 3.2.14.2. Toe rounding and traversable ditches will not be necessary where guide rail is provided to prevent entry to the area.

3.2.14 Ditches

The primary purpose of ditches is to convey collected water safely, efficiently and without damaging the ditch system, the adjacent roadway, or the abutting property. The hydrologic and hydraulic design of ditches is covered in detail in Chapter 8. Three types of ditches are discussed in this chapter: roadway ditches, toe-of-slope ditches and channels, and top-of-slope ditches.

3.2.14.1 Roadway Ditches

Roadway ditches are for use in cut sections. They typically parallel the edge of the traveled way. Under normal circumstances, the need to promote drainage of the subbase (rather than hydraulic capacity requirements) will determine the needed depth of the ditch. The ditch depth, as measured from the outside edge of the traveled way, should typically be 1.2 m for normal to thick pavement sections, wide shoulders and gentle embankment slopes. Shallower ditches will pose less of a hazard to errant vehicles and may be used when the Regional Geotechnical Engineer finds the treatment satisfactory. The normal minimum invert width is 1.2 m. If additional hydraulic capacity is needed, consideration should be given to widening, rather than deepening, the ditch. In general, unshielded roadway ditches should not exceed 1.2 m in depth below the ditch control pavement edge. (See Figure 3-6.)

The safety of motorists is a key concern in the design of roadway ditches. Ditch cross-sections should be designed to be traversable to minimize the risk to occupants of errant vehicles. All plane intersections should be liberally rounded. To promote traversability, the preferred back slope of the ditch should be 1:4 or flatter. The near or fore slope of the ditch should preferably be 1:6 or flatter for highways with anticipated operating speeds equal to or in excess of 100 km/h. Refer to Figure 3-15 High Speed Traversable Ditch Section. For highways with operating speeds less than 100 km/h, the foreslope may be steepened to 1:4 if necessary due to site conditions or right-of-way restrictions. For highways with operating speeds less than 70 km/h, the maximum desirable slope for either side of the ditch is 1:3. Note that the 1:3 fore slope can not be credited towards satisfying the clear zone recovery width requirements, since a vehicle is unlikely to be able to slow or turn on such a slope. Refer to Chapter 3 of AASHTO's *Roadside Design Guide* for other acceptable cross-section alternatives. Refer to Chapter 10, Section 10.3.2.2 of this *Highway Design Manual* for a discussion of non-traversable ditches and recommended practices for addressing them on 3R projects.

When it is not reasonably practical to provide ditches within the desired clear zone width with the desirable geometry for the design speed, consideration should be given to shielding the ditch with a guide rail. If needed, non-traversable ditches may be permitted beyond the design clear zone width or where the ditch is behind a guide rail that is warranted for other reasons. Where it is necessary to provide non-traversable ditches within the desired clear zone width and a guide rail is not otherwise required, the designer should use professional judgement to decide whether it would be more appropriate to shield the ditch or to accept the available clear area to the top edge of the ditch as an acceptable design clear zone width without introducing the obstruction of a barrier. Factors to consider would include the degree of hazard presented by the ditch, its distance from the traveled way, the prevailing design clear zone widths in the vicinity, and the quality of the clear area

that would be available if no barrier were present. Refer to Chapter 10, Section 10.3.2.2 C for discussion of ditches on 3R projects. Note in particular that, because of the tendency of steep-sided ditches to `capture' vehicles, no obstructions should be permitted in their ditch lines. Where it is not practical to provide guide rail to shield a ditch with steeper than desirable slopes, such as in developed areas, consideration should be given to the use of a closed drainage system. As a last resort, steep-sided ditches should be placed as far from the road as practical to provide added recovery width, and delineation, in accordance with the NYS MUTCD, should be considered. Regardless of the rationale, the basis of the decision to not provide guide rail to shield a non-traversable ditch in the design clear zone should be documented in the DAD.

3.2.14.2 Toe-of-Slope Ditches

As with roadway ditches, most of the traffic hazards associated with toe-of-slope ditches may be avoided if closed drainage is used instead. Where use of a closed drainage system is not practical and economical, the most important consideration in the design of toe-of-slope ditches, after hydraulic requirements, is whether or not an errant vehicle may encounter the ditch. Most steep embankment slopes will be provided with a guide rail system that will prevent such encounters. Three measures should be considered when shielding is not present.

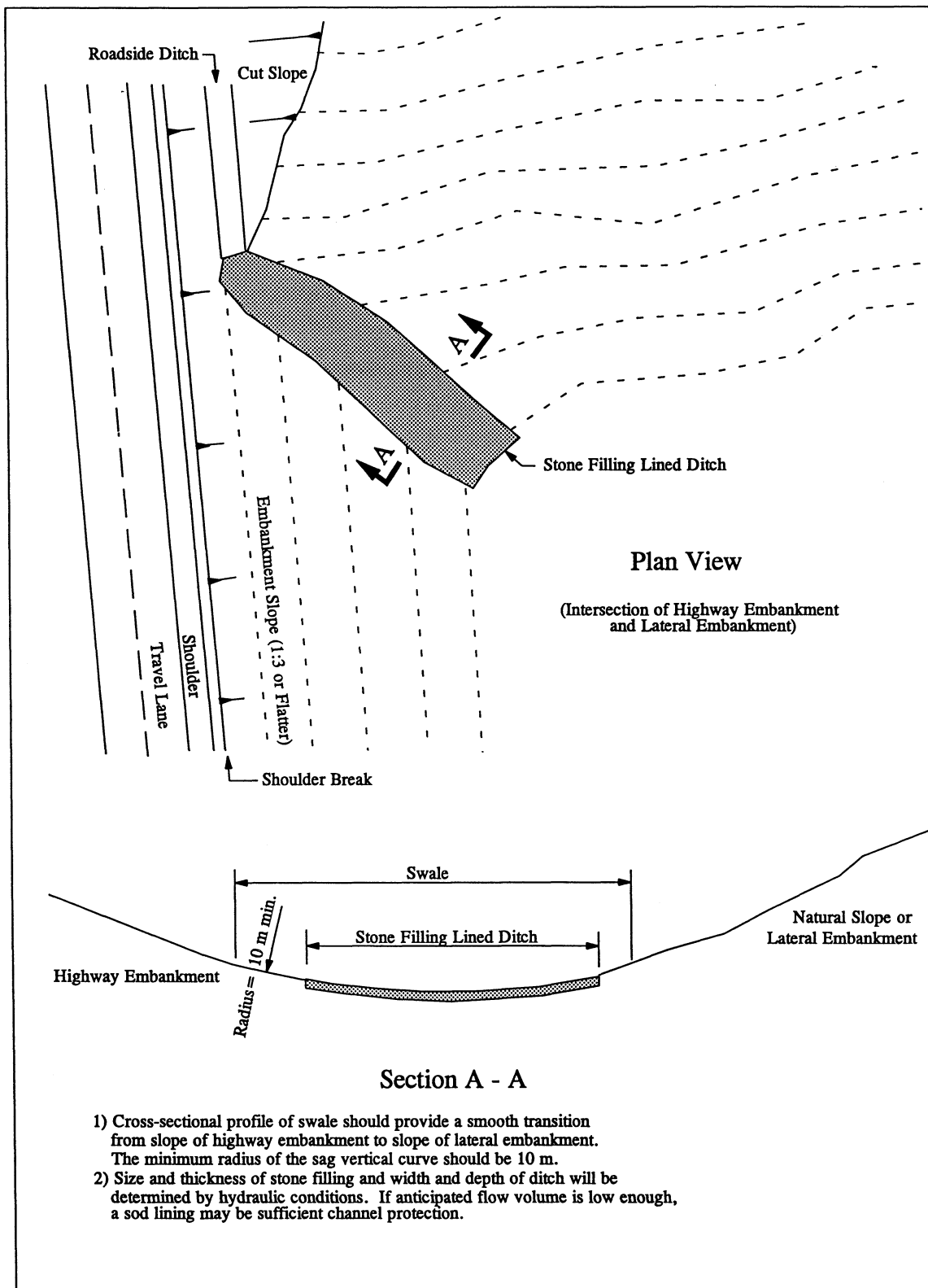
First, when relatively level areas are near the toe of the embankment, a runout width should be provided so that the ditch will be located beyond the clear zone. Second, if it is necessary to include the fore slope of the ditch within the clear zone, it should be made traversable by limiting the slopes to 1:4, or 1:6 for facilities with design speeds of 100 km/h or greater, and liberally rounding all plane intersections. Refer to Figure 3-15 for geometric details for high speed traversable ditches.

Third, where the toe of an embankment slope rests on a hillside or another embankment whose contours run roughly laterally to it, the ditch may be formed by placing stone filling in the "valley" between the two planes. The stone filling should conform to the requirements of section 620-2.03 and be placed in accordance with the requirements of section 620-3.02 of the Standard Specifications. The top surface of the stone should be flush with the ground surfaces and should be rounded to facilitate traversal by an errant vehicle. Hydraulic requirements will dictate the lateral extent of the stone layer. Refer to Figure 3-16, Traversable Ditch at Lateral Embankment for suggested ditch geometry details.

3.2.14.3 Top-of-Slope or Interceptor Ditches

The purpose of top-of-slope ditches is to intercept and divert water that would otherwise seep into the slope or flow over its face. The Regional Geotechnical Engineer and, in developed areas, the Regional Landscape Architect should be consulted to evaluate the need for an interceptor ditch above a given slope. Since these ditches will not be accessible to the general public, they may be steep sided. They should be graded to drain readily, without any low points, to avoid infiltration of water into the slope. Stone channel filling, or other satisfactory protective measures should be provided as needed to prevent erosion.

Figure 3-16 Traversable Ditch at Lateral Embankment



3.2.15.2 Rock Backslopes

Wherever errant vehicles are likely to hit rock backslopes, it is desirable for the portions that may be struck to be as smooth as reasonably practical to limit the possibility of the vehicle snagging and either stopping abruptly or becoming destabilized. In addition to the concern over vehicles striking the face, there is the possibility that material from the slope may fall on or into traffic. Assessment of this potential threat requires special training. Any time a project involves rock slopes, the Regional Geotechnical Engineer should be intimately involved in the design considerations. The Geotechnical Engineer must be consulted to determine whether an existing rock slope should be given a high priority for remediation and/or what the design details of a proposed rock slope should be. The Regional Geotechnical Engineer will normally make arrangements to involve a Departmental Engineering Geologist who will develop the evaluation and construction details for the rock excavation and any rock slope support measures.

Most rock slope problems can be avoided if sufficient flattening is possible. Economics and right-of-way limitations may require the use of high and/or steep slopes. Long term slope behavior is highly variable. Massive durable rock slopes may have very little potential to develop rockfall problems, but the soil overburden may creep towards the crest of the slope conveying boulders over the edge. If adverse jointing conditions are present, frost heave and root prying may loosen large volumes of rock and soil. Weathered rock masses may be cut by weak joint material that can be eroded away leading to loss of support. Some rock masses may be heavily jointed or separated by closely spaced weak bedding planes leading to regular falls of small rocks. Some rock types, notably shales, have poor durability and may weather quickly to small size particles. The Departmental Engineering Geologist will provide recommendations designed to be a reasonable balance between 1) the desire to minimize the potential for rockfall related accidents and 2) the need to keep the cost of property acquisition and rock excavation and stabilization/retention measures within reasonable economic and environmental limits.

While careful design, construction and maintenance measures, such as the use of drain systems, smooth blasting techniques (the Department's specifically prefers pre-splitting), and various rock slope stabilization techniques may delay the deterioration of the slope, most steep rock slopes will eventually weather and incur rock falls. The single most effective measure to limit the effect on traffic is to maintain a wide separation between the rock slope and traffic. The separation provides a catchment area whose designed width and volumetric capacity may be adjusted in consideration of the probable rock fall threats identified by the Departmental Engineering Geologist. In most cases, the catchment area should be level or slope toward the base of the cut to minimize redirection of falling rocks toward the road and, if the area will be part of the clear zone, to maintain a traversable geometry.

The following examples illustrate some possible treatment strategies. The sections are depicted in Figure 3-17, Rock Slope Setback Options. The development of any strategy should be made in consultation with the Regional Geotechnical Engineer and the Departmental Engineering Geologist and should reflect the desire to provide clear zones as well as to address potential rock fall problems. Additional consultation, as appropriate, should be obtained from the Regional Real Estate Officer and from the Regional Traffic Engineer.

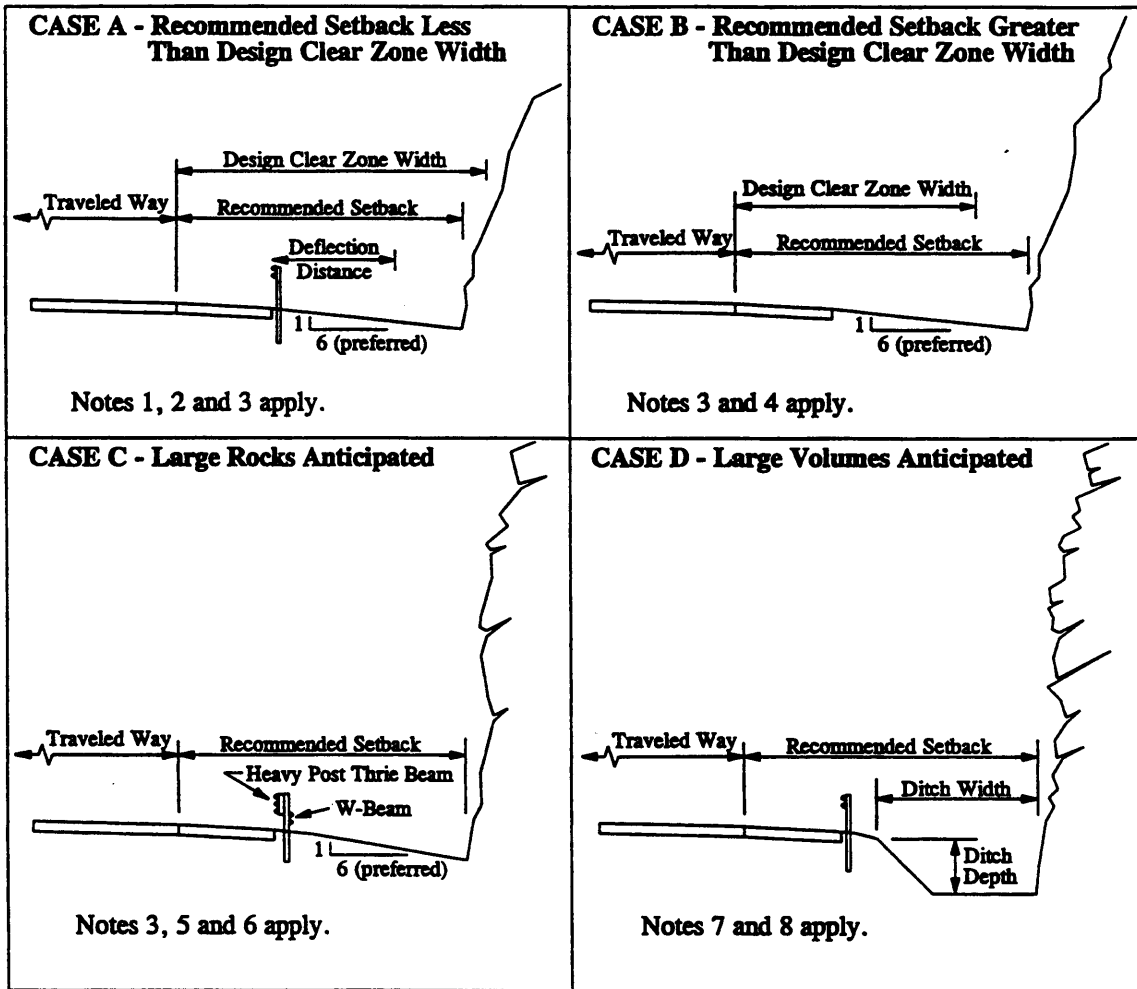
TYPICAL SECTIONS

- a. Small Volume Rockfalls - With modest slope heights, low to moderate traffic volumes, and low anticipated rockfall volumes, it may be sufficient to provide a simple catchment area. If the width of the area does not satisfy the minimum clear zone width, a guide rail should be provided as shown in Figure 3-17 A. The location and type of guide rail selected should be such that the deflection distance will not extend to the rock slope, and preferably will permit some storage area for fallen rock beyond the deflection distance.
- b. High Slopes - Even small rocks falling from high slopes into high speed traffic can produce serious accidents. The Departmental Engineering Geologist should provide recommendations on an appropriate minimum separation between the slope and the traveled way (recommended setback) and may specify measures to control rock fall. Such measures might include hanging wire mesh to keep falling rocks close to the face, installing rock bolts to retain large blocks or shotcreting to wedge and seal wide joints.

Where appropriate clear zone widths and adequate catchment area for falling rocks can be established, as shown in Figure 3-17 B, the absence of a guide rail is beneficial as it facilitates clean-up efforts and avoids the hazard posed by the guide rail itself. Regular inspection and periodic maintenance work may be required to ensure that hazardous sizes of rock are removed from the clear zone in a timely fashion. If it becomes difficult to maintain the effort needed to keep the clear zone free of fallen rocks, consideration should be given to installing a suitable barrier to shield errant vehicles from the fallen rocks.

- c. Fall of Large Rocks - The Departmental Engineering Geologist may develop recommendations for measures, such as rock bolting, to prevent large rocks from falling. Because large rocks may already have a significant lateral velocity due to impacts on the slope face, a heavy guide rail system should be provided adjacent to the shoulder in zones where the fall of large rocks is judged likely. Refer to Figure 3-17 C.
- d. Large Volume Rockfalls - Where large volume rockfalls are judged to be likely, a catchment area sufficient to hold a large volume may be designed by the Departmental Engineering Geologist. (For further insight, see the Geotechnical Engineering Bureau's "*Rock Slope Hazard Rating Procedure*" which references a procedure to size wide, deep ditches to catch rockfalls.) A guide rail may need to be provided to shield the drop-off into the ditch. (See Chapter 10) It is desirable for provision to be made for access behind the rail to facilitate removal of accumulated fallen rock. Refer to Figure 3-17 D.

Figure 3-17 Rock Slope Setback Options



NOTES:

- 1) Select guide rail so that its deflection distance will not reach rock slope. Space beyond deflection distance is also desirable for fallen rock storage. If the setback is less than 4.0 m, consideration may be given to placing a smooth-faced concrete wall or half-section barrier against the base of the slope instead of using guide rail.
- 2) Access and/or equipment should be available to permit timely removal of hazardous sizes and amounts of fallen rock in the deflection distance.
- 3) Ditch slope should be continuous (1:6 preferred) to the bottom of the cut. Avoid the creation of a ramp at the toe that might redirect falling rock towards the roadway.
- 4) Hazardous amounts of fallen rock to be removed from the clear zone in a timely fashion.
- 5) Other barrier options may be acceptable.
- 6) Barrier is required for control of fallen rock regardless of whether or not the setback satisfies the clear zone requirements.
- 7) Ditch width and depth are provided by the Departmental Engineering Geologist, typically based on A) Anticipated volume of a single fall, B) Setback recommendations, and C) "Ritchie Ditch" criteria (these relate slope height and angle to catchment ditch geometry).
- 8) Access for clean-up work is recommended but not required.

3.2.16 Right of Way Width

The procurement of right of way widths that will accommodate reasonable clear zone widths, stable slopes and the construction, drainage, maintenance, and development of an aesthetically pleasing highway is an important part of the overall design. The designer should pay particular attention to right of way width requirements during construction, especially where it will be necessary to maintain traffic during the construction process. If the section involves significant heights of cut or fill, a narrow right of way width may require the construction of a costly temporary retaining wall. Early in the scoping/design process, construction sequencing should be discussed with the Regional Geotechnical Engineer, who can provide valuable assistance in determining whether a temporary wall is needed or feasible and, if so, what type should be used. Wall costs may vary widely and are dependent on the type of wall and soil conditions. If any need for temporary walls is identified, the Real Estate Office should be involved to determine whether it would be preferable to build the wall or avoid that need by acquiring adequate right of way or temporary easements. Consideration should also be given to an off-site detour.

Wide right of way permits the construction of gentle slopes, resulting in more safety for the motorist and easier and more economical maintenance. The acquisition of sufficient right of way at the time of initial improvement permits widening the road section and widening and strengthening the pavement at reasonable costs as traffic increases. In every case, the right of way should not be less than that required for all elements of the design cross section and appropriate border areas, typically including design clear zone widths. Refer to Chapter 10 for a more thorough discussion of clear zone widths and when it might be appropriate to provide for them when acquiring right-of-way.

Generally, utilities can and should be accommodated at the edge of the clear zone or between the edge of the clear zone and the existing or acquired ROW line. However, except when required for municipal utility relocations that are reimbursable by Highway Law, it will not be necessary to make a ROW acquisition for the purpose of accommodating utilities. Border areas may vary from 30 m or more, in rural areas where lower land values prevail, to a few meters (1.5 to 4.5 m) in highly commercialized areas. In developed areas, the buffer width determinations should, as a minimum, take into consideration sidewalk widths and setbacks, snow storage zones and space for signs and utilities.

It may not be feasible on a particular project to provide gently graded traversable areas because of local development or other overriding effects. On those occasions where developed property is encountered adjacent to proposed slope areas, the designer is required to consult with the Regional Real Estate Group as well as the Regional Geotechnical Engineer to determine slope or embankment construction. Such factors as substantial grade change, impairment of access and loss of setback could adversely affect an adjacent improvement to such a degree that it is better to acquire and remove the improvement rather than allow it to remain in undesirable proximity to the highway.

See Chapter 5, Section 5.5 of this manual for additional information on right of way considerations.

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3.3 EXISTING FACILITIES

In general, modifications to an existing facility may be required because additional capacity is needed, because the facility has deteriorated or because a safety problem needs to be addressed. The Scoping Procedure Manual and the Design Procedure Manual describe the steps that should be followed to produce a Scope Summary Memorandum or Design Approval Document. The critical design elements for existing facilities should be obtained in accordance with the current Department guidance for the appropriate classification of Resurfacing, Restoration and Rehabilitation project (See Section 3.1.2). The two-volume *Pavement Rehabilitation Manual* is an important tool in scoping pavement work. Volume I, *Pavement Evaluation*, provides guidance on evaluating the condition of existing pavements and the preparation of Pavement Evaluation Reports. Volume II, *Treatment Selection*, describes accepted rehabilitation alternatives (ranging from preventive maintenance to reconstruction) and provides guidance on selection procedures. Part 3 of Volume II, in particular, describes the procedure for performing a Life Cycle Cost Analysis (LCCA) to identify the least expensive alternative over time. Note that the life cycles provided in Volume II are for a maximum AADT of 35,000. For higher volumes, regions are encouraged to use life cycles that reflect their local experience and to select treatment options accordingly.

A related document, Engineering Instruction 92-026 *Pavement Restoration Techniques, 1992*, lists both the accepted rehabilitation techniques and the "Project Special" and "Experimental Feature" alternatives and their specification numbers. (EI 93-028 provides a minor revision.) Engineering Instruction 92-15 *Project Level Pavement Selection Process* provides the guidance on which procedures should be used in a given selection process. As an example, the EI indicates that an LCCA is generally required to aid in selection of the type of pavement when a reconstruction alternative is required.

The sections that follow give brief descriptions of pavement rehabilitation alternatives involving modifications to the typical sections which go beyond normal preventive maintenance. The alternatives are generally ordered from least to most involved. Following these alternatives, miscellaneous retrofitting and rehabilitation treatments that affect typical sections are discussed, such as addition of underdrains.

3.3.1 Overlays

Overlays of existing pavements are the most commonly used rehabilitation techniques. Overhead clearance requirements and the effects on bridges, curbs, sidewalks, guide rail, driveways, manholes, crossroads, drop inlets, etc. should be checked any time overlays are proposed.

For isolated clearance problems, such as a bridge underpass, the optimum solution is pavement removal and reconstruction in the vicinity of the structure to accommodate the required clearances. The Regional Geotechnical Engineer should be contacted for thickness and drainage details. In developed areas with numerous driveways, cross streets, manholes, drain inlets, curb reveal needs and other appurtenances, the best solution may be reconstruction to accommodate the grade restrictions. Simple milling and use of a thinner overlay is not normally recommended because it

will not achieve the intended service life. Thin overlays are short term maintenance solutions and should not be considered when major rehabilitation is desired. Locations that were previously overlaid and require resurfacing for functional reasons, rather than structural, may be appropriate for milling and inlaying to accommodate clearance limitations.

Overlay projects should not reduce the effective height of curbs to less than 100 mm when their design height is 150 mm, or to less than 75 mm when their design height is 100 mm. To avoid reducing the effective curb heights to less than these minimums, the project may 1) mill down the existing pavement before placing the overlay, 2) reset the curbs, or 3) taper the overlay thickness down towards the curb, provided the rollover and cross slope limitations are not exceeded.

While most overlays will use HMA applied to either flexible or rigid pavements, PCC may also be used as an overlay material, but only on rigid pavements, at present. 'Whitetopping' may be introduced as demonstration projects. Overlay techniques and their conditions for use are catalogued in the *Pavement Rehabilitation Manual (PRM)*, Volume II, *Treatment Selection*.

3.3.1.1 Pre-Overlay Repair and Preparation

The success of any overlay requires proper repair and preparation of the existing pavement. In general, pre-overlay repairs consist of improving or restoring drainage, removing and replacing areas of poor support within the pavement subbase or subgrade, and repairing surface defects to provide a stable platform. If the joints are in bad condition, refer to the PRM for acceptable treatment options.

A. Preparation for Rigid (PCC) Overlays

When placing a PCC overlay on a PCC pavement, the existing pavement repair techniques include removing cracked and broken slabs, repairing spalled areas, and scarifying the entire surface area to a depth of 8 mm. The surface is then sandblasted and cleaned. Preparations for the terminal details of a PCC overlay are complicated by the fact that the minimum thickness of overlay that should be used is 75 mm. Consequently, several slabs at each end of an overlay project must be either milled down so that the overlay thickness for a smooth transition is not thinner than 75 mm, or removed and reconstructed to match the appropriate transition profile. Overlay transition profiles should be designed to merge with the existing profile at existing transverse joints. See Figure 3-18 for guidance on appropriate transition lengths.

B. Preparation for Flexible (HMA) Overlays

The specific techniques used to repair surface defects prior to placing an HMA overlay depend on the existing pavement type.

For existing PCC (rigid) pavements, repairing surface defects may include milling and patching spalled areas, shimming faults, removing cracked slab (if the pavement is not to be cracked and seated or rubblized), and cleaning and filling joints and cracks.

Repairing surface defects in HMA surfaced pavements (HMA or existing HMA overlay on PCC) may include hot-in-place recycling, cold-in-place recycling, milling the entire surface (or selected areas only), shimming wheel ruts and cleaning and filling joints and cracks.

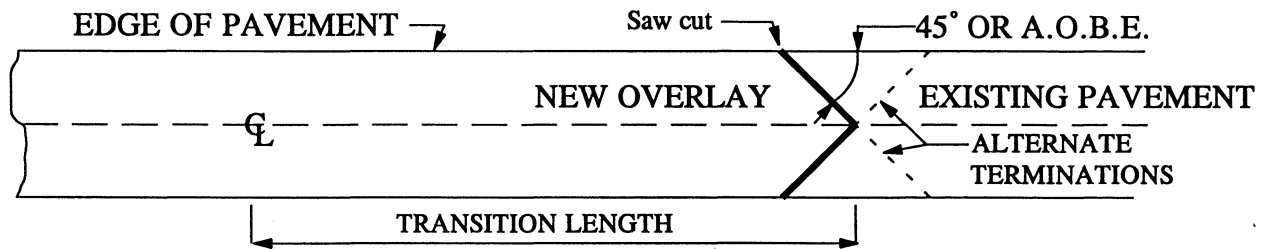
Immediately before placing an HMA overlay, the existing pavement and shoulder surfaces should be cleaned and tack-coated to bond the overlay to the existing surface. Tack coats shall be specified and shown on the typical section drawings whenever resurfacing 1) any PCC pavement, 2) any milled pavement, and 3) any asphalt pavement except when the surface is excessively flushed (high asphalt concentration at the surface). The normal application rates are between 0.14 and 0.32 l/m².

Before placing the overlay, a truing and leveling course should be used, as necessary, to correct depressions and settlement.

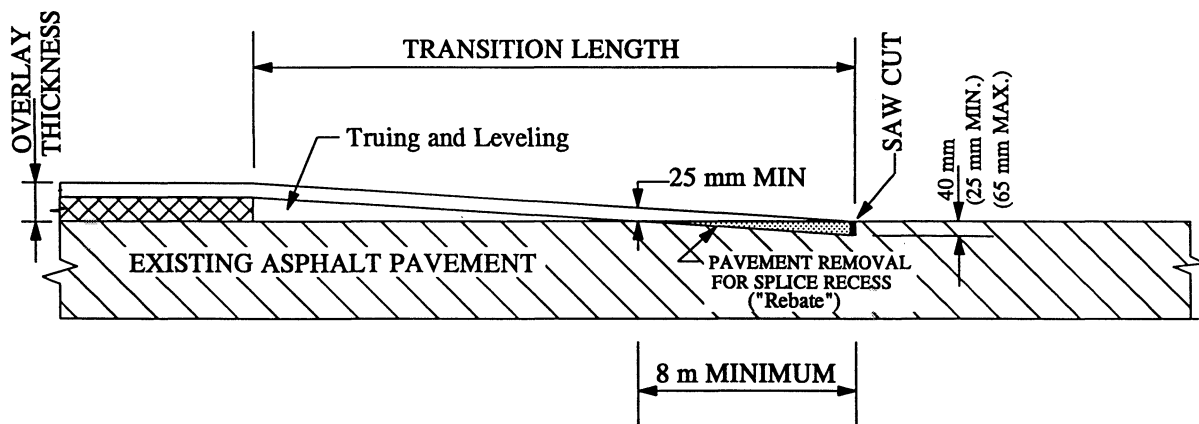
The total thickness for overlays placed on HMA surfaced pavements ranges from 25 to 150 mm. On PCC pavements, overlay thicknesses range from 75 to 150 mm. Overlay thickness depends on the load-carrying capacity of the existing pavement and the type, severity, and extent of distresses present. Refer to the *Pavement Rehabilitation Manual*, Volume II, for layer thicknesses. Note that thick overlays may present problems with overhead clearances and, in developed areas, with driveways, cross streets, manhole rim elevations, drain inlets, curb heights, and other appurtenances. The designer should be aware that, in addition to the normal milling and filling operations for such cases, other techniques, such as concrete inlay or microsurfacing, and particularly reconstruction (see Section 3.3.1) may warrant consideration. Other alternatives include rapid setting polymer concrete, diamond grinding for profiling and texturing, and a patented process called Novachip. For further information on such techniques, consult the Regional Materials Engineer.

Particular attention should be paid to the details of the terminations of the overlays. Since asphalt will ravel if tapered to a feathered edge, it is preferred practice to cut a recess into the existing pavement to permit placement of the top course to a thickness of at least 25 mm. Rebate depths of up to 65 mm may be used to accommodate more than one layer of asphalt. The removal of the recess or "rebate" should be scheduled to minimize the amount of time that it must be left open to traffic. On deeper rebates which will have to carry traffic prior to final paving, temporary asphalt wedges should be placed to reduce the severity of the bump effect between the rebate and the existing pavement. Because of potential compaction complications and Maintenance and Protection of Traffic conflicts, rebates should generally not be deeper than 65 mm. Figure 3-18, Detail of Asphalt Overlay Splice, illustrates an acceptable method of terminating an HMA overlay. Between the rebate and the full overlay thickness, an area of Truing and Leveling (T&L) is indicated as a means of terminating lower lifts of the overlay. The use of truing and leveling and the tapered geometry shown is intended to 1) simplify the calculation of payment quantities and to 2) recognize the greater labor involved in placing the asphalt in this location. In practice, the T&L should be the same material as that used in the adjacent lifts. Also, the T&L should not be thinned to a feather edge as it is likely to be a coarser material that could ravel quickly and become a nuisance to temporary traffic. More than one T&L wedge may be shown if it is necessary to terminate more than one asphalt layer outside of the rebate.

Figure 3-18 Detail of Asphalt Overlay Splice (Pavement Termination Detail)



PLAN



SECTION

Recessed splices should be used for overlay terminations on mainline pavements and major intersections. The length of pavement removed to form the recess may be increased as appropriate for existing gradients, lift thicknesses, etc. For rideability, transition lengths should be at least 4 (and preferably 8) times the value obtained by multiplying the effective overlay thickness (difference between original and overlaid elevations) by the design speed in km/h. (If Design Speed = 100 km/h, and effective thickness = 50 mm, then minimum transition length = $4 \times 50 \text{ mm} \times 100 = 20\,000 \text{ mm} = 20 \text{ m}$.)

Any areas that have been overcut shall be brought up with an acceptable leveling course so lift thickness will not be violated. All surfaces of the transition shall be cleaned and tack-coated prior to asphalt placement.

3.3.1.2 Reflection Crack Control

Overlays on PCC pavements tend to crack above locations of existing cracks and transverse joints in PCC pavement which are locations of thermal expansion and contraction. This is known as reflection cracking. If unaccounted for, reflection cracks will occur shortly after the overlay is placed. Subsequent deterioration of these cracks will then lead to premature overlay failure. Three techniques are used to control reflection cracks:

1. sawing and sealing joints in overlays,
2. cracking and seating existing PCC pavement, and
3. rubblizing existing PCC pavement.

Sawing and Sealing should be used when the majority of thermal expansion and contraction within the PCC pavement will continue to occur at the transverse joints. (This will typically be the case when there are no more than infrequent medium and high severity slab cracks.) Using this technique, a saw cut is made in the overlay directly over the underlying joint in the PCC. This confines reflection crack development to the saw cut. A reservoir is then made by sawing a slightly wider area along the top of the saw cut. Sealant is then placed within the reservoir. This results in an easily maintained, effectively sealed joint which minimizes secondary cracking and the intrusion of water and incompressible fines into the pavement structure.

Cracking and Seating (see Section 3.3.3) should be used when most of the horizontal thermal movement within the existing PCC pavement occurs at erratic transverse slab cracks, rather than at designed transverse joints. When this is the case, the locations and amounts of movement within the slabs are unpredictable. An overlay applied to such a pavement would crack above the movement locations. By deliberately cracking the pavement slabs at short intervals, the Crack and Seat technique shortens the effective slab lengths. Since thermal movement is directly proportional to slab length, the effectively shortened slabs will individually experience less thermal movement. As a result, there will be small contraction at numerous cracked joints rather than large movement at a few joints. This redistribution of stresses and strains will reduce the likelihood and rate of reflection crack occurrence in the HMA overlay.

Rubblizing (see Section 3.3.3), like cracking and seating, should be used when most of the horizontal thermal movement within the existing PCC pavement occurs at transverse slab cracks, rather than at transverse joints. It is selected instead of cracking and seating 1) if the project contains underground utilities which could be damaged by a cracking and seating operation, 2) where the pavement is to be widened, or 3) on badly spalled pavements where surface repairs would be cost prohibitive.

Rubblizing fractures the PCC pavement into pieces generally less than 150 mm wide, creating a high strength granular base. Various references indicate that the rubblized base has a structural coefficient approximately half that of HMA Base courses. Therefore, a 230 mm rubblized pavement overlaid by 150 mm of HMA has the structural capacity of a 265 mm full depth HMA pavement.

Subbase drainage and good subbase/subgrade support are essential for proper rubblizing. For the first reason, edge drains are to be included, typically at the edge of traveled way, on all rubblizing projects. PCC pavement built on poor materials, or built to bridge areas of poor material, will result in structurally inadequate sections after rubblizing. A thorough investigation of subbase and subgrade support is essential.

3.3.2 Cracking and Seating

Where a Portland Cement Concrete (PCC) pavement is cracked (see 3.3.1.2 B) and deteriorated to a point that the other leading feasible rehabilitation alternative is reconstruction, cracking and seating may be an appropriate alternative. (See the PRM for a discussion of other alternatives.) In the Crack and Seat operation, a pavement breaker is used to crack the pavement and a 50 t roller used to seat it. The seated pavement should be overlaid with 125 mm of HMA. Underground utilities may preclude this option. See Section 3.3.3.

3.3.3 Rubblizing

Where PCC cracking and seating would be warranted but is precluded by utilities or joint separation, a resonant frequency machine may be used to rubblize the pavement to aggregate sized particles. The slab should be laterally supported with any necessary reconstructed section prior to rubblization. This support may consist of an existing or reconstructed shoulder, or may be the base for a lane addition. A 150 mm asphalt concrete overlay should be specified. Refer to Figure 3-19 for details of the rubblization process when a lane is being added.

3.3.4 Lane Additions and Widenings

Once it has been determined that a project requires lane widening or additions, the designer must develop typical sections which adequately address, among other concerns, mobility, the roadside design considerations discussed in Chapter 10, and the bicycle and pedestrian concerns discussed in Chapter 18. Additionally, the Regional Geotechnical Engineer must be consulted to review the existing subsurface conditions and provide recommendations for an embankment foundation, drainage provisions and subgrade sufficient to support the pavement structure. At a minimum, a subbase material similar to the existing subbase should be used under the widened pavement. To better ensure adequate drainage, however, it is preferred practice to use the open graded subbase, Crushed Stone Aggregate Subbase Course.

Where it is decided that an edge drain system should be installed, the area outside of the drains may be constructed of normal embankment materials, although subbase is preferred as shown in Figure 3-19. Where no drain is to be provided, the subbase should be carried to daylight and the bottom surface should slope to drain without pockets that might pond water and contribute to frost heave.

Where slopes are cut, the Regional Geotechnical Engineer should be consulted for recommendations on interceptor ditches, slope geometry and treatment, and catchment areas.

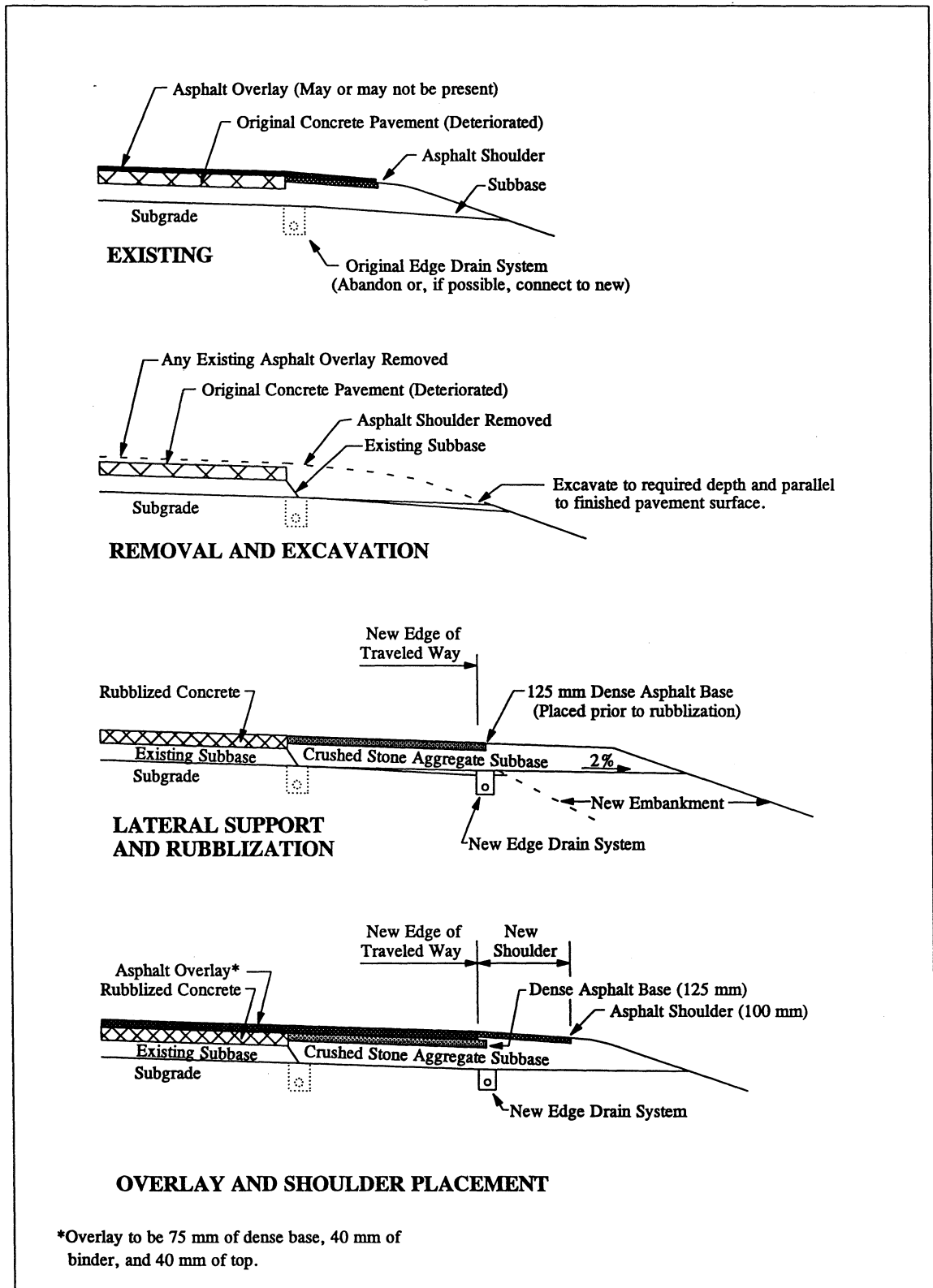
If a concrete lane is to be added adjacent to an existing concrete lane,

- 1) any damaged concrete should be milled out and repaired prior to placing the new concrete slab,
- 2) holes should be drilled into the existing slab in accordance with the design guidance for longitudinal joint ties contained in Standard Specification 502,
- 3) the subbase should be brought to a properly prepared surface to permit pouring of a concrete slab matching the thickness of the existing slab,
- 4) the longitudinal joint ties should be grouted into the existing slab,
- 5) the new slab should be poured with transverse joints matching the locations of the existing transverse joints, and
- 6) the longitudinal joints should be properly sealed to prevent intrusion of unwanted material.

Details for concrete lane additions/widenings that are not covered by the Standard Specifications or Standard Sheets (e.g. construction of unusual transverse or longitudinal joints) should be explained in special details and specifications as necessary.

If an asphalt widening is to be constructed, the subbase should be brought to the appropriate surface, the edges of the existing asphalt courses should be cleaned or saw cut to provide a sound interface, and a tack coat should be applied prior to placing the new asphalt.

Figure 3-19 Rubblizing and Widening Details



3.3.5 Miscellaneous Treatments

In some instances, the Regional Geotechnical Engineer may determine that it is appropriate to add an edge drain to an existing section to reduce the potential of deterioration due to inadequate drainage. Figure 3-20 illustrates the preferred placement details for an underdrain retrofitting. The drain is placed immediately adjacent to the traveled way to intercept the seepage path as quickly as possible without requiring excavation into the full pavement section. The depth of the drain should be chosen to permit continuous positive drainage and should be deep enough to efficiently drain the subbase.

Figure 3-21 presents details of acceptable methods of adding curbs to existing sections. In situations, such as tapers for safety widenings, where the separation between the face of curb and the existing asphalt pavement is too narrow to permit use of a roller to compact asphalt, the space should be filled with concrete. Narrow lane widenings (on the order of 1 m or less), particularly adjacent to existing asphalt pavements, should be avoided.

Figure 3-20 Detail of Underdrain Retrofitting

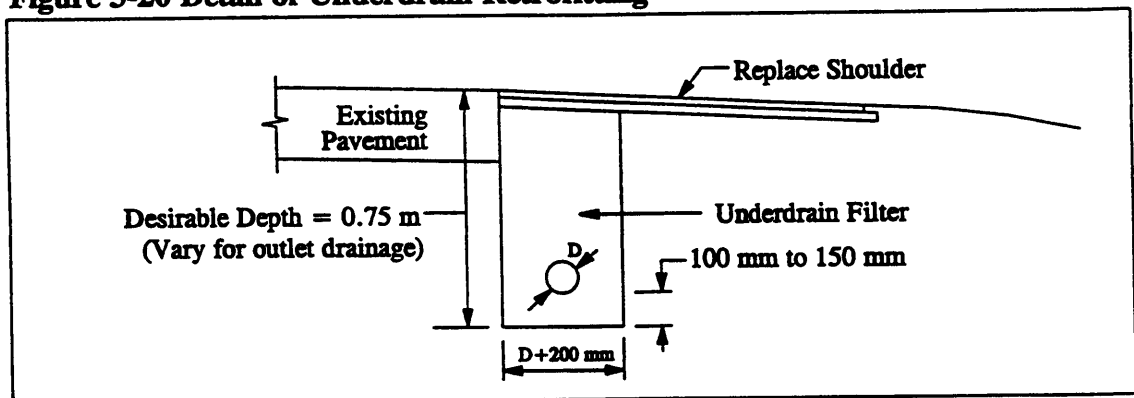
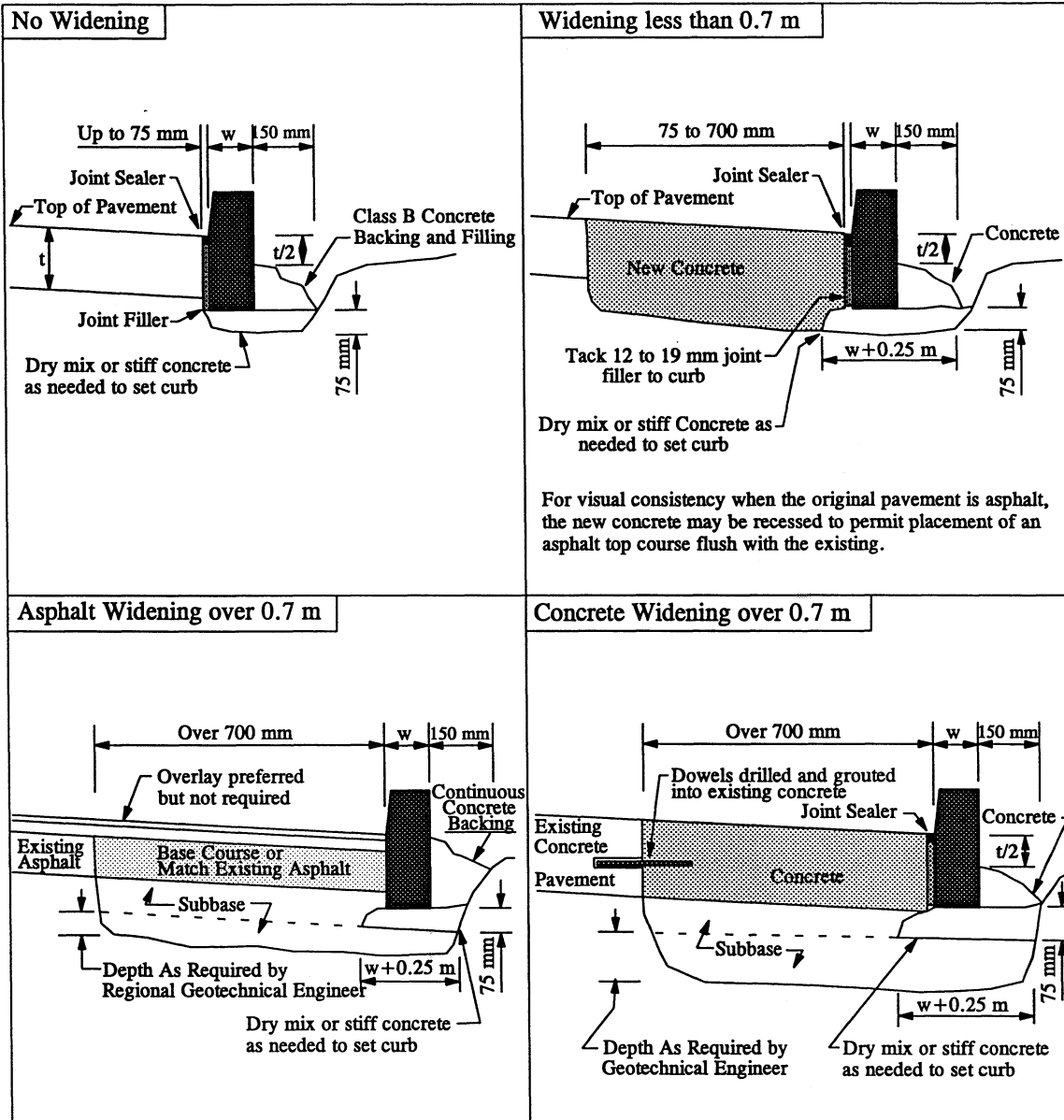


Figure 3-21 Curb Addition Details (Stone or Precast)



- NOTES:
1. Edgedrain addition is not shown, but may be required based on existing drainage features.
 2. When concrete is placed adjacent to existing concrete pavements, transverse joints should be cut or formed as extensions of the existing joints. Existing joints should also be carried through cast-in-place curbs, if used.
 3. Continuous concrete backing up to the projected pavement surface is required when asphalt is to be compacted against the face of the curb. Since placement of concrete pavement will have less shoving, backing support may be at two points for each piece of curb, and the backing height need only be to within $t/2$ of the pavement surface, where t is the nominal pavement depth.

Rutting problems may develop at the edge of shoulder in areas where shoulders are not wide enough to accommodate vehicles, where mailboxes are set well back from the shoulder, and on the inside of turns. Rutting problems are particularly likely to develop in residential areas where ditches are absent or minimal and topsoil extends close to the road. When such roads are to be reconstructed, care should be taken to ensure that steps have been taken to minimize the frequency of vehicles driving off of the shoulder and/or that the material immediately adjacent to the shoulder has reasonably good strength to resist the development of ruts.

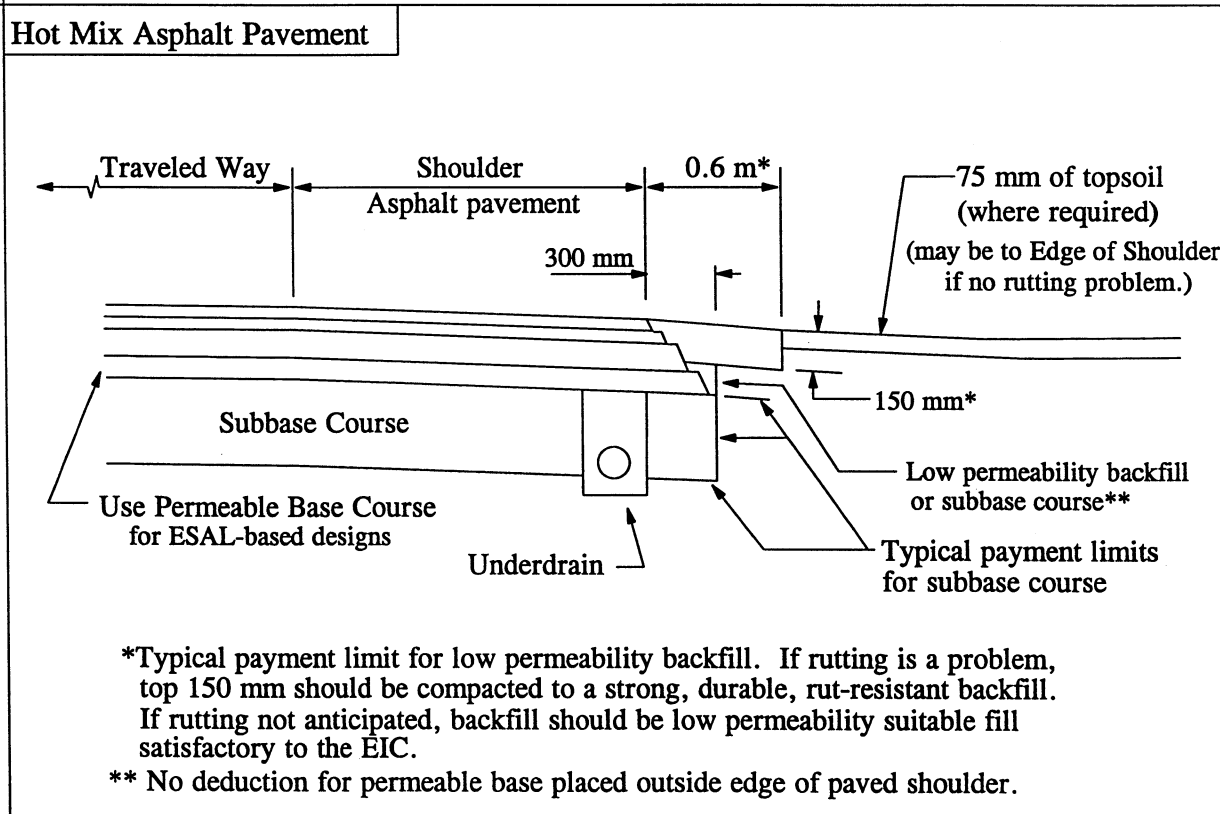
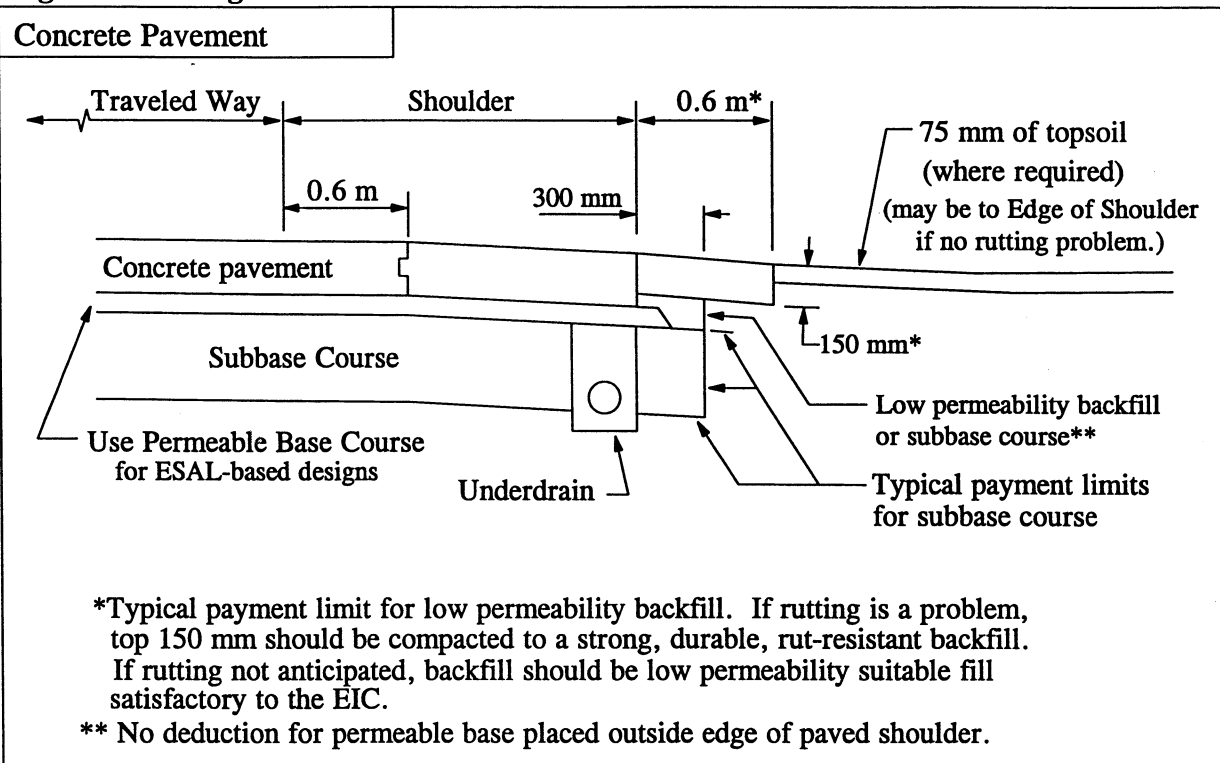
To minimize vehicles driving off of the shoulder, consideration should be given to placing any mailboxes that must be replaced between 200 and 300 mm from the edge of shoulder. Additionally, where conditions permit, the inside radius for heavy duty shoulders at intersections should be equal to or exceed the turning radius of an SU (Single Unit) truck.

The treatment of the area from a depth of 150 mm up to the surface should depend on the anticipated potential for rutting. If there is judged to be little potential for rutting and the homeowners indicate a desire to extend lawn up to the edge of the shoulder, designers may indicate the placement of topsoil, provided that is consistent with Regional policy/practice. If there is the potential for rutting, the normal treatment should be to place subbase material to a thickness of 150 mm adjacent to the shoulder. While limits may vary depending on the job, normal practice would be to indicate payment limits with a depth of 150 mm and a width of 600 mm. In areas that experienced severe rutting prior to construction and where the same potential is expected to exist after construction, consideration may be given to using reclaimed asphalt material in this same shoulder backup area. For reference, see Special Specification 05203.1409 M Shoulder Backup for Newly Placed Shoulders - Reclaimed Bituminous Material Option.

Where the subbase materials in reconstructed sections will not drain laterally to roadside ditches or embankment side slopes ('bath tub' sections), underdrains will typically be installed (see Figure 3-22). The lateral payment limit for the subbase course would typically be 300 mm beyond the edge of the paved shoulder. To limit the amount of surface water that can enter the drain, the backfill between the paved shoulder and the outside of the excavation should include a 150 mm "cap" of fairly low permeability fill. The lateral payment limits for this "cap" material should typically be a 600 mm strip, but may be adjusted to match the job. Typical sections should note that backfill between this "cap" and the subbase course is to be either subbase material or low permeability material selected and compacted to the satisfaction of the EIC. Normally, its lateral payment limit will match that of the underlying subbase. Note that, in many instances, the subbase will both have low permeability and provide good strength to resist rutting.

Where overlays are placed, it is desirable to limit the dropoff at the edge of shoulder. Dropoffs in excess of 50 mm should be addressed during construction. This should be accomplished by either placing a wedge or 'ramp' of backup material at the edge of shoulder or, if the overlay or resulting difference in elevation is large enough, by filling a wider area beyond the shoulder. Within 600 mm of the shoulder, this wedge or filling should be subbase quality material or, if a significant rutting problem exists, the reclaimed asphalt, referenced above, may be considered.

Figure 3-22 Edge of Shoulder Detail - Unditched Section



3.4 DRAWINGS

The typical section drawings shall show all relevant elements to be constructed. This shall include all different rates of slopes of cut and fill, the widths of the roadway, median, and sidewalk, the shape of the finished pavement and shoulders, and the curb and gutter if they are a part of the design. The location of barriers and the design clear zone widths (or clear runout widths where appropriate) shall be indicated and may be supplemented with tables as necessary. Widths should generally be shown in meters and thicknesses in millimeters. All typical sections shall show their relation to a theoretical grade line and a horizontal control line. Centered immediately below each section should be its title and the stationing of the intervals where the section applies. Scale is discussed below. Where elements of the section vary, it is permissible to indicate the variation with station for each element, rather than drawing separate sections. Where an element has numerous variations, a separate table should be provided. Such elements might include guide rail location, shoulder width, clear zone widths, edge drain locations, etc. On smaller projects, these tables may be included on the typical sections sheets. Larger tables on larger projects should be included on the sheets for Miscellaneous Tables. Regardless of where the information is provided, it should be presented in such a manner as to be clear on what the required dimensions are at any station within the project.

For all items shown on the sections, the typical sections should show the payment item numbers and the payment lines (or for appropriate items, the payment limit. See definitions in beginning of Standard Specifications for distinction). In the lower left hand corner of the drawing, the description and payment units for each item number should be provided. On projects with numerous typical sections sheets, this should be done independently for each sheet. On smaller jobs, the items may be described on the first sheet of typical sections and referred to by subsequent sheets, although providing descriptions on each sheet is preferred practice.

In addition to the block or blocks of item descriptions, a block should be provided for notes. If the number of notes is extensive, notes of a more general or comprehensive nature should be placed in the block and notes specific to one part of the drawing should be placed close to that part of the drawing.

In general, the typical section drawings should conform to the guidance in Chapter 21. The drawings should be grouped together with sequenced drawing numbers consisting of a consistent alphabetic code indicating they are typical section drawings followed by sequential numbers. TS is the normal alphabetic code for typical sections, although TY or T may also be used.

It is preferable for typical sections to be drawn to scale, but it is not considered mandatory. When all sections on one sheet are drawn to the same scale, that scale should be indicated in the title block. When individual sections are drawn to different scales, the scale block should indicate "As Shown", and the sections should have their individual scales shown. If the sheet has one or more sections that are not drawn to scale, "NTS" or the words "Not to Scale" should be placed below those sections. Regardless of whether or not the drawings are drawn to scale, all relevant dimensions should be indicated on the typical sections.

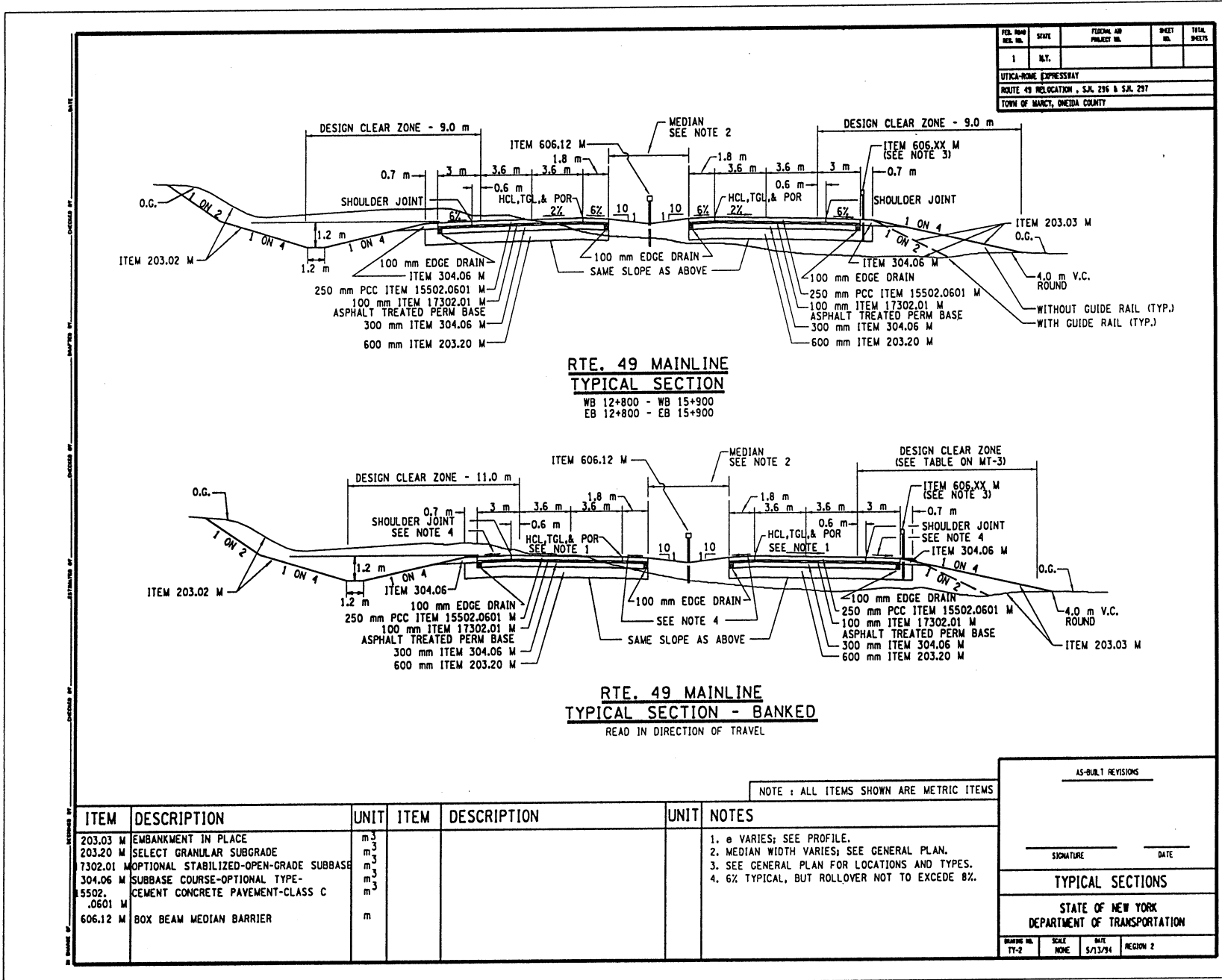
TYPICAL SECTIONS

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Samples of completed Typical Section drawings are shown as Figures 3-23 and 3-24, Sample Typical Sections. These are provided for illustration of drawing organization and should not be referred to for technical details.

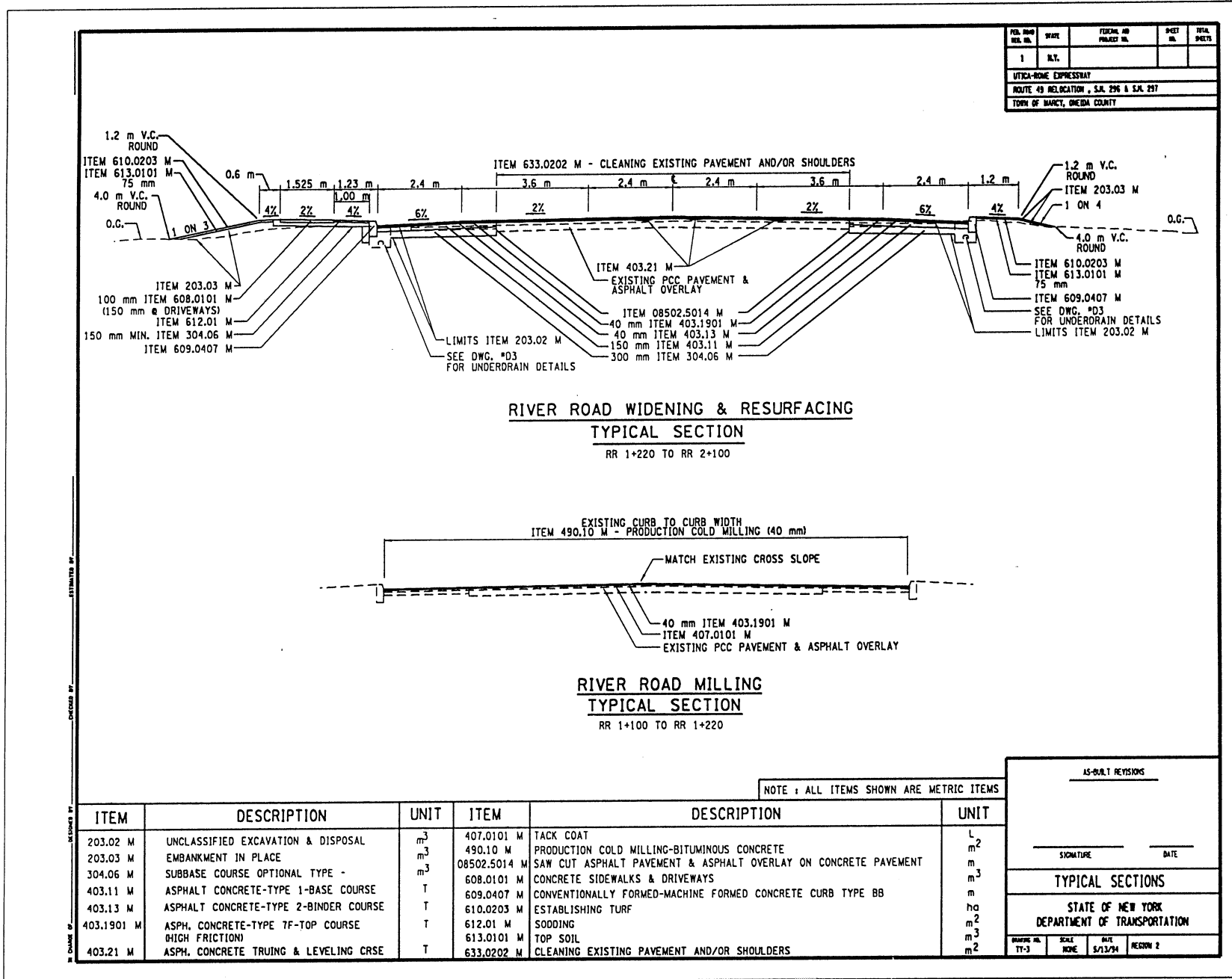
TYPICAL SECTIONS

Figure 3-23 Sample Typical Section - Divided Highway FOR ILLUSTRATION ONLY



TYPICAL SECTIONS

Figure 3-24 Sample Typical Section - Collector Road FOR ILLUSTRATION ONLY



3.5 REFERENCES

1. Americans with Disabilities Act Accessibility Guidelines for Buildings and Facilities, Dec. 1993, Landscape Architecture Bureau, New York State Department of Transportation, State Campus, Albany, New York, 12232.
2. A Policy on Geometric Design of Highways and Streets, 1994, American Association of State Highway and Transportation Officials, Suite 225, 444 North Capitol Street, N.W., Washington, D.C. 20001.
3. Highway Sufficiency Ratings, 1994, Data Services Bureau, New York State Department of Transportation, State Campus, Albany, New York, 12232.
4. NCHRP Synthesis 191 - Use of Rumble Strips to Enhance Safety, National Cooperative Highway Research Program, Transportation Board, National Research Council, 2101 Constitution Avenue, Washington, D.C. 20418.
5. New York State Thickness Design Manual for New and Reconstructed Pavements (Pavement Design Manual), Revision 1, October, 1994, Technical Services Division, New York State Department of Transportation, State Campus, Albany, New York, 12232.
6. (NYSDOT) Manual of Uniform Traffic Control Devices, 1983, request as NYCRR Volume 17B from West Group Order Fulfillment, 620 Opperman Drive, PO Box 64833, St. Paul MN 55164-9752 (Tel. 1-800-328-9352).
7. Pavement Marking Policy, June 1987, Technical Services Division, New York State Department of Transportation, State Campus, Albany, New York, 12232.
8. Pavement Rehabilitation Manual, Volume I - Pavement Evaluation, June 1990, Materials Bureau, New York State Department of Transportation, State Campus, Albany, New York, 12232.
9. Pavement Rehabilitation Manual, Volume II - Treatment Selection, May 1993, Materials Bureau, New York State Department of Transportation, State Campus, Albany, New York, 12232.
10. Policy and Standards for Entrances to Highways, 1998, Support Services Bureau (Plan Sales Unit), New York State Department of Transportation, State Campus, Albany, New York, 12232.
11. Rock Slope Hazard Rating Procedure, October 1993, Soil Mechanics Bureau (now the Geotechnical Engineering Bureau), New York State Department of Transportation, State Campus, Albany, New York, 12232.

12. Safety Investigation Procedure Manual, Traffic Engineering and Highway Safety, New York State Department of Transportation, State Campus, Albany, New York, 12232.
13. Standard Specifications - Construction and Materials, 1995, Support Services Bureau (Plan Sales Unit), New York State Department of Transportation, State Campus, Albany, New York, 12232.

Engineering Instructions

- EI 87-030 Pavement Marking Policy
- EI 92-015 Project Level Pavement Selection Process
- EI 92-026 Pavement Restoration Techniques, 1992
- EI 93-028 Repair of Spalled Areas, Joints and/or Cracks in PCC Pavement
- EI 97-013 Safety Shoulder Rumble Strips (SAFE-STRIPS) Policy and Revised Installation Details

CONVENTIONAL ASPHALT MATERIAL SELECTION

3.6 GENERAL

Selection guidelines for various conventional asphalt pavement items are given below. Refer to the *Standard Specifications*, Section 400 - Bituminous Pavements, for further details on these materials.

As indicated in Tables 3-10 and 3-11, selection criteria for binder and top courses should be based on the Functional Classification as defined in the *Highway Sufficiency Rating* manual (see Table 3-4), the Equivalent Single Axle Loads (ESALs) and, in some cases, the Average Annual Daily Traffic (AADT). The number of ESALs may be estimated by using the "Simple" ESAL calculation method outlined in the PTDM for HMA pavements with modifications for a 15 year period and differing growth rates as discussed in Section 3.2.4.5.

3.7 ASPHALT MIXES**3.7.1 Type 1 Base Course (Dense-Graded)**

This Dense-Graded mix shall be used as a base course for full-depth HMA pavements, full-depth HMA widenings adjacent to either PCC pavement or other dense-graded HMA pavements, and complete or partial replacement of PCC slabs.

The base course thickness will vary according to the required pavement thickness. The minimum lift thickness for the base course shall be 75 mm. The maximum lift thickness shall be 125 mm. If a thicker course is required, multiple lifts must be shown on the plans.

3.7.2 Type 2 Base Course (Open-Graded)

This Open-Graded mix shall only be used when widening adjacent to existing pavements having an Open-Graded base course or when widening adjacent to rubblized concrete. The use of the Open-Graded base course in this manner should maintain the existing drainage pattern and provide for consistent performance across the pavement. The course and lift thickness requirements are the same as for Type I.

3.7.3 Asphalt Treated Permeable Base Course

This course is required as a positive drainage layer under all full depth HMA pavements designed using the ESAL-based procedures presented in the PDM. This course, or a cement-treated permeable base, is also required under PCC pavements designed by the ESAL-based procedures in the PDM. The course shall be placed directly on the prepared subbase course (and edge drain systems) and should extend 100 mm beyond the edges of the subsequent layer.

The thickness of the layer must be 100 mm (nominal). This mix should not be used as a substitute for either Dense Graded or Open Graded Base courses. The specification for this item is presently a Main Office insert.

3.7.4 Type 3 Binder Course Mixes

Type 3 Binder Course

Type 3 HD Heavy Duty Binder Course

Type 3 RA Rut Avoidance Binder Course

Type 3 and Type 3 RA may be used in new HMA pavements or as the Binder course for overlays on 1) PCC, 2) previously overlaid PCC or 3) full-depth HMA pavements for all Functional Classifications (as defined by the Highway Sufficiency Rating manual and shown in Table 3-4).

Type 3 HD may be used in new HMA pavements or as the Binder course for overlays on PCC, previously overlaid PCC or full-depth HMA pavements, but only when placed on a prepared surface (Truing and Leveling course has been placed as needed to permit placement of the Binder at a constant thickness and compaction to achieve high density) and only for Functional Classifications Urban 11, 12, 14, and Rural 01 and 02.

The selection criteria will be based on the Functional Classification of the roadway and a determination of the ESALs which will be encountered over the length of the project. The specific mix selection criteria and thickness requirements for these mixes are given in Tables 3-10, 3-11 and 3-12, which follows these sections on HMA. Type 3 HD and Type 3 RA specifications are presently Main Office inserts.

3.7.5 Type 5 Shim Course

This sand asphalt mix shall be specified for filling wheel or pavement ruts when the ruts are 9 mm or greater in depth (distance measured to bottom of rut from string line stretched across lane width). Typically, the pavement evaluation and treatment selection report (PETSRS) (See EI 92-15) will indicate to the designer the need to specify the use of a Shim and/or a Truing and Leveling course (see below) on the sections, but a site visit will be needed during design to confirm the need and estimate its quantity. If ruts in excess of 25 mm depth are present, other treatment options, such as milling and inlay, should be considered. When Shim is needed, the ruts shall be filled (typically to a width of approximately 1.2 m) and compacted as a separate pay item prior to paving the Truing and Leveling course or Binder course.

The purpose of filling the ruts prior to paving the succeeding layers is to provide an even base on which the next layer may be placed and uniformly compacted. A uniform thickness is necessary to achieve adequate density during compaction.

3.7.6 Truing and Leveling Course

The purpose of a truing and leveling course is to bring the surface of the existing pavement to the same transverse and longitudinal slope required for the finished pavement surface. A Truing and Leveling course should be indicated on the sections when the PETSRS indicates the need. There is no specific Truing and Leveling material. This course will be of variable thickness and its material composition will be adjusted in accordance with the thickness required. The Specifications in Section 401-3.07 provide general guidance on the materials that should be used for the different course thicknesses required. Specific judgements as to the thicknesses required at specific locations and the corresponding materials to be used should be left to the discretion of the Engineer in the field. In general, for thicknesses up to 40 mm, either a Type 5 Shim mix or a top course mix should be used, with the Shim being preferred for the courses that are generally on the thin end of the range. For course thicknesses over 40 mm, a dense binder course mix should be used; however, where compacted thicknesses of 100 mm or greater are required, the Engineer may approve the use of a dense base course mix.

Note that Truing and Leveling is only meant for use in limited areas where it is necessary to bring the surface of the existing pavement to the correct transverse slope and longitudinal slope for the finished pavement surface. See the section on Shim Course (above) for details of the initial filling of wheel ruts between 9 and approximately 25 mm deep. Truing and leveling is not to be used as a substitute for a lift of an overlay by specifying full width applications of a given minimum thickness. When corrections are needed over the length of the project, an 'initial asphalt paving' course of the minimum thickness and the appropriate type to correct the transverse slope is to be specified.

3.7.7 Type 6F Top Course Mixes

Type 6F Top Course
Type 6F HD Heavy Duty Top Course
Type 6F RA Rut Avoidance Top Course
Type 6FX Friction Top Course

The Type 6 mixes are coarser than the Type 7 mixes. The choice of which to use is a matter of regional preference and typically reflects aggregate availability. Additional considerations may be smoothness for bicyclists and pedestrians.

Type 6F and 6FX Top courses and Type 6F RA Rut Avoidance Top course may be used as the surface course for new HMA pavements or as overlays on PCC, previously overlaid PCC, or full-depth HMA pavements.

Type 6F HD Heavy Duty Top course may be used as the surface course for new HMA pavements or as overlays on PCC, previously overlaid PCC, or full-depth HMA pavement, but only when placed on a prepared surface (Truing and Leveling course has been placed as needed) and only for Functional Classifications Urban 11, 12, 14, and Rural 01 and 02.

Depending on the Functional Classification of the highway, the selection criteria will be based on a determination of the ESALs which will be encountered over the length of the project and, in some cases, the AADT volume. When a Binder course is used with any of these materials, the type of Binder course must match the type of Top course used. (i.e. Heavy Duty Binder with Heavy Duty Top).

These items should be used as the primary top course on Department maintained pavements when aggregate quality (occurrence of popouts) is not a concern. The Regional Materials Engineer should be consulted on this restriction. The specific mix selection criteria and thickness requirements for these mixes are given in Tables 3-10, 3-11 and 3-12. The special specifications for Type 6F HD, 6F RA, and 6FX are currently Main Office inserts. Where traffic volumes make dolomite content a concern, as in the 'downstate and high volume' areas specified in note 2 below Table 3-10, Item 6FX should be specified due to its friction aggregate requirements.

3.7.8 Type 7F Top Course Mixes

Type 7F Top Course
Type 7F HD Heavy Duty Top Course
Type 7F RA Rut Avoidance Top Course
Type 7FX Friction Top Course

Type 7F, 7FX and Type 7F RA may be used as the surface course for new HMA pavements or as overlays on PCC, previously overlaid PCC, or full-depth HMA pavements.

Type 7F HD may be used as the surface course for new HMA pavements or as overlays on PCC, previously overlaid PCC, or full-depth HMA pavements, but only when placed on a prepared surface (as above), and only for Functional Classifications Urban 11, 12, 14, and Rural 01 and 02. The selection criteria are the same as for the Type 6F items except that the 7F items should be used when aggregate quality (occurrence of popouts) is a concern. When needed, the type of binder used should match the type of top course used (i.e., use 3 HD under 7F HD). The Regional Materials Engineer should be consulted on the use of these mixes.

The specific mix selection criteria and thickness requirements for these mixes are given in Tables 3-10, 11 and 12. The special specifications for Types 7F HD, 7FX and 7F RA are currently Main Office inserts. Type 7FX, due to its friction aggregate requirements, should be specified where dolomite content is a concern, as in the 'downstate and high volume' areas specified in note 2 below Table 3-10.

3.2.9 Type 10FX Open-Graded Surface Course

This Open-Graded Surface course provides a pavement with both surface and internal drainage channels to reduce "hydroplaning" of vehicle tires under heavy rain conditions by quickly removing excess water from the traveled surface. This mix should be considered for use in areas with a history of a high number of wet-weather skidding accidents. However, open-graded mixes tend to

'cover over' with snow more quickly than adjacent dense graded mixes, primarily at the beginning and end of the winter season.

The minimum thickness of this course shall be 40 mm (nominal). Adjacent shoulder surface courses shall also be open-graded or they will act as dams, reducing the cross-slope drainage characteristics of the pavement. The Regional Materials Engineer must be contacted for the specification and additional guidelines to ensure the proper use of this mix.

3.7.10 Superpave Ice Retardant Top Course Mixes

These surface courses are the same as Superpave top courses, except that they include the use of an anti-icing additive, at varying rates depending on traffic conditions. The additive consists of encapsulated calcium chloride pellets which break down under the action of traffic to form a mild brine which blocks the tight adhesion of ice to the surface. The ice retardant mixes have proven especially useful on bridges with **a significant history of ice-related accidents**. Use of this material must be reviewed and approved by the Regional Traffic Engineer (RTE) based on an analysis of accident data and traffic volumes, unless it is being used where an ice retardant overlay is presently in place. Typically, the RTE will identify the need for this material.

Once an ice retardant top course is used at a site, any subsequent overlays must also use an ice retardant top course, unless a thorough engineering study indicates, to the satisfaction of the RTE, that sufficient site changes have occurred to justify returning to normal top mixes. When a new installation of ice retardant mix is being considered, its cost must be compared to other alternatives that may also reduce the number of ice-related accidents, such as removing trees which shade sections of the pavement. The current estimated cost and service life for ice-retardant asphalt overlays can be obtained from the Regional Materials Engineer (RME). The special specifications for these proprietary items can also be obtained from the RME, along with the details of the mix design, thickness, and compaction requirements. Note that schedules usually need long lead times for ordering and delivery of the additive.

3.8 ASPHALT ITEM SELECTION

Selecting the total thickness of the asphalt section (how much base, binder and top) will depend on the requirements discussed earlier for either conventional asphalt design (Section 3.2.4.3) or ESAL-based design (Section 3.2.4.4). For some low volume roads, the minimum course thicknesses may actually govern. Selection of the specific conventional asphalt item type will involve four decision steps as laid out moving from left to right in Tables 3-10 and 3-11. The decisions are as follows.

1. What is the project's Functional Classification?
2. If it has a high volume Functional Classification (indicated in Table 3-11), does it have either Full or Partial Control of Access?
3. What is the project's location, 15 year ESAL count, and AADT/lanes relationship? For the tables, the City of New York, and the surrounding counties of Dutchess, Nassau, Orange, Putnam, Rockland, Suffolk and Westchester are referred to as "Downstate". "High volume"

refers to 2 or 3 lane highways with design year AADTs over 8000, or for more than three lanes, with AADTs over 13,000.

- Does the project involve less than 5000 Mg of each lift or is it in proximity to areas where vibratory compaction may be a problem?

Table 3-10 Pavement Selection for General Highways - Conventional Asphalt

Functional Classification	ESALs ¹ Less Than 1.5 x 10 ⁶	Downstate ² OR High Volume	Over 5000 Mg AND NOT Vibratory Sensitive	Mix Type
U16 - Urban Minor Arterial U17 - Urban Collector U19 - Urban Local	Yes	Yes	18403.170201, 6 FX 18403.1901, 7 FX	
		No	403.13, 3 403.17, 6F 403.19, 7F	
R06 - Rural Minor Arterial R07 - Rural Major Collector R08 - Rural Minor Collector R09 - Rural Local	No	Yes	Yes	18403.1336, 3 RA 18403.1736, 6F RA 18403.1936 ³ , 7F RA
			No	18403.1335, 3RA 18403.1735, 6F RA 18403.1935 ³ , 7F RA
		No	Yes	18403.1336, 3 RA 18403.1736, 6F RA 18403.1936 ³ , 7F RA
			No	18403.1335, 3RA 18403.1735, 6F RA 18403.1935 ³ , 7F RA

NOTES

- Compute ESALs using "Simple" method with compound traffic growth detailed in the "NYS Thickness Design Manual for New and Reconstructed Pavements" using 15 year service life. For projects with differing AADTs, use the maximum AADT encountered over the length of the project.
- The City of New York, and the surrounding counties of Dutchess, Nassau, Orange, Putnam, Rockland, Suffolk and Westchester are referred to as 'downstate'. All other areas are referred to as 'upstate'. 'High volume' refers to 2 or 3 lane highways with design year two-way AADTs over 8000, or for more than three lanes, with two-way AADTs over 13,000. Low volume refers to highways with lower volumes for the specified number of lanes.
- These mixes require the concurrence of the Regional Materials Engineer.

3.9 LIFT THICKNESS LIMITATIONS

In general, minimum lift thicknesses are constrained by the maximum size aggregate used in the mixture. Maximum lift thicknesses are set to ensure that the full thickness of the lift is adequately compacted. If the required course thickness (structural requirements in Sections 3.2.4.3 and 3.2.4.4) of a given item exceeds the maximum permissible lift thickness, then multiple lifts are to be used to obtain the required course thickness. Table 3-12 lists the minimum and maximum lift thicknesses for the mix types.

Table 3-11 Pavement Selection for High Volume Highways - Conventional Asphalt

Functional Classification	Full/Partial Control of Access	Downstate ¹ OR High Volume	Over 5000 Mg AND NOT Vibratory Sensitive	Mix Type
U11 - Urban Principal Arterial Interstate	Yes	18403.1318, 3 HD 18403.1718, 6F HD 18403.1918, 7F HD		
U12 - Urban Principal Arterial Expressway	No	Yes	Yes	18403.1336, 3 RA 18403.1736, 6F RA 18403.1936 ² , 7F RA
U14 - Urban Principal Arterial Other			No	18403.1335, 3RA 18403.1735, 6F RA 18403.1935 ² , 7F RA
R01 - Rural Principal Arterial Interstate		No	Yes	18403.1336, 3 RA 18403.1736, 6F RA 18403.1936 ² , 7F RA
R02 - Rural Principal Arterial Other			No	18403.1335, 3RA 18403.1735, 6F RA 18403.1935 ² , 7F RA

NOTES

1. The City of New York, and the surrounding counties of Dutchess, Nassau, Orange, Putnam, Rockland, Suffolk and Westchester are referred to as 'downstate'. All other areas are referred to as 'upstate'. 'High volume' refers to 2 or 3 lane highways with design year two-way AADTs over 8000, or for more than three lanes, with two-way AADTs over 13,000. Low volume refers to highways with lower volumes for the specified number of lanes.
2. These mixes require the concurrence of the Regional Materials Engineer.

Table 3-12 Limits on Permissible Lift Thicknesses - Conventional Asphalt

Mix Types	Minimum Lift Thickness (mm)	Maximum Lift Thickness (mm)
3, 3 HD, 3 RA	40	75
6F HD, 6F RA	40	50
7F HD, 7F RA	40	50
6F, 6 FX	25	50
7F, 7FX	25	50

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