



STATE OF NORTH CAROLINA  
DEPARTMENT OF TRANSPORTATION

MICHAEL F. EASLEY  
GOVERNOR

LYNDO TIPPETT  
SECRETARY

January 23, 2008

**MEMORANDUM TO:** 2001 Roadway Design Manual Holders

**FROM:** Rodger D. Rochelle, PE  
State Alternative Delivery Engineer

**SUBJECT:** 2001 Roadway Design Manual June Revision  
and New Guidelines for Revisions

Please find attached revisions and new guidelines to Part I and Part II of the *2001 Roadway Design Manual*. Please insert these revisions in your Manual in the appropriate place. These revisions are effective immediately. This transmittal letter should be detached from the revision and inserted in front of the Manual for future reference. Please recycle discarded pages from your manual. The *2001 Roadway Design Manual* has been updated and is available on the web at:

<http://www.ncdot.org/doh/preconstruct/altern/value/manuals/>

If you have any questions and comments about this revision or the Roadway Design Manual, please contact Mr. Frankie Draper or Mr. Robert McKeithan of my staff at (919) 250-4234.

## REVISION NOVEMBER 2007

### Part I – Roadway Design Manual

#### 1. INTRODUCTION

Note: Design Services Deleted from all references.

Remove and discard 1 sheet and replace with 1 revised sheet

**MAILING ADDRESS:**  
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ALTERNATIVE DELIVERY UNIT  
1591 MAIL SERVICE CENTER  
RALEIGH NC 27699-1591

TELEPHONE: 919-250-4128  
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WEBSITE: [WWW.NCDOT.ORG](http://WWW.NCDOT.ORG)

**LOCATION**  
CENTURY CENTER COMPLEX  
ENTRANCE B-2  
1020 BIRCH RIDGE DRIVE  
RALEIGH NC

## **2. PART 1 UTILIZATION OF DESIGN MANUAL AND MANUAL FORMAT**

Note: Design Services Deleted from all references.

Remove and discard 1 sheet and replace with 1 revised sheet

## **3. Chapter 1-Section 1 DESIGN POLICY INTERPRETATION**

Note: A Policy on Geometric Design reference updated from 2001 to 2004.

Remove and discard 1 sheet and replace with 1 revised sheet

## **4. Chapter 1-Section 1-1, 1-1A, and 1-1B.**

### Section 1-1 SELECTION OF PROJECT DESIGN CRITERIA

Note: Design Services Deleted from all references.

### Section 1-1B DESIGN SPEEDS

Note: A policy on Geometric Design reference updated from 2001 to 2004.

### Section 1-C TRAFFIC VOLUMES

Note: Design Services Unit reference changed to Alternative Delivery.

Note: A policy on Geometric Design reference updated from 2001 to 2004.

### Section 1-D TERRAIN CLASSIFICATIONS

Note: A policy on Geometric Design reference updated from 2001 to 2004.

### Section 1-E PROJECT COST REDUCTION GUIDELINES

Note: A policy on Geometric Design reference updated from 2001 to 2004.

Remove and discard 6 sheets and replace with 6 revised sheets

## **5. Chapter 1-Section 1-4B USABLE AND GRADED SHOULDERS**

Note: Assistant Head of Roadway Design or the Engineering Coordinator of Design Services has been changed to Assistant State Roadway Design Engineer.

Remove and discard 1 sheet and replace with 1 revised sheet

**6. Chapter 1 Section 1-4C N.C. DOT PAVED SHOULDER POLICY**

Note: Design Services Engineer deleted from reference.

Remove and discard 1 sheet and replace with 1 revised sheet

**7. Chapter 1 Section 1-4G PAVED SHOULDERS WITH RIGID PAVEMENT**

Note: Econocrete reference changed to concrete shoulder.

Remove and discard 1 sheet and replace with 1 revised sheet

**8. Chapter 1 Section 1-6F MEDIAN SLOPES**

Note: Change reference of Figure 2A thru 4 to Figure 1 thru 4.

Remove and discard 1 sheet and replace with 1 revised sheet

**9. Chapter 1 Section 1-8 RAISED ISLANDS**

Note: For widths greater than 16', cost-comparison should be made between monolithic islands and grass covered islands instead of 3" concrete.

Note: Delete covered islands in the sentence regarding construction cost.

Note: Contract Office Project Engineer in Design Services is now changed to Plans Standards Engineer in Project Services.

**Section 1-11 SPIRAL CURVES**

Note: A policy on Geometric Design reference updated from 2001 to 2004.

Remove and discard 1 sheet and replace with 1 revised sheet

**10. Chapter 1 Section 1-12, 1-13, 1-14, 1-15 and 1-16**

Note: A policy on Geometric Design reference updated from 2001 to 2004.

Note: Roadway Design Assistant Unit Head changes to Assistant State Roadway Design Engineer.

Remove and discard 3 sheets and replace with 3 revised sheets

**12. Chapter 1 Section 1-17, 1-18, and 1-19**

Note: A policy on Geometric Design reference updated from 2001 to 2004.

Remove and discard 1 sheet and replace with 1 revised sheet

### **13. Chapter 2 Section 2-1 MISCELLANEOUS DESIGN CRITERIA**

Note: Reference Design Services Unit changed to Alternative Delivery Unit.

Note: Removed reference State Design Services Engineer.

#### **Section 2-2 CLIMBING LANES**

Note: Reference Design Services Unit changed to Alternative Delivery Unit.

Note: A policy on Geometric Design reference updated from 2001 to 2004.

Note: Removed reference to Engineering Coordination Engineer.

#### **Section 2-5 TRUCK ESCAPE RAMPS**

Note: A policy on Geometric Design reference updated from 2001 to 2004.

Note: Design Services Unit reference changed to Alternative Delivery Unit.

#### **Section 2-6 BARRIERS FOR NOISE ABATEMENT**

Note: A policy on Geometric Design reference updated from 2001 to 2004.

Note: Design Services Unit reference changed to Alternative Delivery Unit.

Note: Removed reference to Design Services Unit.

#### **Section 2-7 CUL-DE-SACS**

Note: Deleted “and Design Services Unit”

Note: A policy on Geometric Design reference updated from 2001 to 2004

Remove and discard 5 sheets and replace with 5 revised sheets

### **16. Chapter 3 Section 3-2E STRUCTURE ANCHOR UNITS**

Note: General Updates.

Remove and discard 2 sheets and replace with 2 revised sheets.

**17. Chapter 3 Section 3-10 GUARDRAIL ATTACHMENT AND RETROFIT MANUAL.**

Note: Removed Design Services Unit from Reference.

Note: Changed Structure Design Unit Head to Assistant State Bridge Design Engineer.

**Section 3-11 POSITIVELY ANCHORED TEMPORARY PRECAST  
CONCRETE BRIDGE BARRIER – TYPE S**

Note: Replace Traffic Engineering and Safety Systems with Work Zone Traffic Control.

Note: Changed Roadway Project Engineer to Roadway Project Group Engineer.

Note: Changed Structure Design Project Engineer to Structure Design Project Group Engineer.

**Section 3-12 PROPRIETARY IMPACT ATTENUATORS & TERMINAL  
END UNITS (cont.)**

Note: Changed Design Services Unit to Alternative Delivery Unit.

Remove and discard 4 sheets and replace with 4 revised sheets

**18. Chapter 5 Section 5-15 RIP RAP**

Note: Removed reference to Design Services Unit.

Remove and discard 1 sheet and replace with 1 revised sheet

**19. Chapter 5 Section 5-18 HYDRAULIC DATA ON PLAN SHEETS**

Note: Removed reference to Design Services Section Engineer.

Remove and discard 1 sheet and replace with 1 revised sheet

**20. Chapter 5 Section 5-20 PIPE END TREATMENT GUIDELINES**

Note: Updated reference to Roadway Standard Drawings.

Remove and discard 1 sheet and replace with 1 revised sheet

**21. Chapter 5 Section 5-23 SHOULDER BERMS, GUTTERS, AND CURBS**

Note: Replaced Soil and Foundation Section with Geotechnical Engineering.

Note: Updated reference to Roadway Standard Drawings.

Note: Added sentence regarding expressway gutter.

Remove and discard 1 sheet and replace with 1 revised sheet

**22. Chapter 7 Section 7-1 SIGHT DISTANCES AT RAILROADS FOR UNSIGNALIZED CROSSING**

Note: Removed reference to Design Services Section Engineer.

Remove and discard 1 sheet and replace with 1 revised sheet

**23. Chapter 8 Section 7 VERTICAL SIGHT DISTANCE CONTROL FOR CREST CURVES AT DIAMOND INTERCHANGES**

Note: Removed reference to Design Services Section Engineer.

Remove and discard 1 sheet and replace with 1 revised sheet

**24. Chapter 10 Section 10-1 DESIGN OF COMMERCIAL ENTRANCES**

Note: Changed Design Services to Project Services.

Note: Updated link to Driveway Access Policy.

Remove and discard 1 sheet and replace with 1 revised sheet

**25. Chapter 11 Section 11 QUANTITY CALCULATIONS**

Note: Updated link to Calculation of Quantities worksheets.

Remove and discard 1 sheet and replace with 1 revised sheet

**26. Chapter 12 Section 12-1 MISCELLANEOUS DESIGN GUIDE**

Note: Changed Design Services to Project Services.

Remove and discard 1 sheet and replace with 1 revised sheet

## **Part II – Roadway Design Manual**

### **27. PART TWO – UTILIZATION OF DESIGN MANUAL AND MANUAL FORMAT**

Note: Removed reference to Design Services.

Remove and discard 1 sheet and replace with 1 revised sheet

### **28. Chapter 3 Section 3-1 PURPOSE**

Note: Link changed for checklist.

#### Section 3-1D PROJECT NUMBERS

Note: Added “ON FINAL PLANS” to title.

Note: Deleted “And Total Sheet Numbers”

Note: Added References to Survey Control Sheets & Centerline Coordinate List.

Remove and discard 1 sheet and replace with 1 revised sheet

### **29. Chapter 4 Section 4-1 PURPOSE**

Note: Link changed for General Notes.

Remove and discard 1 sheet and replace with 1 revised sheet

### **30. Chapter 5 Section 5-1 PURPOSE AND LOCATION OF ROADWAY STANDARDS**

Note: Name changed from Design Services to Project Services

Note: Link changed for Drawing Standards.

#### Section 5-1A PURPOSAL LINE UP.

Note: Link changed for Bidding Proposal Information.

#### Section 5-2 PLANT QUARANTINES

Note: Design Services omitted in responsibility for assisting Division Engineer.

Note: Engineering Coordination Section Engineer omitted in responsibility.

Section 5-3 RARE AND ENDANGERED PLANT SPECIES

Note: Design Services Unit name changed to Project Services Unit.

Remove and discard 2 sheets and replace with 2 revised sheets.

**38. Chapter 6 Section 6-1A NUMBER OF TYPICAL SECTIONS**

Note: Added two statements specifying when typical section are not needed.

Remove and discard 1 sheet and replace with 1 revised sheet

**39. Chapter 7 Section 7-2 BENCHING EXCAVATION FOR EMBANKMENT**

Note: Geology Engineer changed to Geotechnical Engineer.

Note: Geotechnical Unit changed to Geotechnical Engineering Unit

Section 7-4 LOCATION

Note: Change Preliminary Field Inspection to Final Design Inspection.

Remove and discard 2 sheets and replace with 2 revised sheets, Complete Chapter

**40. Chapter 10 Section 10-1 FENCING CONTROL & PARTIAL CONTROL OF ACCESS**

Note: Change Preliminary Field Inspection to Final Design Inspection.

Section 10-3 FENCING OF TRUCK WEIGH STATIONS

Note: Change Design Engineer to Design Section Engineer.

Note: Change Design Services Unit to Roadway Design Unit.

Section 10-8 TYPES OF FENCES

Note: Change Preliminary Field Inspection to Final Design Inspection.

Note: Format Change.

Section 10-10 GATES

Note: Change Preliminary Field Inspection to Final Design Inspection.



Remove and discard 2 sheets and replace with 2 revised sheets, Complete Chapter

**41. Chapter 12 Section 12-2 TRAFFIC OPERATIONS PLAN (continued)**

Note: Change Preliminary Field Inspection to Final Design Field Inspection.

Section 12-3 TRAFFIC CONTROL PLAN REVIEW MEETINGS

Note: Change Preliminary Field Inspection to Final Design Inspection.

Note: Change existing Final Field Inspection to Pre-Let Field Inspection.

Section 12-4 DESIGN ON-SITE DETOURS AND MEDIAN CROSSEOVERS

Note: Change Preliminary Field Inspection to Final Design Field Inspection.

Section 12-6 PAVEMENT MARKINGS FOR CONSTRUCTION PROJECTS

Note: Change reference to Traffic Design Branch to Work Zone Traffic Control Unit.

Note: Delete Part of the Last Sentence “Long-Life Pavement etc....”

Remove and discard 5 sheets and replace with 5 revised sheets, Complete Chapter

**50. Chapter 13 Section 13-1 ROADWAY PLANS**

Note: Delete reference to Design Services Unit.

Note: Changed Preliminary Field Inspection to Final Design Field Inspection.

Remove and discard 4 sheets and replace with 4 revised sheets, Complete Chapter

**51. Chapter 14 Section 14-2 COORDINATION WITH THE STRUCTURE DESIGN UNIT**

Note: Change Soils and Foundation Section of Design Unit Services to Geotechnical Engineering.

Note: General revisions to the last paragraph.

Remove and discard 2 sheets and replace with 2 revised sheets, Complete Chapter

**52. Chapter 15 Section 15-1 ROADWAY ELECTRICAL PLANS**

Note: Removed reference to the Design Service Unit.

Note: Changed State Design Engineer to State Highway Design Engineer.

Remove and discard 1 sheet and replace with 1 revised sheet

### **53. Chapter 16 Section 16-1 LANDSCAPE PLANS**

Note: Changed reference from Design Services to Project Services.

Note: Removed final plans paragraph.

Remove and discard 1 sheet and replace with 1 revised sheet, Complete Chapter

### **54. Chapter 17 Section 17-1 SIGNING CONCEPTS FOR PRELIMINARY DESIGN**

Note: Changed Traffic Engineering Unit to Traffic Congestion and Signing Unit.

#### Section 17-2 SIGNING PLANS

Note: Changed Traffic Engineering to Traffic Engineering and Safety Systems Branch.

#### Section 17-3 COORDINATION FOR SIGN SUPPORTS

Note: Changed Traffic Engineering to Traffic Congestion and Signing.

Note: Removed reference for Design Services.

Remove and discard 2 sheets and replace with 1 revised sheet, Complete Chapter

### **55. Chapter 18 Section 18-2 UTILITY PLANS**

Note: Changed Roadway Design Engineer to Roadway Design Project Engineer.

Note: Changed Design Service reference to Project Services.

Remove and discard 1 sheet and replace with 1 revised sheet, Complete Chapter

### **56. Chapter 19 Section 19-1 PLOTTING OF CROSS-SECTION SHEETS**

Note: Changed vertical scale from 1" = 5' to 1" = 10' for normal projects and 1"=20' for mountainous projects.

Note: Changed Geotechnical Unit to Geotechnical Engineering Unit.

#### Section 19-3 EARTHWORK BALANCE SHEET

Note: Added Figure 1 reference to shrinkage factor info.

Note: Changed Geotechnical Unit to Geotechnical Engineering Unit.

Note: Changed Design Services to Project Services.

#### Section 19-4 NOTE ON CROSS SECTION (EXCLUDING LUMP SUM GRADING PROJECTS)

Note: Added “and Lump Sum Bid” in title of section

Note: Added “or cross section summary” to first sentence.

Remove and discard 5 sheets and replace with 6 revised sheets

### **61. Chapter 20 Section 20-1 ITEMS FOR FIELD INSPECTION REVIEW**

Note: Removed all occurrences of “or Design Services Engineer”.

Note: Fixed link for website.

Remove and discard 1 sheet and replace with 1 revised sheet, Complete Chapter

### **62. Chapter 21 Section 21-3 ADDITIONAL INFORMATION ON PUBLIC HEARINGS**

Note: Changed Geotechnical Unit to Geotechnical Engineering Unit.

Note: Removed Design Services from (P) Project Services Consultant Coordination.

Remove and discard 1 sheet and replace with 1 revised sheet1

### **63. Chapter 22 Section 22-1 PURPOSE**

Note: Changed link for website.

Remove and discard 1 sheet and replace with 1 revised sheet, Complete Chapter

### **64. Chapter 23 Section 23-1 STANDARD FORMS**

Note: Removed reference to Design Services

Note: Changed Design Services Unit to Project Services in first paragraph

Note: Fixed Link for Calculation of quantities forms.

Note: Removed “Field Inspection Questions.”

Note: Removed “Cost Based Quantities Estimate Form.”

Note: Removed reference to Roadway Server.

Note: Fixed Link for templates

Remove and discard 1 sheet and replace with 1 revised sheet, Complete Chapter

## **65. Chapter 24 Section 24-1 REFERENCE MATERIAL**

Note: Removed reference to Design Services.

### Section 24-2 OTHER PUBLICATIONS

Note: Changed Design Services reference to Project Services.

### Section 24-3 SECONDARY ROAD NAMES

Note: Changed Design Service reference to Project Services.

Note: Fixed Website link for secondary roads.

Remove and discard 2 sheets and replace with 2 revised sheets, Complete Chapter

RDR/RM/blj

Attachments

cc:

Mr. Jay A. Bennett, PE

Mr. Jimmy Travis, PE

Mr. Frankie Draper

# ROADWAY DESIGN MANUAL

## DESIGN MANUAL

### ROADWAY DESIGN

#### INTRODUCTION

This Design Manual has been prepared for guidance in the preparation of plans, specifications and estimates. Utilization of this manual will ensure more uniformity in the design of highways by the Roadway Design Unit and other design units. It is emphasized that this manual is not intended to provide an explanation to every design problem encountered by design personnel. Neither is this manual a substitute for engineering knowledge, experience, or sound judgement. This manual will still require adjustments, additions, and deletions to keep design personnel abreast of improved design technology resulting from research and experience.

Design information that can be found in textbooks, Federal and State publications, and other sources of transportation related information has not been repeated unless design personnel frequently utilize it. In part one of this manual, frequent references to design information developed by the American Association of State Highway and Transportation Officials will be made.

Design information not included in charts, illustrations, or the Policy and Procedure Manual will appear in a brief narrative form. Frequent references will be made to other engineering publications available to all design personnel. Any publications not available in the design units will be available in the Alternative Delivery Unit, Special Services Group.



# ROADWAY DESIGN MANUAL

## ROADWAY DESIGN AND DESIGN SERVICES UNITS

### UTILIZATION OF DESIGN MANUAL AND MANUAL FORMAT

#### PART ONE

Part one of this manual provides design criteria in charts, tables and illustrations. When the information is in one of these forms, usually an explanation does not accompany them except for notes to cover varying conditions. Because all of the design concepts presented can not be completely covered, references to additional literature is given at the bottom of the chart. The Reference or Guide Manual denoted will be accompanied by a page number. The page numbers are for "quick" reference when more background information is necessary. Reference to these manuals will alleviate the repeating of detailed information in the reference books.

Design information is also included in narrative form. Any design criteria not included in this manual in narrative or chart form will be in the Roadway Policy and Procedure Manual or references made to other publications listed in Part Two, Chapter 24 of this manual. No reference will be made to design practices believed to be common knowledge by the well informed and experienced Design Engineers.





## CHAPTER ONE

## GENERAL DESIGN

**DESIGN POLICY INTERPRETATION****1**

The adoption of the policy, “A Policy on Geometric Design of Highways and Streets” (2004) by AASHTO and the Federal Highway Administration will supersede all of the previous AASHTO policies and guides dealing with the geometric design of new construction and reconstruction projects. “A Policy on Design Standards - Interstate System AASHTO, 1991” is also approved.

It is the responsibility of the Section Engineers and Project Engineers to be assured that all plans, specifications, and estimates (PS&E’s) for federal-aid projects conform to the design criteria in “A Policy on Geometric Design of Highways and Streets” (2004) (“Green Book”) and the Roadway Design Manual.

Much of the material contained in the 1973 Policy on Design of Urban Highways and Arterial Streets and the 1965 Policy on Geometric Design of Rural Highways and the “1984, 1990 and 1994, Greenbook” has been incorporated into, “A Policy on Geometric Design of Highways and Streets” (2004). While material from the superseded guides, as well as much other valuable criteria and information is included in “A Policy on Geometric Design of Highways and Streets” (2004), only certain portions should be viewed as controlling criteria. Therefore, those criteria related to design speed, lane and shoulder widths, bridge width, structural capacity, horizontal and vertical alignment, grades, stopping sight distance, cross slopes, superelevation, and horizontal and vertical clearances contained or referenced in Chapter VI, VII, and VIII are to be controlling criteria and require formal design exceptions when not met. In the absence of material covering controlling criteria in the above chapters, criteria are to be set based on Chapters III and IV. Criteria in Chapter V, Local Roads and Streets, apply only to off-system projects.

Deviations from the above controlling criteria will require the processing of a design exception letter by the Section Engineer or Project Engineer through the Unit Head.



## CHAPTER ONE

## GENERAL DESIGN

**SELECTION OF PROJECT DESIGN CRITERIA****1-1**

Selection of the correct design criteria for a project is one of the most important tasks that confront the highway designer. There are unlimited factors that can affect the design of a particular project making it impossible to provide explanations for them. However, design criteria is more strongly affected by the functional classification, design speed, traffic volumes, character and composition of traffic and type of right of way. Usually when full control of access is purchased, the design standards are much higher than on a project with partial or no control. Other control factors such as unusual land features, safety and economics are always highly reflected in the design criteria.

Since functional classification, design speed, traffic volumes and terrain classifications are the major points of design that must be established, a brief explanation of each is provided in the following section. The Project Development and Environmental Analysis Branch includes information in the planning report necessary for the Design Engineer to establish most design criteria, but the designer may have adequate justification to revise some of this information as in depth design studies are undertaken.

The designer must realize that the design criteria provided outlines minimum and desirable criteria for use in designing most roadway projects. It will be the responsibility of the Project Engineer and/or Section Engineer to determine when deviations from the design criteria are necessary. When deviations are required, it shall be discussed with the State Roadway Design Engineer.

When the functional classification, design speed, traffic volumes and terrain classification are chosen, the design criteria for the particular project can be established.

Critical design elements not meeting AASHTO Standards will require an approved design exception. These critical design elements are design speed, lane width, shoulder width, bridge width, structural capacity, vertical clearance, horizontal alignment, vertical alignment, stopping sight distance, cross slope, superelevation, design life and grades. On projects requiring step by step Federal Highway Administration review, the design exception must be approved by the Federal Highway Administration. On all other projects, the State Highway Design Engineer must approve design exceptions. Any other significant design elements not meeting AASHTO standards should be documented in the project file.

**FUNCTIONAL CLASSIFICATION****1-1A**

Functional classification is the process by which streets and highways are grouped into classes, or systems, according to the character of services they are intended to provide. The designer must realize that individual roads and streets do not serve travel independently. Rather, most travel involves movement through a network of roads. Therefore, the functional classification of a road must be determined before design criteria can be established for any proposed improvements being studied by the Design Engineer. On a normal roadway project with an approved planning report, the functional classification is normally given. They will be one of the following: Interstate, Freeway, Arterial (including expressways), Collector, and Local.

**DESIGN SPEED****1-1B**

Geometric design features should be consistent with the design speed as shown in the planning report or as determined by the Project Engineer or Section Engineer. Consideration should be given to roadside development, vertical and horizontal alignment, terrain, functional classification, traffic volumes and other contributing factors that are not specifically mentioned but may be a factor on a project by project basis. When design speeds are established, every effort shall be made to use the highest design speed that is practical to attain a desired degree of safety, mobility and efficiency. The design speed of a facility should be a minimum of 5mph above the anticipated posted speed.\*

NOTE: The design speed in the Planning Report for bridge replacement projects pertain to the horizontal curvature recommended in the report. Actual design speed attainable for the bridge and approaches will be determined by the Project Design Engineer or Assistant Section Engineer after reviewing grades, possible right of way damages, posted speed, etc.

It is the responsibility of the Project Engineer in Roadway Design to review the design speed selected. The selected design speed shall be shown on the project title sheet with other design data.

The following guidelines provide minimum design speeds for each functional classification. (See the following pages)

\* Note: The design speed can be the same as the posted speed on projects with a short project length. It can be considered on bridge replacement projects with length of approximately 2000' or less.

**DESIGN SPEEDS (continued)****1-1B**

Design speed is a selected speed used to determine the various design features of the roadway. Geometric design features should be consistent with a specific design speed selected as appropriate for environmental and terrain conditions. Designers are encouraged to select design speeds equal to or greater than the minimum.

Low design speeds are generally applicable to roads with winding alignment in rolling or mountainous terrain or where environmental conditions dictate. High design speeds are generally applicable to roads in level terrain or where other environmental conditions are favorable. Intermediate design speeds would be appropriate where terrain and other environmental conditions are a combination of those described for low and high speed. See Part I, 1-1D for information on terrain classifications.

**LOCAL RURAL ROADS****MINIMUM DESIGN SPEEDS**

See “A Policy on Geometric Design of Highways and Streets” (2004), Exhibit 5-1 (Page 381)

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**LOCAL URBAN STREETS**

Design speed is not a major factor for local streets. For consistency in design elements, design speeds ranging from 20 to 30 mph may be used, depending on available right-of-way, terrain, likely pedestrian presence, adjacent development, and other area controls. In the typical street grid, the closely spaced intersections usually limit vehicular speeds, making the effect of design speed of less importance. Since the function of local streets is to provide access to adjacent property, all design elements should be consistent with the character of activity on and adjacent to the street, and should encourage speeds generally not exceeding 30 mph.

**DESIGN SPEEDS (continued)****1-1B**

## RURAL COLLECTORS

MINIMUM DESIGN SPEEDS

See “A Policy on Geometric Design of Highways and Streets” (2004), Exhibit 6-1.  
(Page 422)

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## URBAN COLLECTORS

MINIMUM DESIGN SPEEDS

Design speed is a factor in the design of collector streets. For consistency in design, design speed of 30 mph or higher should be used for urban collector streets, depending on available right-of-way, terrain, adjacent development, likely pedestrian presence, and other site controls.

In the typical urban street grid, closely spaced intersections often limit vehicular speeds and thus make the consideration of design speed of lesser significance. Nevertheless, the longer sight distances and curve radii commensurate with higher design speeds result in safer highways and should be used to the extent practical.

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## RURAL ARTERIALS

MINIMUM DESIGN SPEEDS

Rural arterials should be designed with design speeds of 40 to 75 mph depending on terrain, driver expectancy and, in the case of reconstruction projects, the alignment of the existing facility. Design speeds in the higher range -60 to 75 mph- are normally used in level terrain, design speeds in the midrange -50 to 60 mph- are normally used in rolling terrain, and design speeds in the lower range -40 to 50 mph- are used in mountainous terrain.

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**DESIGN SPEEDS (continued)****1-1B**

## URBAN ARTERIALS

MINIMUM DESIGN SPEEDS

Design speeds for urban arterials generally range from 30 to 60 mph. Lower speeds apply in more developed areas and in central business districts, while higher design speeds are more applicable in outlying suburban and developing areas.

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## URBAN AND RURAL FREEWAY

MINIMUM DESIGN SPEEDS

As a general consideration, the design speed of urban freeways should not be so high as to exceed the limits of prudent construction, right-of-way, and socioeconomic costs. However, this design speed should not be less than 50 mph. Wherever this minimum design speed is used, it is important to have a properly posted speed limit, which is enforced during off-peak hours.

On many urban freeways, particularly in developing areas, a design speed of 60 mph or higher can be provided with little additional cost. In addition, the corridor of the main line may be relatively straight with the character of the roadway and location of interchanges permitting an even higher design speed. Under these conditions, a design speed of 70 mph is desirable because higher design speeds are closely related to the overall quality and safety of a facility. For rural freeways, a design speed of 70 mph should be used. In mountainous terrain, a design speed of 50mph to 60 mph, which is consistent with driver expectancy, may be used.

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**DESIGN SPEEDS (continued)****1-1B**

## INTERSTATES

MINIMUM DESIGN SPEEDS

See A Policy on Design Standards - Interstate System, AASHTO, July 1991, Page 3.

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**TRAFFIC VOLUMES****1-1C**

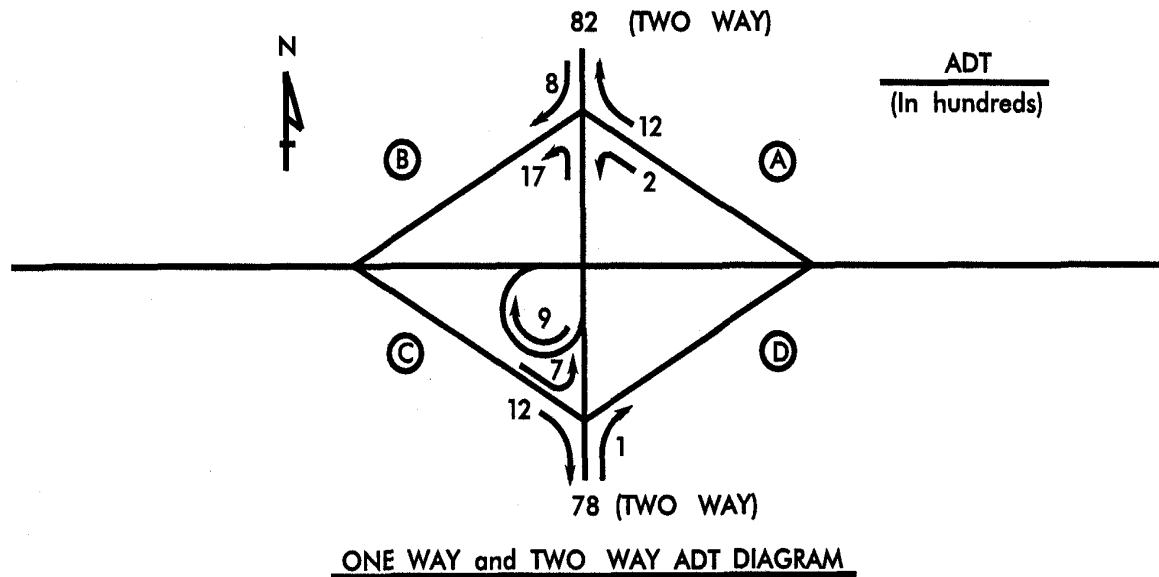
Traffic volumes are a major factor in selecting design criteria. All design criteria is based on a Design Hourly Volume (DHV) or annual Average Daily Traffic (ADT). Sometimes on minor low volume roads, the Average Daily Traffic (ADT) is the only traffic volume listed in the planning report. In this case, the ADT is used as the design basis. However, on most major highways, the design is based on a design hourly volume (DHV). The DHV is based on the 30th highest hourly volume. The design year is listed in the planning report and is usually either ten or twenty years beyond the beginning of construction.

If projects are delayed, the design year traffic should be updated. Design year traffic that is 17 years or less from the beginning of construction should be updated to twenty years. For example, a project has a twenty year design period and is scheduled to be let in 1998. The design year traffic listed in the planning document is 2015. The traffic volumes should be updated to the year 2018. These traffic updates should occur as necessary at the beginning of the preliminary design, right of way plans, and final plans.

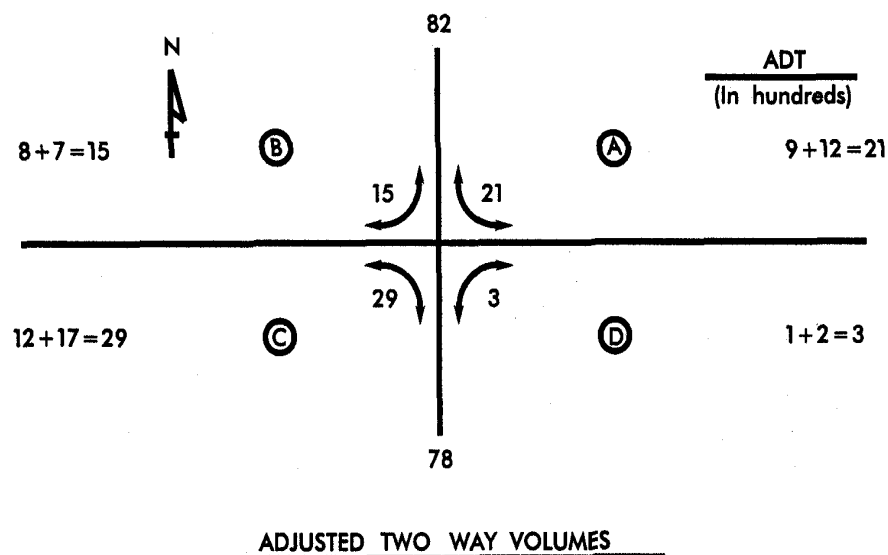


**TRAFFIC VOLUMES (continued)****1 - 1C****CONVERTING ADT TO DHV**

Below is an example of converting ADT to DHV in interchange areas.

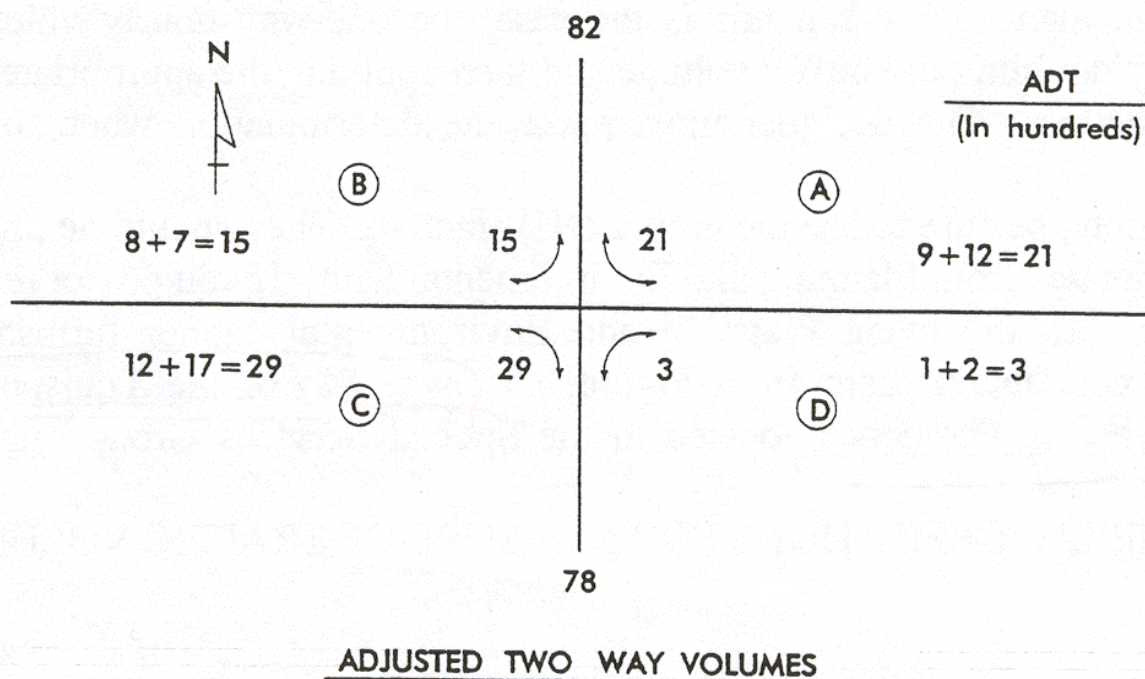


Convert the traffic volume to a stick diagram by combining the moves from one approach to the other. For instance, the movement from westbound to northbound is 1200 ADT and the counter moves from southbound to eastbound is 900 ADT for a total of 2100 ADT. Likewise the movement from southbound to westbound is 800 ADT and from eastbound to northbound is 700 ADT for total of 1500 ADT. This procedure will produce a stick two-way ADT diagram as followed:



**TRAFFIC VOLUMES (continued)****1-1C**

The Project Development and Environmental Analysis Branch is in agreement with this concept. The actual conversion from ADT to DHV is accomplished by the usual method of applying the appropriate DIR and DHV factors. Please note that this method results in directional peaks for all movements simultaneously and may not be appropriate for all cases, such as restricted or urban areas. In restricted or urban areas A.M. and P.M. or a 60% vs. 40% direction may be required.

**COMPLETED DHV CONVERSION**

This procedure cannot be used when the given one-way daily volumes are excessively unbalanced. When this is the case, the one-way hourly volume will be determined by doubling the traffic volume and then applying the appropriate directional and hourly factors. The designer must make the determination when to apply this procedure.

As a final note, be sure to use the proper DHV factors. They should be provided with the traffic estimates from the Project Development and Environmental Analysis Branch. If you do not receive them, ask for them. In the event the Project Development and Environmental Analysis Branch cannot furnish the DHV Factors, you can obtain them from Figure 4.9 (page 85) of the Transportation and Traffic Engineering Handbook located in the Special Services Group, of the Alternative Delivery Unit.

**TRAFFIC VOLUMES (continued)****1-1C**

NOTE: GENERAL DEFINITIONS FOR MEASURE OF TRAFFIC VOLUME

AVERAGE DAILY TRAFFIC (ADT)

The most basic measure of the traffic demand for a highway is the Average Daily Traffic (ADT) volume. The ADT is defined as the total volume during a given time period (in whole days), greater than 1 day and less than 1 year, divided by the number of days in that time period. The current ADT volume for a highway can be readily determined when continuous traffic counts are available. When only periodic counts are taken, the ADT volume can be estimated by adjusting the periodic counts according to such factors as the season, month, or day of week.

DESIGN YEAR ADT

Design Year ADT is the general unit of measure for projected Average Daily Traffic (ADT) to some future design year. Usually, the Design Year is about 20 years from the date of beginning construction but may range from the current year to 20 years depending on the nature of the improvement.

See "A Policy on Geometric Design of Highways and Streets" (2004), Ch.2. Also see Chapter 4 of this manual.

**TERRAIN CLASSIFICATIONS****1-1D**

For design purposes, three terrain classifications are utilized in North Carolina. These classifications have an affect on the design criteria and will be reflected in the design charts. They are as follows:

- Level: In level terrain, highway sight distances, as governed by both horizontal and vertical restrictions, are generally long or can be designed to be so without construction difficulties or major expense. In level terrain, the slope is considered to range from 0% to 8%. Any reference to a slope shall mean the rise and fall on the grade measured both parallel and perpendicular to the centerline.
- Rolling: In rolling terrain, natural slopes consistently rise above and fall below the highway grade line, and occasional steep slopes offer some restriction to normal highway horizontal and vertical roadway alignment. In rolling terrain, the slope is considered to range from 8.1% to 15%.

**TERRAIN CLASSIFICATIONS (continued)****1-1D**

Mountainous: In mountainous terrain, longitudinal and transverse changes in the elevation of the ground with respect to a highway are abrupt. Benching and side hill excavation is frequently needed to obtain acceptable horizontal and vertical alignment. In mountainous terrain, the slope is considered to range over 15%.

See “A Policy on Geometric Design of Highways and Streets” (2004), Ch.3.

When a terrain classification is chosen, geographical locations should not be the major factor. For example, a segment of road west of Asheville may have land characteristics of roads in level or rolling terrain.

**PROJECT COST REDUCTION GUIDELINES****1-1E**

The primary objective of highway design is to design a safe, functional, aesthetically appearing facility which is adequate for the design traffic volumes, for the minimum life cycle costs. These guidelines suggest possible design changes to help reduce project costs. The suitability of each suggested change should be evaluated within the context of the primary objective of highway design.

(1) Avoid overdesign.

Consider using minimum design criteria where doing so will not significantly compromise safety or function.

(2) Cross Section

- a) Median width - Use the minimum width that is compatible with the type of facility, the needs of projected traffic, positive drainage requirements, and median crossover design.
- b) Lane width - See “A Policy on Geometric Design of Highways and Streets” (2004), Exhibit 5-5, for desirable lane widths. Arterial lane widths may be reduced to 11 ft. when restrictive or special conditions exist. Less than desirable lane widths may remain on reconstructed highways where alignment and safety records are satisfactory.
- c) Shoulder width - See Part I, Chapter 1-4 of this manual, for minimum shoulder widths. Partial width shoulders may be considered where full width shoulders are unduly costly, as in mountainous terrain.

**PROJECT COST REDUCTION GUIDELINES (continued)****1-1E**

- d) Roadway ditch - See part I, Chapter 1-2A, Figure 1, of this manual, for standard methods of designing roadway ditches. Flatter or steeper slopes than those shown in Figure 1 may be warranted by project specific soil conditions, accident history, or requirements for balancing earthwork.
- e) Ramp widths - The standard ramp pavement width is 14 ft. 12 ft. ramp pavement width may be used if the full usable width of right shoulder is to be paved. (See Paved Shoulder Policy - Part I, Chapter 1-4O)
- f) Y-lines - Select Y-line pavement width and intersection radii which is appropriate for Y-line traffic volumes and characteristics, and compatible with the existing Y-line cross-section.

**(3) Earthwork**

Earthwork is one of the highest cost items on projects; therefore, every effort should be made to reduce and balance earthwork.

- a) The steepest slopes practical should be used while considering soil conditions, safety requirements, constructability and maintenance.
- b) Alignment - To help reduce earthwork, give careful attention to the selection of horizontal and vertical alignments. Attempt to balance cut and fill sections, and avoid areas with poor soil conditions. The Project Engineer and Project Design Engineer should both carefully review project alignments.
- c) Use waste to flatten slopes, build false cuts, etc., to improve safety and eliminate guardrail, and eliminate the need for waste pits. (Where possible, use unsuitable material to flatten slopes.)
- d) Utilize cost effective analysis to determine if it is more economical to flatten slopes or use guardrail. (Consider R/W cost, and the cost of providing waste areas.)
- e) Preliminary grades are usually based on contour maps and errors of 5 feet in elevation are possible. When beginning right of way plans, the preliminary grades should be reviewed and refined so they will be accurate and cost effective.

**PROJECT COST REDUCTION GUIDELINES (continued)****1-1E****(4) Right of Way**

- a) Where feasible, use temporary easements rather than purchasing property. This reduces right of way costs and the unnecessary taking of property. See Part II, Chapter 9-4 of this Manual.
- b) Consider using an "L" or "Tee" type turn around instead of a circular cul-de-sac to save pavement cost and reduce right of way on roads being dead-ended.
- c) Consider reducing commercial channelization to that required for sight distance and maintenance of roadway.

**(5) Drainage**

- a) Review drainage and have Hydraulics Unit recheck whenever it appears changes could be made to reduce cost. Use stone lined ditches where possible in lieu of paved ditches.
- b) Reduce length of paved ditch or stone lined ditches where possible.
- c) In interchange areas, look closely at drainage to see if grading adjustments could simplify drainage and reduce drainage items.

**(6) Pavement Design**

- a) Use pavement components, which give a reduction in number of layers and construction operations.
- b) All pavement designs including mainline, Y-lines, ramps, loops and detours should be obtained from the Pavement Management Unit.

**(7) General**

- a) Carefully review high cost items (bridges, culverts, barriers, special designs, etc.) to reduce or eliminate where possible.

**SHOULDERS****1-4**

Paved or unpaved shoulders will be based on traffic volume warrants and the pavement composition of the adjacent pavement utilized for the mainline, ramp and etc. Figure 1-4F outlines typical paved shoulder construction. The pavement design report will specify the type of paved shoulder to construct. All utility poles shall be placed outside the Clear Zone as defined by the 2002 Roadside Design Guide.

**SHOULDER WIDTHS ON MAINLINE****1-4A**

See 1-4B (Figure 1) for usable and graded shoulder widths for local, collector, arterial, interstate and freeway roads.

NOTE: Due to frequent on-shoulder parking and other special design features, Subdivision Roads and Streets shall conform to NCDOT Minimum Construction Standards For Subdivision Roads and may not conform to the above design guidelines.

**USABLE AND GRADED SHOULDERS****1-4B**

See 1-4B (Figure 1) for usable and graded shoulder widths and their relationship to the overall shoulder width. Shoulders shall not exceed these values unless specified otherwise in the Planning Report or unless approved by the Assistant State Roadway Design Engineer.

NOTE: These guidelines apply to new construction, not 3-R projects.

When guardrail is required on a project, additional shoulder width, as noted in Figure 1, is needed for guardrail installation and clearance. At times, this added shoulder width is continued throughout the project for uniformity. As a cost-reduction measure, normal shoulder widths should be specified where guardrail is not required and then transitioned to wider shoulders where guardrail is required. Engineering judgement would be used in considering this method by taking into account the length of the project and the amount of guardrail required.

SHOULDER WIDTHS

LOCALS AND COLLECTORS

IN THE DESIGN OF LOCALS AND COLLECTORS, USE THE FOLLOWING MINIMUM SHOULDER WIDTHS.

ADT	DESIGN YEAR			
	UNDER 400	400 – 1500	1501 – 2000	OVER 2000
LOCALS AND COLLECTORS	2' *	5' **	6'	8'

\* WHEN GUARDRAIL IS WARRANTED, THE MINIMUM OFFSET FROM THE EDGE OF THE TRAVEL LANE TO THE FACE OF THE GUARDRAIL IS 4'-0".

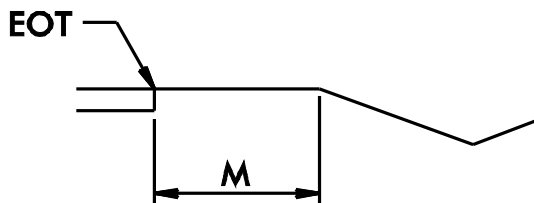
\*\* WHERE ENVIRONMENTAL CONSTRAINTS ALLOW, 6-FOOT SHOULDERS SHOULD BE UTILIZED RATHER THAN THE 5-FOOT SHOULDERS.

SEE "A POLICY ON GEOMETRIC DESIGN OF HIGHWAYS AND STREETS", (2001) EXHIBITS 5-5 AND 6-5.

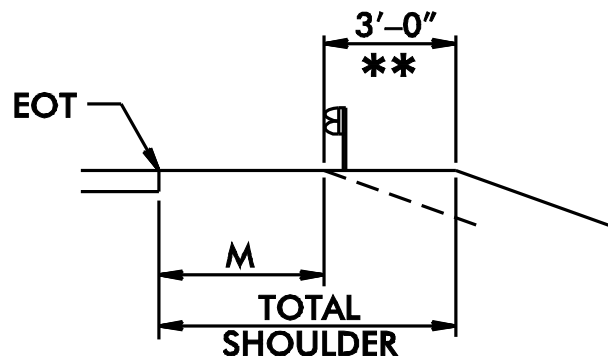
MINIMUM SHOULDER

M = MINIMUM SHOULDER  
EOT = EDGE OF TRAVEL LANE

WITHOUT GUARDRAIL



WITH GUARDRAIL



\*\* WHEN GUARDRAIL IS WARRANTED, THE MINIMUM SHOULDER WIDTH IS INCREASED BY 3'-0" AS SHOWN IN THE ABOVE DIAGRAM.

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SHOULDER WIDTHS

ARTERIALS, INTERSTATES, AND FREEWAYS

IN THE DESIGN OF ARTERIALS, INTERSTATES AND FREEWAYS,  
USE THE FOLLOWING MINIMUM USABLE SHOULDER WIDTHS.

ADT	DESIGN YEAR			
	UNDER 400	400 – 1500	1501 – 2000	OVER 2000
ARTERIALS	4'	6'	6'	8' **

NOTE: SEE "A POLICY ON GEOMETRIC DESIGN OF HIGHWAYS AND STREETS" (2001), EXHIBIT 7-3.

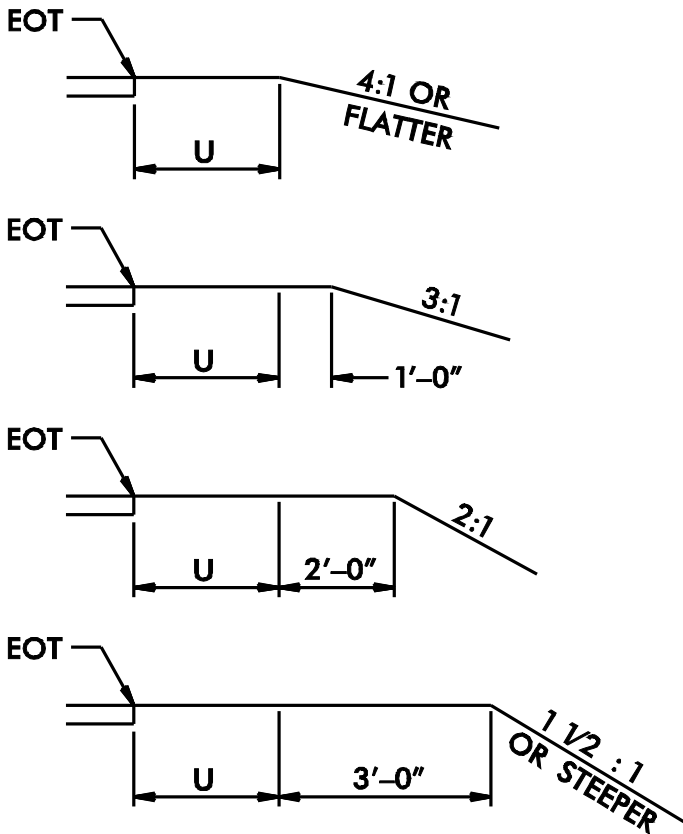
\*\* 10' ON FREEWAYS, EXPRESSWAYS, AND INTERSTATES AND  
12' ON FREEWAYS AND INTERSTATES WHEN TRUCK DHV EXCEEDS 500.

NOTE: SEE ARTERIAL MAP PROVIDED IN THIS MANUAL.

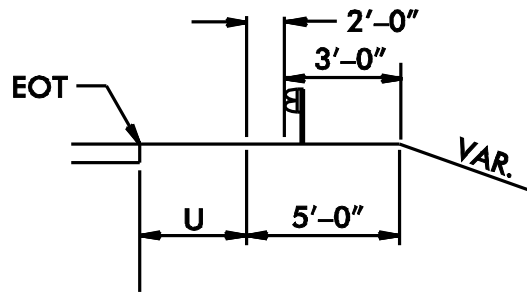
USABLE SHOULDER

U = USABLE SHOULDER  
EOT = EDGE OF TRAVEL LANE

WITHOUT GUARDRAIL



WITH GUARDRAIL



Revision Date 10/2006

Revision No. 4

**N.C. DOT PAVED SHOULDER POLICY****1-4C**

The NCDOT Paved Shoulder Policy incorporates the findings of an in-depth study of construction, maintenance, safety, operational and economic issues related directly to the usage of paved shoulders. The economics of providing a safe overall highway system were also considered in determining an appropriate level of expenditure for this design feature. The resultant policy is a standardized method developed specifically for the purpose of consistently providing acceptable paved shoulder designs for each roadway classification. Engineering judgement may be used to determine the need for a higher type shoulder design than is required by this policy on a case-by-case basis. Usage of paved shoulder widths in excess of the requirements of this policy must be approved by the State Roadway Design Engineer. See 1-4O, and 1-4O, Figure 1, of this manual for additional information.

**SHOULDER WIDTH ON LOOPS****1-4D**

Inside Shoulder – 14' Des. 12' Min. (Right Side of Traffic)  
Outside Shoulder – 12' Des. 10' Min. (Left Side of Traffic)

If pavement widening is required, it shall be placed on the inside of the curve. The 2'-6" concrete curb and gutter is placed adjacent to the inside edge of pavement to control drainage and reduce shoulder maintenance. See Chapter 8-1 of this manual for loop pavement widths.

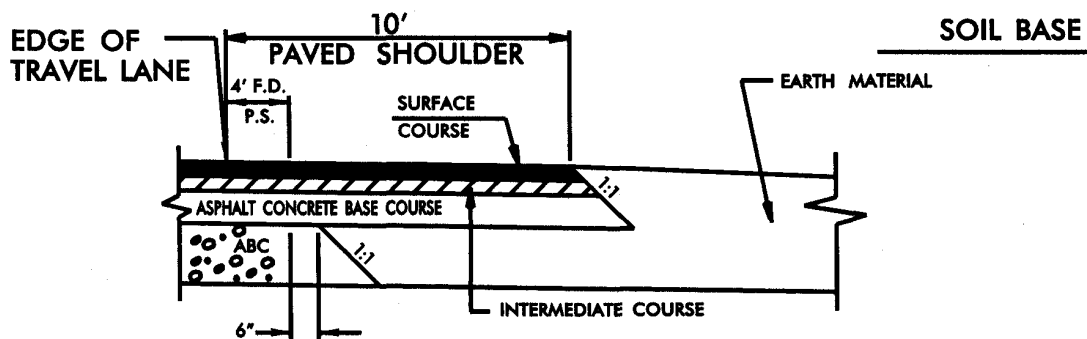
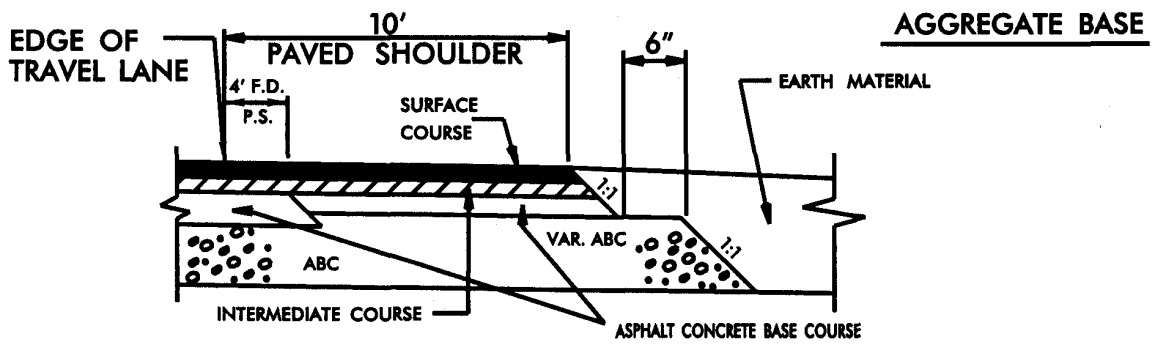
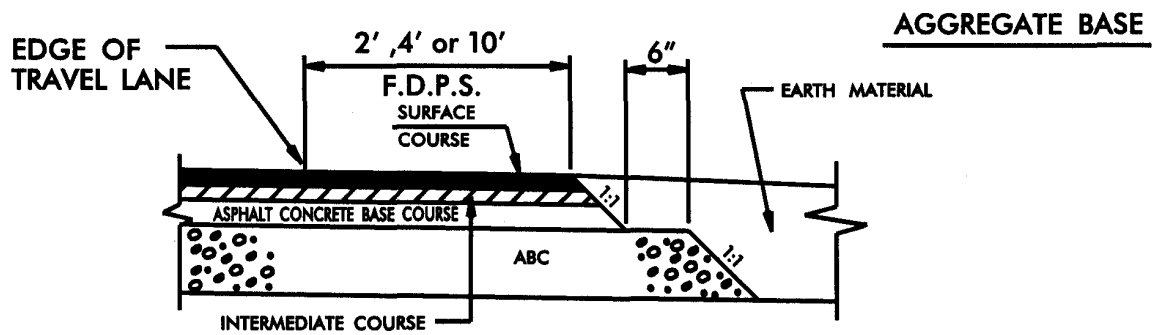
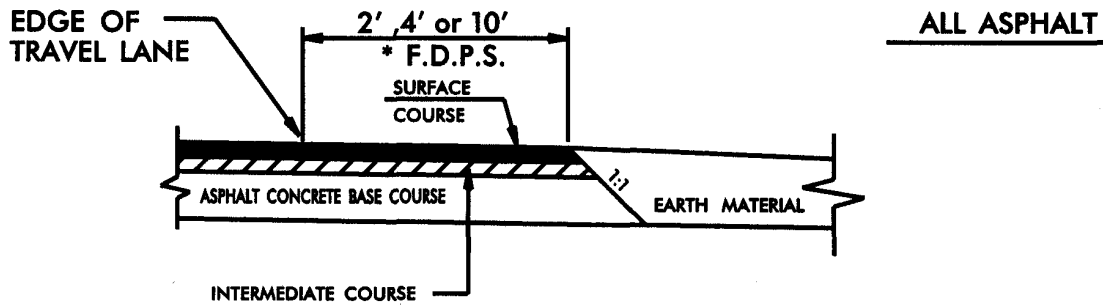
**SHOULDER WIDTHS ON RAMPS****1-4E**

Inside Shoulder – 12' Des. 10' Min. (Left Side of Traffic)  
Outside Shoulder – 14' Des. 12' Min. (Right Side of Traffic)

See Chapter 8-2 of this manual for ramp pavement widths.

PAVED SHOULDERS WITH FLEXIBLE PAVEMENT

1-4F



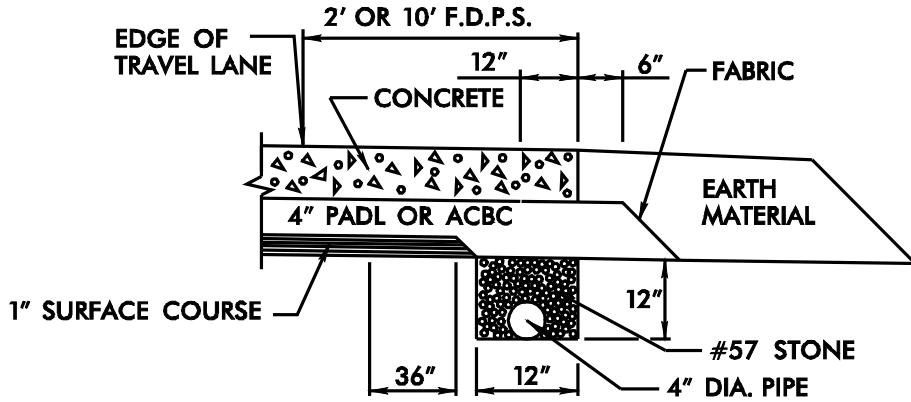
NOTE: FOR PROJECTS WITH A 10' PAVED SHOULDER, THE SHOULDER DESIGN WILL BE RECOMMENDED BY THE PAVEMENT MANAGEMENT UNIT.

\* F.D.P.S. - FULL DEPTH PAVED SHOULDER

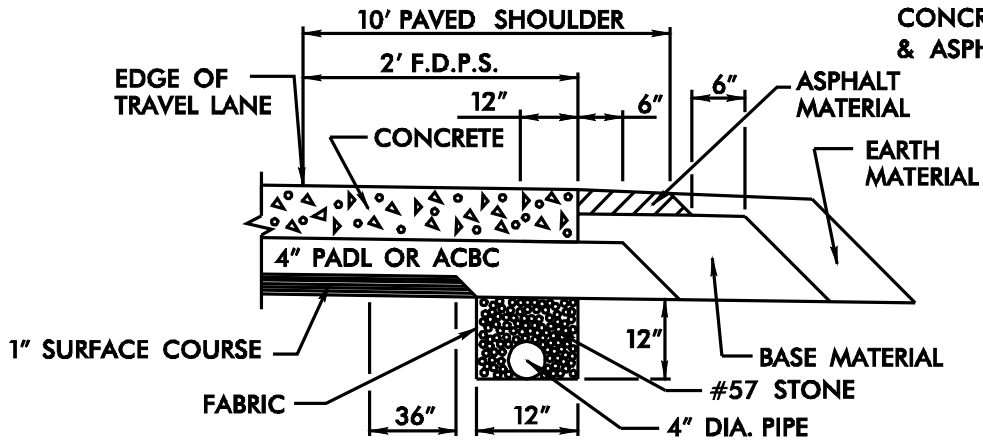
PAVED SHOULDERS WITH RIGID PAVEMENT

1 - 4G

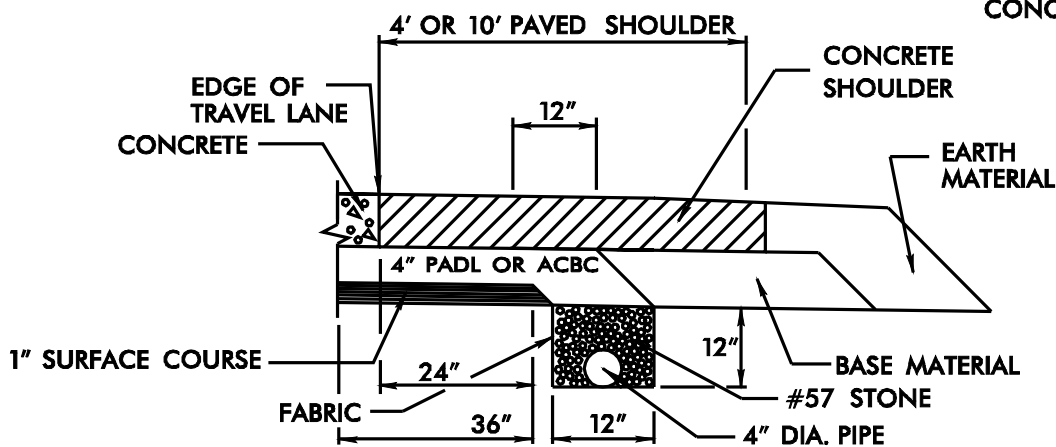
CONCRETE



CONCRETE & ASPHALT



CONCRETE



F.D.P.S. - FULL DEPTH PAVED SHOULDER  
 PADL - PERMEABLE ASPHALT DRAINAGE LAYER  
 ACBC - ASPHALT CONCRETE BASE COURSE

**MEDIAN SLOPES (continued)****1-6F**

- NOTE:
1. For projects with flat grades, variable median slopes that increase the ditch grade to improve longitudinal drainage capability shall be considered.
  2. Ditch slopes should meet "Roadside Design Guide" criteria for preferred ditch sections.

**PROPOSED MEDIANS**  
(New Roadways)

When determining the width and maximum (steepest) slopes of a proposed median, consideration shall be given to the following design criteria:

- A - Design Year Traffic Volume and Level of Service
- B - Design Speed
- C - Clear Zone Requirements "Roadside Design Guide"
- D - Adequate Drainage of the Pavement Structure

When optimum median width has been established, the ditch slopes should be set as shown in Part 1-2B, Figure 1 thru 4. In no case shall the slopes be steeper than those specified for existing medians.

NOTE: The important hydraulic role of the median ditch in removing water from the roadway surface and protecting the integrity of the pavement structure cannot be overly stressed. In order to provide adequate drainage, shoulder drains and underdrains shall be considered along with median slopes, which will adequately drain both the roadway surface and subgrade. The Pavement Management Unit will make recommendations to the Design Engineer on a project by project basis.

**EARTH BERM MEDIAN PIER PROTECTION****1-6G**

With median widths 70' and less, Pier Protection shall be provided. An earth berm, guiderail, or guardrail shall be placed as pier protection, when the median width is 70'. When earth berms are placed, pier footings shall be designed accordingly and slope protection placed according to the applicable standards. An earth berm for pier protection is desirable for medians 70' wide (Roadway Standard Drawings, Std. No. 225.08). If the earth berm is not feasible or cost effective, guardrail or guiderail should be utilized.

Median widths over 80' require no impact protection. For additional information, see 17/2 in the Policy and Procedure Manual. See Roadway Standard Drawings, Std. No. 225.08.

**MEDIAN DESIGN ON STRUCTURES****1-6H**

See Part I, Chapter 6-4 of this manual.

**MEDIANS ON -Y- LINES****1-6I**

The type of median to be constructed in interchange areas shall be determined early in the design stage. If raised islands are proposed across the structure, this shall be shown on the structure recommendations. See Part I, Chapter 6-6 of this Manual.

**MEDIAN CROSSOVER GUIDELINES****1-6J****Median Crossover Guideline Statement**

Median divided facilities provide the benefits of separating opposing travel lanes, controlling left turn conflicts, allowing a recovery area for out of control vehicles, and a space for future travel lanes. Research data also concludes that the median divided facilities improve traffic flow (travel speeds), traffic operations (reduces congestion), and traffic safety (lower crash rates), when compared to non-divided facilities. Median crossovers may be necessary on median divided facilities that are not fully access controlled) to allow for additional turning and through movements. A median crossover is defined as any connections of the opposing travel lanes that crosses the median of a divided highway. Median crossover includes directional crossovers, U-turns or all-movement crossovers.

Placement of crossovers should be considered carefully since crossovers introduce conflict points along a divided facility and thus may reduce the safety and capacity of the median divided facility. Therefore, it is important to follow these guidelines when considering the addition of median crossovers. The following guidelines have been developed as a guide for design engineers, traffic engineers, and field personnel when considering the placement or addition of median crossovers. The median crossover guidelines shall be used for all new crossovers, even in the cases where adjacent crossovers were approved under previous guidelines.

**RAISED ISLANDS****1-8**

Flush pavement with markings is often more desirable than raised islands especially where speeds exceed 45 mph. However, when it has been determined that raised islands will be required, both construction and maintenance costs should be considered.

In most instances, monolithic construction should be utilized on islands up to 16' in width due to greater cost-effectiveness, ease and speed of placement, and reduced future maintenance requirements. For widths greater than 16', cost-comparisons should be made between monolithic islands and grass covered islands with curb and gutter to determine the most cost-effective design. In making the determination, consideration should be given to the projected maintenance cost-savings of the monolithic island and the traffic operation requirements for the particular project.

Full depth pavement is normally utilized under the narrower bulb-type islands and under raised median islands when traffic operations during construction will require vehicular traffic in the median area. When traffic operations are not required in the median, it is more economical to place the monolithic island on a compacted aggregate base.

In special cases, grassed, landscaped, or covered islands may be used in urban or residential areas where recommended by the Division Engineer and approved by the Roadside Environmental, Construction, and Maintenance Units. These islands provide an aesthetically pleasing appearance with all surroundings, but only when well maintained. The construction costs of grassed or landscaped islands are considerably lower than those of monolithic islands. However, the greatly increased maintenance costs and the increased danger involved in maintenance operations prevents these islands from normally being justified except under unusual circumstances.

When any type of concrete curb is proposed on a project and it is not in accordance with Roadway Standard Drawings, Std. No's. 846.01, 852.01, and 852.02, a special detail shall be shown in the plans. The Plans and Standards Engineer in Project Services shall be consulted prior to drawing any details. This section has developed several concrete curb configurations that provide satisfactory results. For raised island treatment on structures, see this Manual Part I, Chapter 6-6G.

**STANDARD CONCRETE CURB AND GUTTER****1-9**

See Roadway Standard Drawings, Std. No. 846.01.

All utility poles shall be placed outside the Clear Zone as defined by the 2002 Roadside Design Guide.

For Curb and Gutter where posted speed is 45 MPH or less, all utility poles shall be placed outside the Clear Zone where practicable. If this cannot be achieved due to right of way restraints, the utility pole may be placed a minimum of 12 feet from the face of the curb. All utility poles that are placed closer than 12 feet shall be breakaway poles. See Figure 1-7D, F-4 for Detail.

**STEPS****1-10**

The type of steps to construct shall be determined by the Division Engineer. When existing steps are being disturbed, it is customary to replace the same type of step. For additional information, see Roadway Standard Drawings, Std. No's. 844.01 and 844.02.

**SPIRAL CURVES****1-11**

Spiral curves are required on interstates, freeways, expressways and all major arterials. Where terrain and topography restrict their use, the Project Engineer will have the option to delete spirals on collector roads, local roads and streets, and on minor arterials with a design speed less than 45 mph. Spirals (including tangent runout) should be avoided on bridges and in all cases should not begin or end on the bridge. In cases where spirals are absolutely required on bridges, the increment spacing should be equally spaced across the entire length of the bridge.

There are several methods for computing the length of Spirals. The recommended method for determining spiral lengths is to use A POLICY ON GEOMETRIC DESIGN OF HIGHWAYS AND STREETS (2004), Chapter 3.

**COMPOUND SPIRALS****1-11A**

Compound Spirals should be used between two curves if the radius of one curve is twice the radius of the second curve.

Compound Spirals should also be used on all interstates, freeways, expressways, arterials, and on ramps in interchange areas as the preferred method to change superelevation rates.



**DESIGN CONTROL FOR VERTICAL CURVES****1-12****Design Controls for Crest Vertical Curves-Open Road Conditions**

See "A POLICY ON GEOMETRIC DESIGN OF HIGHWAYS AND STREETS " (2004), Exhibits 3-75 and 3-76

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**Design Controls for Sag Vertical Curves-Open Road Conditions**

See "A POLICY ON GEOMETRIC DESIGN OF HIGHWAYS AND STREETS " (2004), Exhibits 3-78 and 3-79.

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**Design Controls for Crest Vertical Curves Based on Passing Sight Distance**

See "A POLICY ON GEOMETRIC DESIGN OF HIGHWAYS AND STREETS " (2004), Exhibit 3-77.

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**MINIMUM WIDTH OF TRAVELED WAY AND SHOULDERS****1-13****Minimum Width of Traveled Way and Shoulders for Local Roads and Streets**

See "A POLICY ON GEOMETRIC DESIGN OF HIGHWAYS AND STREETS " (2004), EXHIBIT 5-5.

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**Minimum Width of Traveled Way and Shoulders for Collector Roads and Streets**

See "A POLICY ON GEOMETRIC DESIGN OF HIGHWAYS AND STREETS " (2004), EXHIBIT 6-5.

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**Minimum Width of Traveled Way and Usable Shoulders for Rural Arterials**

See "A POLICY ON GEOMETRIC DESIGN OF HIGHWAYS AND STREETS " (2004), EXHIBIT 7-3.

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**MAXIMUM GRADES****1-14****Maximum Grades for Rural and Urban Freeways.**

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See “A POLICY ON GEOMETRIC DESIGN OF HIGHWAYS AND STREETS ” (2004), EXHIBIT 8-1.

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**Maximum Grades for Rural Arterials**

See “A POLICY ON GEOMETRIC DESIGN OF HIGHWAYS AND STREETS ” (2004), EXHIBIT 7-2.

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**Maximum Grades for Urban Arterials**

See “A POLICY ON GEOMETRIC DESIGN OF HIGHWAYS AND STREETS ” (2004), EXHIBIT 7-10.

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**Maximum Grades for Rural Collectors**

See “A POLICY ON GEOMETRIC DESIGN OF HIGHWAYS AND STREETS ” (2004), EXHIBIT 6-4.

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**Maximum Grades for Urban Collectors**

See “A POLICY ON GEOMETRIC DESIGN OF HIGHWAYS AND STREETS ” (2004), EXHIBIT 6-8.

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**Maximum Grades for Local Rural Roads**

See “A POLICY ON GEOMETRIC DESIGN OF HIGHWAYS AND STREETS ” (2004), EXHIBIT 5-4.

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**SUPERELEVATION RATES****1-15****Minimum Superelevation Runoff and Tangent Runout Lengths**

See “A POLICY ON GEOMETRIC DESIGN OF HIGHWAYS AND STREETS ” (2004),  
EXHIBIT 3-29.

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**Minimum Radius for Design of Rural Highways, Urban Freeways, and High-Speed Urban Streets Using Limiting Values of (e) and (f).**

See “A POLICY ON GEOMETRIC DESIGN OF HIGHWAYS AND STREETS ” (2004),  
EXHIBIT 3-14.

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**Diagrammatic Profiles Showing Methods of Attaining Superelevation**

See “A POLICY ON GEOMETRIC DESIGN OF HIGHWAYS AND STREETS ” (2004),  
EXHIBIT 3-37.

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**SUPERELEVATION RATES (continued)****1-15**

If maximum superelevation rates are used other than those shown the guidelines, it shall be discussed with the appropriate Assistant State Roadway Design Engineer.

**SUPERELEVATION GUIDELINES**

<b>TYPE OF ROADWAY</b>	<b>LOCATION &amp; CONDITIONS</b>	<b>SUPERELEVATION (1)</b>
Interstates & Freeways	<ul style="list-style-type: none"> <li>Statewide</li> </ul>	.08 or .10 (2)
Ramps & Loops	<ul style="list-style-type: none"> <li>Statewide</li> </ul>	.08
Flyovers (Directional ramps with bridges)	<ul style="list-style-type: none"> <li>Statewide</li> </ul>	.06
Arterials & Rural Collectors	<ul style="list-style-type: none"> <li>Statewide</li> <li>Limited Access</li> </ul>	.08
Arterials & Urban Collectors with 60 mph design speed or greater	<ul style="list-style-type: none"> <li>Statewide</li> <li>Partial or no control of access</li> </ul>	.06
Urban Collectors with 50 mph or less design speed	<ul style="list-style-type: none"> <li>Statewide</li> <li>Curb &amp; Gutter or shoulders with driveways</li> </ul>	.04
Bridge replacement projects, locals, & Secondary Roads	<ul style="list-style-type: none"> <li>Statewide</li> </ul>	.04 or .06 Choose table that fits characteristics of area

- (1) Refers to particular design superelevation table shown in the 2004 AASHTO "Green Book" ( pages 156 to 165) that the designer should use.
- (2) Don't use in locations susceptible to icy conditions.

Bridges – it is desirable to use a degree of curve that the superelevation will not exceed .06 on any bridge.

## Hydroplaning Awareness Outline

- I. Contributing Factors
  - A. Water film and thickness
  - B. Pavement cross slope and longitudinal slope
  - C. Pavement roughness
  - D. Vehicle speed
  - E. Tire condition and so forth
- II. Identification of Problem Areas
  - A. Existing conditions
    1. Skid testing
    2. Accident Reports
    3. Visual Observation
    4. Reports from Department personnel and citizens
  - B. Proposed/Design Condition
    1. Design Analysis
    2. Accident Reports and so forth upon project completion (see Existing)
- III. Remedial and Countermeasures
  - A. Existing Condition
    1. Improve pavement surface – open graded asphalt friction courses
    2. Improved surface water removal
      - a. Improved drainage systems
      - b. Improved longitudinal and transverse pavement and shoulder slopes
    3. Warning signs
  - B. Proposed/Design Condition – Roadway Design
    5. Typical section
      - a. Pavement Cross Slope
      - b. Shoulder cross slope
      - c. Rooftop section
    6. Grades
      - a. Minimum of 0.3% (tangent and along VC)
      - b. Vertical Curves
        1. Sag (K factors greater than 167 can create drainage problems, AASHTO p 286)
        2. Crest (avoid 0.3% except within 50 ft. of high or low point)
    7. Superelevation
      - a. Resolve SE about centerline instead of median EOP
      - b.
      - c. Avoid long SE transition areas
    8. Combination of the above factors

**HYDROPLANNING AWARENESS OUTLINE (continued)****1-16**

- B. Proposed/Design Condition – Hydraulic Design
  - 1. Hydrology
    - a. Design Storm Frequencies
    - b. Drainage Areas (size, shape, cover, slope, future development)
    - c. Discharge Rates (Hydrological Method)
  - 2. Highway Geometry
    - a. Longitudinal Slopes and Cross Slopes
    - b. Grade Elevations
    - c. Typical Sections
  - 3. Critical Locations for Collecting Runoff
    - a. Cross Drainage
    - b. Points for Reducing Spread
    - c. Sags
    - d. Upgrade of Zero Cross Slopes
    - e. Upgrade of Street Entrances
    - f. Upgrade of Bridges
    - g. Driveway Entrances
  - 4. Highway Drainage Structures
    - a. Cross Pipes, Culverts, Bridges
    - b. Storm Drainage Systems (Catch Basin, Drop Inlets, Berm Inlets)
    - c. Funnel Drains
    - d. Bridge Scuppers

**DESIGN CONTROLS FOR STOPPING SIGHT DISTANCE  
ON HORIZONTAL CURVES****1-17**

See “A POLICY ON GEOMETRIC DESIGN OF HIGHWAYS AND STREETS ” (2004),  
EXHIBITS 3-57 and 3-58.

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**Passing Sight Distance for Design of Two-Lane Highways**

See “A POLICY ON GEOMETRIC DESIGN OF HIGHWAYS AND STREETS ” (2004),  
EXHIBIT 3-7.

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**DESIGN VALUES FOR TRAVELED WAY PAVEMENT WIDENING  
AND WIDTHS ON OPEN HIGHWAY CURVES AND TURNING ROADS****1-18**

See “A POLICY ON GEOMETRIC DESIGN OF HIGHWAYS AND STREETS ” (2004),  
EXHIBITS 3-51, 3-52, 3-53, 3-54 AND 3-55.

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**MINIMUM TURNING PATHS FOR DESIGN VEHICLES****1-19**

See “A POLICY ON GEOMETRIC DESIGN OF HIGHWAYS AND STREETS ” (2004),  
EXHIBITS 2-3 thru 2-23.

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## CHAPTER TWO

## MISCELLANEOUS DESIGN CRITERIA

**GLARE SCREENS****2-1**

Background: The following information is from "Evaluation of Glare Screens-Final Report, November 2, 1988," prepared by Ashley B. Vaughn.

A copy of this report is on file in the Roadway Design Library and in the Special Services Group, Alternative Delivery Unit.

Additional information on glare screens mounted on guardrail can be found in the Roadway Standard Drawings, Std. No. 866.05.

I. Criteria for Use of Glare Screens

a. Glare screens should be considered in the median on multilane highways, in interchange areas, and where service roads are in close proximity to major arterials.

b. Opposing traffic with 20' or less of separation should be highly considered for using a glare screen.

c. Widths of 21' to 50' should be considered on a project by project basis and justified using the following criteria:

New Facilities

Vertical and horizontal alignment  
Traffic volumes  
Field review of graded roadway

Existing Facilities

Accident experience  
a. Day/night ratio of accidents  
b. Age of drivers in night accidents  
c. Unusual distribution by type of accident  
Day/night traffic volumes  
Public input  
Vertical and horizontal alignment  
Measure of glare (Use Pritchard Photometer)

d. Traffic separated by 50' or more, will not need glare screens.

**GLARE SCREENS (continued)****2-1**

e. Normal height should be 50" and up to 80" in sag verticals.

f. Cutoff angle for opposing highlight glare for screens on tangent alignments is twenty degrees (20°). The cutoff angle for screens on horizontal curves should be twenty degrees (20°) plus degree of curvature.

**II. Types of Glare Screens**

a. Type I - A continuous screen that is essentially opaque to light from all angles.

b. Type II - A continuous screen of an open material that is opaque to light at angles to about 20 degrees and increasingly transparent beyond 20 degrees.

c. Type III - Individual elements positioned to block light at angles from 0 degrees to 20 degrees. Beyond 20 degrees visibility is clear between the elements.

The following types of glare screens are recommended:

Plants

Extended Concrete Barrier

½" Mesh Chain Link Fence (Vinyl Coating Optional)

Modular Guidance System

The State Roadway Design Engineer's approval will be required for any use of glare screen in areas other than interchanges or in areas in the 21' to 50' width. The submittal should include drawings and justifications.

**CLIMBING LANES****2-2**

A climbing lane is the response to the increasing amount of traffic delays and the number of serious crashes occurring on grades due to heavy loaded and slow moving vehicles.

Consideration should be done during the original construction planning stage and on Safety Improvement Projects.

Criteria for recommending and designing climbing lanes is outlined in A POLICY ON GEOMETRIC DESIGN OF HIGHWAYS AND STREETS (2004), ch. 3. and the Highway Capacity Manual, Chapter Three.

**CLIMBING LANES (continued)****2-2**

Report No. FHWA-IP-88-015 Grade Severity Rating System (GSRS) can be used to determine the maximum safe descent speeds for trucks according to weight and to determine the need for an auxiliary lane.

Additional information on climbing lanes can be found in the FHWA Report: "New Methods for Determining Requirements for Truck-Climbing Lanes" located in the Roadway Design Library and/or Alternative Delivery Library.

The locations proposed by the Project Engineer shall be discussed with the Assistant State Roadway Design Engineer. Justification studies and cost estimates will be required when the Project Engineer proposes climbing lanes.

**PEDESTRIAN OVERPASSES****2-3**

Pedestrian overpasses should be included in the environmental document for the project. If the potential need for the overpass is determined during the design phase of the project, then a request and justification should be made to the Project Development and Environmental Analysis Branch. The design of pedestrian overpasses should be submitted to the Federal Highway Administration and/or the Structure Design Unit as a structure recommendation report using the A POLICY ON GEOMETRIC DESIGN OF HIGHWAYS AND STREETS (2004), CH. 4.

**PEDESTRIAN UNDERPASSES****2-3A**

Pedestrian underpasses should be considered where greenway facilities with pedestrian or bicycle use are existing or part of a planned system. Underpasses for greenways that are determined by using floodway maps and have not been designated as actual 'trails' can be constructed if the city or county supplements the cost.

**APPALACHIAN NATIONAL SCENIC TRAIL****2-4**

Projects conflicting with the Appalachian National Scenic Trail should be included in the environmental document and any mitigation should be resolved at the planning stage. Trail crossings of any project on new location will most likely require a grade separation.

Truck escape ramps have generally been used on long mountain grades in rural areas. They should also be considered in urban areas on steep, short grades where high truck volumes are mixed with dense traffic and development. The urban areas have a higher probability of fatalities or property damage than the rural areas especially if a stop condition or turn occurs at the bottom of the grade.

It has also been suggested that an area should be provided at the top of the grade for truckers to check their brakes, read any information available about the upcoming grade and shift to the correct gear for the downgrade.

Justification for truck escape ramps (TERs) involve several considerations and have not been formalized into specific warrants or processes. The principal factor for a TER need is determined by runaway accident experience. Site conditions such as grade length, percent of grade, a combination of horizontal alignment, and end-of-grade conditions weigh about equally.

Average daily traffic and percent trucks count about the same as site conditions. Although available right of way and topography are factors in site selection, they are not factors in determining the need for a ramp.

The "Grade Severity Rating System (GSRS)" was developed to determine the maximum safe speed for vehicles of different weights. It can also be used to establish the need and location for truck escape ramps by calculating the brake temperatures at ½ mile intervals on a grade. A computer program is available with this report.

Also, available in the Roadway Design Unit library is a very informative Transportation Research Board publication:

"NCHRP Synthesis 178  
Truck Escape Ramps  
A Synthesis of Highway Practice"

Limited information is also available in "A POLICY ON GEOMETRIC DESIGN OF HIGHWAYS AND STREETS (2004), CH. 3. Additional research information is available in the Special Services Group, Alternative Delivery Unit.

**BARRIERS FOR NOISE ABATEMENT****2-6**Type I Projects

A Type I project is defined as a proposed Federal, or Federal-aid highway project for the construction of a highway on new location or the physical alterations of an existing highway which significantly changes either the horizontal or vertical alignment, or increases the number of through-traffic lanes. For Type I projects, the consideration of noise abatement as a part of the highway construction project is mandatory if Federal-aid funds are to be used and if a traffic noise impact is expected to occur.

Type II Projects

The only purpose of a Type II project is to construct noise abatement along an existing roadway. NCDOT does not participate in retrofitting (Type II) projects.

## Information for the Public and Local Officials:

In an effort to prevent future noise impacts on currently undeveloped lands, NCDOT will use the following criteria:

- A. The “Date of Public Knowledge” of the locations of a proposed highway project will be the approval date of CE’s, FONSI’s, ROD’s, or the Design Public Hearing, whichever comes later. After this date, the Federal/State governments are no longer responsible for providing noise abatement measures for new development for which building permits are issued within the noise impact area of the proposed highway project.
- B. For development occurring after this public knowledge date, it is the responsibility of the local governing bodies to insure that noise compatible designs are utilized.
- C. The date for determining when undeveloped land is “....planned, designed, and programmed...” for development will be the issuance of a building permit for an individual site.

During the project development stage of a proposed highway project, informational meetings, both formal and informal, will be conducted to solicit comments, opinions, and concerns from local officials and the public. A list of potentially affected areas and reasonable and feasible noise abatement measures will be developed by the Air and Noise Sections of the Project Development and Environmental Analysis Branch. These noise sensitive areas will be addressed in environmental documents prepared for the project.

**BARRIERS FOR NOISE ABATEMENT (continued)****2-6**

Likely noise abatement measures will be presented and discussed at the Design Public Hearing. Following public comment, a Final Noise Report will be prepared. Abatement design measures deemed reasonable, feasible, and cost effective by staff Engineers, will be incorporated into this report and presented at a final meeting. In this forum, the opinions of the impacted residents are once again solicited to make a final determination on the reasonableness and feasibility of noise abatement.

The Department of Transportation will furnish the results of all highway traffic noise analyses to local government officials within whose jurisdiction a proposed highway project is located. Specifically, environmental documents and design noise reports will contain noise contours and other pertinent design information. Local officials should coordinate and distribute this information to the local area affected. Following this procedure will encourage planners, developers, and affected communities to practice noise compatible development.

**Sound and Noise**

Sound is created when an object moves. This movement causes vibrations or waves in air molecules like ripples on water. When vibrations reach our ears, we hear sound. Sound is quantified by a meter, which measures units called decibels (dB). For highway traffic noise, an adjustment or weighting of the highway and low-pitched sounds is made to approximate the way that an average person hears sound. The adjusted sounds are called "A-weighted level" (dBA).

Noise is defined as unwanted or excessive sound. It is an undesirable by-product of our modern way of life. Noise descriptors such as Leq are used to describe the time-varying nature of noise. In noise abatement studies, Leq(h) or hourly equivalent sound level, is defined as the constant, average sound level, which over a period of time contains the same amount of sound energy as the varying levels of the traffic noise.

**Noise Abatement / Impact Determination**

In NCDOT highway projects, traffic noise abatement must be considered when either of the following two conditions exist.

**BARRIERS FOR NOISE ABATEMENT (continued)****2-6**

- A. The predicted design year noise levels approach or exceed those values shown for the appropriate activity category of the FHWA Noise Abatement.

Please note: NCDOT has defined approach values as being 1 dBA less than those in the table and; the design year is 20 years after the start of construction.

- B. The predicted design year noise levels substantially exceed existing noise level as defined below:

<u>Existing (Leq(h))</u>	<u>Increase</u>
≤ 50 dBA	> 15 dBA
> 50 dBA	≥ 10 dBA

Please note: Depending on the existing noise levels, NCDOT uses both a 10 dBA increase to define a substantial increase. This sliding scale allows a greater increase at a lower existing noise level before a substantial increase is defined. A 10 dBA increase is judged by most people as a doubling of the loudness of the sound; a 15 dBA increase represents more than a doubling of the loudness.

Since NCDOT has no Type II program, noise abatement will generally not be considered for heavy maintenance, rehabilitation projects and existing conditions.

Feasibility and Reasonableness

After a determination has been made to consider noise abatement under A&B above, several factors including benefits, cost of abatement, and overall social, economic, and environmental effects should be examined to determine both the feasibility and reasonableness of constructing a noise abatement device.

**BARRIERS FOR NOISE ABATEMENT (continued)****2-6**

A. Feasibility: Feasibility deals primarily with engineering considerations. The following items should be considered in order to determine feasibility.

1. Can a barrier be built given the topography of the location?
2. Can a minimum 5 dBA reduction, but preferably 8 dBA or more, be achieved for design receptors (first row receptors) given certain access, drainage, safety, or maintenance requirements?
3. Is other noise sources present in the area?
4. Can noise reduction (insertion loss) provided by the wall be a minimum 5 dBA, but preferably 8 dBA or more, for design receptors (first row receptors) ?
5. Unless special conditions exist and effective abatement can be provided, it is not considered feasible to provide noise abatement on non-controlled or partial access controlled facilities.

B. Reasonableness: Reasonableness is a more subjective criterion. It should show that common sense and good judgement were used in arriving at a decision. A determination of reasonableness should include the following:

1. Barrier Cost - the abatement measure should be cost effective. Cost effective is defined as \$25,000 (construction cost) per effectively protected (5 dBA or more reduction) residence.
2. Barrier Height - The exposed height of a wall should not exceed a maximum of 25 feet.
3. Barrier Scale Relationship - It generally will not be reasonable to provide abatement unless the receptor is located a distance of four times the height of the wall or more from the proposed wall. Noise walls have a dominant visual effect on receptors in close proximity to the wall.
4. Difference Between Existing and Future Noise Levels - It generally will not be reasonable to provide abatement if the change in existing noise levels and design year noise levels are 3 dBA or less (a barely perceptible change).
5. Opinions of the Impacted Residents - There must be documented support of the benefited residents (those that receive a 5 dBA or more reduction by the construction of the abatement measure). These opinions are solicited at informal and formal meetings, depending on the scope of the project.



**BARRIERS FOR NOISE ABATEMENT (continued)****2-6**

6. Unless special conditions exist, it is not considered reasonable to provide noise abatement for impacted businesses or isolated receptors. Businesses generally prefer visibility from the transportation facility. Based on past project experience, it is considered unreasonable to provide abatement for isolated residences, due to the cost of abatement versus the benefits provided.
7. Unless special conditions exist and effective abatement can be provided, it is not considered reasonable to provide noise abatement on non-controlled or partial access controlled facilities.
8. The noise barrier will be located beyond the clear recovery zone or incorporated into safety devices.
9. In areas of impacted receptors where abatement measures have been considered, a vegetative barrier may be considered for aesthetic screening, even though an acoustical barrier is not justified.

The above listing is not intended to be all encompassing. Rather, it is intended to indicate some of the factors that should be considered in determining the reasonableness of proposed noise abatement measures.

It is the Policy of NCDOT that the type of material used in construction of these structures should be an engineering decision based on economics, effectiveness, and to a limited degree, visual impact. Visual impact considerations will assure the proposed barrier meets a basic aesthetic level and a basic durability level such that deterioration or excessive corrosion will not occur during the design life of the barrier.

It is also part of this Policy to have traditional highway resources pay for the required noise abatement. Should a local jurisdiction request that a material be used for the noise barrier that is more costly than that proposed by NCDOT, the requesting body must assume 100% of the additional cost.

If a local jurisdiction insists on the provision of a noise abatement measure deemed not reasonable by NCDOT, a noise barrier may be installed, provided the locality is willing to assume 100% of the cost of the abatement measure including but not limited to preliminary engineering, construction, maintenance, and that NCDOT's material, design and construction specifications are met.

**BARRIERS FOR NOISE ABATEMENT (continued)****2-6**

Additional information is available in the Special Services Group, Alternative Delivery Unit. Information also can be found in the following publications:

1. “A POLICY ON GEOMETRIC DESIGN OF HIGHWAYS AND STREETS” (2004), ch. 3 and ch. 4.
2. “Fundamentals and Abatement of Highway Traffic Noise” – Roadway Design Unit Library.
3. “Highway Traffic Noise in the United States: Problems and Response” – Roadway Design Unit Library.

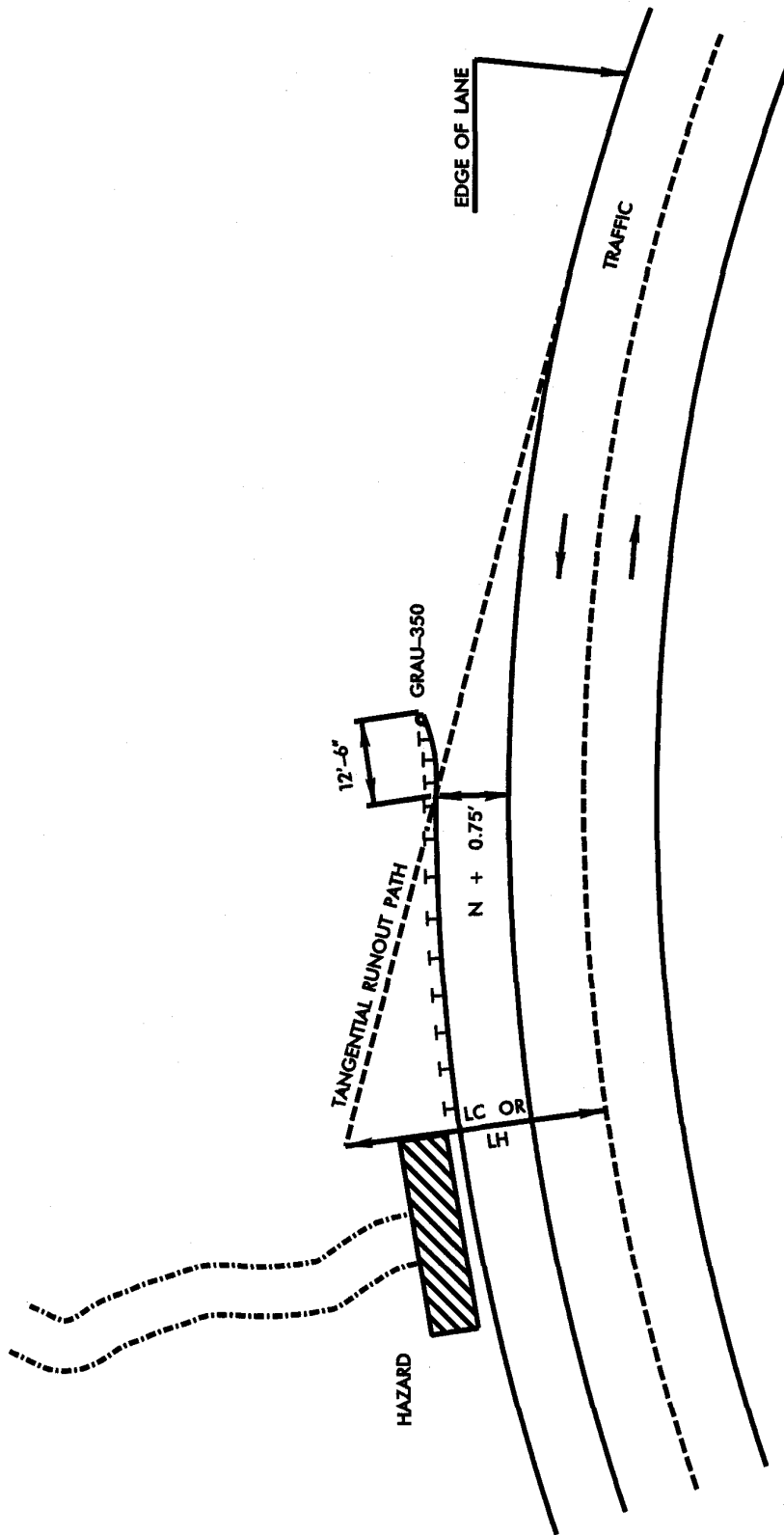
**CUL-DE-SACS****2-7**

The Design Engineers should provide turn arounds on roads that are dead-ended. Cul-de-sacs should be provided if extensive right-of way costs are not required for their construction. Other type facilities should be considered in lieu of providing a simple barricade. For additional information on cul-de-sacs and dead-end streets, see A POLICY ON GEOMETRIC DESIGN OF HIGHWAYS AND STREETS (2004), ch. 5. Also, see NCDOT “Subdivision Road Manual”.

The cul-de-sacs shall be designed and discussed on the Preliminary Field Inspection. Usually when a street has to be dead-ended, the Division Engineer will be responsible for any administrative action required in closing the facility.

DETAIL 2D

3 - 2D



# DETAIL OF GUARDRAIL PLACEMENT ON APPROACH END OF HAZARD LOCATED ON A HORIZONTAL CURVE

GUARDRAIL ANCHOR UNITS

3-2E

The anchor units most commonly used are listed and their usage is described below:

Guardrail Anchor Unit Type 350: (GRAU-350)

The GRAU-350 is a crashworthy tangential end section, which is used along the outside shoulders in instances where there is a chance of hitting the guardrail “head-on” within the vehicle’s clear zone. Locations where this end section is used are as follows:

On the approach ends of guardrail along the outside shoulders.

On the trailing ends of guardrail along two lane two way roadways.

On the trailing ends of guardrail along outside shoulders where the end of the guardrail is within an opposing vehicle’s clear zone.

As stated previously, the GRAU-350 is a tangential end unit. However, these units will be flared over the last 50 feet to provide a 1-foot offset. This minimal flare allows the terminal to be offset so that no component of the unit extends beyond the face of the guardrail. The tangential end unit should not be flared greater than a 50:1 flare rate. No curb is allowed within the limits of this unit.

Median Anchor Unit Type 350: (M-350)

M-350 anchor units are flared end sections. Within the medians along dual lane bridge approaches, there is a need to flare the guardrail to move it away as quickly as possible from the inside travel lane. The flared guardrail must be anchored with a flared end section. Therefore, the M-350 Anchor unit is used in the following situations:

Within the median on the approach to a dual lane bridge.

Within the median on the trailing end of a dual lane bridge if the backside of the approach anchor unit is within the clear zone. (See Roadway Standard Drawings, Std. No. 862.01, Sheet 2)

The M-350 has a flare and is flared for a distance of 37.5 feet. The unit has a 4 foot offset.

No curb is allowed within the limits of this unit.

Cable Anchor Terminal: (CAT-1)

The Cable Anchor Terminal (CAT-1) end treatment is not crashworthy and should only be used at locations where there is not an opportunity to have a “head-on” hit within a vehicle’s clear zone

GUARDRAIL ANCHOR UNITS (continued)

3-2E

Typically, the CAT-1 is used on the trailing end of guardrail along multi-lane highways. (Exceptions would be in the median as noted in the previous discussion of the M-350).

Anchor Terminal: (AT-1)

The Anchor Terminal's (AT-1) usage is limited to anchoring the shop curved guardrail at intersections, which have radii between 20 to 75 feet. Typically, vehicles will be approaching the intersection at a lower speed in order to stop. Therefore, this anchor system is appropriate for this condition. (Refer to Roadway Standard Drawings, Std. No. 862.01 Sheet 7 for an example of this application).

Terminal End Section:

This end section is not an anchor unit. As its name implies, it is an end section, which is placed at locations where an anchor unit is not needed. Typically, the terminal end section is placed on sections of guardrail that are used to terminate or "dead-end" roadways.

Structure Anchor Units:**Type III:**

This anchor unit is used to anchor guardrail to bridges with metal bar railing or any other rail design that has a vertical shape allowing the Type III attachment (See Roadway Standard Drawings, Std. No. 862.03). The 4" curb adjacent to the anchor unit is not required in locations where the bridge rail is behind the sidewalk. This anchor unit can be used on temporary bridges.

**Type B-77 (with rubrail):**

This guardrail anchor unit is used to attach guardrail to concrete Jersey shape barrier as illustrated in Roadway Standard Drawings, Std. No. 857.01. This anchor unit should also be use on bridges with Jersey shaped barrier rail that has 4" curb or no approach curb. The anchor unit has a rubrail which prevents vehicles from "snagging" the barrier (See Roadway Standard Drawings, Std. No. 862.03). This anchor unit can be used on temporary bridges.

**Type B-83**

This anchor unit should be used on existing bridges with a Jersey shape barrier and an 8" or higher curb on the approach slab. The curb must extend the full pay limits of the guardrail anchor unit. This may require additional curb construction. This anchor unit is mainly used in retrofit situations replacing the old Type X, XI, XII, and XIII anchor units (See Roadway Standard Drawings, Std. 862.03).

DETERMINING TOTAL GUARDRAIL LENGTH

3-2F

The total length guardrail needed at an installation is obtained by adding the length of need to the guardrail length which is needed throughout the limits of the hazard, and then deducting the applicable anchors' unit length. Anchor unit deductions, to be used in calculations, are listed below: The total length of guardrail should be rounded so it is divisible by 12.5 ft.

ANCHOR DEDUCTIONS

<u>ANCHOR</u>	<u>DEDUCTIONS</u>
GRAU-350	50.0'
M-350	37.5'
CAT-1	6.25'
AT-1	6.25'
*Type III	18.75'
*B – 77	18.75'
*B – 83	25.0'

\*Measured from the end of the bridge or approach slab rail.

GUARDRAIL INSTALLATION AT INTERSECTIONS

3-3

When installing guardrail around intersections, care must be taken to ensure adequate sight distance is maintained at the intersection. Also, the guardrail should not impede the turning path of a vehicle. When guardrail is warranted around an intersection, provide as much offset as possible from the edge of the travel lane to the face of the guardrail. This will ensure adequate sight distance and place the guardrail farther from a vehicle's turning path.

In installations along curb and gutter facilities, the guardrail should preferably be placed 12 feet from the face of the curb instead of at the face of the curb. If 12 feet is not available, place the guardrail, as far away from the face of the curb as the berm width will allow. When guardrail is placed at the face of the curb, sight distance and the vehicle's turning ability is impeded.

See Roadway Standard Drawings, Std. No. 862.01, Sheet 7, for a pictorial view showing placement of guardrail at intersections.

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**GUARDRAIL ANCHOR UNITS ON STRUCTURES** 3-8

For additional information on Guardrail Anchor Units on Structures, see Part I, Chapter 6-6C of this manual. Also, refer to Roadway Standard Drawings, Std. No. 862.03.

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**GUARDRAIL ON CURB AND GUTTER BRIDGE APPROACHES** 3-9

The guardrail should be placed at the back of the sidewalk so that it ties directly into the bridge rail as shown on Roadway Standard Drawings, Std. No. 862.01 Sheet 4.

The bridge rail used with the sidewalk installation is the bar metal rail. A Type III Guardrail Anchor Unit will be used to anchor the guardrail to the end of all bridges. The Type III Guardrail Anchor is shown on Roadway Standard Drawings, Std. No. 862.03, Sheet 2.

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**GUARDRAIL ATTACHMENT AND RETROFIT MANUAL** 3-10

The Guardrail Attachment and Retrofit Manual has been prepared for use as a guide in the Structure Design Unit and Roadway Design Unit. The Roadway Design Project Engineer will coordinate guardrail attachments required at existing bridges with the Structure Design Project Group Engineer assigned to the project. If the project has not been assigned to a Structure Design Project Group Engineer, coordinate with the Assistant State Bridge Design Engineer.

The manual contains examples or special details of guardrail attachment used on previous projects. If a required detail is not in the manual, the Structure Design Project Group Engineer will prepare the detail and the finalized detail will be sent to the Engineering Development Section in the Structure Design Unit for distribution. At times, measurements from the Bridge Maintenance Unit will be necessary before the details can be finalized.

NOTE: The Structure Design Project Group Engineer is responsible for determining the appropriate design detail to be used or if a new design is required.

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**POSITIVELY ANCHORED TEMPORARY PRECAST  
CONCRETE BRIDGE BARRIER – TYPE S** 3-11

During staged construction, widening or specific rehabilitation projects, Work Zone Traffic Control Unit may require a temporary bridge rail. In general, the pay item for temporary bridge barrier will be a traffic control item. Close coordination between Structure Design, Roadway Design and Work Zone Traffic Control Unit is extremely important.

POSITIVELY ANCHORED TEMPORARY PRECAST  
CONCRETE BRIDGE BARRIER – TYPE S (cont.)

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3-11

The following procedure shall be followed:

- (a) The Structure Design Project Group Engineer will contact the Roadway Project Group Engineer and the Traffic Control Project Engineer to determine the width of the bridge deck needed to maintain traffic during construction. This will determine the location of the temporary barrier. The offset distance shall be the distance from the back of the barrier to the edge of the slab.
- (b) If the offset distance is from 0'-0" to 3'-11", the Type S barrier will be positively anchored to the slab. Roadway Design will include the detail of the Type S barrier in their plans. This barrier will be a Traffic Control pay item. Work Zone Traffic Control Unit will be responsible for determining pay limits and estimating pay item quantities for the Engineer's Estimate. The Structure Design Project Group Engineer will include a sketch of the Type S barrier with the offset distance dimensioned and a note to see the Traffic Control plans for location and pay items of the positively anchored temporary pre-cast concrete bridge barrier - Type S.

The Structure Design Project Group Engineer will furnish the beginning and ending approach slab stations to the Traffic Control Project Engineer and the Roadway Design Project Engineer.

- (c) If the offset distance is from 4'-0" to 5'-11", the standard precast temporary concrete median barrier Roadway Standard Drawings, Std. No. 1170.01 shall be used.

The Structure Design Project Group Engineer will furnish the beginning and ending approach slab stations to the Traffic Control Project Engineer and the Roadway Design Project Engineer. This will be used to determine the pay limits for the barrier. The Work Zone Traffic Control Engineer puts the following note in their plans.

THE TEMPORARY PRECAST MEDIAN BARRIER ON THE BRIDGE SHALL BE RESTRAINED AGAINST LATERAL MOVEMENT BY THE ANGLE AND ANCHOR SYSTEM. SEE THE BRIDGE PLANS FOR DETAIL AND PAYMENT FOR THE ANGLE AND ANCHOR SYSTEM.

- (d) If the offset distance is 6'-0" or greater, the standard precast temporary concrete median barrier Roadway Standard Drawings, Std. No. 1170.01 shall be used. No attachment to the bridge deck is required. This will be a Traffic Control pay item.



POSITIVELY ANCHORED TEMPORARY PRECAST  
CONCRETE BRIDGE BARRIER – TYPE S (cont.)

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3-11

- (e) If a bridge member is over stressed due to the use of the barrier specified in paragraph (b), (c) or (d), the Structure Design Project Group Engineer will coordinate with Work Zone Traffic Control Unit and Roadway Design to use an alternate type of rail.

PROPRIETARY IMPACT ATTENUATORS AND TERMINAL END UNITS

3-12

Impact attenuators are installed to shield rigid objects or hazardous conditions that cannot be removed, relocated or made breakaway. Terminal end units are installed when standard guardrail anchor units will not work or for experimental purposes.

For warrants, see the "AASHTO Roadside Design Guide".

When use of an impact attenuator or terminal end unit is indicated, the following guidelines need to be considered:

1. Only those items that have been crash tested and found to meet the requirements of NCHRP-350 will be considered for use where there is a chance of hitting the guardrail “ Head on ” within the vehicle’s clear zone.
2. Each location must be evaluated to determine the appropriate width and type of attenuator which will meet the site needs, geometric conditions, expected frequency of impact, and economy of installation and maintenance. (See 3-12, Table 1)
3. The effects of impacts with respect to the safety of subsequent vehicles.

TABLE 1

3 - 12

FHWA APPROVED, TYPE 350  
(IMPACT ATTENUATORS & GUARDRAIL ANCHOR UNITS)

UNIT	DESCRIPTION			IMPACT ATTENUATORS		GR. ANCH. UNITS *SF	FIXED OBJECT
	WIDTH	LENGTH	SUPPLIER	*DF	MED. BARRIER		
ADIEM	1'-8" to 2'-4"	30'	TRINITY		X		X
BRAKEMASTER	1'-6"	32'	ENERGY ABSORPTION	X	X		X
CAT	2'-3"	32'	TRINITY	X	X		X
REACT 350	3'	30'-8"	ENERGY ABSORPTION		X		X
**QUADGUARD	2' 2'-6" 3'-0"	8'-6" to 41'-6"	ENERGY ABSORPTION		X		X
**TRACC	2'-7"	21'-0"	TRINITY		X		
BEST (No Offset)	1'-8"	50'	INTERSTATE STEEL CO.			X	X
ET-2000 (No Offset)	1'-6"	50'	TRINITY			X	X
SKT 350	1'-6"	50'	ROAD SYSTEMS, INC.			X	X
SENTE	2'	17'	ENERGY ABSORPTION			X	X
SRT 350	1'-6"	37'-6"	TRINITY			X	X
FLEAT	1'-6"	37'-6"	ROAD SYSTEMS, INC.			X	X
REGENT	1'-6"	37'-6"	ENERGY ABSORPTION			X	X

\* DF = DOUBLE SPACE  
SF = SINGLE SPACE  
\*\*NON-GATING UNIT

- a. Water-filled units should not be placed where expelled water will stand on or flow across the travel way.
  - b. Sand-filled units should not be placed where the sand from impacted containers will spill into the travel way.
4. There may be a need for additional delineation to reduce the frequency of impacts (refer to TRR 1111, "Traffic Accident Analysis, Visibility Factors, and Motorists Information Needs" in the Alternative Delivery Unit Library).
  5. The availability and storage of repair parts should be evaluated.
  6. Proprietary devices require special attention during final plan process on both State and Federal projects. Three comparable alternatives are desired for the final plans. If only one alternative is used, then written approval must be given by the FHWA Division Administrator (NHS projects) or State Highway Design Engineer (state funded or non-NHS projects). The approvals must be requested based on one of the following criteria:
    - 1) The device is the only alternative available to do the job and its use is in the Public interest.
    - 2) The device is to be used for experimental purposes.

TABLE 1 provides basic information on known systems as an aid to initial selection.

This chapter should provide the Engineer guidelines for selecting an efficient and cost-effective barrier system. Past performance will highly affect the Engineer's decisions. Therefore, Divisions are encouraged to record and document maintenance experience with traffic barriers and provide this information to the Value Management Section, Alternative Delivery Unit.

#### Example of Guardrail Summary

3-13 Example

#### **I. Protection at Median Bridge Piers (Roadway Standard Drawings, Std. No. 862.01 Sheet 1)**

Assume:

1. 46' median
2. 12' median shoulders
3. 6.56' = face of guardrail to face of guardrail under bridge
  - a.  $3' + (2 \times 1.5) + (2 \times 0.28') = 6.56'$

Example of Guardrail Summary (cont.)

3-13 Example

Note: 3' = width of pier  
 1.5' = width of barrier and offset  
 0.28' = width of guardrail

4.  $6.56' - 2' = 4.56'$  this is the width that has to be closed

Note: 2' = assumed width of impact attenuator (this is the narrowest width impact attenuator)

5.  $4.56' \times 7.5$  (assuming 15:1 taper on both sides) = 34.20' say 37.5' taper

6. 37.5' taper + 25' GRAU Type XI Modified = 62.5' per attachment

7. 250' guardrail per bridge location (4 Attachments @ 62.5')

8. 2 impact attenuator units, Type 350 per location

9. 60' pier spacing

10. 120' single face concrete barrier (60' x 2 sides of median piers)

**II. Guardrail Approaching Dual Lane Bridge (Roadway Standard Drawings, Std. No. 862.01 Sheet 2)**

Assume:

1. 40' wide bridges
2. 12' outside shoulders
3. 6' inside shoulders
4. 70 miles per hour design speed
5. 46' median
6. 100' guardrail required by fill height on right shoulder on trailing end of bridge

**III. Guardrail at Two Lane – Two Way Bridges (Roadway Standard Drawings, Std. No. 862.01 Sheet 3)**

Assume:

1. 32' wide bridge
2. over 2000 ADT (Design Year)
3. 60 miles per hour design speed

**IV. Guardrail at Bridges with 2' – 6" Curb and Gutter and Sidewalk  
(Roadway Standard Drawings, Std. No. 862.01 Sheet 4)**

Assume:

1. 64' face to face curb and gutter
2. 10' berm
3. 50' miles per hour design speed
4. Bridge has three bar metal rail
5. Bridge is 175' in length

**V. Beginning of Guardrail in Cut or Fill (Roadway Standard Drawings, Std. No. 862.01 Sheet 5)**

Assume:

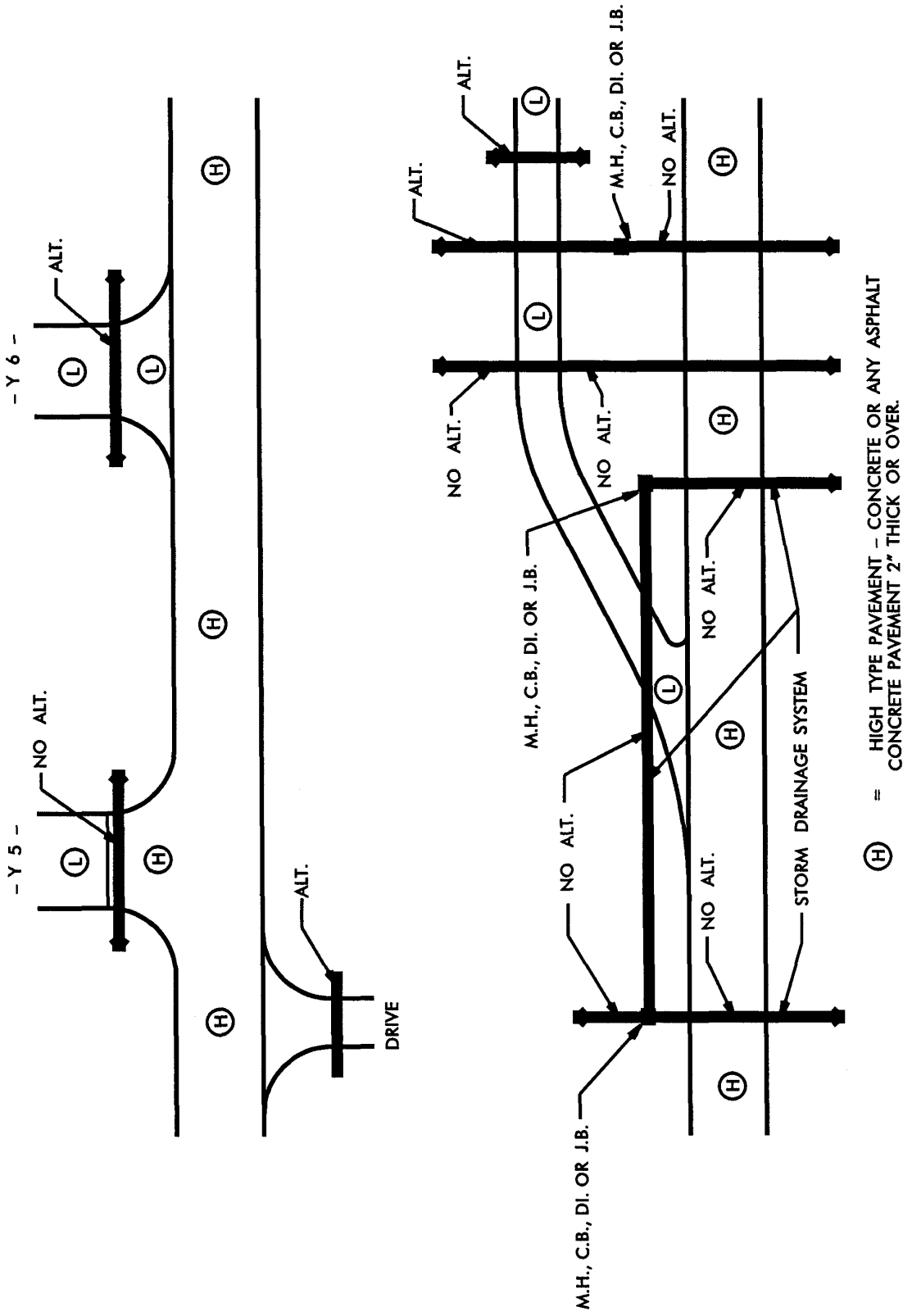
1. four lane divided section
2. 70 miles per hour design speed
3. 12' shoulder

[Click Here to View Guardrail Summary Sheet](#)



FIGURE 1

5 - 12  
F - 1



(H) = HIGH TYPE PAVEMENT - CONCRETE OR ANY ASPHALT  
CONCRETE PAVEMENT 2" THICK OR OVER.

(L) = LOW TYPE PAVEMENT - ASPHALT SURFACE TREATMENT OR ANY  
ASPHALT CONCRETE PAVEMENT LESS THAN 2" THICK.

### EXAMPLE OF TYPICAL PIPE INSTALLATION

The class of rip rap to be constructed on a project will be specified by the Hydraulics Unit when drainage recommendations are submitted to the Roadway Design Unit. See Part I, 1-5D and 1-5E of this Manual for additional information on rip rap for ditches.



## HYDRAULIC DATA ON PLAN SHEETS (continued)

5-18

Hydraulic data related to box culverts and bridges will be shown on the profile sheet near the proposed structure location. The Hydraulic data to be shown as follows:

Design Discharge = \_\_\_\_\_ CFS.  
 Design Frequency = \_\_\_\_\_ YRS  
 Design High Water = \_\_\_\_\_ FT.  
 100 Year Discharge = \_\_\_\_\_ CFS.  
 100 Year Frequency = 100 YRS  
 100 Year High Water = \_\_\_\_\_ FT.

Overtopping Flood Elevation = \_\_\_\_\_ FT.  
 Frequency = \_\_\_\_\_ YRS.  
 Discharge = \_\_\_\_\_ CFS.

At bridge sites, the Hydraulics Unit will provide the estimated normal water surface elevation of the stream, river or lake along with the elevation on the date of survey. Any unusual anticipated fluctuations, such as an upstream dam that routinely opens and closes gates, should also be noted. This data will be shown on the profile sheet near the proposed structure location.

Estimated Normal Water  
 Surface Elevation = \_\_\_\_\_ FT.  
 Date of Survey = \_\_\_\_\_  
 W.S. Elev. at Date of Survey = \_\_\_\_\_ FT.

Hydraulic data to be included in the plans will be included with the drainage recommendations submitted by the Hydraulics Unit. When this information is not submitted, it will be the responsibility of the Roadway Design Project Design Engineer to obtain the information.

NUMERICAL SYSTEM FOR DRAINAGE LAYOUT

5-19

A numerical system for detailing drainage on plans has been developed to provide plans that are easier to finalize and follow. This system is especially beneficial on large urban projects, curb and gutter projects, and other type projects requiring an extensive system.

The numbering system sequence shall be consecutive for the entire project. The numbering shall be in chronological order, beginning at the start of the project and proceeding according to stations. Where drainage structures are opposite each other at the same station, number the structure on the left first. The drainage item numbers shall be shown in the following enclosure to distinguish them from parcel numbers. These structure numbers shall be shown on the Summary of Drainage Quantities sheets with the length of pipe and related items.

See 5-19 Figures 1 and 2, in this Chapter, for examples of Numerical Drainage layouts.

## PIPE END TREATMENT GUIDELINES

5-20

The following guidelines apply to TIP projects on the primary system. The guidelines do not apply to the secondary road system.

The criteria provided within this section (5-20) is intended as a "Guide" only. Engineering judgment should be used to determine if a different, but more appropriate, treatment is necessary.

The following guidelines for Pipe End Treatment shall be used in conjunction with the guidelines on clear zone distances. (See Part I, 1-4N, of this Manual to determine clear zone distances.)

Recommended Pipe End Treatments are listed below in order of preferential treatment. (Use the first recommendation listed under each heading if practical.)

A. Pipe End Treatment for Cross Pipes On All Roadways

(For further information, See "Roadway Standard Drawings", Std. No's. 310.03 and 310.05)

(1) Pipes Outside Clear Zone

Use endwall on inlet end for 36" or over (unless specified otherwise by Hydraulics Unit).

(2) Pipes Inside Clear Zone

a. Extend all pipe beyond clear zone and use endwall on inlet end for 36" or over (unless specified otherwise by Hydraulics Unit).

b. Use a Cross Pipe end section (4:1 slope) for 30" or under. Use guardrail for 36" or over with endwall on inlet end (unless specified otherwise by Hydraulics Unit). On the outlet end, use a Cross Pipe end section (4:1 slope) with safety bars, or protect with guardrail.

B. Pipe End Treatment For Parallel Pipes

(For further information, See "Roadway Standard Drawings", Std. No's. 310.02 and 310.04)

(1) At Median Crossover Locations

a. Use a grated drop inlet with 10:1 or flatter slopes.

b. At existing locations without sufficient depth for drainage structures, use Parallel Pipe end sections and 6:1 slope.

(2) At Grade Intersections and Driveways

- a. \* Multilane Highways with Design Speed greater than 50 mph.
  1. Place all pipe beyond Clear Zone (see Part I, 5-20, F-2 of this Manual) and use an endwall on inlet end of 36" or over (unless specified otherwise by Hydraulics Unit).
  2. On approach ends, use a grated drop inlet with 6:1 or flatter slopes where practicable and where existing or proposed drainage systems are available.
  3. On approach ends, use parallel pipe end section (6:1 slope) for 24" or under and use guardrail for 30" or over. Trailing ends require no special treatment other than endwalls on the inlet end for 36" or over (unless specified otherwise by Hydraulics Unit).
- b. \* Multilane Highways with Design Speeds  $\leq$  50 mph and All Two Lane Highways.

No special end treatment is required on two lane highways and multilane highways with design speeds  $\leq$  50 mph. However, endwall placement is required on inlet end for 36" or over unless otherwise specified by Hydraulics Unit.

\* Note: This treatment for multilane highways applies to new construction and major reconstruction projects. It does not apply to resurfacing, bridge replacement, or spot safety projects. Pipe end treatment on these type of projects (including private installations) will be the same as existing pipes unless accident history warrants special consideration.

Endwalls shall be constructed perpendicular to the centerline of pipe unless specific site conditions warrant construction of an endwall parallel to the roadway. (See Hydraulics Unit for approval.) It will be necessary to extend the pipe to allow the end of the endwall to tie into the toe of the fill. See Part I, 5-20, F-1 in this Chapter for an example. Any additional backfill material necessary to extend this pipe shall be covered under Section 300 of the Standard Specifications for Roads and Structures. The quantities for the endwalls constructed perpendicular to the centerline of pipe will be based on a 90° skew rather than skew of pipe.

Following are guidelines for the use of shoulder berms, gutters and curbing on the outside edge of fill shoulders. Their purpose is to minimize the shoulder and slope erosion resulting from sheet flow off the pavement.

#### Existing Facilities

When erosion at the curb on existing installations causes undermining of the curb and erosion of fill slopes, the following guidelines should remedy the problem.

On existing facilities with 2' or 4' paved shoulders, removal of the curb and stabilizing the shoulder and slope is generally the most cost-effective solution.

On 10' paved shoulder facilities, extending the paved shoulder to abut the curb is the preferred treatment. In all cases, the Hydraulics Unit and the Geotechnical Engineering Unit should assist in defining the proper solution based on individual site conditions.

#### Proposed Construction

##### Shoulder Berm

In general, it is better to allow surface water to flow across the fill shoulders and down the slope. Certain conditions will sometimes make it necessary to use positive control of sheet flow. These conditions include, but are not limited to:

- (1) Easily erodible soils or soils not conducive to vegetative growth along shoulder and embankment.
- (2) Extreme values of runoff flow and velocity due to/or in combination with:
  - Width of Pavement
  - High superelevation rates
  - Steep roadway grade
- (3) Roadside development which might require stricter control of runoff.

The decision for or against intercepting sheet flow at the shoulder edge should be made only after consideration of input from the Hydraulics Unit, the Geotechnical Engineering Unit, and the Division Engineer. The determination should be made on a project-by project basis. Shoulder treatment should be fully addressed during the preliminary field inspection. The most current listing of Field Inspection questions can be found on our computer website:

<http://www.ncdot.org/doh/preconstruct/highway/roadway/manuals>

When a need is determined, an earth shoulder berm should be used, (See Roadway Standard Drawings, Std. No. 846.03). Portions of the flow line at the outlet points will require shoulder berm gutter Std. No. (846.01). The flow line between outlets will require stabilization with Matting for erosion control or concrete depending upon soil characteristics. Coordination should be made with the Hydraulics Unit to determine the type of drainage pick-up structures and outlet spacing. Input from the Geotechnical Engineer Unit and Division Engineer should be obtained regarding the method of stabilizing between outlets.

A shoulder berm can only be used where guardrail is otherwise required with the face of the rail directly above the flow line. This may sometimes require a further addition to the overall shoulder width in order to maintain a minimum usable shoulder (See Part I, 1-4B of this Manual for shoulder criteria).

#### Expressway Gutter

When positive control of sheet flow is needed and guardrail is not warranted, an expressway gutter shape is required, (See Roadway Standard Drawings, Std. No. 846.01). The specific method of stabilizing the flow line should be determined as noted for shoulder berms. Expressway gutter used in combination with guardrail must be recommended by the Hydraulics Unit.

## CHAPTER SEVEN

## RAILROADS

SIGHT DISTANCES AT RAILROADS  
FOR UNSIGNALIZED CROSSING

7-1

The sight distance at railroad crossings is of utmost importance. When the exposure index does not merit grade separations or railroad signals, use A Policy on Geometric Design of Highways and Streets (2001), Exhibit 9-103, to provide safe stopping sight distances. If physical barriers exist and it is not economically feasible to provide the required distances, it shall be discussed with the Assistant State Roadway Design Engineer.

NOTE: Exhibit 9-103 is based on conditions of a 65' truck crossing a single set of tracks at 90°. This allows for a margin of safety for conditions using other design vehicles. If it is determined by the designer that a small number of trucks will be using the facility, consideration may be given to reducing the sight distance.

For Additional Information See:

- A. Roadway Standard Drawings, Std. No. 1205.11 - Pavement Markings for Railroad Crossings
- B. Chapter 18 of The Policy and Procedure Manual.
- C. Railroad-Highway Grade Crossing Handbook "Report No. FHWA - TS - 86 - 215, September, 1986"
- D. A POLICY ON GEOMETRIC DESIGN OF HIGHWAYS AND STREETS (2001), Ch 9.
- E. For Federal Highway-Rail Grade Crossing Relevant web links, go to:  
"[http://safety.fhwa.dot.gov/fourthlevel/prof\\_res\\_hiwaygradexing\\_links.htm](http://safety.fhwa.dot.gov/fourthlevel/prof_res_hiwaygradexing_links.htm)".

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**F. Railroad – Highway Grade Crossing**

See "A POLICY ON GEOMETRIC DESIGN OF HIGHWAYS AND STREETS " (2004), EXHIBIT 9-102.

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**SIGHT DISTANCES AT RAILROADS  
FOR UNSIGNALIZED CROSSING (Continued)**

7-1

**G. Moving Vehicle to Safely Cross or Stop at Railroad Crossing**

See “A POLICY ON GEOMETRIC DESIGN OF HIGHWAYS AND STREETS ” (2004), EXHIBIT 9-103.

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**H. Required Design Sight Distance for Combination of Highway and Train Vehicle Speeds; 65' Truck Crossing a Single Set of Tracks at 90°.**

See “A POLICY ON GEOMETRIC DESIGN OF HIGHWAYS AND STREETS ” (2004), EXHIBIT 9-104.

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**I. Departure of Vehicle from Stopped Position to Cross Single Railroad Track.**

See “A POLICY ON GEOMETRIC DESIGN OF HIGHWAYS AND STREETS ” (2004), EXHIBIT 9-105.

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**TRACK CLEARANCE REQUIREMENTS ON CURB AND GUTTER  
PROJECTS PERPENDICULAR TO A RAILROAD**

7-2

When curb and gutter is being constructed on a project that crosses a railroad, the curb and gutter should be terminated 13'-6" from the centerline of the nearest rail of the tracks. The distance is measured perpendicular from the centerline of the rail to the face of curb. In switching areas where obstructions would be a hazard to trainmen, more than 13'-6" may be required. The termination of the curb and gutter shall be discussed on the field inspection and with the railroad companies if unusual conditions exist.

**TRACK CLEARANCE REQUIREMENTS ON CURB AND GUTTER  
PROJECTS PARALLEL TO A RAILROAD**

7-3

When it is necessary to construct curb and gutter parallel and in close proximity to a railroad, the location of the curb and gutter in relation to the nearest rail should be discussed with the Utility Agent in the Right of Way Branch.

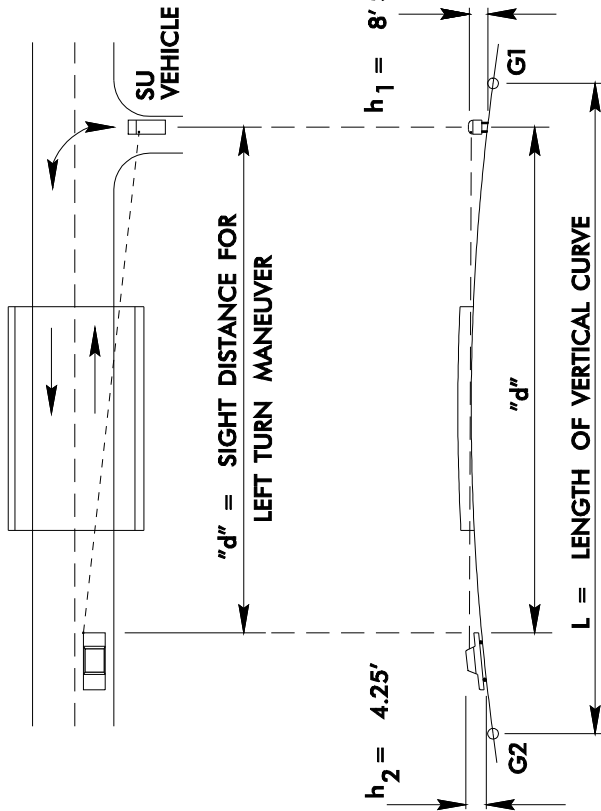


**TABLE 1**

CROSSROAD DESIGN SPEED	SIGHT DISTANCE "d" REQ'D. FOR SU RAMP VEHICLE, LEFT TURN MANEUVER <sub>1</sub>	"K" REQ'D. FOR STOPPING SIGHT DISTANCE ALONG CROSSROAD <sub>2</sub>	"K" REQ'D. TO PROVIDE SIGHT DISTANCE "d" FOR SU RAMP VEHICLE LEFT TURN MANEUVER <sub>3</sub>	"K" REQ'D. TO PROVIDE SIGHT DISTANCE "d" FOR SU RAMP VEHICLE SIGHTING OVER BRIDGE RAIL <sub>4</sub>
70 MPH	1060 FT.	247 *	235	442
60 MPH	910 FT.	151 *	173	326
50 MPH	760 FT.	84	121 *	227
40 MPH	610 FT.	44	78 *	147

\* DENOTES MINIMUM "K" TO BE USED FOR EACH DESIGN SPEED

**VERTICAL SIGHT DISTANCE ELEMENTS**



$$K = L/A$$

A = ALGEBRAIC DIFF. IN GRADES (G2 - G1)

VERTICAL SIGHT DISTANCE SHOULD BE PROVIDED IN COMBINATION WITH HORIZONTAL SIGHT CONTROLS. THE DESIGN DATA LISTED ABOVE IS BASED ON UTILIZING THE SU VEHICLE AS THE RAMP VEHICLE. WITH A PASSENGER CAR AS THE RAMP VEHICLE, THE SIGHT DISTANCE PROVIDED WITH THE DESIGN DATA LISTED ABOVE ALLOWS FOR APPROACH SPEEDS GREATER THAN THE CROSSROAD DESIGN. WITH A WB-50, THE AVAILABLE SIGHT DISTANCE ALLOWS FOR APPROACH SPEEDS OF ABOUT 75% OF THE CROSSROAD DESIGN SPEED WHICH IS APPROXIMATELY THE AVERAGE RUNNING SPEED OF THE CROSSROAD TRAFFIC.

**NOTES:**

- SIGHT DISTANCE "d" IS ESTABLISHED BY AASHTO CRITERIA FOR THE SU CONDITION; A POLICY ON GEOMETRIC DESIGN OF HIGHWAYS AND STREETS (2004)
- MINIMUM "K" FOR STOPPING SIGHT DISTANCE ALONG CROSSROAD ACCORDING TO THE 2001 AASHTO CRITERIA
- DERIVED FROM  $K = \frac{d^2}{100 (\sqrt{2h_1} + \sqrt{2h_2})^2}$  WITH  $h_1 = 8.0', h_2 = 4.25'$
- RAMP VEHICLE DRIVER SIGHTS OVER BRIDGE RAIL (2.67' RAIL HT.). RAIL DOES NOT OBSTRUCT HORIZONTAL OR VERTICAL SIGHT LINES FOR REQUIRED "d";  $h_1 = (8.0' - 2.67') h_2 = (4.25' - 2.67')$

SIGHT DISTANCE OBTAINED BY SIGHTING INSIDE BRIDGE RAIL.

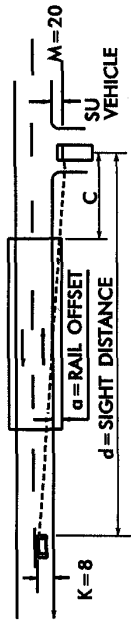
**TABLE 2**

8 - 7

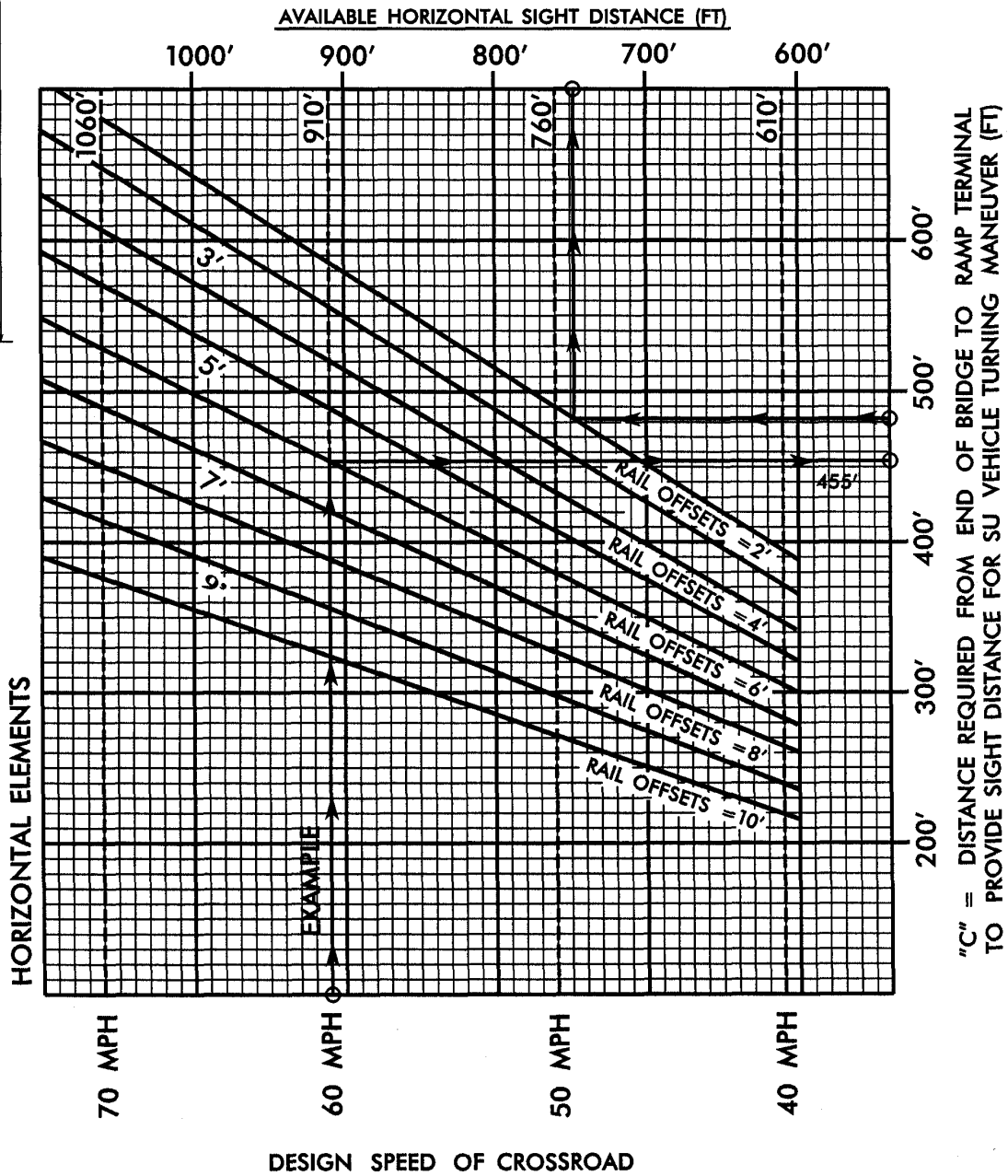
**DESIGN REQUIREMENTS FOR CROSSROAD SIGHT DISTANCE  
SINGLE UNIT VEHICLE CRITERIA - DIAMOND INTERCHANGE**

T - 2

NOTE: FOR PRELIMINARY INTERCHANGE LAYOUT ONLY. ALL INTERCHANGES SHOULD BE ANALYZED ON AN INDIVIDUAL BASIS IN PREPARING FINAL DESIGN.  
CHART BASED ON TANGENT HORIZONTAL ALIGNMENT ON CROSSROAD



$$d = \frac{c(m+k)}{m-a}$$



"C" = DISTANCE REQUIRED FROM END OF BRIDGE TO RAMP TERMINAL TO PROVIDE SIGHT DISTANCE FOR SU VEHICLE TURNING MANEUVER (FT)

## CHAPTER TEN

## ENTRANCES

DESIGN OF COMMERCIAL ENTRANCES

10-1

A paved driveway turnout (Std. No. 848.04) shall be used for commercial type entrances that generate 500 ADT or more. A shopping center is considered a major traffic generator. To provide the most efficient ingress and egress movements, minimum 25' radii should be provided. Longer radii should be considered to better accommodate service type vehicles. The designer is also encouraged to provide as much channelization as possible into any commercial development that is being constructed in conjunction with a roadway project.

For commercial type developments that generate less than 500 ADT, a paved driveway turnout (Std. No. 848.02 or Std. No. 848.03) may be used. A small family business is considered a minor traffic generator.

For additional information, see the "Policy on Street and Driveway Access to North Carolina Highways" from the Alternative Delivery Unit or on the NCDOT website:

<http://www.ncdot.org/doh/preconstruct/altern/value/manuals/>

DESIGN OF PRIVATE ENTRANCES

10-2

A minimum 20' width should be used for standard driveway turnouts in conjunction with curb and gutter (Std. No. 848.02 or Std. No. 848.03). A 16' width driveway turnout may be used where justified and approved by the Engineer.

ENTRANCE PIPES

10-3

On minimum type driveways, the total graded width should not be less than 16'. This allows for an effective paved or aggregate travelway of 12'. Normally, 20' of 15" pipe would be required for a drive of this type having minimum cover. However, sound engineering judgment should be used in determining the proper driveway width and length of pipe based upon factors such as skew of drive, height of cover, type of drive, and unusual traffic patterns. On drives where commercial vehicles are subject to encroach upon the end of pipe, extension of the pipe may be justified.

When a clear roadside recovery area is being provided on a project, the ditches shall be graded to allow installation of the entrance pipes at the same specified distances. See Part I, Chapter 5-20, of this Manual for additional information.

DISCUSSION OF ENTRANCES ON FIELD INSPECTIONS

10-4

Standard street and driveway turnouts shall always be discussed during the Field Inspections. The type and location shall be approved by the field inspection review team. This information is included in the “notes for field inspection”.

There is information available in the Manuals Group, Special Services Section of the Alternative Delivery Unit, for the designer's use in the design of parking lots.

There is also information available on the channelization of intersections and commercial establishments.

REPLACEMENT OF EXISTING DRIVEWAYS

10-5

When widening an existing roadway, the Project Engineer shall assure that all existing access connections that are to be replaced conform to the current edition of the “Policy on Street and Driveway Access to North Carolina Highways”. No new driveway turnouts/connections shall be placed/alterd on the final plans without the express consent and approval of the local District Engineer. When it is determined that a new access connection will be allowed, a separate agreement between the Department of Transportation and the applicant will be required.

## CHAPTER ELEVEN

## COMPUTATIONS

QUANTITY CALCULATIONS

The Calculation of Quantities Worksheets, for most of the major pay items encountered in finalizing projects, can be found on the computer website:

“<http://www.ncdot.org/doh/preconstruct/ps/contracts/standards/quantities/default.html>”.

These work sheets contain information (formulas, sketches, etc.) to explain the Method of Calculating Quantities. Additional information is available in this chapter and can be discussed with the Plan Review Engineer.

ROADWAY ITEM (PAVEMENT)

11-1

PROOF ROLLING

11-1A

Proof rolling is recommended by the Geotechnical Engineering Unit. When the pavement design recommendations are submitted to the Project Engineer, proof rolling recommendations will be included. The recommendations shall also be discussed on the field inspection.

Proof rolling is to be performed to a width of 2' (feet) outside the proposed top edges of full depth pavement. Proof rolling is computed at the rate of three hours per 24' width of full depth pavement per mile. Full depth pavement widths other than 24' shall be prorated to correspond with this unit measurement. Final payment will be in accordance with Section 260 of the "Standard Specifications for Roads and Structures".

Example Methods Of Computing Hours Per Mile Of Proof Rolling For Various Width Pavements.:

Example 1. 22' Width Roadway, With No Paved Shoulders.

$22' \text{ ( two } 11' \text{ Lanes )} + 4' \text{ ( } 2' \text{ outside lt. \& rt. Full Depth Pavement )} = 26' \text{ width.}$

$26' \text{ width} \times \text{( 3 hrs. per mile \ per } 24' \text{ roadway width )} = 3.25 \text{ hrs. per mile.}$

Example 2. 24' Width Roadway, With 2' Full Depth Paved Shoulders.

$24' \text{ ( two } 12' \text{ Lanes )} + 4' \text{ ( } 2' \text{ Full Depth Paved Shoulders lt. \& rt. )} + 4' \text{ ( } 2' \text{ outside lt. \& rt. Full Depth Pavement )} = 32' \text{ width.}$

$32' \text{ width} \times \text{( 3 hrs. per mile \ per } 24' \text{ roadway width )} = 4.00 \text{ hrs. per mile.}$

Example 3. 60' Width Roadway, With 4' Full Depth Paved Shoulders.

$60' \text{ ( five } 12' \text{ Lanes )} + 8' \text{ ( } 4' \text{ Full Depth Paved Shoulders lt. \& rt. )} + 4' \text{ ( } 2' \text{ outside Full Depth Pavement lt. \& rt. )} = 72' \text{ width.}$

$72' \text{ width} \times \text{( 3 hrs. per mile \ per } 24' \text{ roadway width )} = 9.00 \text{ hrs. per mile.}$

AGGREGATE BASE COURSE (ABC)11-1B

When all calculations are completed and totaled, the following procedures shall be used in the computation of ABC quantities.

- 0 TO 1000 TONS OF ABC – ADD 10%
- 1001 TO 5000 TONS OF ABC – ADD 5%
- 5001 TONS OF ABC AND ABOVE – ROUND OFF TO NEXT 100 TONS

PRIME COAT11-1C

Section 600 of the Standard Specifications For Roads and Structures states that prime coat will not be required unless called for on the plans and in the estimate.

Areas where prime coat should be included on a project are as follows:

1. On mainline and/or -Y- line paving areas when requested by Division Engineer, if approved by the Pavement Management Unit.
2. On any paving project (including detours and paved shoulders) when the bituminous concrete thickness is less than 2".
3. In conjunction with 10' paved shoulders, if the remainder of the shoulder is all ABC, this area should be primed at a rate of 0.5 gallons per Sq. Yd.

Areas to be primed are shown on the typical sections.

SUBGRADE STABILIZATION11-1D

When stabilized Subgrade is specified in the Geotechnical Recommendations for Pavement Design, it shall be included in the Pavement Schedule and shall be shown on the applicable typical sections. (See Pavement Schedule in this manual, Part II, 6-ID, F-1.) The following widths shall be used for stabilization:

- (1) Width in curb and gutter sections - Edge of pavement to edge of pavement.
- (2) Width in shoulder sections - One foot outside the top edges of the full depth pavement structure. (Include full depth paved shoulders.)
- (3) Do not use stabilization on pavement widths less than six feet.

## CHAPTER 12

## MISCELLANEOUS

MISCELLANEOUS DESIGN GUIDES

12-1

The following design guides are available in the Special Services Section in the Alternative Delivery Unit. There is other design information available that is not specifically listed.

- (A) Parking layouts (See this Chapter, 12-1, Figure 2.)
- (B) Channelization layouts
- (C) Truck turn templates and related information
- (D) Truck-tractors pulling 28 ft. trailers and other larger trucks are permitted on designated interstate highways and on other principal roads in N.C. The designers shall determine if their projects are involved with the twin-trailer routes and be aware of potential safety effects that will result when allowing these larger trucks on these routes; i.e., overriding shoulders and curbs during turns and at curves, accelerated deterioration of the pavement, setback of roadside guardrail and signing. See A POLICY ON GEOMETRIC DESIGN OF HIGHWAYS AND STREETS (2004) edition, Ch's. 2 and 9.
- (E) Bus turn templates and related information





# ROADWAY DESIGN MANUAL

## ROADWAY DESIGN UNIT

### UTILIZATION OF DESIGN MANUAL AND MANUAL FORMAT

#### PART TWO

Part two of this manual is primarily directed to the actual preparation of the plans. Most of the information is provided in narrative form. Illustrations are provided for some of the information, which should become standardized in all roadway plans. However, to provide the Project Engineer, Section Engineer and the designer with some flexibility in plan preparation and still maintain reasonable conformity in the finalization of plans, specifications and estimates; rigid guidelines such as "sample plans" or "plan illustrations" are not provided.

This manual provides design criteria in charts, tables and illustrations. When the information is in one of these forms, usually an explanation does not accompany them except for notes to cover varying conditions. Because all of the design concepts presented can not be completely covered, references to additional literature is given at the bottom of the chart. The Reference or Guide Manual denoted will be accompanied by a page number. The page numbers are for "quick" reference when more background information is necessary. Reference to these manuals will alleviate the repeating of detailed information in the reference books.

Design information is also included in narrative form. Any design criteria not included in this manual in narrative or chart form will be in the Roadway Policy and Procedure Manual or references made to other publications listed in Part Two, Chapter 24 of this manual. No reference will be made to design practices believed to be common knowledge by the well informed and experienced design staff of the Department of Transportation.



## CHAPTER THREE

## TITLE SHEET

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**PURPOSE** **3-1**

The Title Sheet provides information related to location of project, length of project, and type of work. Specific information to be shown on the title sheet is included below and in the Checklist:

[http://www.ncdot.org/doh/preconstruct/ps/specifications/specifications\\_provisions.html](http://www.ncdot.org/doh/preconstruct/ps/specifications/specifications_provisions.html)

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**LOCATION OF PROJECT AND TYPE OF WORK** **3-1A**

The location of project and type of work is used repeatedly on various engineering documents throughout the duration of a project. Since the space available on various project documents for writing this information is usually limited, the descriptions for the location and type of work shall be kept to an absolute minimum. In describing the location, the information shall be limited to the county or counties, route, and the beginning and ending points. In listing the type of work, it shall be limited to the major types of construction.

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**PROJECT LAYOUT** **3-1B**

The project layout is a small scale drawing of each plan sheet. The sheet number is shown on each superimposed plan sheet on the layout. This provides a quick reference to a specific location in the plans. The layout should include all interchanges, intersections, service roads, structures, railroads, outstanding geographical features, and any other major landmarks that may be used as reference points.

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**VICINITY MAP** **3-1C**

A vicinity map is required to show sufficient identifying information so that the project may be easily located on a county or state map. The vicinity map may be a tracing of any type map that will provide the most beneficial information. The beginning and ending points of the project should always be shown on the vicinity map. Major transportation facilities convenient for transporting construction materials to the project site should also be shown.

PROJECT NUMBERS ON FINAL PLANS3-ID

A contract number and TIP number is required on the left-hand margin of the title sheet. Use the TIP number at the begin and end project designations on the title sheet. The TIP number will also be used on the title sheet when listing project lengths. WBS elements and Federal Aid Project numbers are to be shown in the upper right hand title block. An example of the title sheet is shown on 3-1E, F-1. Sheets that follow the title sheet require that only the TIP numbers be shown.

INDEX OF SHEETS3-IE

FINAL PLAN SHEET ARRANGEMENT  
INDEX OF SHEETS

<u>Sheet Number</u>	<u>Sheet</u>
1	Title Sheet
1-A	Index of Sheets, General Notes, and List of Standards
1-B	Conventional Symbols
1-C	Survey Control Sheets
1-D	Centerline Coordinate List
2, 2-A, 2-B, 2-C, etc.	Typical Sections, Pavement Schedule, and Miscellaneous Details not covered by the Roadway Standards
*3	Summary of Quantities (known as No. 3 Sheet)

Number 3 and the alphabet will be used to organize the sheets that appear below. The alphabetical lettering may be different for each project dependent upon the number of sheets required in this series. Unless unusual conditions are experienced, the suggested order of sheets shall be used. When conditions will not permit, discuss the sheet arrangement with the Plan Review Engineer.

<u>Sheet Number</u>	<u>Sheet</u>
*3 - Series	(Second Sheet) Summary of Drainage Quantities Summary of Guardrail
<u>Sheet Number</u>	<u>Sheet</u>
	Summary of Pavement Removal
	Miscellaneous Removal Summaries
	Earthwork Summary

## CHAPTER FOUR

## GENERAL NOTES

PURPOSE

4-1

General notes are provided to help clarify the plans. The most frequently used general notes appear on the website at:

<http://www.ncdot.org/doh/preconstruct/ps/contracts/standards/checklists/1A.html>

It is the responsibility of the Project Engineer or Project Design Engineer to denote the general notes pertinent to his project and to write additional notes which do not appear on the website. Only general notes relative to project should be shown.



## CHAPTER FIVE

## ROADWAY STANDARDS, SPECIAL PROVISIONS AND CONTRACTS

PURPOSE AND LOCATION OF ROADWAY STANDARDS 5-1

A list of the roadway standards that are applicable to each project is to be listed in the plans. Usually, these standards are listed on Sheet 1-A of the plans. An up-to-date list of the standards is available on Project Services WebPages.

For additional information related to roadway standards, refer to the current Roadway Standard Drawings Manual.

NOTE: For up-to-date listing of Roadway Standard Drawings, Please, see our WebPages at

[http://www.ncdot.org/doh/preconstruct/ps/std\\_draw/](http://www.ncdot.org/doh/preconstruct/ps/std_draw/).

PROPOSAL LINE UP 5-1A

A list of information that is required for inclusion into bidding proposals is available on our WebPages at:

<http://www.ncdot.org/doh/preconstruct/ps/contracts/expedi/default1.html>.

It is the responsibility of the Project Engineer to prepare a checklist for the applicable project special provisions and standard special provisions for each project. It shall be the responsibility of the State Contract Officer to review the checklist prior to the final assembly of the proposal form.

The following lists are available:

- (1) Proposal line up
- (2) General construction projects
- (3) Resurfacing projects

PLANT PEST QUARANTINES 5-2

The Roadway Design Unit is responsible for assisting the Division Engineer in maintaining compliance with the federal and state plant pest quarantines. A list of counties with plant pest quarantines is provided in this guideline (5-2A).

It is the responsibility of the Project Engineer to determine if a project is in a quarantine area. This shall always be discussed on the field inspection. When a project is in a quarantine area, a special provision will be required in the contract.

## LIST OF COUNTIES WITH PLANT PEST QUARANTINES

5-2A

COUNTY	IMP. FIRE ANT	WITCHWEED	OTHER NOXIOUS WEEDS*
Anson	X		
Ashe			X
Avery			X
Beaufort	X		
Bladen	X	X	X
Brunswick	X		X
Buncombe			X
Carteret	X		
Chatham			X
Cleveland			X
Columbus	X	X	X
Craven	X	X	
Cumberland	X	X	X
Dare	X		
Duplin	X	X	
Durham			X
Forsyth			X
Gaston			X
Granville			X
Greene		X	
Halifax			X
Harnett		X	
Haywood			X
Henderson			X
Hoke	X		X
Hyde	X		X
Jackson			X
Johnston		X	
Jones	X		
Lenoir	X	X	
Lincoln			X
Madison			X

\*NOTE: The movement of class A or B noxious weeds or any regulated article infested with class A or B noxious weeds into North Carolina is prohibited. The movement of class A noxious weed or any regulated article infested with any class A noxious weed or any regulated article infested with any class A noxious weed is prohibited throughout the state. For further information on other noxious weeds, refer to Title 2, Chapter 43, Subchapter A, Sections .1701- .1708 of the North Carolina Administrative Code. Copies of the regulations for state noxious weeds are available by contacting the N.C. Department of Agriculture, P.O. Box 27647, Raleigh, NC 27611, (919-733-6930).



## LIST OF COUNTIES WITH PLANT PEST QUARANTINES (continued)

5-2A

Martin	X		
Mecklenburg	X		
Mitchell			X
Montgomery	X		
New Hanover	X		X
Northampton			X
Onslow	X		X
Orange			X
Pamlico	X		
Pender	X	X	
Perquimans			X
Pitt	X	X	
Randolph			X
Richmond	X		
Robeson	X	X	
Rowan			X
Rutherford			X
Sampson	X	X	
Scotland	X		
Tyrrell	X		X
Union	X		
Wake			X
Warren			X
Washington	X		
Watauga			X
Wayne		X	
Yancey			X

\*NOTE: The movement of class A or B noxious weeds or any regulated article infested with class A or B noxious weeds into North Carolina is prohibited. The movement of class A noxious weed or any regulated article infested with any class A noxious weed is prohibited throughout the state. For further information on other noxious weeds, refer to Title 2, Chapter 43, Subchapter A, Sections .1701- .1708 of the North Carolina Administrative Code. Copies of the regulations for state noxious weeds are available by contacting the N.C. Department of Agriculture, P.O. Box 27647, Raleigh, NC 27611, (919-733-6930).

RARE AND ENDANGERED PLANT SPECIES

5-3

The Project Development and Environmental Analysis Branch is responsible for conducting research to determine the probability of rare and endangered plant species which may be encountered on proposed highway projects. However, when research and on-site investigations are being conducted by the Project Engineer and it is determined that sensitive plants are being disturbed, it shall be discussed with the Roadside Environmental Unit.

When a plant species is being disturbed, a special provision will be required in the contract. See the Contracts Section in the Project Services Unit.

CHAPTER SIX  
TYPICAL SECTIONS

PURPOSE 6-1

---

A typical section is a cross-sectional representation of a proposed roadway showing grading and paving details. Typical sections shall include all elements necessary to construct the roadbed and/or pavement structure.

NUMBER OF TYPICAL SECTIONS 6-1A

---

Typical sections shall be drawn for each different pavement design and for major variations in component widths. Partial typical sections and notes should be used for minor variations; thereby minimizing the number of typical sections required.

Typical sections or part sections are not needed for auxiliary lanes or tapers (plans cover this)

Typical sections are not needed to cover super-elevations unless there are no normal crown conditions on the segment of roadway for which the typical section applies. (Roadway standard drawings 560.01 and 560.02 show this method of constructions).

DIMENSIONS 6-1B

---

Dimensions shall be shown for all typical section elements. Horizontal dimensions shall be shown in feet and inches to the nearest inch. Dimensions shall be limited to those required to clearly explain the intent of the typical section.

LIMITS OF USE 6-1C

---

Each typical section shall include a listing of the locations where it applies. These locations shall be designated by survey line and station to station limits. Station to station limits shall be broken at beginning and ending of bridges (not approach slabs). Stations shall also be broken for Equalities, if applicable.

PAVEMENT SCHEDULE 6-1D

---

A full pavement schedule shall be shown on the first typical section sheet and shall contain a code and a description for all elements of the various pavement designs applicable to the project. The engineer shall show an abbreviated pavement schedule on the remaining Typical Section Sheets for easy reference. The following code letters shall be used:

## PAVEMENT SCHEDULE (continued)

6-1D

CODE LETTER	ITEM
A	Portland Cement Concrete Pavement
B	Open-Graded Asphalt Friction Course, Type FC
C	Asphalt Concrete Surface Course, Type S
D	Asphalt Concrete Intermediate Course, Type I
E	Asphalt Concrete Base Course, Type B
F	Asphalt Surface Treatment
G	Cement Treated Base Course
J	Aggregate Base Course
K	Soil-Cement Base Lime-Treated Soil
L	Stabilizer Aggregate
M	Soil Type Base Course
P	Prime Coat
R	Combination Concrete Curb and Gutter Concrete Curb 5" Monolithic Concrete Island Concrete Island Cover
S	Concrete Sidewalk
T	Earth Material
U	Existing Pavement
V	As needed
W	Variable Depth Asphalt Pavement (See Standard Wedging Detail).
X	Permeable Asphalt Drainage Course, Type P
Y Z	As needed

## CHAPTER SEVEN

## SPECIAL DETAILS

PURPOSE

7-1

Construction details that are not included in the Roadway Standard Drawings have to be detailed in the plans. The squad responsible for the Final Construction Plans prepares details for BENCHING EXCAVATION FOR EMBANKMENT, UNDERCUT EXCAVATION, and FALSE CUTS.

Before special construction details are drawn for a project, the Project Engineer shall check with the Standards Engineer. He has copies of special drawings that have been used on previous projects. Usually, these details can be adapted to fit most projects.

The Standards Engineer will also be familiar with any general notes, special provisions, or references that need to be made to the Special Construction Details.

BENCHING EXCAVATION FOR EMBANKMENT

7-2

Benching excavation is to be shown on the plans in accordance with the Soils and Foundation Section. The locations to be benched shall be discussed on the preliminary field inspection. If the field inspection party is not agreeable to the locations shown on the plans, the Project Engineer shall discuss the locations with the Geotechnical Engineer. If there are any revisions to be made, they shall be made on the final plans and discussed on the final field inspection.

For additional information related to benching, see Section 235 of the Standard Specifications for Roads and Structures.

UNDERCUT EXCAVATION

7-3

A Special Detail shall be shown in the plans to show the limits of undercut excavation. The area to be undercut shall also be shown on the profile sheets and cross-sections.

When subsurface plans are provided by the Geotechnical Engineering Unit, the proposed undercut excavation shown on the plans shall not deviate from their recommendations.

When subsurface plans are not available, a general note shall be included in the plans stating that no subsurface plans are available.

The limits of undercut varies, dependent upon the location and project conditions.

FALSE CUTS7-4

---

False cuts are designed to eliminate or reduce hazards and may sometimes be used for noise abatement. Utilization of false cut must be based on a project by project basis with strong consideration given to economics, aesthetics, safety and engineering judgment.

See 7-4, Figure F-1 & F-2 for examples of false cuts.

LOCATION

The use of false cuts should be discussed and locations determined at the Final Design Inspection.

FIGURE 1

7 - 4  
F - 1

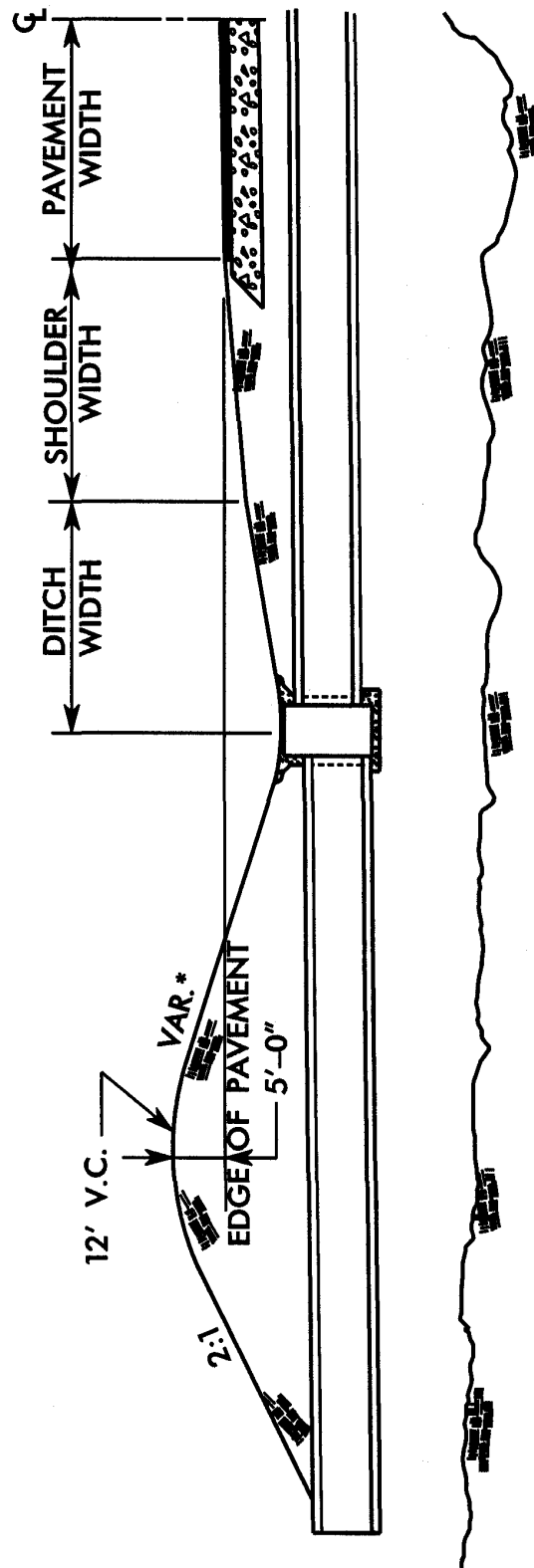


FIGURE ONE

FALSE CUT IN DRAW BETWEEN CUT SLOPES

FOR USE IN LOCATIONS WHERE IT CAN BE CONSTRUCTED WITHOUT IT'S COST EXCEEDING APPROXIMATELY TWO TIMES THE COST OF PROVIDING GUARDRAIL

\*BLEND SLOPE TO MATCH ADJACENT CUT SLOPE  
NO FLATTER THAN A 3:1

FIGURE 2

7 - 4  
F - 2

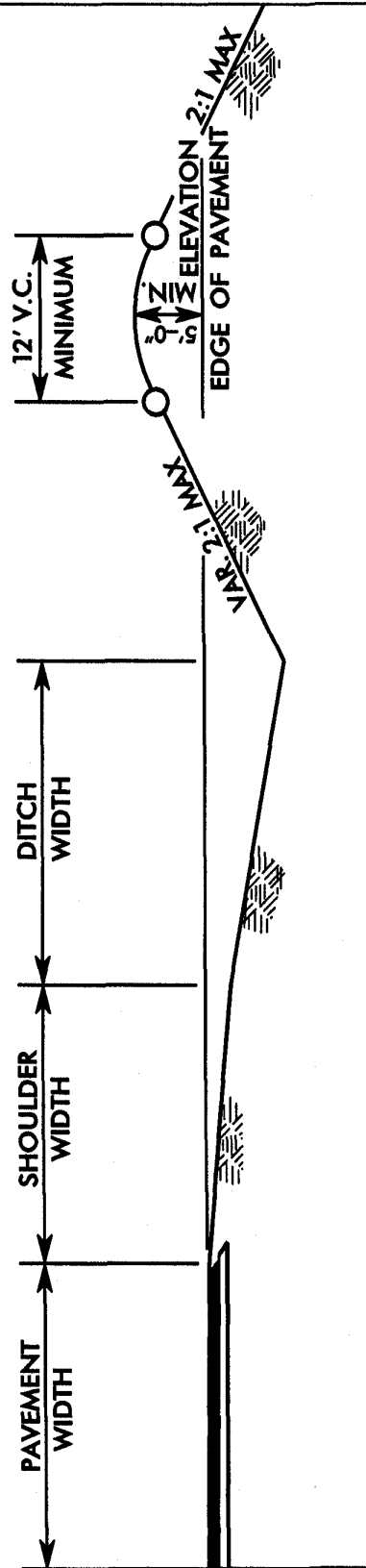


FIGURE TWO  
WASTE PROJECTS

FALSE CUT TO BE USED ON WASTE PROJECTS  
WHERE FILL HEIGHT EXCEEDS 30'



## CHAPTER TEN

## FENCING

FENCING OF FULL CONTROL & PARTIAL CONTROL OF ACCESS 10-1

All full control and partial control of access projects will be fenced along the right of way or in the outer separation when frontage roads are present, unless the terrain prohibits access to the roadway by either vehicles or pedestrians by natural means. Each project shall be studied individually to determine if the fence can be eliminated at such things as rivers, streams, deep cuts or high fills. Questionable areas should be discussed at the Final Design Inspection and recommendations included in the Field Inspection Report from the Division Engineer. See Policy and Procedure Manual, 19/3.

FENCING OF REST AREAS & WELCOME CENTERS 10-2

The type fence to be used at each rest area or welcome center shall be determined on an individual basis through coordination with the Roadside Environmental Unit.

FENCING OF TRUCK WEIGH STATIONS 10-3

The type fence to be used at each truck weigh station will be determined on an individual basis through coordination with the Special Design Section Engineer of the Roadway Design Unit.

FENCING IN PROXIMITY TO AIRPORTS 10-4

Fencing in proximity to airports shall be discussed with the Federal Aviation Administration to determine if nonmetallic fencing should be used. Contact can be made through the DOT Director of Aviation.

FENCE LOCATIONS AT RIVERS AND STREAMS 10-5

The proposed method of fencing at streams shall be detailed in the plans and discussed at the field inspection. At stream crossings, the fence should be installed under the structure. The fence should be tied into the wingwall at box culverts.

---

FENCE LOCATIONS AT 54" PIPES AND ABOVE 10-6

At pipes 54" and above, the fence should be tied into the end walls.

---

FENCE LOCATIONS AT OVERPASSES 10-7

Fencing at overpasses shall be installed in accordance with one of the suggested treatments shown in Figure 1 and 2. In locations where the fence is tied into the bridge, extreme caution shall be taken to assure that sight distances are not obstructed.

---

TYPES OF FENCE 10-8

Either woven wire or chain link fence may be used for establishing control of access. Unusual conditions may justify the use of a special type fence, which must be approved by the State Roadway Design Engineer and FWHA if applicable.

The type of fence to be used shall be discussed at the Final Design Field Inspection and recommendations included in the Field Inspection Report from the Division Engineer. If there are differences of opinion, they shall be resolved prior to distribution of the right of way plans.

(A) WOVEN WIRE FENCE

Woven wire fence shall be used except where there is a specific need for chain link fence or a special type of fence. When chain link or a special type fence is being considered, actual land usage at the time the project is in the design stage should be the determining factor, unless a change in land use is imminent. This decision should not be based on blanket categories such as anticipated development, zoning classifications, inside or outside city limits or rural-urban classifications.

See Roadway Standard Drawings, Std. No. 866.02 and 866.03

(B) CHAIN LINK FENCE

Chain link fence shall be used in the following areas:

- (1) A residential area where the average size of those lots adjacent to the right of way does not exceed one (1) acre.
- (2) Any area where medium to heavy pedestrian activity will routinely occur closer than 150 feet to the proposed fence location. All developed land should be studied to determine if this type of activity is generated. Chain link fence shall not be used in institutional, commercial, office, or industrial areas that do not generate such activity. The presence

TYPES OF FENCE (continued)

10-8

of buffer zones or park like areas adjacent to a developed area will often preclude the need for chain link fence.

(3) Any area which the right of way agreement with the property owner requires that chain link fence be installed by the Department of Transportation.

(4) Where short sections of woven wire fence would be required to comply with the policy.

See Roadway Standard Drawings, Std. No. 866.01.

(C) SPECIAL TYPE FENCE

Special type fences will be considered on an individual basis and discussed during the preliminary field inspection or during right of way negotiations. Special fences include security fences, masonry walls and different types of fences used for screening, landscape purposes, or sound barriers.

HEIGHT OF FENCING

10-9

Woven Wire Fence	47" Fabric
Chain Link Fence	48" Fabric

Where bikepaths are being separated from the roadway, a minimum 4.5-foot high fence is recommended.

Exceptions to the above heights or inclusion of a top rail on chain link fence must be considered on a project by project basis.

GATES

10-10

When it is necessary to gain access to utilities and drainage areas, locked gates shall be considered. Use of gates will be determined on a project by project basis, on Final Design Field Inspection and during right of way negotiations. After it has been determined that a gate is required, it will usually be stipulated in the right of way agreement, and shown on the Final Construction Plans.

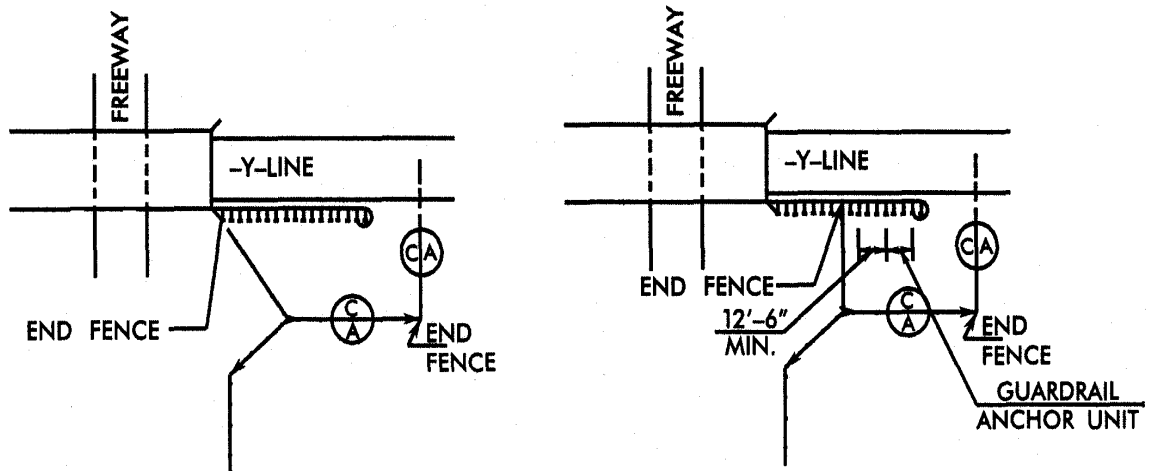
See Roadway Standard Drawings, Std. Nos. 866.01, 866.02 and 866.03

FIGURE 1

10 - 7

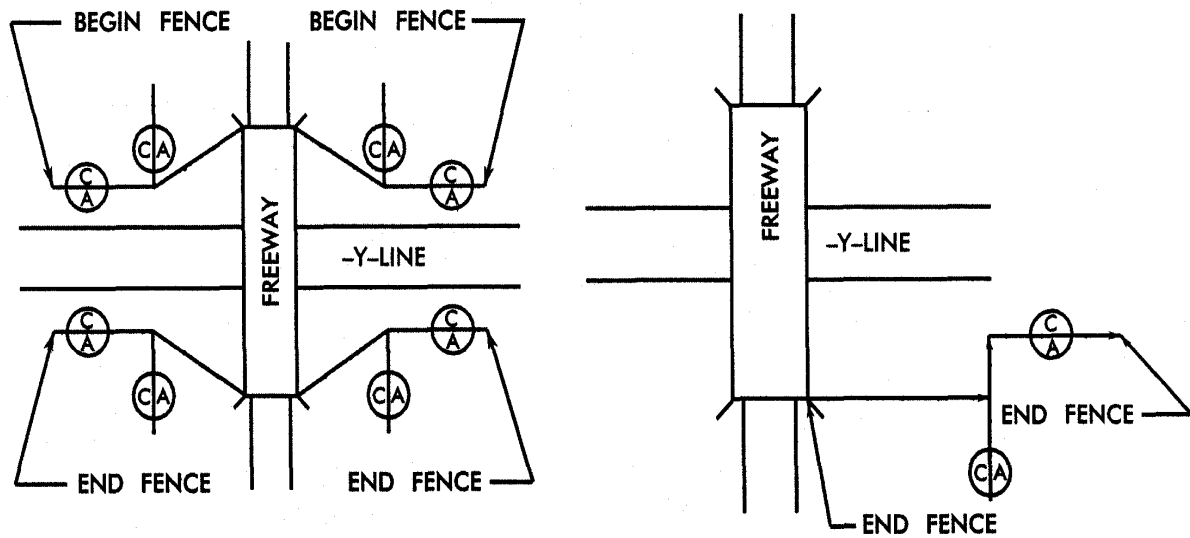
GUIDE FOR FENCE LOCATIONS

F - 1



-Y- LINE OVER FREEWAY

F - 2



FREEWAY OVER -Y-LINE

## CHAPTER 12

## TRAFFIC OPERATIONS

MAINTENANCE OF TRAFFIC DURING CONSTRUCTION12-1

In the design of a project, the traffic control plan is an essential element in determining a method for maintaining a safe flow of traffic through a construction zone, determining the need for on-site detours, or directing traffic to alternate routes. The traffic control plans are a part of the final construction plans and are prepared by the Traffic Control Unit in coordination with the Roadway Project Design Engineer.

Maintenance of traffic should be considered during the functional and preliminary designs. A conceptual plan should be prepared for any detours, and should be made a part of the Combined or Design Public Hearing Map, especially if the detour will require additional right of way. On Categorical Exclusions for Bridge replacements projects, the determinations of either an on-site detour, or detouring traffic around the project by alternate routes, is an integral part of the document.

TRAFFIC OPERATIONS PLAN12-2

The Roadway Project Design Engineer, in coordination with the Traffic Control Project Engineer, shall prepare a Traffic Operations Plan. This plan should be used to convey the design decisions that were determined necessary to provide constructability of the project, while safely maintaining traffic through the construction zone. It should be included with a set of plans submitted to the Traffic Control Unit at the same time plans are submitted to the Hydraulics Unit.

The Traffic Operations Plan should include the following:

- 1) A sketch map showing the overall project, along with roads and streets planned to be used for alternate routes during construction, or phases of construction should be provided. Proposed off-site detours should be marked on the map and described with a note. (Maps similar to a county map would be adequate for a sketch map.)

- 2) A layout map, similar to the plan sheet layout on the title sheet, should be used to show on-site detours, off-site detours, construction phasing and traffic patterns through the construction zone. Notes describing the phasing or traffic shifts should be included on the layout map. On complicated projects, two or more layout maps may be required for clarity of construction phasing. Controlling earthwork and undercutting operations must be carefully considered to ensure constructability.
- 3) Using construction year traffic, a capacity analysis of all streets, roads and intersections that will be used for detours should be performed, and reviewed to determine if improvements will be required to handle additional traffic.
- 4) Show a typical section of any proposed new detour alignments or phasing areas.
- 5) Mark any streets that will be dead ended.
- 6) Show locations of existing signals and proposed temporary signals.
- 7) Identify culverts and bridges that will require staged construction.
- 8) Identify potential grade problems between existing and proposed.

The Work Zone Traffic Control Unit will further develop this Traffic Operations Plan, coordinating with the Roadway Design Project Engineer, to prepare a Construction Staging Concept package to be incorporated into the Final Design Field Inspection plans and presented by the Work Zone Traffic Control Unit at the Final Design Field Inspection meeting. After initial discussions at the Final Design Field Inspection, The Construction Staging Concept should be removed from the plans.

TRAFFIC CONTROL PLAN REVIEW MEETINGS

12-3

Approximately 4 to 6 weeks after the Final Design Field Inspection, a separate meeting may be held, if needed, to discuss constructability and design problems related to the maintenance of traffic. Attendees normally should include at least one member each from Roadway Design and Work Zone Traffic Control, as well as the Resident Engineer and/or their Assistant, Division Construction Engineer, Area Roadway Construction Engineer and/or Area Bridge Construction Engineer, Division Traffic Engineer and others, as required. The Traffic Control Unit, notifying the appropriate personnel will coordinate this meeting by form letter.

Similarly, another meeting to discuss details of traffic control may be held after the Pre-Let Field Inspection, approximately three weeks prior to the date that the Traffic Control Plans are due to be turned in. At this time, the Work Zone Traffic Control Unit will present plans for review and discussion that incorporated any recommendations from the Pre-Let Field Inspection meeting, and are approximately 90% to 100% complete for turn-in.

These traffic control plan review meetings are additional meetings to discuss the traffic control in depth. They are not a replacement for the Final Design and Pre-Let Field Inspections. Traffic Control Plans should still be presented and discussed at these meetings.

DESIGN OF ON-SITE DETOURS AND MEDIAN CROSSOVERS

12-4

After the Final Design Field Inspection, the Roadway Project Design Engineer will coordinate the location and design of on-site detours and median crossovers with the Work Zone Traffic Control Project Engineer. The design of on-site diversions and median crossovers (including horizontal and vertical alignments) will be the responsibility of the Roadway Design Unit, and will be a part of the roadway plans. The design of the crossovers or diversions may be shown on a separate plan sheet, and should be included in the roadway plan. Similarly, typical sections for detours, median crossovers and temporary widening should also appear in the roadway plans.

Median crossovers or detours not requiring right of way can be included with the detail sheets. Cross-reference notes will be required on both roadway plans and traffic control plans.

DESIGN OF ON-SITE DETOURS AND MEDIAN CROSSOVERS (continued) 12-4

Detour designs will be based on the functional classification of the roadway. **THE FOLLOWING CRITERIA WILL BE THE MINIMUM ACCEPTABLE DESIGN STANDARDS FOR EACH CLASSIFICATION:**

INTERSTATE AND FREEWAYS:

The design speed (V) of horizontal and vertical curves for crossovers and diversions on interstates and freeways will be the same or greater than the posted speed limit. They will be designed so that there will not be a need for a reduction in the posted speed limit.

Exceptions:

- 1) For short-term lane closures, design speed (V) does not have to be maintained for cross-over designs. It is often desirable to slow down the traffic.

Detours and median cross-overs should also be designed without a reduction in the number of lanes of traffic.

Exceptions:

- 1) Traffic Control phasing will sometimes allow short term lane closures during daylight hours, but detours should be designed to maintain existing number of lanes during peak hours.
- 2) Certain Interstate and freeway routes may have low traffic volumes. The Traffic Control Unit will determine on a case-by-case evaluation if long-term lane closures are permitted.

Superelevation for proposed horizontal alignments in median crossovers cannot meet design speed standards due to existing restraints. It is more desirable to have lower Superelevation rates, that smoothly transition vehicles through the alignment, than higher rates, with short lengths of change that create abrupt vehicle behavior. It is, however, critical that the surface of the proposed roadway be reviewed for areas that do not drain well. Hydroplaning during periods of rain can be created by long, level sections of pavement, and also by concrete barrier placed along the edge of the roadway. Grade and superelevation changes or special drainage features should correct these problems. Shoulder widths should be a minimum of 4' wide with 2' paved shoulders. The clear zone and recovery area should be maintained in accordance with the "Roadside Design Guide," or protected by guardrail or concrete median barrier. In areas where guardrail or median barrier is placed in close to the travel lane, special care shall be taken to avoid creating an unpaved drop-off area between the edge of the paved shoulder and the face of the barrier or guardrail.



DESIGN OF ON-SITE DETOURS AND MEDIAN CROSSOVERS (cont'd)

12-4

In construction areas, it is preferred that the face of temporary guardrail or barrier be placed flush with the edge of pavement to eliminate this problem.

EXPRESSWAYS AND MAJOR ARTERIALS:

The design speed (V) of detours, and median crossovers for expressways and major arterials with partial or no control of access may be lowered to 10 miles per hour below the posted speed limit. This should only take place when the capacity of the roadway is not affected by the lowering of the speed limit. It is possible to temporarily increase capacity by adjusting signal timings, eliminating drives, median openings, and specific movements at intersections, such as left turns, removing parking, or diverting wide vehicles to other routes.

The number of lanes required for the detour of an expressway or major arterial in operation during peak hours should be based on current average daily traffic.

## Necessary # of Lanes for Detour

Unrestricted Traffic	During Peak Hours
0 to 30,000 ADT	Two lanes (one in each direction)
30,000 to 50,000	Four lanes (two in each direction)
50,000 to 80,000	Six lanes (three in each direction)
80,000 +	Eight lanes ( four in each direction)

Shoulder widths should be a minimum of 4' wide with 2' paved shoulders. The clear zone and recovery area should be maintained in accordance with the "Roadside Design Guide" or protected by guardrail or concrete median barrier. In areas where guardrail or median barrier is placed in close proximity to the travel lane, special care shall be taken to avoid creating an unpaved drop-off area between the edge of the paved shoulder and the face of the barrier or guardrail.

MINOR ARTERIALS, COLLECTORS, AND LOCAL ROADS:

During construction activity, it will be permissible to control traffic in a one-lane, two-way pattern controlled by a flagging operation. This operation should not be scheduled or permitted during peak hours of that facility.

DESIGN OF ON-SITE DETOURS AND MEDIAN CROSSOVERS(cont'd)

12-4

A traffic signal may be utilized in lieu of a flagger during one-lane, two-way operation in special conditions approved by the Traffic Control Unit. Two-way peak hour traffic volume should not exceed 670 vehicles.

The design of an on-site detour to be used without a traffic signal or flagger, should be two-lane, two-way, with a minimum posted speed of 35 MPH.

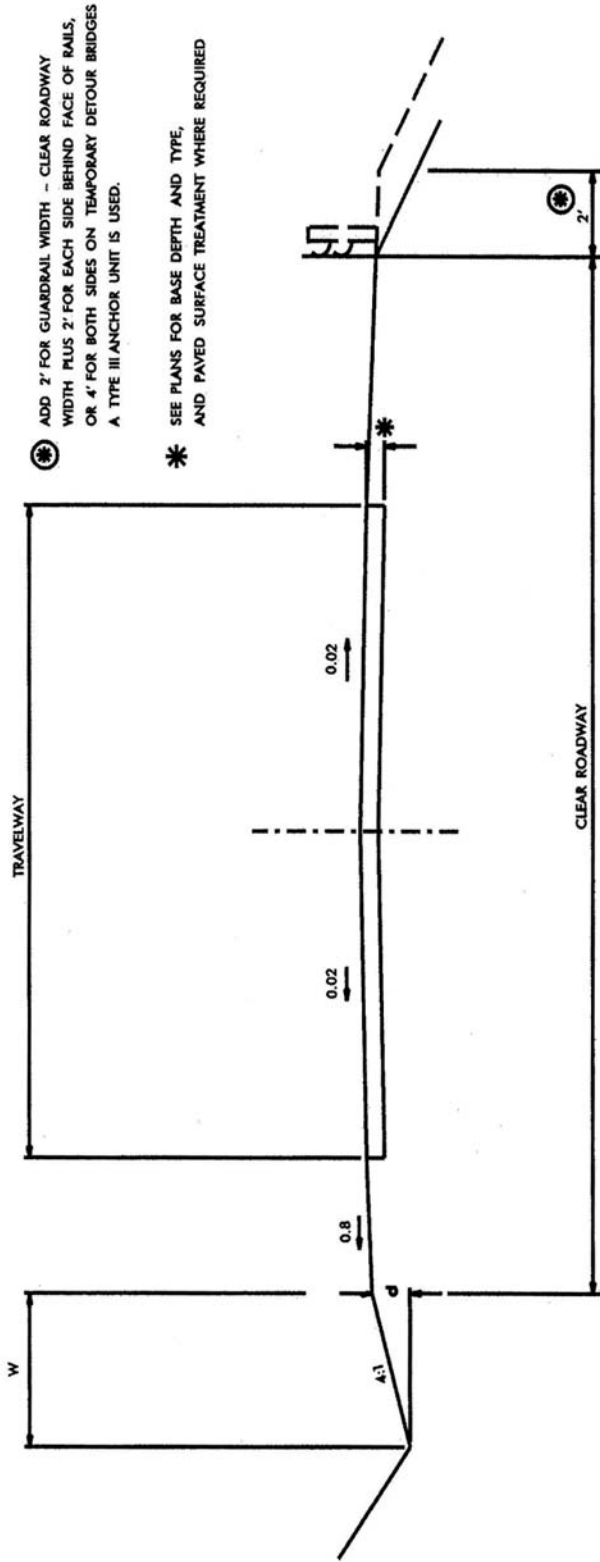
The design speed of the detour should not be more than 10 MPH below the posted speed of the existing roadway. Minimum widths for traveled way and shoulders should be determined by traffic volumes according to the following criteria:

	DHV < 100	DHV 100-400	DHV 400+
Width of Traveled Way (ft)	20	22	24
Graded Shoulder Width, each side, (ft)	4	6	8

Shoulder widths should be a minimum of 4' wide, with 2' paved shoulders. The clear zone recovery area should be maintained in accordance with the "Roadside Design Guide," or protected by guardrail or concrete barrier. In areas where guardrail or median barrier is placed in close proximity to the travel lane, special care shall be taken to avoid creating an unpaved drop-off area between the edge of the paved shoulder and the face of the barrier or guardrail.

When a one-lane, two-way bridge structure is being replaced, a similar one-lane, unsignalized temporary detour structure may be utilized. In this situation, the sight distance shall allow the entire bridge travelway to be seen from either approach, two-way ADT must be 1000 VPD or less, and the detour structure should be adjacent to the existing structure, such that the detour approach alignments are operating with essentially the same traffic pattern as existing.

FIGURE 1



TYPICAL SECTION

	SPEEDS			
	0-25	26-35	36-45	46-55
MAX. DEGREE	30°	30° - 15°	15° - 8° 30'	8° 30' - 5° 30'
MAX. GRADE	15 %	12 %	9 %	8 %
DESIRABLE STOPPING SIGHT DISTANCE	160'	160' - 250'	250' - 375'	375' - 550'
SUPER ELEVATION (MIN.)	.02 - .06	.02 - .06	.02 - .06	.02 - .06
				55 + 5° 30' OR LESS

TYPE	VPD	SURFACE		MIN. ROADWAY SHOULDER TO SHOULDER	DITCH WIDTH (w)	DITCH DEPTH (d)
		UNPAVED	PAVED			
A	0-250	✓		20'	2'	9"
B	251-750	✓		24'	2'	9"
C	751-2000	✓	DESIRABLE	28'	3'	12"
D	2001-5500	✓	✓	32'	3'	12"
E	5501-15000	✓	✓	38'	3'	12"
F	15000-ABOVE	✓	✓	40'	3'	12"

WIDTHS FOR TWO WAY TRAFFIC (LESSER WIDTH MAY BE USED FOR ONE-WAY)

STANDARD DESIGN CRITERIA FOR TEMPORARY DETOURS (MAINTENANCE OF TRAFFIC)

OFF-SITE DETOURS

12-5

Where adequate alternate routes exist in reasonable proximity to the project, they should be used to re-route traffic as much as possible. Before making a final determination, all potential detour routes should be visually inspected to evaluate the condition of the existing pavement and bridges.

If the adequacy of the existing pavement is questionable, or if it is determined that additional surfacing is required to enable a selected detour route to carry the additional traffic, the Pavement Design Engineer shall be consulted. It will also be necessary to consult with the Federal Highway Administration on projects with federal funding, and to coordinate with Project Management. Where City streets are required for an off-site detour, coordination and approval from the municipality will be required.

PAVEMENT MARKINGS FOR CONSTRUCTION PROJECTS

12-6

The Work Zone Traffic Control Unit will provide the Roadway Design Unit with recommendations for final pavement markings and markers for all contract construction projects.

The recommendations will be based on the Work Zone Traffic Control Unit's "Long Life Pavement Marking Policy" and "Reflective Pavement Marker Policy," and will be made early in the design stages of the traffic control plan. Initial recommendations and estimates will be provided as part of the preliminary scoping estimate, when applicable.

The Work Zone Traffic Control Unit will discuss their intentions with the Division Construction Engineer, the Area Traffic Engineer, and the Roadway Design Project Engineer prior to sending a formal recommendation letter. The Work Zone Traffic Control Unit recommendations for final pavement markings will be forwarded to the Roadway Design Project Engineer by form letter.

The determination of types of pavement markings and raised markers will be based on many factors such as ADT (volume per lane), length of project, type of facility, type of pavement, speed limits, geometrics, date of application (seasonal restrictions), annual snowfall, prevalent fog, ambient light conditions, and consideration of adjacent projects and existing marking materials.

PAVEMENT MARKINGS FOR CONSTRUCTION PROJECTS (continued) 12-6

In general, current policy normally calls for long-life pavement marking material for final pavement markings on Interstate and Freeways, or when the traffic volumes exceed 2000 vehicles per day, per lane, for thru-lanes. Long-life pavement markings utilized by NCDOT consist of thermoplastic, epoxy, preformed plastic, or other durable markings. Raised, reflective pavement markers will normally be applied to Interstate and Freeways, and for other roadways with traffic volumes in excess of 1000 vehicles per day for thru-lanes. (Snowplowable markers are not normally warranted unless these volumes exceed 2500 vpd per thru-lane). Projects qualifying for permanent raised pavement markers should have temporary raised pavement markers throughout the construction limits, for the duration of construction, for any traffic pattern that exceeds, or is expected to exceed 30 calendar days. Temporary raised pavement markers are also to be used for delineation of construction detours. For additional information concerning warrants, types, and selection of pavement markings and reflective markers, consult the Work Zone Traffic Control Unit



## CHAPTER 13

## ROADWAY PLANS

ROADWAY PLANS

13-1

The development of roadway plans is the primary responsibility of the Roadway Design Unit. The completed roadway plans consist of the following basic information: typical sections for the roadways to be constructed, the horizontal and vertical alignments, the proposed drainage pipes, ditches, structures, and the proposed right of way necessary for the roadway construction. Also included are basic summaries such as earthwork, guardrail, and pavement removal.

There are many other items that are also shown on the roadway plans. In order to develop roadway plans, there are four basic design phases that occur. These phases are functional design, preliminary design, right of way plan preparation, and final design. The various design phases require many activities and much coordination with other units within the Highway Design Branch, Project Development and Environmental Analysis Branch, Right of Way Branch, Construction Unit, and the public. While the activities vary depending upon the complexity of the project, the following provides a general listing of the Roadway Design Unit's activities during the various design phases.

FUNCTIONAL DESIGN (R/3 FUNCTIONAL AREA CODE 2060)

A project is included within the Transportation Improvement Program.

The project is assigned to a Roadway Project Engineer and Roadway Project Design Engineer.

A schedule, which outlines the time sequence for design phases, is established according to the TIP.

Attend project-scoping meeting, which is normally conducted by the Project Development and Environmental Analysis Branch.

Coordinate with the Location and Surveys Unit and Photogrammetry Unit to obtain mapping (quad mapping and aerial photography.)

Attend public/public officials' meetings as necessary.

Develop corridors and functional designs within each corridor.

Obtain right of way cost estimates and construction cost estimates for each corridor.

Finalize recommended “feasible” corridors based on information gathered from public meetings, correspondence with Project Development and Environmental Analysis Branch, and right of way and construction estimates.

Prepare a corridor public hearing map which shows the feasible corridors.

Schedule a corridor hearing map review.

Make necessary corrections to hearing map and obtain copies for the Public Involvement and Community Studies.

Attend corridor public hearing and prepare notes on major issues discussed.

Schedule and attend the post corridor public hearing meeting.

Implement comments following the post corridor public hearing meeting and determine if a corridor can be recommended.

After a corridor is selected proceed to preliminary design.

#### PRELIMINARY DESIGN (R/3 FUNCTIONAL AREA CODE 2060)

Obtain updated traffic projections.

Supply recommended and approved corridor to the Photogrammetry Unit to fly so preliminary contour mapping can be obtained.

Establish design criteria in accordance with AASHTO and the Roadway Design Manual.

Develop the preliminary design within the corridor.

Establish a recommended design and obtain a right of way and construction cost.

Prepare a design public hearing map.

Schedule and attend the design public hearing map review.



Make changes as recommended to the map, obtain copies of the map and furnish to the Public Involvement and Community Studies.

Attend the design public hearing and note issues discussed.

Schedule and conduct the post design public hearing meeting to discuss concerns and needed changes in the recommended design.

Implement recommendations and provide a recommended alignment to the Location and Surveys Unit for staking.

Obtain plan sheets from the Photogrammetry Unit and proceed to the development of right of way plans.

#### RIGHT OF WAY PLAN PREPARATION (R/3 FUNCTIONAL AREA CODE 2070)

Obtain the preliminary pavement design from the Pavement Management Unit.

Develop preliminary typical section for mainline.

Finalize horizontal alignment.

Establish the gradelines.

Using CADD levels and files, place travel lanes, paved shoulder or curb and gutter on the plan sheets.

From updated traffic data, analyze each intersection.

Develop designs for each intersection and/or interchange.

Finalize typical sections for the mainline and Y lines.

Place templates on cross sections.

Place slopestakes onto plan sheets.

Furnish the Hydraulics Unit and Geotechnical Engineering Unit with a set of plans, so they can prepare their design and recommendations.

Receive the drainage recommendations and preliminary erosion control recommendations from the Hydraulics Unit.

Prepare structure recommendation plans for all bridges within the project and send to the Structure Design Unit.

After receipt of the erosion control recommendations, establish the proposed right of way and necessary easements.

Schedule a Final Design Field Inspection and send plans and memorandums to all involved personnel.

Attend the Final Design Field Inspection.

Gather and implement comments rendered there.

If project is a National Highway System project, obtain the Federal Highway Administration's approval of the plans.

Finalize the right of way plans.

Obtain Location and Design Approval.

Obtain Right of Way authorization.

Distribute plans to the Right of Way Branch.

Compute updated construction cost estimate.

Review the application for the environmental permits to ensure the permit application is in conformance with the roadway plans.

Request the final pavement design.

Proceed to the development of final plans.

FINAL PLAN PREPARATION (R/3 FUNCTIONAL AREA CODE 2080)

Coordinate with the right of way agents as necessary to make needed right of way plan revisions.

Coordinate as required with the Structure Design Unit, Traffic Engineering and Safety Systems, Work Zone Traffic Control Unit, the Geotechnical Engineering Unit, the Division, and the Roadside Environmental Unit to obtain their recommendations.

Receive the final pavement design and incorporate and finalize typical sections.

Schedule a Pre-Let Field Inspection, distribute plans and memorandums to all involved personnel.

Incorporate comment from the field inspection as well as other units.

Compute contract quantities.

Complete the final plans review checklist to ensure accuracy and completeness of the plans.

Correct all errors on plans and review plans sent in by other units for conformance.

Complete the formal summaries to be placed within the plans such as Earthwork Summary, Guardrail Summary and Pavement Removal Summary.

Note applicable General Notes, standards and any needed special provisions.

Complete the response to the Division Engineer and explain why certain Division recommendations were not included within the plans.

Upon receipt of environmental permits, review the permits to ensure permit conditions have been met and the permit is in conformance with the design.

Compile a list of final quantities and prepare an estimate.

Compile the project file; purge any unnecessary or trivial data from the files.

PROJECT FILE CONTENT

Required content for files submitted with final plans to the Contract Office, at the specified flow chart date, is contained in bound files and loose files.

The Bound File (Brown Folder) should include information as follows:

1. All approvals and denials.
2. Field inspection correspondence.
3. Information related to any pending actions.
4. Correspondence providing historical or background information on controversial matters.
5. Justification studies for special or unusual matters.
6. Correspondence originated in the Highway Design Branch.
7. Correspondence in which the Highway Design Branch was the primary recipient.
8. Geology recommendations.
9. Structure recommendations.
10. Any other items that in the judgement of the Project Engineer should be retained.

The loose file (Manila Folder) should contain information as follows:

1. Review list for final construction plans (Complete each requirement on the list prior to indicating it complete with a check mark).
2. Completed check list for coordination of Roadway and Structure plans.
3. Estimates.
  - A. Latest Roadway Computer Estimate.
  - B. Estimates from other units.
  - C. Cost Based Estimates Quantity Breakdown Summary Sheet.
  - D. Force Account Estimates.
4. Earthwork Summary Worksheet.
5. Earthwork Computations
6. Calculation of Quantities Package.
7. List of Roadway Standard Drawings.
8. General Notes.
9. Special Provisions.
10. The XY\_Coord. CSV electronic File generated by the "Centerline coordinate list" procedure.

Materials and/or correspondence that should be removed is as follows:

1. Preliminary Designs.
  - A. Drawings.
  - B. Estimates.
  - C. Calculations.
2. Subsurface investigations and reports (These are included in the Subsurface Plans).
3. Transmittal slips and/or memorandum forms (except the last one) and right-of-way revision memorandums.
4. All Duplications.
5. All Engineers Estimates except the latest printout.

Please label file tabs with the WBS Element, T.I.P. number, Contract Number, and County.

Submit the plans to the Plan Review Section

Receive and incorporate comments from the Plan Review Section.

Once the project is sent to the Proposals and Contract Section, answer any questions that may arise.

Project is advertised for bid; project is let and then awarded.

Make any necessary construction revisions and charge these revisions to function code 264.



## CHAPTER 14

## BRIDGE PLANS

BRIDGE PLANS

14-1

The bridge plans are the responsibility of the Structure Design Unit. The bridge plans are always a separate set of plans and are never combined with the roadway plans. However, the structure can be combined into the roadway contract. This preliminary determination of letting the Structure and Roadway as combined should be made early so the affect on traffic handling can be determined. The Contract Time Committee usually makes the final determination in the later stage of final preparation.

Reinforced concrete box culverts will usually be included in the same contract with the roadway. Many of the same coordination measures are required for culverts as for bridges.

Although the bridge and culvert sheet numbers are included in the roadway plans index of sheets, the plans are handled separately, including the printing and distribution.

COORDINATION WITH THE STRUCTURE DESIGN UNIT

14-2

There are a number of items, listed below, which require close coordination to insure that the bridge plans and roadway plans are compatible. This is the joint responsibility of the Structure Design Squad Leader and the Roadway Project Design Engineer. When unusual conditions occur, they shall be handled in an appropriate manner.

GRADES

The Roadway Design Unit sets the proposed grade lines. However, on roadway and railroad overpass structures involving significant embankments, the excess vertical clearance tolerance is severely limited and the assistance of the Structure Design Unit may be required to properly establish the grades. The Structure Design Unit is responsible for obtaining the necessary approvals when it appears that the vertical clearance is excessive.

EMBANKMENT SLOPES

The Geotechnical Engineering Unit determines the side slopes, and this information is furnished to the Structure Design Unit for all bridge and box culvert locations.

COORDINATION WITH THE STRUCTURE DESIGN UNIT DRAINAGE (cont.) 14-2

The Roadway Design Unit shall furnish all information relating to drainage in close proximity to a bridge or box culvert as early as possible in the plan development. This is particularly important where railroads are involved since the Structure Design Unit must obtain approval from the Railroad Company involved.

UNDERCUT AND DRAINAGE DITCH EXCAVATION

Where it is necessary to undercut below the floor slab of a box culvert to be let as a separate contract and the undercut done by the Roadway Contractor, notes shall be placed on the roadway plans as follows:

- (1) "No work shall be done on the culvert at STA. \_\_\_\_\_ until the roadway contractor has undercut the area of the box culvert and replaced unsuitable material with suitable material, properly compacted, to the elevation of the bottom of the proposed floor slab. The limits of this undercut excavation shall be at least the limits of the box culvert including the wings."
- (2) "No separate payment will be made for any culvert excavation required to construct the proposed culvert."

Notes (1) and (2) above will be provided to the Roadway Design Unit by the Structure Design Unit to be placed on the Roadway Plans. If additional undercut excavation is required to achieve the limits as specified in (1) above, the Structure Design Unit will compute the additional quantity and supply the Roadway Design Unit with this quantity.

If the bottom of culvert is below limits of unsuitable material, place the following note on the culvert plans: "Roadway undercut to be performed prior to constructing the culvert." If needed, the Structure Design Unit will provide this note to the Roadway Design Unit to be placed on the Roadway Plans.

The computation of and limits of drainage ditch excavation shall be carefully considered and indicated on the plans so as not to overlap the limits of the culvert excavation.



COORDINATION WITH THE STRUCTURE DESIGN UNIT (continued) 14-2GUARDRAIL ATTACHED TO BOX CULVERTS

All box culverts shall be reviewed immediately after proposed grades are set to determine if it will be necessary to attach guardrail posts to the top slab. The Structure Design Unit shall be advised of locations where this is required.

RIP RAP

Where rip rap will appear in both the bridge plans and roadway plans at the same site, care shall be exercised in clearly defining the limits covered by each set of plans.

REVISIONS

When revisions occur in the roadway plans during plan development affecting areas where bridges or box culverts occur, the Roadway Design Project Design Engineer shall be responsible for keeping the Structure Design Unit advised of all revisions that would affect them.

There are also several items of information, initially furnished on the structure recommendation plans, which should be confirmed immediately prior to completing final plans. These include points of guardrail attachment, drainage devices, and the location and type of median barriers. See Part I, Chapter 6 for structure recommendation plan information.



## CHAPTER 15

## ELECTRICAL PLANS

ROADWAY ELECTRICAL PLANS

15-1

When a Project Engineer or Section Engineer has a project which he feels may warrant lighting, he should provide the Lighting/Electrical Engineer a print of the title sheet, traffic volumes, project numbers, (both preliminary and construction) and a letting date with a request to evaluate the project for potential lighting. This request should be made shortly after the preliminary field inspection but in no case later than the date final field inspection data is furnished to the Division. The Department's policy is to consider lighting only on fully controlled access facilities. See Policy and Procedure Manual, Chapter 15 for interchange lighting policy.

The Lighting/Electrical Section will need specific information relating to geometrics, operational features, environmental aspects, and accident data. The Lighting/Electrical Section will obtain this information directly from the Project Design Engineer or Assistant Section Engineer and the Traffic Engineering Branch.

The Lighting/Electrical Engineer will evaluate the project for lighting and make a recommendation to light, provide electrical duct for future lighting or not to light. The recommendation will be submitted to the State Highway Design Engineer for further action.

If approval of lighting or electrical duct is granted by the State Highway Design Engineer, the Project Engineer or Section Engineer will provide CADD files of the necessary plan sheets for the Lighting/Electrical Section to use in preparing lighting plans.

PLANS FOR ELECTRICAL CONDUIT

15-2

If it is determined to provide electrical duct only, the Lighting/Electrical Section will provide the Project Engineer or Section Engineer plan files with location of duct and circuit markers to be included in the Roadway Plans. The Lighting/Electrical Section will also provide the special provisions and estimate. The Project Engineer or Section Engineer will include the lighting items on the summary of quantities sheet.

The Lighting/Electrical Section will need approximately two weeks for evaluation of the project for lighting and an additional two weeks to prepare electrical duct plans including special provisions and estimates.

PLANS FOR LIGHTING

15-3

If lighting of the project is approved, the Lighting/Electrical Section will provide plans, special provisions and estimates to incorporate into the roadway plans. The Project Engineer or Section Engineer will be responsible for including lighting quantities on the summary of quantities sheets.

The Lighting/Electrical Section will need approximately eight weeks after approval to prepare lighting plans, special provisions and estimates.

If lighting for electrical duct is warranted, the Lighting/Electrical Engineer should advise the Utility Agent to assure that any work by the utility company to provide electrical service for lighting is included in the project utility agreement and project estimate.

DESIGN GUIDELINES FOR LIGHTING WELCOME CENTERS  
AND REST AREAS

15-4

The IES (Illuminating Engineering Society) Lighting Handbook shall be used for design criteria except modified as follows:

- (1) The design lux and uniformity shall not be excessively better than the minimum values listed in the handbook.
- (2) Lighting will not be installed on the roadways leaving the rest area beyond the point where the car and truck traffic merge.
- (3) Lighting will not be installed on the entrance to the rest area except in the immediate gore area where the rest area traffic separates from the main roadway.
- (4) Lighting will not be installed on the interior roads except at gores where truck, car or camper traffic separates and special situation areas, such as curves, or beginning of curb section. Where interior roadway is lighted, an illumination level of 6.5 minimum maintained average lux with a uniformity ratio of four-to-one is to be used.
- (5) Parking areas should be evaluated to determine how much of the area will be utilized for night parking. This night parking area may range from 50 to 100 percent of the total parking area depending on the capacity and night traffic volume. Night parking areas should be lighted to 6.5 minimum maintained average lux and uniformity of four-to-one. The remaining parking area should be lighted for security.

## CHAPTER 16

## LANDSCAPE PLANS

LANDSCAPE PLANS

16-1

The Roadside Environmental Unit prepares separate plans for welcome centers, rest areas, landscape planting of roadways, junkyard screening, and reforestation.

The Roadway Design Unit is responsible for developing plans for roadways lighting and parking areas of the welcome centers and rest areas. The Product Services Unit is responsible for providing and/or contracting utility construction plans.

Usually these plans are incorporated into the construction of the main line roadway project and the normal plan preparation methods are followed.

The landscape planting and junkyard screening projects are prepared entirely by the Roadside Environmental Unit. The Special Design Engineer reviews these plans. Comments, recommendations and/or approvals are then returned to the Roadside Environmental Unit for incorporation into the plans.

The final plans are transmitted to the Roadway Design Unit for inclusion into the final plans.

The Roadside Environmental Unit is also involved in planning for erosion control measures as discussed in Chapter 11 of this manual.



## CHAPTER 17

## SIGNING PLANS

SIGNING CONCEPTS FOR PRELIMINARY DESIGN

17-1

On urban freeways or interstate projects with complex interchanges, the designer should request the Traffic Congestion and Signing Unit to review the project for possible signing conflicts.

SIGNING PLANS

17-2

Signing plans are the responsibility of the Traffic Engineering and Safety Systems Branch. Upon completion of signing plans and specifications, they will be submitted to the Roadway Design Unit for inclusion into the plans. Coordination of signing plans with Traffic Engineering is in accordance with Chapter 6/6 in the Policy and Procedure Manual.

Prior to the Pre-Let Field inspection, the Signing Engineer should provide the Roadway Engineer a copy of the signing plans. Roadway Design should design all traffic barriers required to shield a sign structure within the clear zone of the highway, unless breakaway sign supports are utilized. If sign supports are placed in the median of a divided highway, Roadway Design will coordinate any revision to the plans with the Hydraulics Unit.

COORDINATION FOR SIGN SUPPORTS

17-3

Urban freeways often require large sign structures in the concrete median barrier. The detailing of these sign structures requires close coordination between Traffic Congestion and Signing, Structure Design, and Roadway Design.

Projects with proposed concrete median barrier sign foundations should be handled as follows:

- Signing will provide both the Roadway Project Design Engineer and Structure Design locations of all proposed Concrete Median Barrier Sign Foundations. This should be accomplished by week 26 of the project flow chart.
- The Roadway Engineer will then provide Structure Design with the type of barrier, typical sections, and grades at each barrier location.

COORDINATION FOR SIGN SUPPORTS (continued)

17-3

- The Roadway plans will call for Roadway Standard Drawings Std. No. 854.05 Concrete Median Transition Barrier.
- Structure Design will furnish a special Concrete Median Barrier Foundation for Sign Assembly detail for each location to Signing for inclusion in the signing plans. A copy of this detail will also be provided to Roadway for use in preparing median barrier quantities only (do not place in the Roadway Plans).
- The cost of the sign base and foundations are included in the cost of the overhead sign assembly. The transition sections for median barrier are Roadway pay items.



## CHAPTER 18

## UTILITY PLANS

COORDINATION DURING PRELIMINARY DESIGN

18-1

The Environmental Planning document should discuss the magnitude of impact of the utility conflicts. (See Policy and Procedures Manual, Chapter 20, Policy 1)

The Roadway Design Project Engineer should consider the utility conflicts during the preliminary design phase of the project. The Location and Surveys Unit should provide general information about the location and types of utilities during the scoping meeting for the project.

When the utility impacts have been identified as high or medium, the Roadway Design Unit should submit preliminary plans to the Utility Agent, at the same time plans are submitted to the Hydraulics Unit. The project will then be reviewed by the Utility Conflicts Committee to determine if revisions to the plans could reduce utility impacts.

UTILITY PLANS

18-2

The utilities by others and/or utility construction plans, special provisions and estimates are prepared by the Utilities Section of the Project Services Unit. This information will be incorporated into the roadway plans. See Chapter 20, Policy 1 of the Policy and Procedure Manual for details.



## CHAPTER 19

### EARTHWORK

#### PLOTTING OF CROSS-SECTION SHEETS 19-1

For most projects, cross-sections are plotted on a horizontal and vertical scale of 1"= 10'. On mountainous projects with extremely high cuts and fills 1" = 20' might be more practical. In all cases horizontal and vertical scales should be the same. Half-size plots are sent out with plans having over 30 cross-section sheets. Full-size plots are sent out on projects with 30 or less cross-section sheets. If the Division request full-size plots for stake out and construction purposes, these should be provided.

#### USE OF CADD FOR EARTHWORK 19-2

Most cross sections will be created from a DTM (Digital Terrain Model) originating from Location and Surveys Unit or the Photogrammetry Unit. Geopak can be utilized to plot existing cross-sections, and complete proposed templates and earthwork. (Refer to Geopak Reference Manuals for procedures.)

#### EARTHWORK BALANCE SHEET 19-3

An earthwork balance sheet is required in the project file. Furnish a copy to the Geotechnical Engineering Unit on projects with available subsurface plans. Adhere to the following guidelines when preparing the Earthwork Balance Sheet:

##### A. BREAKDOWN QUANTITIES AS FOLLOWS:

1. Summary points at every 3,000'  $\pm$ .
2. Summary points end/begin at each bridge (stream or grade separation).
3. Summary points end/begin near each major at-grade multi-lane intersection or at-grade railroad crossing.
4. Separate Y line, ramp, loop and other major construction items from mainline earthwork, but include in the respective summary.
5. On widening projects, respective summaries are provided for right and left side if the material cannot be hauled across traffic.
6. On existing divided facilities to be widened, respective summaries are provided for right side, left side and median widening if the material cannot be hauled across traffic.
7. Projects with complex construction phasing plans may require phasing of the summary points. Coordinate phasing with the Division and The Traffic Control Unit.

- B. Include recommendations from the Geotechnical Engineering Unit and/or the Soils and Foundation Section as follows:
1. Shrinkage Factor – (See Figure 1)
  2. Loss Due to Clearing and Grubbing - This volume is estimated for loss in cuts of up to one (1) foot in depth. Any loss in fills is included in the shrinkage factor.
  3. Undercut Excavation - A recommendation for excavating benches at grade points and removing unsuitable material below subgrade. This normally should be wasted, but in certain conditions can be used in embankments.
  4. Top Soil on Borrow Pits - On projects requiring borrow material, an additional 5% of the total borrow should be computed for replacing the top soil on the borrow pit.
  5. Rock – “Hard Rock” is only shown on the Earthwork Balance Sheet. All rock on the project should be used in embankments before using suitable excavation and should be computed on a one-to-one basis unless recommendations specify otherwise.

The earthwork balance sheet, shown in Part II, 19-3, F-2, (with numbered columns) is for use with the descriptions below.

- C. The information for a basic Earthwork Balance Sheet should be listed as follows:
1. List, in column one, the survey line reference and beginning station for each summary point.
  2. Record, in column two, the ending station for each summary point.
  3. Show, in column three, the volume of all material excavated between summary point stations (except material covered by other excavation pay items such as undercut excavation and drainage ditch excavation).
  4. Column four contains volumes of "hard" rock that is excavated as a part of unclassified excavation.
  5. Record, in column five, volumes of material excavated beneath the roadway subgrade.
  6. Show, in column six, volumes of any unclassified excavation that is not suitable for roadway embankments.

7. Column seven contains Unclassified Excavation (less "hard" rock) volumes that are suitable for constructing roadway embankments.
8. List the total embankment (include backfill for undercut) in column eight. This figure is the volume of all the different materials used (do not include shrinkage or swell factors).
9. Show, in column nine, the volume of embankment that is to be constructed from "hard" rock. Use the "hard" rock portion of unclassified excavation, before the earth, to construct embankments within each summary point.
10. Show, in column ten, the volume of embankment that is to be constructed from earth.
11. Column eleven reflects the actual volume of material needed to construct the embankment. A shrinkage factor must be applied to the earth portion and then the "hard" rock is added if applicable. Shrinkage and swell factors do not apply to "hard" rock unless specified by the Geotechnical Engineering Unit.
12. Column twelve shows the amount of borrow material needed to construct embankments after the suitable excavation (rock and earth) has been utilized within the summary points.
13. Any "hard" rock excavation not utilized in embankments must have the volume listed in column thirteen.
14. Record, in column fourteen, the volume of any suitable excavation (undercut or unclassified) not utilized in embankments. Exclude "hard" rock.
15. In column fifteen, record the volume of excavation (unclassified or undercut) that does not have the necessary properties to be used in embankments.
16. Column sixteen shows the summation of volumes recorded in columns thirteen, fourteen, and fifteen.

After the listing of the summary points is completed, a "TOTAL" is needed. Total each respective column, three through sixteen. Make earthwork adjustments after the "TOTAL" as follows:

1. "Loss due to clearing and grubbing" volumes, recommended by the Geotechnical Engineering Unit, are to be deducted from columns three and seven. This figure also needs to be deducted from columns fourteen and sixteen on waste projects or added to column twelve on borrow projects.
2. "Hard" rock waste, used to replace borrow, is to be added in column nine. It must be deducted from columns ten, twelve, thirteen and sixteen.

3. Another line of adjustment is needed to "Adjust for rock waste." The volume of rock used to replace borrow should have the shrinkage factor applied (example: a project with 20% shrinkage should have this volume multiplied by 0.20). This adjustment must be deducted from columns eleven and twelve because the shrinkage factor was applied to the material within the summary points, but hard rock is not subject to the shrinkage factor.
4. Any earth waste to replace borrow should be deducted from columns twelve, fourteen, and sixteen.
5. Borrow projects with graded shoulder sections require a line of adjustment with volumes for shoulder material shown in columns eight and ten. These volumes, increased by the shrinkage factor, should show in columns eleven and twelve. Curb and gutter or shoulder trench sections do not need to be included. Projects, with enough usable waste material to build the graded shoulder section, should have a separate pay item of "Shoulder Borrow" which reflects this volume. Do not cover shoulder borrow within the earthwork balance sheet. This should be shown at the bottom of the sheet (below the grand total of earthwork balance sheet items). Do not use the "Shoulder Borrow" pay item on projects with the "Borrow Excavation" pay item.
6. Additional undercut (undercut not shown on plans such as grade point undercut, contingency undercut, etc.) should have an earthwork adjustment line if other undercut is shown within the summary points. This volume is to show in columns five, eight, ten, fifteen and sixteen. List this volume in column fourteen (instead of fifteen) if undercut is suitable. Show this volume, increased by the shrinkage factor, in columns eleven and twelve. Projects with no undercut shown within the summary points can have this volume listed, as estimated undercut, at the bottom of the sheet (below the grand total of earthwork balance sheet items). Using this method should result in the undercut quantity shown on the earthwork summary and the quantity on the summary of quantities being identical.

Other adjustments (select borrow, rock swell, flyash, etc.) may be warranted on select projects. The method of including this information on the earthwork balance sheet can vary due to recommendation format.

Total each respective column, three through sixteen, after the above adjustments are complete. This will be the "Grand Totals" on waste projects and "Project Totals" on borrow projects. Borrow projects need an additional 5% added to the figure shown in column twelve of the "Project Totals" line. This is an "Estimated 5% for Replacing Topsoil on Borrow Pits" which must be included in the "Grand Total" of borrow projects.

"Say" quantities should be shown beneath the "Grand Totals" for any volumes shown in columns that require a pay item.

The following note should be included on each Earthwork Balance Sheet: Note: "Earthwork quantities are calculated by the Roadway Design Unit. These quantities are based in part on subsurface data provided by the Geotechnical Engineering Unit."

The "Earthwork Summary" shown in the Roadway Plans shall be restricted to information shown in columns one, two, three, five, eleven, twelve and sixteen of the Earthwork Balance Sheet (Part II, 19-3, F-2). Do not show the shrinkage factor in the embankment +% column (eleven) of the Earthwork Summary in the plans.

An example of the earthwork balance sheet for a "Borrow" project shows in Part II, 19-3, F-3. See Part II, 19-3, F-4 for an example showing a "Waste" project.

The Plan Review Section of the Project Services Unit will assist you at your request.

NOTE ON CROSS SECTIONS

(EXCLUDING LUMP SUM GRADING AND LUMP SUM BIDPROJECTS)

The following note shall be shown on the first cross-section or cross section summary sheet:

Note: "Quantities are approximate only. The Resident Engineer will re-cross-section the work accurately when the project is staked out. These cross-section notes will be used in computing the final quantities for which the contractor will be paid."

NOTE FOR LUMP SUM GRADING

The following note shall be shown on the first cross-section sheet, the Earthwork Summary, and the Pavement Removal Summary on Lump Sum Grading projects:

Note: Approximate quantities only. Unclassified Excavation, Borrow Excavation, Shoulder Borrow, Fine Grading, Clearing and Grubbing, Breaking of Existing Pavement, and Removal of Existing Pavement will be paid for at the contract lump sum price for "Grading."

For additional information, see Chapter 11 of the Policy and Procedure Manual.

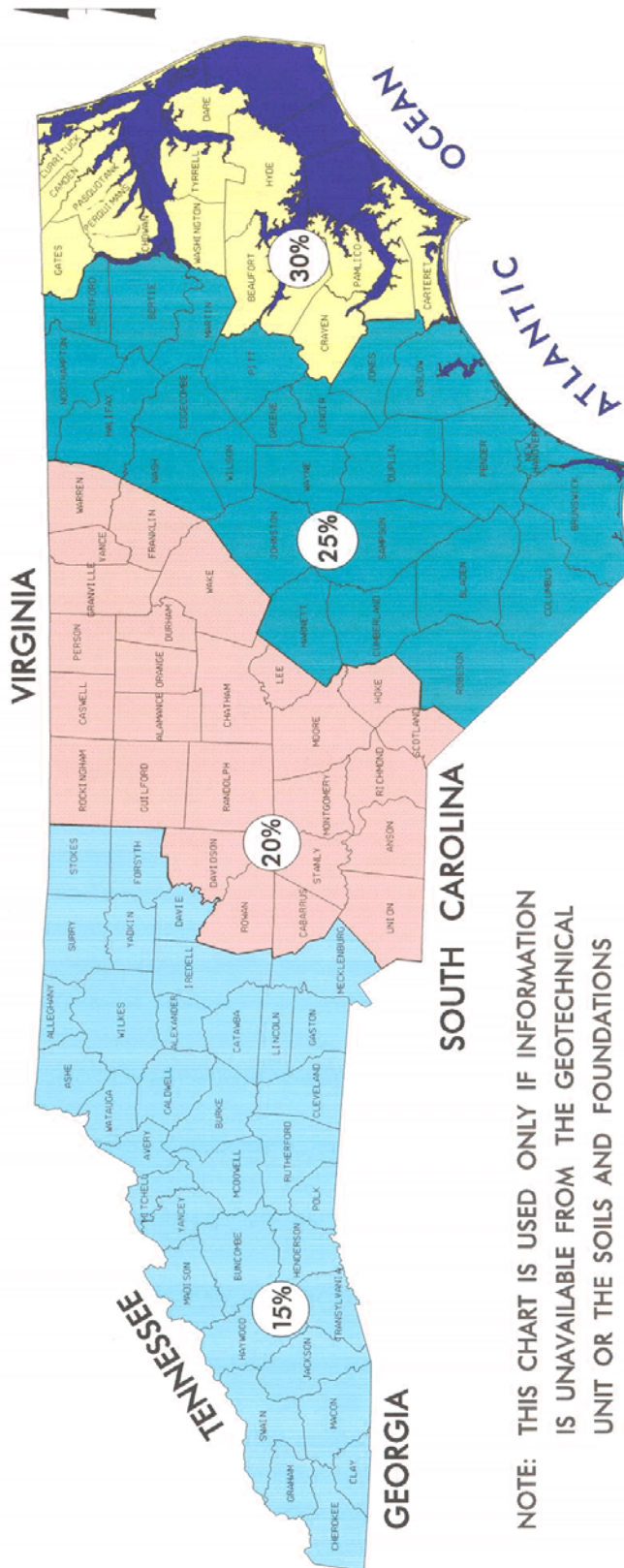




# North Carolina

## SHRINKAGE FACTORS

( FOR THE EARTH PORTION OF UNCLASSIFIED  
EXCAVATION USED TO CONSTRUCT EMBANKMENTS )



NOTE: THIS CHART IS USED ONLY IF INFORMATION IS UNAVAILABLE FROM THE GEOTECHNICAL UNIT OR THE SOILS AND FOUNDATIONS SECTION.



**FIGURE 2**

**19-3  
F-2**

PROJECT \_\_\_\_\_ COUNTY \_\_\_\_\_ Volumes in Cubic \_\_\_\_\_ SHEET \_\_\_\_\_ OF \_\_\_\_\_ SHEETS  
 DATE \_\_\_\_\_ COMPILED BY: \_\_\_\_\_

STATION	STATION	EXCAVATION					EMBANKMENT					BORROW			WASTE		
		TOTAL UNCLASS.	ROCK	UNDERCUT	UNSUIT. UNCLASS.	SUITABLE UNCLASS.	TOTAL	ROCK	EARTH	EMBANK. (+) %	BORROW	ROCK	SUITABLE	UNSUIT.	TOTAL		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16		

Note: Earthwork quantities are calculated by the Roadway Design Unit. These quantities are based in part on subsurface data provided by The Geotechnical Engineering Unit

PROJECT \_\_\_\_\_ COUNTY \_\_\_\_\_ Volumes in Cubic \_\_\_\_\_ COMPILED BY: \_\_\_\_\_ SHEET \_\_\_\_\_ OF \_\_\_\_\_ SHEETS  
 DATE \_\_\_\_\_

STATION	EXCAVATION				EMBANKMENT			BORROW			WASTE		
	TOTAL UNCLASS.	ROCK	UNDERCUT UNCLAS.	SUITABLE UNCLAS.	TOTAL	ROCK	EARTH	EMBANK. (+) 20%		ROCK	SUITABLE	UNCLAS.	TOTAL
L 120+00	60,000	5,000	3,000	7,000	75,000	5,000	70,000	89,000				10,000	10,000
Y1 10+00	10,000				8,000		8,000	9,600				400	400
SUBTOTAL	70,000	5,000	3,000	7,000	83,000	5,000	78,000	98,600				400	10,400
L 150+00	50,000	10,000			7,000	7,000	7,000	7,000		3,000	40,000		43,000
SUBTOTAL	50,000	10,000			7,000	7,000	7,000	7,000		3,000	40,000		43,000
L 180+00	40,000			8,000	80,000		80,000	96,000				8,000	8,000
Y2 20+00	20,000		7,000		25,000		25,000	30,000				7,000	7,000
SUBTOTAL	60,000		7,000	8,000	105,000		105,000	126,000				15,000	15,000
TOTAL	180,000	15,000	10,000	15,000	195,000	12,000	183,000	231,600		3,000	40,400	25,000	68,400
Loss due to clear. & grub.	-5,000												
Rock waste to repl. bor.				-5,000									
Adjust. for rock waste						3,000	-3,000	-600				-3,000	-3,000
Earth waste to repl. bor.													
Est. Shoulder Material					12,000		12,000	14,400					
Additional Undercut			5,000		5,000		5,000	6,000				5,000	5,000
PROJECT TOTALS	175,000	15,000	15,000	145,000	212,000	15,000	197,000	251,400				30,000	30,000
Est. for repl. Topsoil on borrow pits												4,570	
GRAND TOTALS	175,000											95,970	
SAY	175,500											96,500	

Note: Earthwork quantities are calculated by the Roadway Design Unit. These quantities are based in part on subsurface data provided by The Geotechnical Engineering Unit



**FIGURE 4**

PROJECT \_\_\_\_\_ COUNTY \_\_\_\_\_ Volumes in Cubic \_\_\_\_\_ SHEET \_\_\_\_\_ OF \_\_\_\_\_ SHEETS  
 DATE \_\_\_\_\_ COMPILED BY: \_\_\_\_\_

STATION	STATION	EXCAVATION					EMBANKMENT			BORROW	WASTE				
		TOTAL UNCLASS.	ROCK	UNDERCUT	UNCL. UNCL.	SUITABLE UNCL.	TOTAL	ROCK	EARTH		EMBANK. (+) 20 %	ROCK	SUITABLE	UNCL. UNCL.	TOTAL
L 220+00	250+00	75,000	10,000	5,000	1,000	64,000	10,000	50,000	70,000				4,000	6,000	10,000
Y10 15+00	25+00	8,000				8,000		10,000	12,000			4,000			
	SUBTOTAL	83,000	10,000	5,000	1,000	72,000	10,000	60,000	82,000			4,000	6,000	10,000	
L 250+00	280+00	14,000	2,000			12,000	2,000	18,000	23,600	9,600					
	SUBTOTAL	14,000	2,000			12,000	2,000	18,000	23,600	9,600					
L 280+00	310+00	80,000			12,000	68,000		40,000	48,000				20,000	12,000	32,000
Y11 27+00	39+00	20,000	1,000	7,000		19,000	1,000	2,000	3,400				16,600	7,000	23,600
	SUBTOTAL	100,000	1,000	7,000	12,000	87,000	1,000	42,000	51,400				36,600	19,000	55,600
TOTAL		197,000	13,000	12,000	13,000	171,000	13,000	120,000	157,000	13,600			40,600	25,000	65,600
Loss due to clear. & grub.		-5,000											-5,000		-5,000
Adjust undercut				5,000				5,000	6,000	6,000			5,000	5,000	5,000
Waste to repl. Borrow										-19,600			-19,600		-19,600
GRAND TOTALS		192,000	13,000	17,000	13,000	166,000	13,000	125,000	163,000				16,000	30,000	46,000
SAY		192,500													

Note: Earthwork quantities are calculated by the Roadway Design Unit. These quantities are based in part on subsurface data provided by The Geotechnical Engineering Unit



## CHAPTER 20

## FIELD INSPECTION

## PLOTTING OF CROSS-SECTION SHEETS

20-1

The field inspection review questions for final design, combined and Pre-Let inspections are available on website:

<http://www.ncdot.org/doh/preconstruct/highway/roadway/manuals/>

To expedite and improve the coordination between Construction and Design personnel in scheduling and holding field inspections, the following suggestions should be adhered to:

- (1) Make sure everyone involved in project development is aware that flow chart dates are the latest dates for activities to occur.
- (2) The Roadway Design Project Engineer should send field inspection plans to the Division prior to the Flow Chart date, to allow ample time for plan familiarization.
- (3) Design personnel should take notes at field inspections so that plan revisions can begin prior to receiving the Division's Field Review letter.
- (4) For projects with tight schedules, the Roadway Design Project Engineer should make preliminary plans available to the Division for familiarization prior to submittal for field inspection.
- (5) Field inspection dates should be established by phone between the Roadway Design Project Engineer and the appropriate Division representative. Memorandum transmitting field inspection plans should indicate time, date, and location for field inspection.
- (6) Send only the questions that pertain to the project. Do not send the entire list of questions.
- (7) It is the responsibility of the Roadway Design Project Engineer to advise the Structure Design Unit when they schedule a preliminary and/or final field inspection. This will allow them to review the project and determine if they should attend the field inspection.

Determine which one (1) of three (3) question sets (final design, combined or pre-let) is appropriate for your field inspection letter. Once you have selected the proper question set, edit the questions to delete, add, and /or revise the questions that pertain to the project.





ADDITIONAL INFORMATION ON PUBLIC HEARINGS

21-3

- (1) The Roadway Design Project Engineer will be responsible for the hearing map review. The hearing map should be reviewed by the following:
- (A) Federal Highway Administration (if applicable)
  - (B) State Highway Design Engineer
  - (C) Public Involvement and Community Studies
  - (D) State Roadway Design Engineer and Assistant State Roadway Design Engineer
  - (E) Program Development - TIP Development Unit
  - (F) Traffic Engineering and Safety Systems Branch, Congestion Management Section
  - (G) Signals and Geometrics Section (if applicable)
  - (H) Project Development and Environmental Analysis Branch
  - (I) Hydraulics Unit (if applicable)
  - (J) Structure Design Unit (if applicable)
  - (K) Public Affairs
  - (L) Geotechnical Engineering Unit
  - (M) MPO Representative (If in MPO area).
  - (N) Division Staff (Division Engineer or Division Construction Engineer).
  - (O) Right-of-Way Branch representative.
  - (P) Consultant Coordination Section (If any part of the project is to be done by a Private Engineering Firm).
  - (Q) Corps of Engineers (If applicable).

At the design public hearing, the Roadway Design Project Engineer or appointed representative should prepare good notes of the oral comments rendered at the hearing. These notes will be used in developing the agenda for the Post Design Hearing Meeting. (The Public Hearing transcript may not be available in all cases; the notes will provide a good summary in case the transcript is not available.)

After the comment period is over, the Roadway Design Project Engineer will contact the Citizens Participation Unit to obtain a copy of all written comments received following the hearing. The Project Engineer will then begin to compile the summary of comments, which will be used as an agenda for the post hearing meeting. In order to address the public's concerns in a timely manner, the post hearing meeting date should ideally be held no longer than six weeks after the date of the design public hearing. (There may be extenuating circumstances or additional studies that may delay this date).

#### Post Design or Combined Public hearing Meeting

The Roadway Design Project Engineer will set the post hearing meeting date and will invite all the attendees who were invited to the design public hearing map review. In addition, if the project is extremely controversial or not favored by the public, it may be appropriate to invite the Board of Transportation Members. In a

situation where there is extreme controversy, the hearing comments should be discussed with the Public Involvement and Community Studies Unit, Roadway Design Assistant Unit Head and Unit Head to determine the appropriate attendees.

Following the post hearing meeting, the Roadway Design Project Engineer will prepare the post hearing meeting minutes or summary. These minutes are to be reviewed by the Roadway Design Assistant Unit Head and should be prepared as a memorandum to the Post Hearing Meeting Attendees for the State Roadway Engineer's signature.

These minutes should be very formal and informative. They should also state resolution of issues or issues that are to require further studies. Also, any letters from citizens that seek additional information or require a written response should be discussed to determine who will prepare the written response.

- (2) Once the hearing map review has been held, the Public Hearing Officer may need the following information from the Project Engineer.
  - (A) Hearing map
  - (B) Two (2) replicas of hearing map, one for a relocation study and one for display prior to the hearing.
  - (C) Information for public handouts at hearing.

NOTE: Contact between the Public Hearing Officer and the Project Engineer shall be immediately after a hearing map is reviewed for a public hearing.

- (3) Combined public hearing maps are not to be prepared on aerial mosaics without approval of the Public Hearing officer.
- (4) The Corridor Public Hearing Map is to be reviewed by the State Highway Design Engineer.

## CHAPTER 22

## CHECK LISTS

PURPOSE22-1

Checklists for Preliminary, Right of Way, and Final Plans are provided for the designer's assistance in the preparation of plans, specifications, and estimates.

A checklist for final plans shall be turned in when final plans are submitted to the Plan Review Project Engineer for review. These lists are available from the website:

[http://www.ncdot.org/doh/preconstruct/ps/specifications/specifications\\_provisions.html](http://www.ncdot.org/doh/preconstruct/ps/specifications/specifications_provisions.html)



## CHAPTER 23

## STANDARD FORMS

## STANDARD FORMS

23-1

Standard forms are provided for various activities that are conducted by the Roadway Design. Copies of these forms are available in the Records and Documents Group of the Project Services Unit. The calculation of quantities forms are available from the website:

<http://www.ncdot.org/doh/preconstruct/ps/contracts/standards/quantities/default.html>

The following forms are also available on the above website:

- Various Checklists
- General Project Notes
- Standards Lists
- Special Detail Requests

There are also template files available on the Roadway Design Unit website:

<http://www.ncdot.org/doh/preconstruct/highway/roadway/V8/>

These include:

- Geopak Templates
  - Criteria
  - Earthwork
- Excel Templates
  - Balance Card
  - Various Summary Sheets
  - Earthwork XSC Volumes
  - Right of Way Parcel Sheets

Access Templates for Compbook Quantities



## CHAPTER 24

## REFERENCE MATERIAL

## REFERENCE MATERIAL

24-1

There is no limit to the amount of reference material available to Roadway Design Unit personnel. Research information is filed in the Value Management Section (See the Development and Publication Engineer); also, there is a large library in the Research and Analysis Group of the Environmental, Planning, and Local Governmental Affairs Program Development Branch.

To supplement the Policy and Procedures Manual and the Design Manual specifically prepared for Roadway Design personnel, a list of some of the more prominent Division of Highway manuals, books, etc., are listed below. If assistance is needed in locating this material, the Research and Production Engineer will provide it.

- (1) Employee Handbook
- (2) Manual for Construction Layout
- (3) North Carolina State Personnel Manual
- (4) Field Fiscal Procedures Manual
- (5) Route Location and Design by Thomas F. Hickerson
- (6) Roadway Standard Drawings
- (7) Standard Specifications for Roads and Structures
- (8) Roadway Design Policy and Procedures Manual
- (9) Roadway Design Manual
- (10) Structure Design Policy and Procedures Manual
- (11) Structure Design Manual
- (12) Highway Capacity Manuals
- (13) Guidelines for Placement of Garbage Collection Containers on State Highway System Right of Way
- (14) Guidelines Curb Cuts and Ramps for Disabled Persons
- (15) Manual on Driveway Entrance Regulations
- (16) Highway Action Plan
- (17) North Carolina Transportation Improvement Program
- (18) Subdivision Roads - Requirements and Minimum Construction Standards
- (19) Guidelines for Drainage Studies
- (20) Construction Manual
- (21) Right of Way Manual
- (22) Policies and Procedures for Accommodating Utilities on Highway Rights of Way
- (23) Outdoor Advertising
- (24) Property Survey Manual

## REFERENCE MATERIAL (continued)

24-1

- (25) Survey Manual
- (26) Manual on Uniform Traffic Control Devices
- (27) A Guide to North Carolina Laws Related to Traffic Engineering Operations
- (28) A Policy on Geometric Design of Highways and Streets
- (29) Road and Highway Laws of North Carolina
- (30) Motor Vehicle Laws of North Carolina
- (31) General Ordinances of North Carolina
- (32) North Carolina Administrative Code
- (33) Traffic Count Books
- (34) Federal Aid Policy Guide
- (35) County Map Books
- (36) Book I and Book II - Traffic Engineering Operating Manual
- (37) Guide for Resurfacing, Restoration and Rehabilitation (R-R-R) of Highways and Street
- (38) Federal Laws, Regulations, and Material Relating to the Federal Highway Administration
- (39) Roadside Environmental Unit Manual
- (40) Transportation and Traffic Engineering Handbook
- (41) Emergency Response Guidebook
- (42) N. C. Special Permits Manual
- (43) N. C. Administrative Procedures Act (Title 19A NCAC)
- (44) Roadside Design Guide (AASHTO)
- (45) Pay Item List
- (46) North Carolina Bicycle Facilities Planning and Design Guidelines
- (47) Transportation Planning Handbook (ITE)
- (48) Traffic Engineering Handbook (ITE)
- (49) Workplace Safety Manual
- (50) Other State Design Manuals, AASHTO Manuals, FHWA Publications and reference material
- (51) Permits, Permit Drawings and Mitigation Publications
- (52) Roundabouts: An Informational Guide
- (53) Safety Policy and Procedure Manual
- (54) Traditional Neighborhood Development Street Design Guidelines



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OTHER PUBLICATIONS

24-2

The National Cooperative Highway Research Program was established in 1962 to provide a continuing program of highway research. Their publications are more commonly known as NCHRP'S. We make frequent use of their research material in our designs. A list of their publications is available in the Alternative Delivery Library. (See the Research and Production Engineer in the Value Management Section).

Following are other publications available in the Alternative Delivery Library:

- (1) Transportation Research Record
- (2) Texas Transportation Institute Report
- (3) Transportation Research News
- (4) Transportation Research Board - Special Report
- (5) Transportation Research Circular
- (6) Nat. Coor. Highway Research Program Synthesis
- (7) Nat. Coor. Highway Research Program Report
- (8) Nat. Coor. Highway Research Program
- (9) Highway Research Record
- (10) Highway Research Board

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SECONDARY ROAD NAMES

24-3

A list of statewide secondary road numbers and names has been compiled for your use in preparing plans. This list is available in the Alternative Delivery Library. (See the Development and Publication Engineer in the Value Management Section).

Also, Secondary Road Name Inquiry System is available on the North Carolina State, Department of Transportation's WebPages, located at:

<http://apps.dot.state.nc.us/srlookup/SecondaryRoads.aspx>

