TRAINING MANUAL FOR CONSTRUCTION LAYOUT

Georgia Department of Transportation

ACKNOWLEDGEMENT AND APPRECIATION

The Georgia Department of Transportation (GDOT) wishes to express the most sincere thanks to the North Carolina Department of Transportation (NCDOT) for the tremendous work involved in developing this manual. NCDOT has graciously permitted GDOT to use this material for the purpose of supporting the work being done by both agencies. For that permission, GDOT is explicitly thankful. All information gathered and work compiled is the product of the exceptional team at NCDOT. With the exceptions of modifications to correct conflicting laws, regulations, and policies; all drawings, plans, appendices, etc. remain in the original format developed by the original authors.

ACKNOWLEDGEMENTS

In order to establish minimum standards for construction layout and uniformity in staking procedures, the North Carolina Department of Transportation developed this Construction Layout Manual.

The Department would like to thank the many people who participated in the development of this document. A special thank you is extended to all Division Construction offices that assisted with the reviewing and editing process, and to the Location and Surveys Unit that provided information concerning the Global Positioning System (GPS).

The Manual for Construction Layout was edited and published by the North Carolina Department of Transportation – Construction Unit-IMPACT Public Information Program.

PREFACE

This Manual is being provided by the Georgia Department of Transportation as a training tool that provides guidance for highway construction layout. The State Office of Utilities encourages utility companies to train their employees, agents, contractors or any other person performing work on highway construction projects in order to improve utility coordination. By becoming familiar with highway construction surveying and assorted terms, Utilities, their subcontractors or continuing contractors should reduce the challenges and costs associated with utility relocation issues where facilities are being installed or adjusted into roadway or bridge "conflict" areas. Finally, another benefit to understanding the contents of this Manual will enhance the communication between the Utilities and Highway Contractors and provide for a more efficient construction schedule.

INTRODUCTION

The purpose of the Manual for Construction Layout is to familiarize Contract Surveyors with the standards and procedures required to survey and stake a GDOT project. The majority of construction layout procedures encountered during a typical project are detailed within this manual. If an item is not included, contact the Department's Engineer (Area Engineer, Construction Project Engineer or Utility Inspector) administering the project for the appropriate procedure.

Construction Surveying is essential to completing a high quality and economical project. The Contract Surveyor is involved in construction layout at all stages of the project – from verifying initial control points through project completion. By knowing and understanding the standards and procedures for construction layout, the Contract Surveyor helps to improve the overall quality, productivity and profitability of the project.

In any successful partnership, effective communication is vital. Everyone involved with the project must communicate effectively to increase overall understanding of both the information being established in the field and submitted for review. GDOT realizes that the effectiveness of this manual is an important element in the construction layout of a project. If, while surveying a department project, you develop a more efficient procedure, please submit it to the Construction Unit. We then will evaluate its viability for inclusion in the next revision of this manual.

Reference Materials

In addition to the Manual for Construction Layout, you should have access to the following:

- Standard Specifications for Roads and Structures
- Roadway Standard Drawings
- Project contract and plans
- Any and all revisions for the project

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Chapter 1
General Information

1.1 General Information

Perform all construction layout in accordance with the current edition of the "DEPARTMENT OF TRANSPORTATION, STATE OF GEORGIA STANDARD SPECIFICATIONS, CONSTRUCTION OF TRANSPORTATION SYSTEMS." (section 149 - Construction Layout Section), and the project Contract.

Set all types of stakes at intervals of 50 feet (20 meters) unless otherwise detailed or directed. Intervals may be adjusted by the Engineer to properly construct the project.

Reference all elevations to the finished grade.

Accuracy is a degree of conformity with a standard or accepted value. According to *Definitions of Surveying and Associated Terms*, accuracy relates to the quality of a result, and is distinguished from precision which relates to the quality of the operation by which the result is obtained. The accuracy ratio shall not exceed an error of closure of 1 foot per 20,000 feet (1 meter per 20,000 meters) of perimeter for all control and structure surveys and 1 foot per 10,000 feet (1 meter per 10,000 meters) of perimeter for all other horizontal surveys. The accuracy for vertical surveys shall not exceed

$$0.10\text{ft.}\sqrt{(\text{x})miles} \quad (30.48\text{mm}\sqrt{.62137(\text{x})km})$$

for control and structure surveys, and

$$\left|0.05\text{ft.}\sqrt{(\text{x})miles} \quad (15.24\text{mm}\sqrt{.62137(\text{x})km})\right|$$

for all other vertical surveys. The precision for surveying each operation is detailed within this manual.

1.2 Safety

The number one concern in construction stakeout is ensuring that all work is conducted in a safe manner. Proficiency, accuracy and timeliness should never take precedence over safety of the crew and/or public. The consequences of any accident, no matter how minor, cannot be justified by the desire to complete work within a given schedule. Remember, when operating in a hazardous area, the top priority is the safety of each individual – equipment is secondary.

The stakeout crew is exposed constantly to moving vehicles and equipment on the construction site. Earthmoving equipment can dwarf a survey crew member, making it difficult for the

equipment operator to see the individual standing on the ground. Therefore, one should always notify the Contractor of his/her intended area of operation and the expected time period of occupancy. Crew members should be alert for backing equipment. When one is setting stakes, it is recommended to have a standing person close by to make the operation more visible and act as the eyes of the stake driver. If working beneath a construction operation, each crew member should wear an approved safety helmet. In some cases, the Prime Contractor may require the use of safety helmets while performing work within the project limits.

When stakeout is required adjacent to active travel lanes, extreme caution should be taken to protect the crew from oncoming traffic. Each member of the crew should stay alert and watch for potential hazardous situations. In addition, the appropriate traffic control measures should be installed according to Section 150 - Traffic Control and the current edition of the Manual on Uniform Traffic Control Devices "MUTCD".

The stakeout crew will be exposed to the elements, insects and some poisonous plants. Therefore, the appropriate clothing should always be worn.

1.3 Required Submittals

The Department's Construction Layout/Stakeout Sheet provides construction alignment information concisely on one or multiple plan sheets. However, this sheet may not be provided by GDOT on small projects.

Submit the following information to the Engineer for review and approval.

- A printout of horizontal verification, as well as coordinates, differences and error of closure.
- A printout of vertical control verification, with benchmark location elevations, and differences from plan elevations.
- Sketch of location of newly referenced horizontal control, with text printout of coordinates, method of reference and field notes associated with referencing control.
- Description of newly established benchmarks with location, elevation and closed loop survey field notes.
- The proposed method for recording information in field books to ensure clarity and adequacy.
- All updated electronic and manuscript survey records on a monthly basis.
- Two (2) copies of all layout drawings for utility construction systems and drainage systems.
- Layout drawing for each structure and culvert.
- Computations for buildups over beams, screed grades and overhang form elevations.
- Sign S-Dimension information on an 11 ½ inch x 17 inch drawing depicting the theoretical finished section at each proposed overhead sign assembly location.
- Coordinate data showing differences between supplied baseline coordinates and field obtained GPS coordinates, including report detailing preliminary input data.

- Any proposed plan alteration to rectify a construction stakeout error, including design calculations, narrative and sealed drawings.
- Validation of right-of-way marker locations.
- Alignment of baseline for each borrow pit location.
- Detailed sketch of proposed overhead and Type A and B ground mounted sign locations along with any obstructions that may interfere with installation.

Chapter 2
Staking Control Points

2.1 General Information

The initial control is the foundation from which the entire project will be surveyed. Therefore, it is critical to establish accurate control. The Department strives to provide accurate baseline control. The expectation is that the Contract Surveyor will easily be able to verify the Department's control within the specified accuracy, and will preserve such accuracy in referencing the control outside the project limits.

2.2 Verifying Control Points

Horizontal Control

Verify the Department's horizontal control by performing a closed traverse of the baseline control points. All baseline control points should be occupied. Notify the Engineer in writing of any discrepancies in the horizontal control. The Engineer should provide written direction before control points, which do not validate within the specified accuracy, are utilized.

Submit to the Engineer a printout of the control verification, as well as coordinates, differences and error of closure.

Vertical Control

Verify the Department's vertical control by performing a closed loop survey utilizing differential leveling. Notify the Engineer, in writing, of any discrepancies in the vertical control.

Submit to the Engineer a printout of all benchmarks with locations, elevations and differences from plan elevations.

2.3 Referencing Control Points

Horizontal Control

Approved methods for referencing horizontal control points shall include a minimum of three (3) points and one (1) angle. An offset baseline traverse is an approved method for referencing horizontal control. (See *Figure 2.1*.)

Submit to the Engineer a sketch showing location of new control, a text printout of coordinates, the method of reference and the field notes associated with referencing control.

Vertical Control

An approved method for referencing vertical control is to establish a new benchmark by performing a closed loop survey utilizing differential leveling.

Submit to the Engineer a description of the new benchmark, location, elevation and closed loop survey field notes. (See *Figure 2.2*.)

2.4 Type of Stakes

Recommended Stake Size: 60D nail or 18” #5 rebar for horizontal control point ¾" x 1 ¾" x 36" for guard stake Railroad spike may be used for vertical control or other approved points. A paint mark will not be acceptable. A ¾" x 1 ¾" x 18" stake should accompany the benchmark with the elevation information legibly written upon it.

2.5 Staking Accuracy

Horizontal Control

The accuracy ratio shall not exceed an error of closure of 1 foot per 20,000 feet (1 meter per 20,000 meters) of perimeter (1:20,000).

Vertical Control

The error of closure shall not exceed $0.05\text{ft.}\sqrt{(x)miles}$ $(15.24\text{mm}\sqrt{62137(x)km})$..

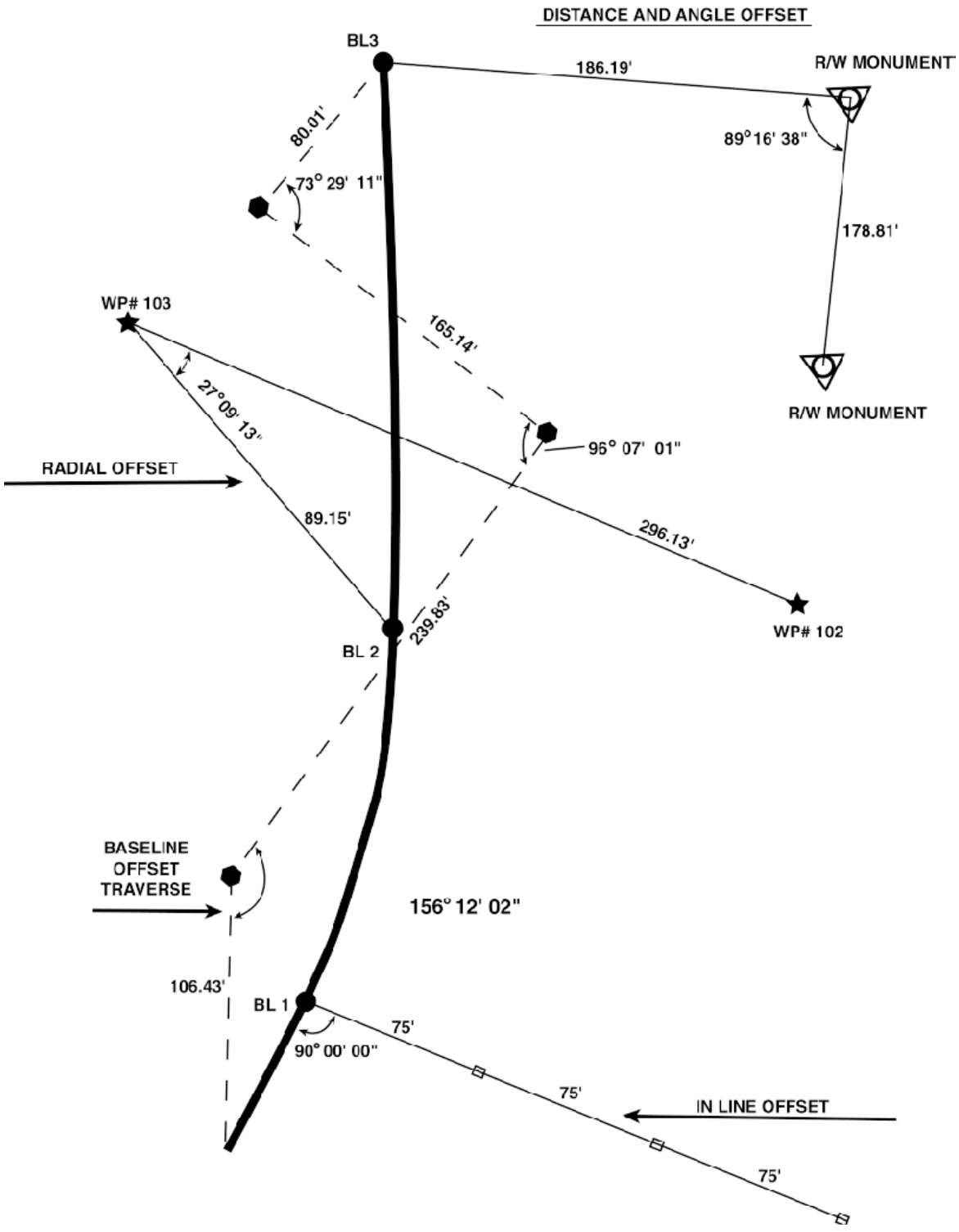

METHODS OF REFERENCING HORIZONTAL CONTROL
DISTANCE AND ANGLE OFFSET
BL3
186.19'
R/W MONUMENT
80.01'
89° 16' 38"
73° 29' 11"
178.81'
WP# 103
165.14'
27° 09' 13"
R/W MONUMENT
95° 07' 01"
RADIAL OFFSET
89.15'
296.13'
239.83'
WP# 102
BL 2
BASELINE
OFFSET
TRAVERSE
156° 12' 02"
106.43'
BL 1
75'
90° 00' 00"
75'
IN LINE OFFSET
75'

Figure 2.1

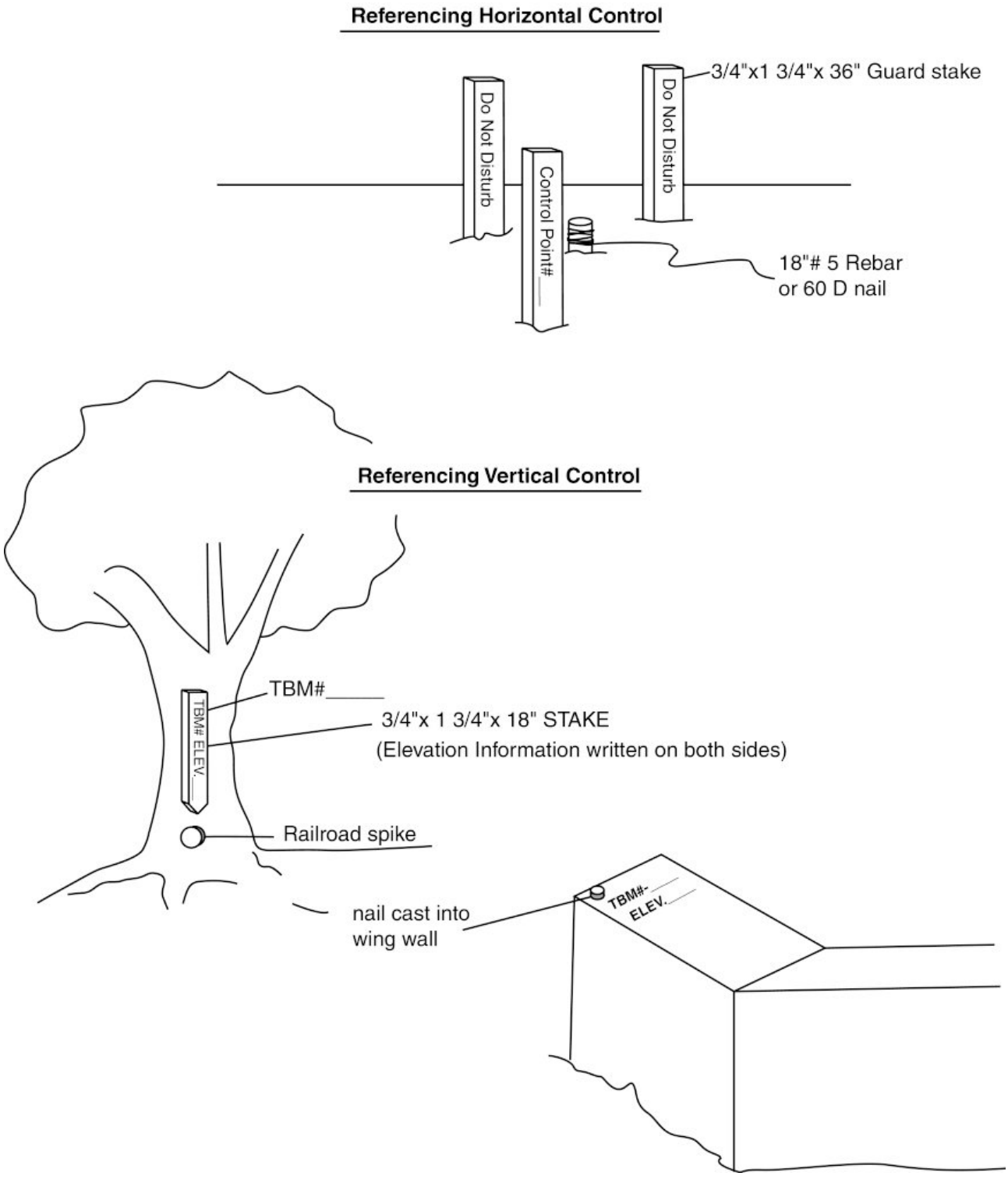

Referencing Horizontal Control
3/4"x1 3/4"x 36" Guard stake
Do Not Disturb
Control Point#___
Do Not Disturb
18"# 5 Rebar
or 60 D nail
Referencing Vertical Control
TBM#_____
TBM# ELEV.___
3/4"x 1 3/4"x 18" STAKE
(Elevation Information written on both sides)
Railroad spike
nail cast into
wing wall
TBM#-____
ELEV.____

Figure 2.2

Chapter 3
Centerline Stakes

3.1 General Information

With today's technology and the use of baseline surveys, the need to install centerline stakes has diminished. However, there are different types of projects across Georgia which, for various reasons, may require the installation of centerline stakes. If the centerline is inaccessible, an offset line may be required. Centerline stakes typically will be installed for measurement of earthwork quantities on the project and in borrow pits or for establishing the initial control for a future project.

3.2 Guideline Information

Set centerline stakes at 50 foot (20 meter) intervals, including all cardinal points (TS: point of change from tangent to spiral, SC: point of change from spiral to circle, CS: point of change from circle to spiral, ST: point of change from spiral to tangent, equalities, etc.).

3.3 Type of Stake

Recommended Stake Size: ¾" x 1 ¾" x 18"
Recommended Flagging: Orange
Precision: Horz. 0.1'
Stake Use: Location and Information
Abbreviation: C/L - Centerline

3.4 Stake Information

The information described below is detailed in *Figure 3.1*.

1. Station number
2. Offset (if necessary)
3. Designation of alignment

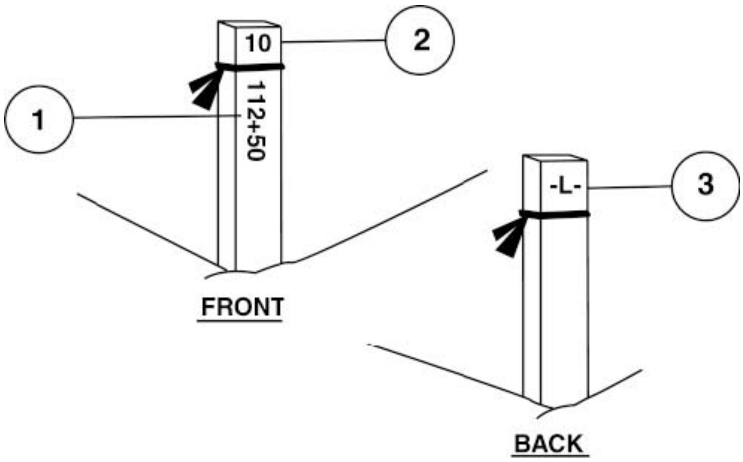


Figure 3.1

Chapter 4
Clearing and Grubbing

4.1 General Information

One of the initial operations on a new project is to establish the limits for clearing and grubbing, which prepares the project for grading within the construction limits.

4.2 Guideline Information

Utilize Erosion Control Plans, Standard Drawings, Roadway Plans and Project Cross-Sections in establishing clearing limits. In critical areas – such as wetlands, condemned parcels and any other areas deemed necessary by the Engineer – install slope stakes prior to establishing clearing limits. Flagging tape may be tied on stable trees to supplement the clearing stakes. Retain the clearing stakes throughout the clearing and grubbing operation.

4.3 Type of Stake

Recommended Stake Size: ¾" x 1 ¾" x 36"
Recommended Flagging: Blue and White Striped
Precision: Horz. 1.0' unless slope staking is required, then Horz. 0.1'
Stake Use: Location

4.4 Stake Information

The information described below is detailed in *Figure 4.1*.

1. Denotes type of stake (clearing limits)
2. Station

CLEARING LIMITS

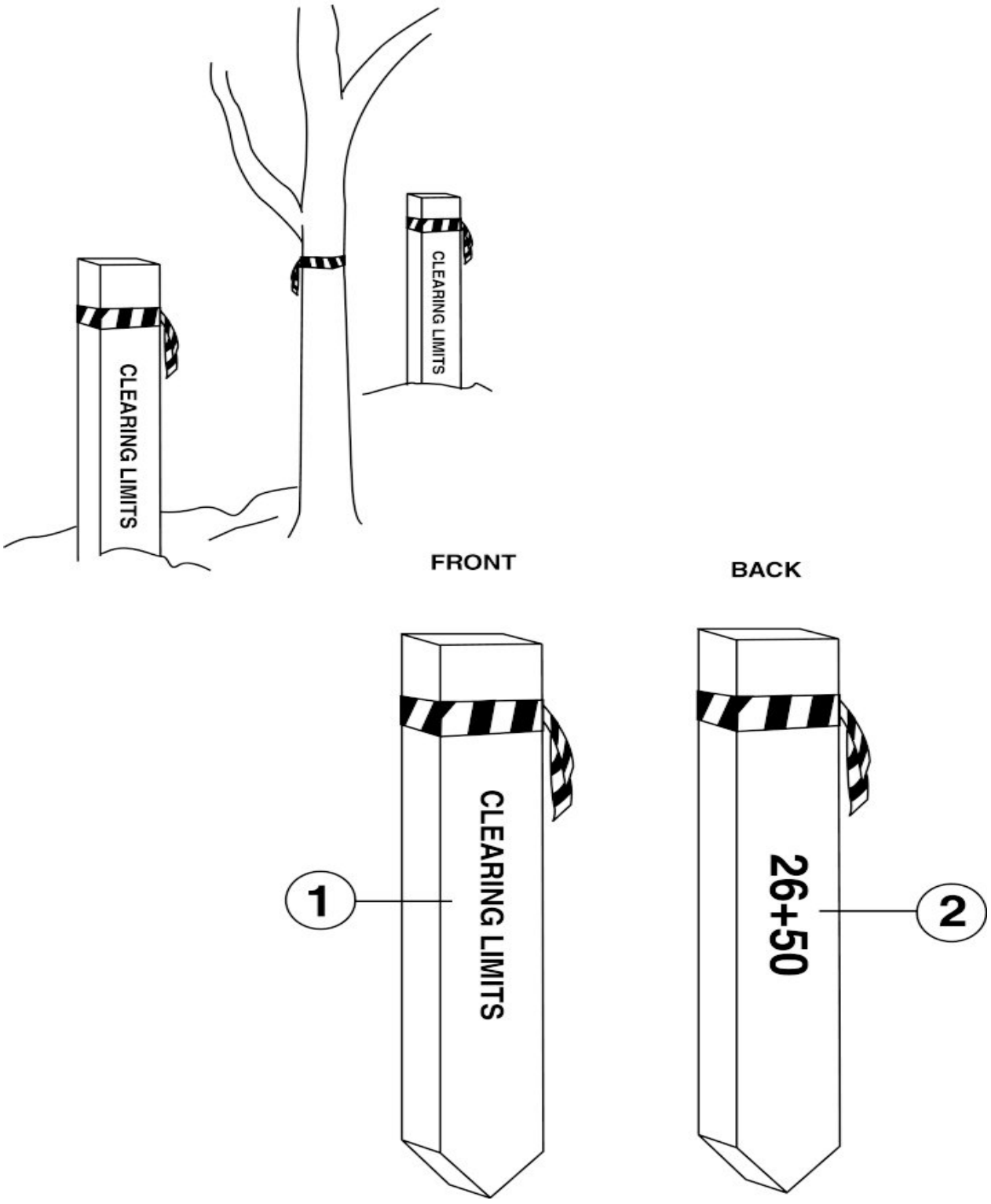


Figure 4.1

Chapter 5
Slope Stakes

5.1 General Information

Before beginning earthwork construction, the extremities of the cuts and fills must be identified for equipment operators. Slope stakes establish the intersection of either the top of cut or the toe of fill with the natural ground. They also reference the centerline location and quantify the depth of material to be excavated or placed. Slope stakes should remain in place until the slopes are completed, inspected and permanently seeded.

5.2 Guideline Information

Install slope stakes with a minimum offset distance of 10 feet (3 meters). Slope stakes shall not be scaled from the plans or determined from plan cross sections. Instead, they should be determined mathematically in the field prior to grading operations.

If a hinge point is detailed, set the slope stake to the hinge point. Otherwise, set the slope stake to the shoulder point or ditchline.

5.3 Type of Stake

Recommended Stake Size: ¾" x 1 ¾" x 18"
Recommended Flagging: Orange
Precision: Horz. 0.1', Vert. 0.1'
Stake Use: Information and Location
Abbreviation: O/S - Offset

5.4 Stake Information

The information described below is detailed in *Figure 5.1*.

1. Offset distance (horizontal distance between catch point and slope stake)
2. Total fill or cut from the base point to intercept point with natural ground
3. Total horizontal distance of slope
4. Rate of slope
5. Total distance from centerline to intercept point
6. Offset difference (+, -) (vertical difference between intercept point and offset stake point)
   + offset stake point higher than intercept point
   - offset stake point lower than intercept point
7. Station number
8. Superelevation

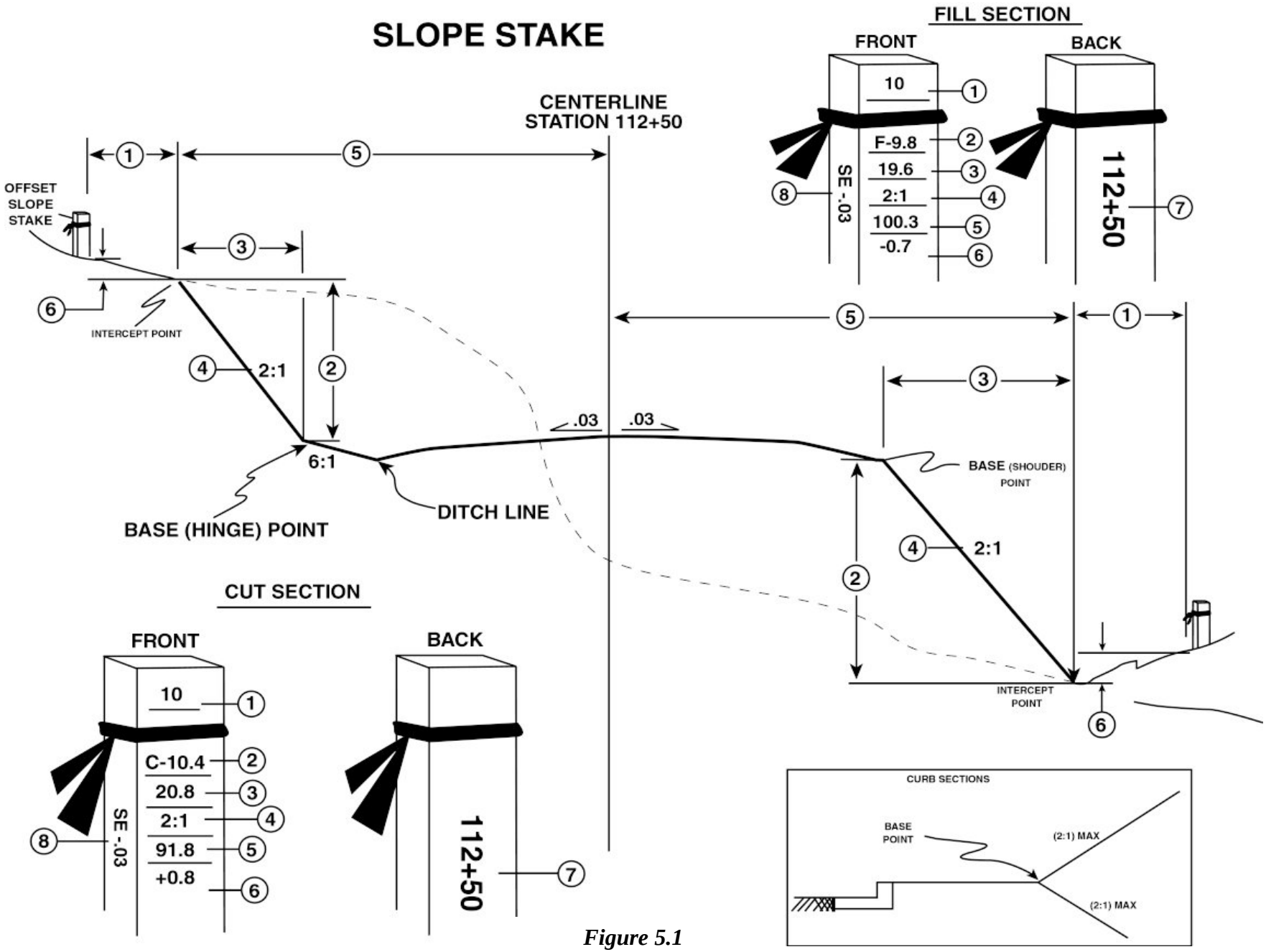

SLOPE STAKE
FILL SECTION
FRONT
BACK
10
F-9.8
19.6
2:1
100.3
-0.7
SE -.03
112+50
CENTERLINE
STATION 112+50
OFFSET
SLOPE
STAKE
INTERCEPT POINT
2:1
.03
.03
6:1
BASE (HINGE) POINT
DITCH LINE
BASE (SHOUDER)
POINT
INTERCEPT
POINT
CUT SECTION
FRONT
BACK
10
C-10.4
20.8
2:1
91.8
+0.8
SE -.03
112+50
CURB SECTIONS
BASE
POINT
(2:1) MAX
(2:1) MAX

Figure 5.1

Chapter 6
Ditch Stakes

6.1 General Information

Drainage ditches typically are located at the toe of fill sections to provide a controlled channel to carry storm water. Ditch stakes provide the location, depth and width of such channels.

6.2 Guideline Information

Utilize Roadway Plans, Project Cross-Sections, slope stake information and drainage ditch details when establishing the location and depth of a drainage ditch. Ditch stake elevations should be established from the profile plan sheets. The ditch typical section will override profile grades in order to achieve minimum depths. The ditch depth should be measured either to the top of the ditch lining or to the flow line of the ditch (if no lining is specified).

6.3 Type of Stake

Recommended Stake Size: ¾" x 1 ¾" x 18"
Recommended Flagging: Blue
Precision: Horz. 0.1', Vert. 0.1'
Stake Use: Information and Location
Abbreviations: DC – Ditch Cut, FB – Flat Bottom

6.4 Stake Information

The information described below is detailed in *Figure 6.1*.

1. Offset distance to intercept point of back slope with natural ground
2. Cut to bottom of ditch from stake
3. Back slope of ditch
4. Base width
5. Ditch typical from plans
6. Offset difference (+, -)
   (verticle difference between intercept point and offset ditch stake point)
   + offset ditch stake point higher than intercept point
   - offset ditch stake point lower than intercept point
7. Station

DITCH STAKES

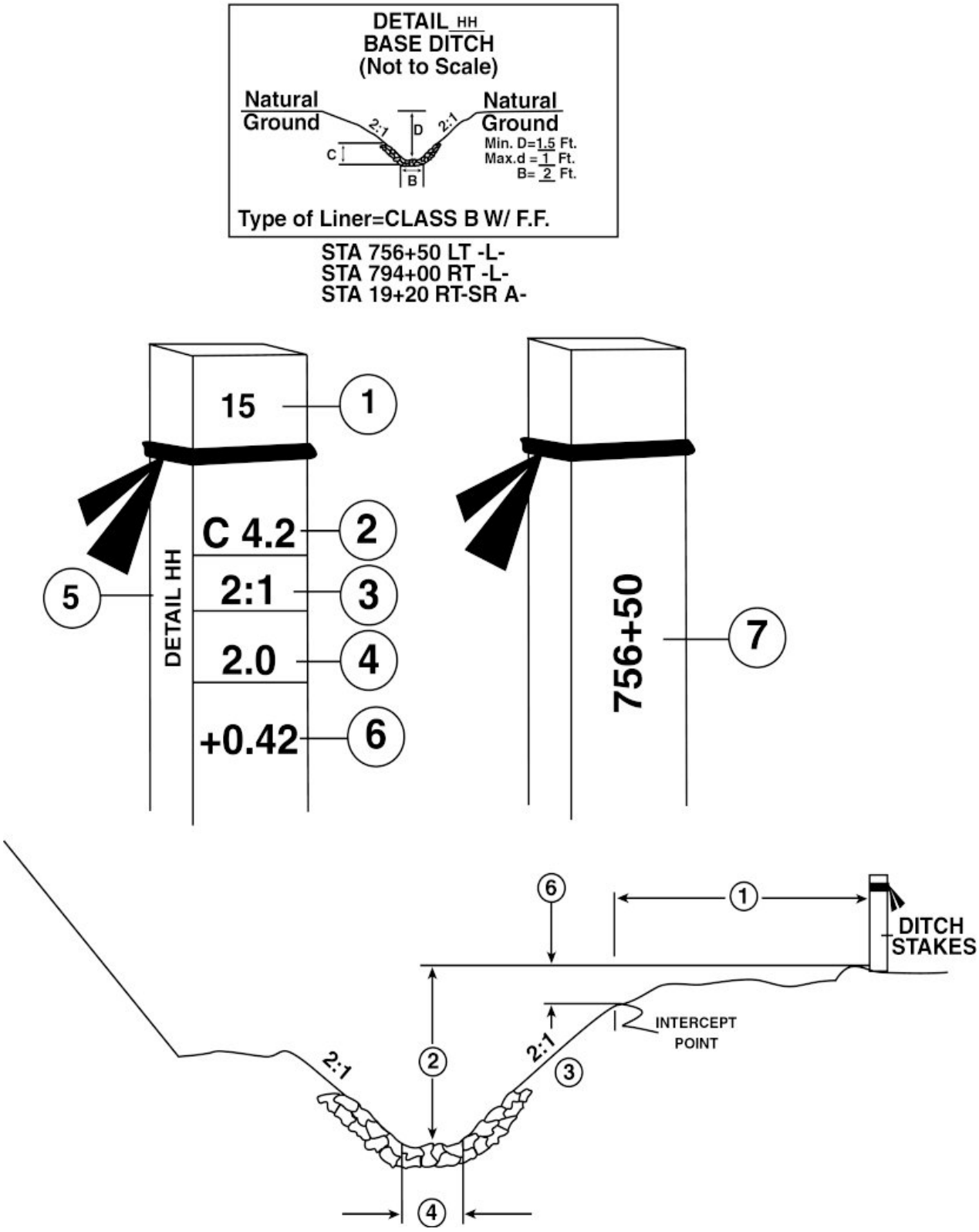


Figure 6.1

Chapter 7
Pipe Stakes

7.1 General Information

Utility relocation is a significant undertaking on most GDOT projects; an option that could increase profit by controlling the cost of materials, labor, and staking is heavy equipment control systems using Global Positioning system (GPS) and laser technology. It should be noted that Georgia Contractors are using GPS and single beam pipe lasers for installing storm and sanitary sewer, or any gravity flow pipe line when grade and line are required. The drainage must be installed so that it effectively collects and distributes storm water. During construction stakeout, the survey crew should identify potential drainage problems and make recommendations for correction to the Engineer. It is the responsibility of the construction stakeout crew to ensure that the drainage systems detailed in the plans will function properly as staked. If a concern exists that the drainage system may be inadequate, based upon field observations, it also should be addressed with the Engineer.

7.2 Guideline Information

Prior to calculating and staking the drainage system detailed in the plans, perform a field investigation of the proposed area. Consider the locations and elevations of all existing and proposed utilities, proposed utility construction, and existing and proposed drainage systems in the layout of the drainage system. A layout drawing of the drainage system must be submitted to the Engineer for review and approval. (See Appendix A.) However, before submitting the drawing, verify that all the required information is included by referring to the *Checklist For Drainage Layout Submittal* (located in Appendix A). In addition, unless otherwise instructed, calculate the entire network before submitting any portion of the network for approval. Adjust pipelines with camber to allow for settlement (reference *Camber for Pipe and Box Culverts* contained in Appendix A).

Establish pipe lengths from the drainage structure locations and/or actual location of the slope intercept with existing streams, natural ground or proposed drainage ditches as measured during the field investigation and/or layout. Use 12” hubs for referencing the pipe’s line and flowline elevation. Pipelines greater than 200 feet will require intermediate hubs set on 100 foot intervals or on smaller intervals as deemed necessary by the Engineer. The intermediate hubs shall contain cuts or fills relative to the pipe’s invert elevations directly adjacent to the intermediate hubs’ location. For pipes laid with camber, establish and stake the line and flowline elevation on 50 foot intervals along the pipe length. Stationing of the pipe shall begin with 0+00 at the outlet end of the pipe and advance to the inlet end. Provide one reference line, consisting of two hubs with corresponding reference stakes, for the inlet and outlet of the pipeline. The first reference hub shall be a minimum of 10 feet (3 meters) from the reference point with the second hub installed at an equal distance from the first hub.

7.3 Type of Stake

Recommended Stake Size: ¾" x 1 ¾" x 36"
Recommended Flagging: Blue
Stake Use: Information and Guard

Recommended Stake Size: 1 ¾" x 1 ¾" x 12" hub
Precision: Horz. 0.01', Vert. 0.01'
Stake Use: Grade and/or Alignment

7.4 Stake Information

Reference stakes will be used in conjunction with hubs to provide the required information as detailed below and depicted in *Figure 7.1*.

At First Reference Hub

1. Offset to the reference point of pipe
2. Station of the point referenced with respect to the pipe line
3. Cut or fill from hub to invert
4. Length size and type of pipe
5. Grade of pipe in percent with either inlet or outlet defined
6. Structure number

At Second Reference Hub

(Reference location of pipe by alignment with first hub)

1. Offset to the reference point of pipe
2. Station of the point referenced with respect to the pipe line
3. Length size and type of pipe
4. Structure number

At Intermediate Hubs

1. Offset to the pipe
2. Station with respect to the pipe line
3. Cut or fill from hub to invert

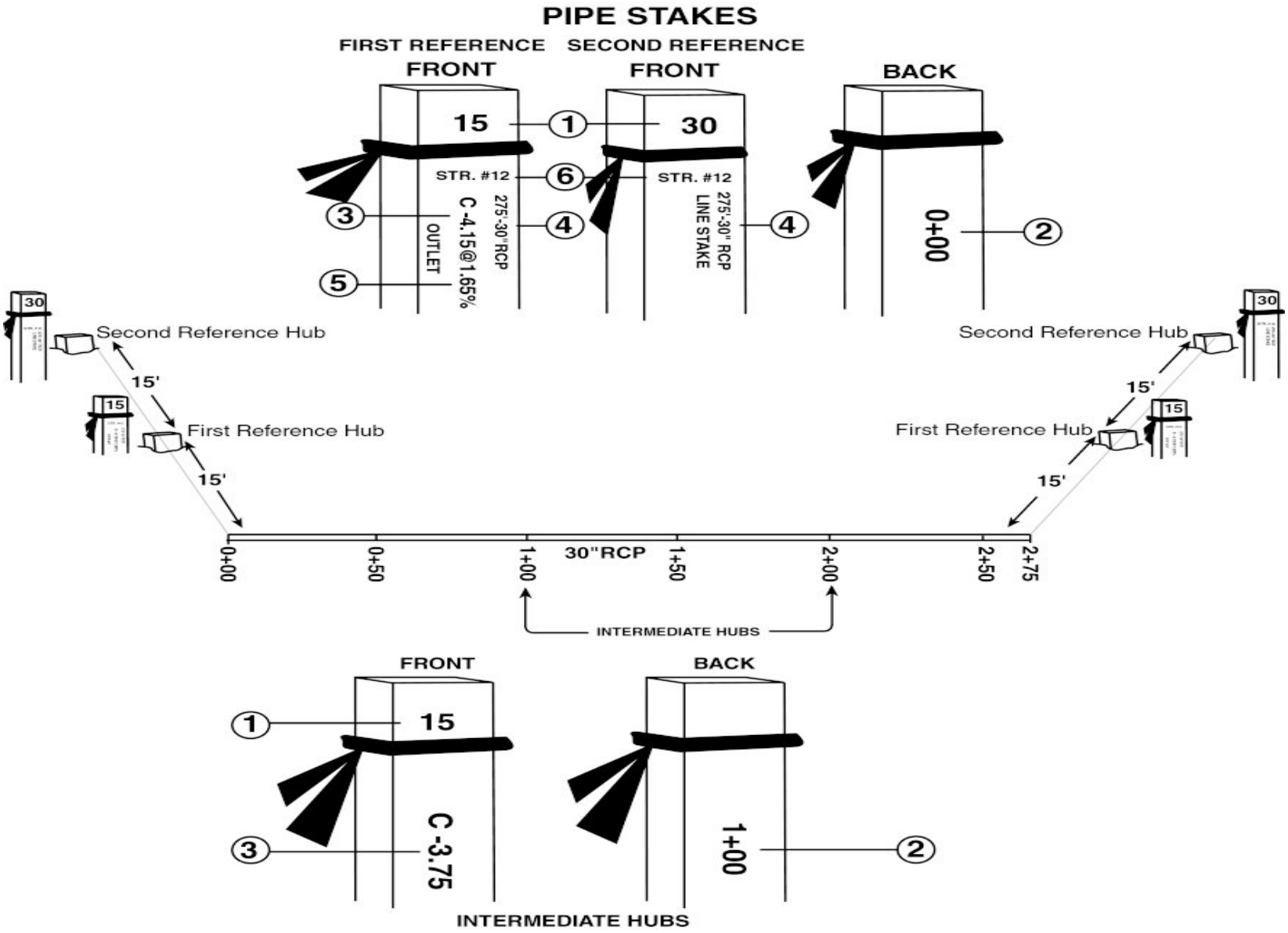

PIPE STAKES
FIRST REFERENCE
SECOND REFERENCE
FRONT
FRONT
BACK
15
30
STR. #12
STR. #12
C -4.15@1.65%
275'-30" RCP
OUTLET
275'-30" RCP
LINE STAKE
0+00
Second Reference Hub
Second Reference Hub
First Reference Hub
First Reference Hub
15'
15'
15'
15'
30"RCP
0+00
0+50
1+00
1+50
2+00
2+50
2+75
INTERMEDIATE HUBS
FRONT
BACK
15
C -3.75
1+00
INTERMEDIATE HUBS

Figure 7.1

Chapter 8
Minor Structure Stakes

8.1 General Information

During construction stakeout, the survey crew should identify potential drainage problems in the field and make recommendations for correction to the Engineer. It is the responsibility of the construction stakeout crew to ensure that the drainage systems detailed in the plans will function properly as staked. Verify the location of all drainage structures within sag verticle curves and reposition as necessary to assure the structure is located at the lowest point. Superelevations at both the roadway and shoulder should be considered in establishing the lowest point. If a concern exists that the drainage system may be inadequate based upon field observations, it should be addressed with the Engineer.

8.2 Guideline Information

Stake each drainage structure independently of each pipeline. Each structure will require a reference line for alignment and grade, consisting of at least one hub on opposite sides of the drainage structure. The hubs should have equal offsets and be a minimum of 10 feet (3 meters) from the reference point. The reference line should mark the centerline of junction boxes and drop inlets, and the inside back wall of catch basins. Grades should be set and referenced from the hubs to top of structure for junction boxes and catch basins, and flow line of grate for drop inlets. Refer to the Standard Drawings for the grate and frame dimensions.

Prior to submitting a drainage system layout drawing, refer to the *Checklist For Drainage Layout Submittal* (located in Appendix A) to verify that all of the required information is included. Unless otherwise approved, calculate the entire network before submitting any portion of the network.

8.3 Type of Stake

Recommended Stake Size: ¾" x 1 ¾" x 36"
Recommended Flagging: Blue
Precision: Horz. 0.01', Vert. 0.01'
Stake Use: Information
Abbreviations: IBW – Inside Back Wall

Recommended Stake Size: 1 ¾" x 1 ¾" x 12" hub with tack
Recommended Flagging: Blue
Precision: Horz. 0.01', Vert. 0.01'
Stake Use: Grade and/or Alignment

8.4 Stake Information

The information described below is detailed in *Figure 8.1*.

1. Offset to the center of the structure
2. Reference line of hubs with respect to drainage structure
3. Cut or fill from hub to invert and top of structure for drop inlets and junction boxes, top of grate for catch basins
4. Structure number

MINOR DRAINAGE STRUCTURE

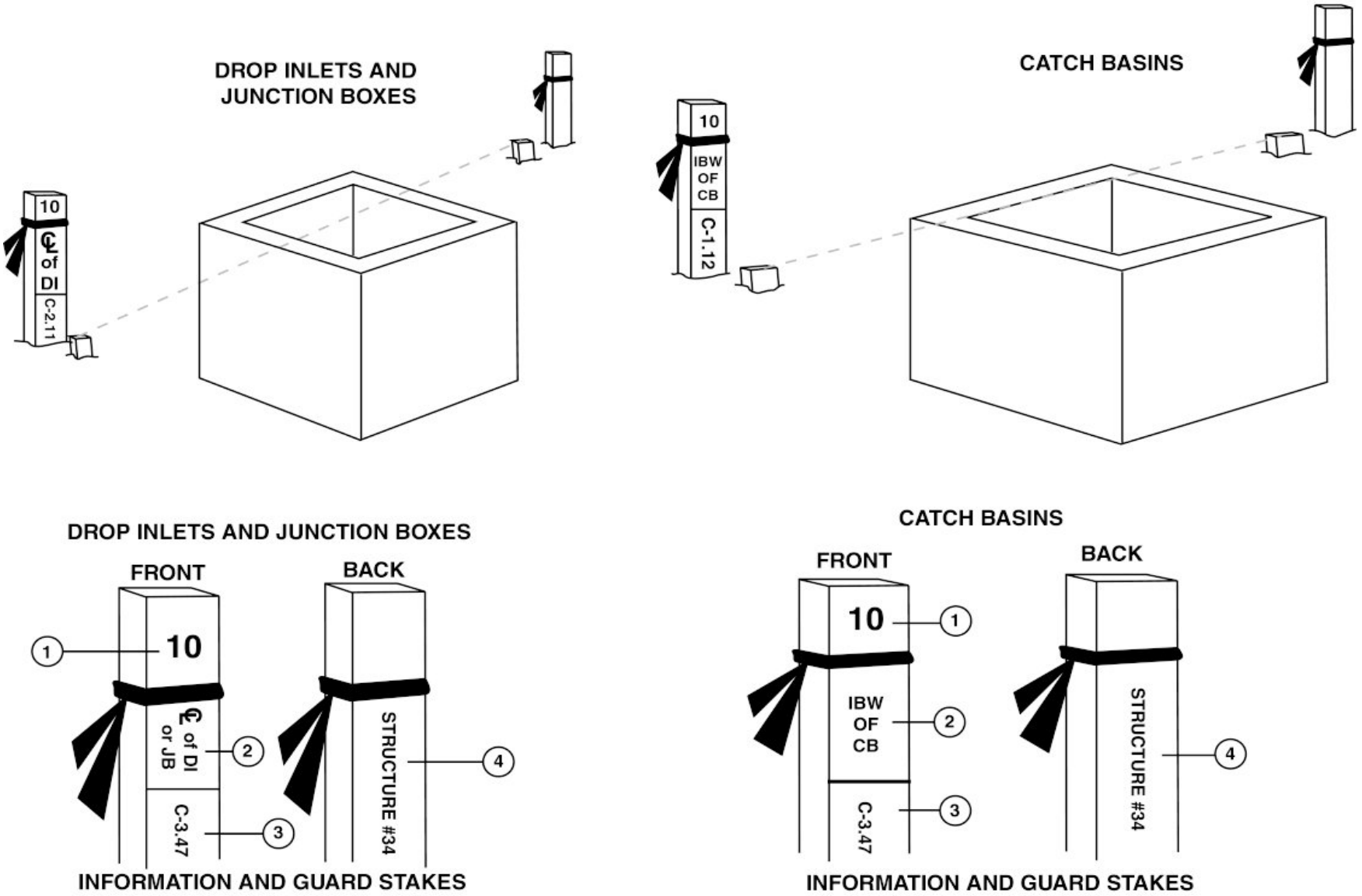


Figure 8.1

Chapter 9
Endwall Stakes

9.1 General Information

Endwalls assist in channeling water into the pipe network, minimizing erosion of the stream channel and retaining the embankment above the pipe. Prior to staking the endwall, you must know the limits of your embankment and pipe.

9.2 Guideline Information

Prior to staking the endwall, set slope stakes to establish the limits of the embankment. Stake endwalls perpendicular to the pipe. Adjust the slope and pipe length to accommodate the endwall. Endwalls require one reference line with a hub on each side of the proposed structure. The line should be referenced to the outside face of the endwall. Grades should be set and referenced from the hubs to a known or calculated elevation on the proposed structure. (See *Figure 9.1*.) When locating the endwall, the fill slope should be projected to intersect with the inside wall of the endwall.

9.3 Type of Stake

Recommended Stake Size: ¾" x 1 ¾" x 36"
Recommended Flagging: Blue
Precision: Horz. 0.01', Vert. 0.01'
Stake Use: Information

Recommended Stake Size: 1 ¾" x 1 ¾" x 12" hub with tack
Recommended Flagging: Blue
Precision: Horz. 0.01', Vert. 0.01'
Stake Use: Grade and/or Alignment

9.4 Stake Information

The information described below is detailed in *Figure 9.2*.

1. Offset to the center, outside face of endwall
2. Cut or fill from hub to reference point on endwall (typically top of wall)

ENDWALL REFERENCING

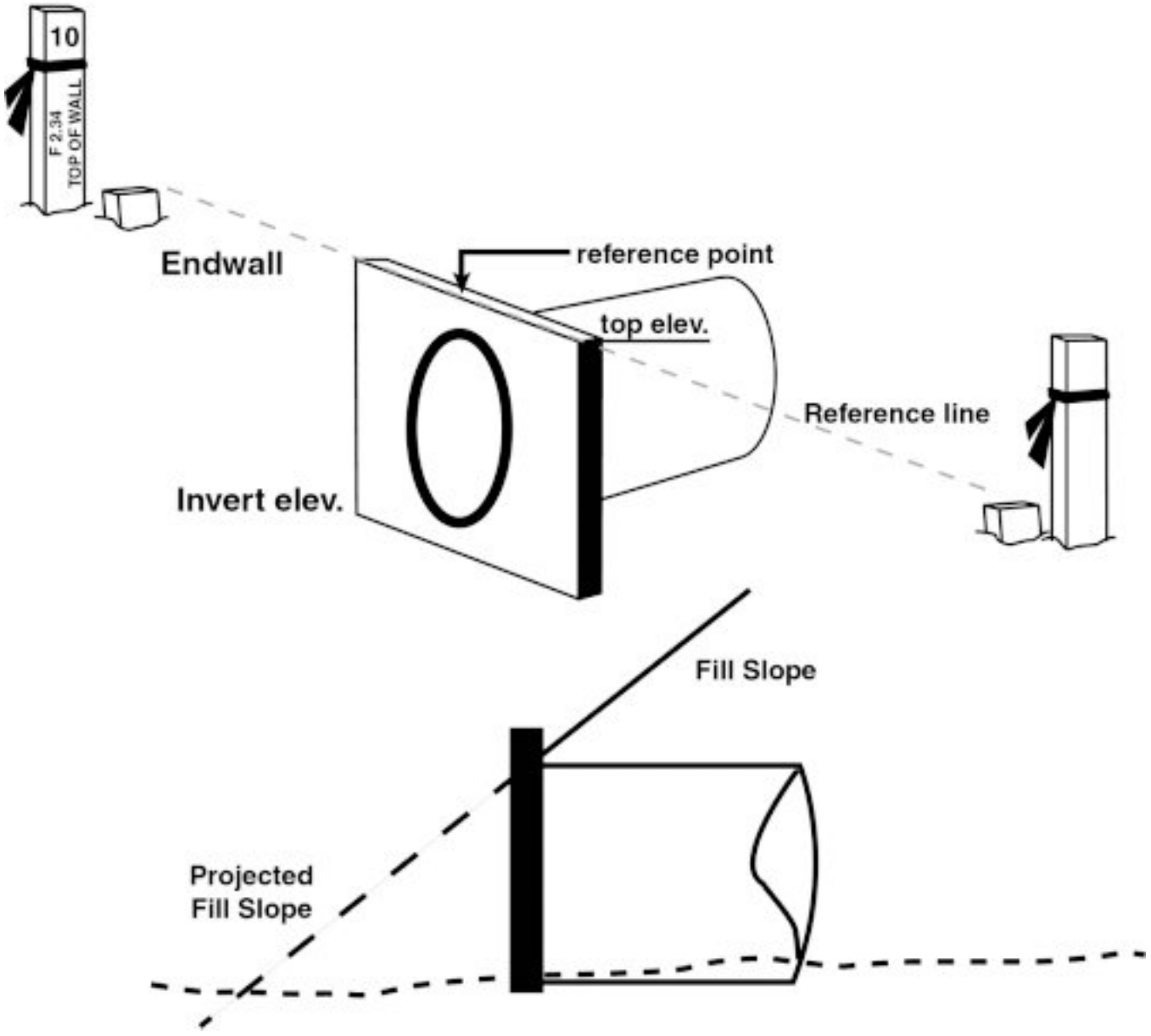


Figure 9.1

ENDWALLS

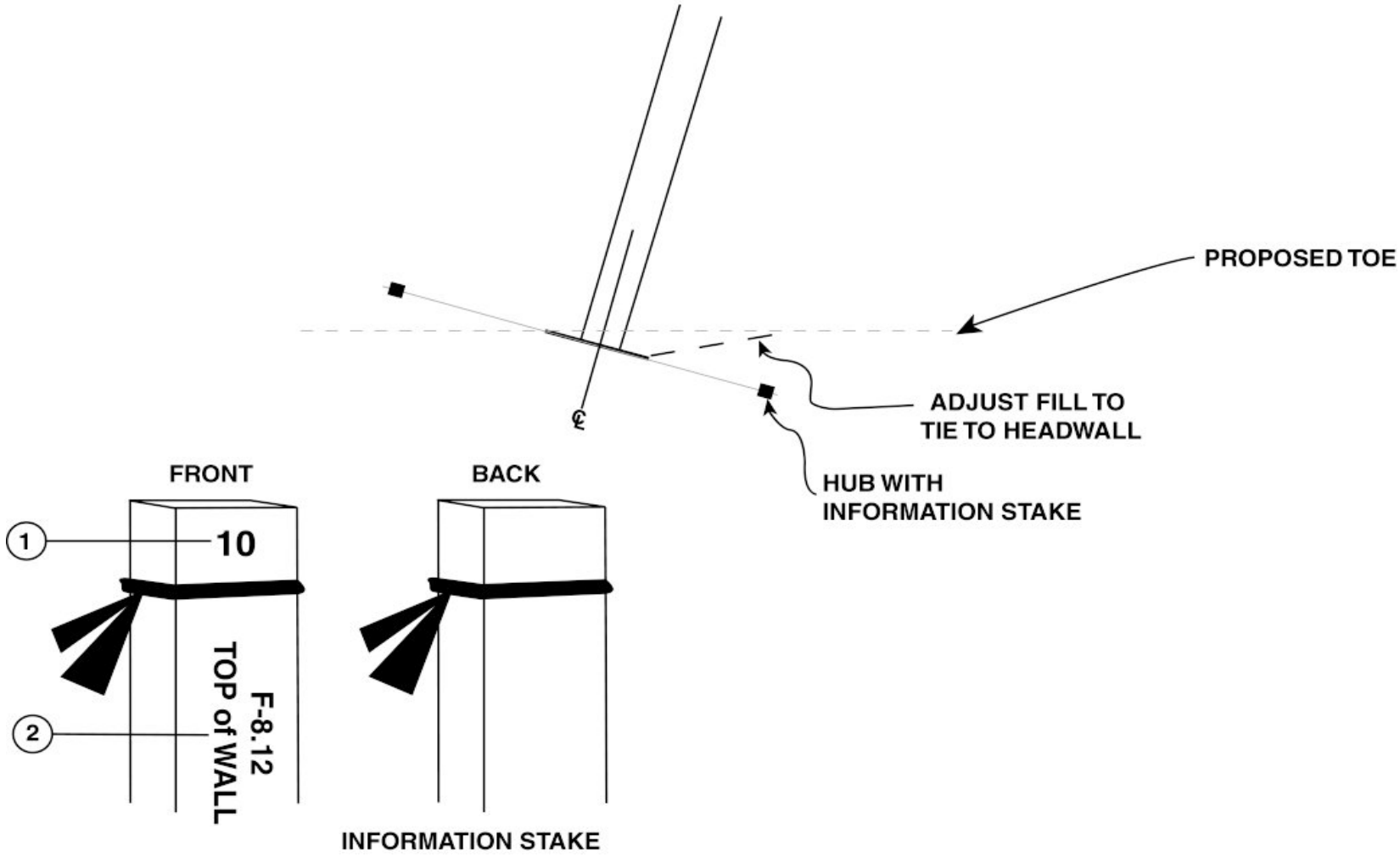


Figure 9.2

Chapter 10
Curb Stakes

10.1 General Information

Various types of curb are specified within GDOT projects to assist in collecting and distributing storm water to a controlled outlet. Although several types of curbs or curb and gutters may be specified, they should be staked uniformly as detailed below.

10.2 Guideline Information

Stake curb and gutter on 50 foot (20 meter) or smaller intervals in sharp radii, tapers and along flat grades as deemed necessary. Intervals may be adjusted by the Engineer to properly construct the project. Stake curb and gutter with a minimum 3 foot (0.9 meters) and maximum 6 foot (1.8 meter) offset. Set hubs with tacks on the offset line used for horizontal and vertical control. Reference grades to the top of the curb and the offset to the back of the curb. Reference will be taken from the tack in the hub.

When staking radii, stake and mark the curve radius point along with the PC point, the PT point and one or more points equally distributed throughout the curve. When staking radii for -Y- lines, the grades along -L- should override those of the -Y- line to facilitate rideability of the -L- line. Adjust the -Y- lines accordingly.

Consult the Standard Drawings for *Curb Slopes for Variable Superelevations.*

10.3 Type of Stake

Recommended Stake Size: ¾" x 1 ¾" x 18"
Recommended Flagging: Orange
Stake Use: Information and Guard

Recommended Stake Size: 1 ¾" x 1 ¾" x 12" with tack
Precision: Horz. 0.01', Vert. 0.01'
Stake Use: Grade and Alignment
Abbreviations: BC back of curb, EP edge of pavement

10.4 Stake Information

The information described below is detailed in *Figure 10.1*

1. Offset to back of curb
2. Cut or fill to top of curb
3. Gutter slope
4. Super elevation of pavement
5. Station number

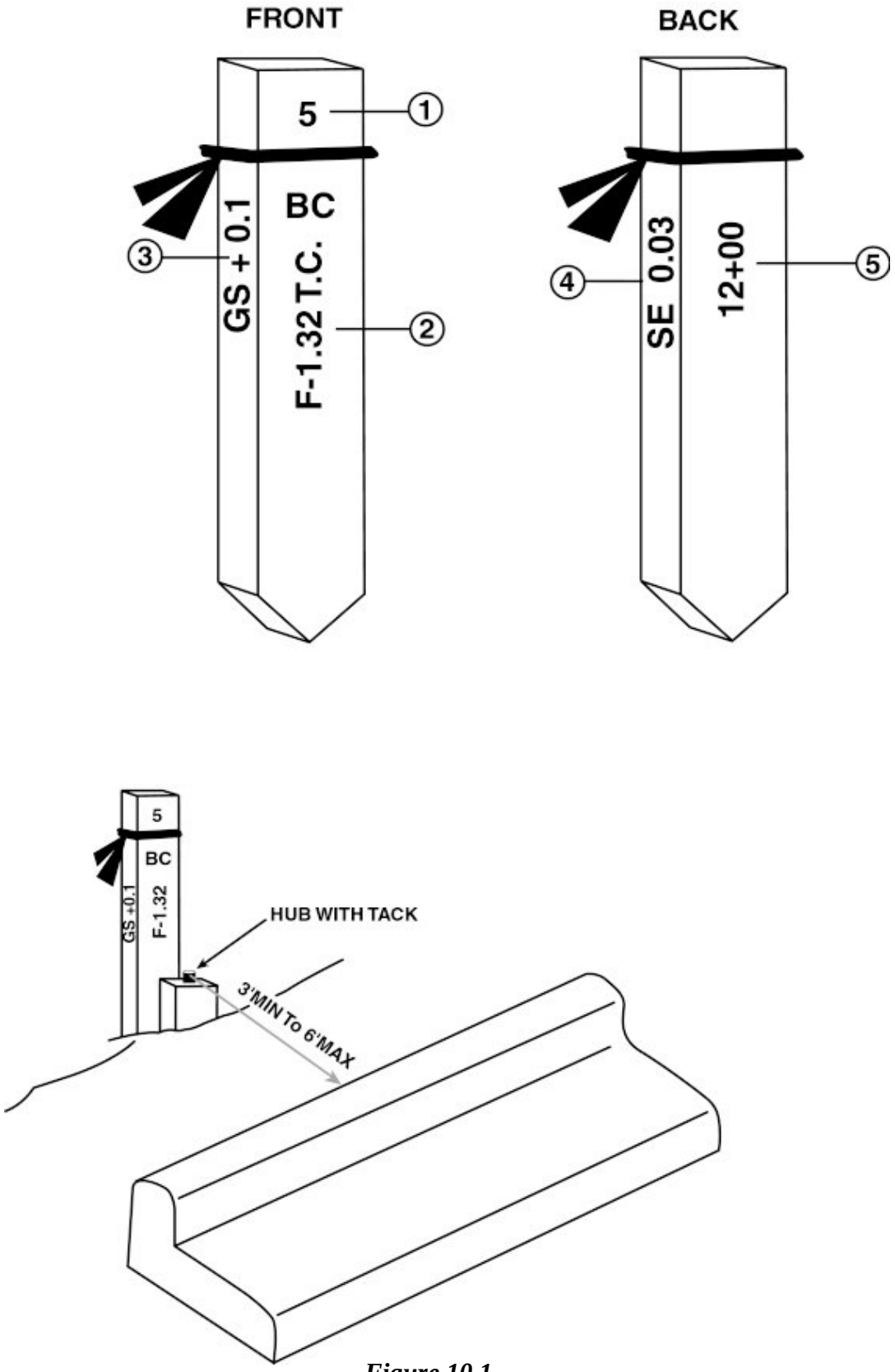

FRONT
BACK
5
BC
GS + 0.1
F-1.32 T.C.
SE 0.03
12+00
1
2
3
4
5
HUB WITH TACK
3'MIN To 6'MAX

Figure 10.1

Chapter 11
Fence Line Stakes

11.1 General Information

The majority of fence on projects will be control of access fence. However, different fences may be specified for Right-of-Way or safety considerations.

11.2 Guideline Information

Set fence stakes at the intervals required by field conditions, not to exceed 100 feet (30 meters). If the control of access and right of way lines differ, set stakes on the control of access line. Otherwise set stakes on the right of way line. Establish the Department's Right-of-Way or controlled access line by using the plans and/or any applicable revisions.

Stake other fences along the alignment detailed in the Plans.

11.3 Type of Stake

Recommended Stake Size: ¾" x 1 ¾" x 18"
Recommended Flagging: White
Precision: Horz. 0.1'
Stake Use: Alignment
Abbreviations: R/W Right of Way, C/A Control Access, L/A Limited Access

11.4 Stake Information

The information described below is detailed in *Figure 11.1*.

1. Denotes type of fence
2. Offset
3. Station and distance from centerline

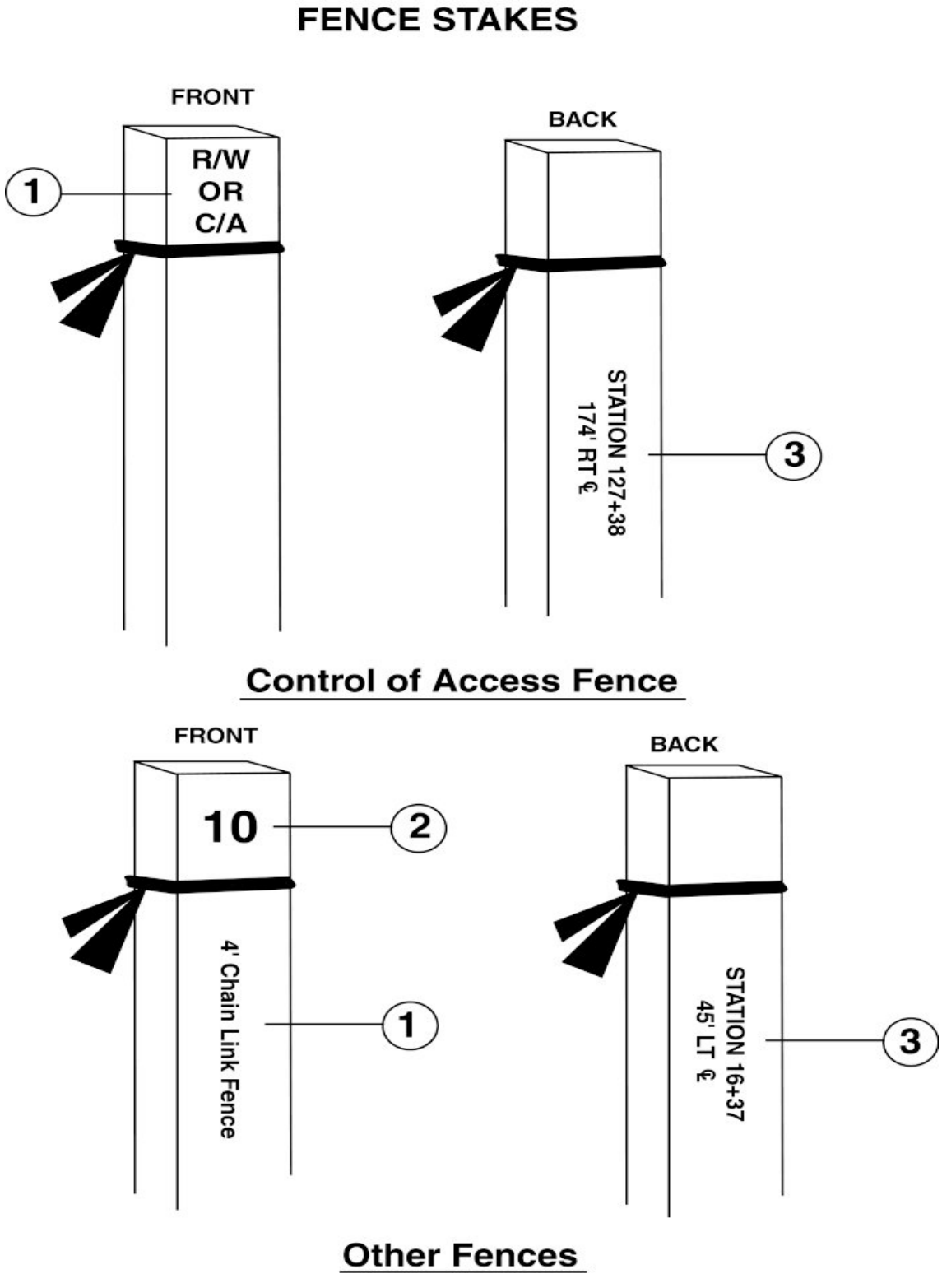

FENCE STAKES
FRONT
R/W
OR
C/A
1
BACK
STATION 127+38
174' RT ℄
3
Control of Access Fence
FRONT
10
2
4' Chain Link Fence
1
BACK
STATION 16+37
45' LT ℄
3
Other Fences

Figure 11.1

Chapter 12
Fine Grade Hubs

12.1 General Information
Fine grade hubs reference the proposed finish elevation. They are used to establish and check the elevation of all layers of the pavement schedule up to the final layer of surface. Typically set upon completion of rough grading, fine grade hubs provide reference for the elevation of all layers of the pavement – including subgrade, base and pavement.

12.2 Guideline Information

Install and reference all fine grade hubs to finish grade. Set fine grade hubs at a maximum 50 foot (20 meter) interval. A smaller interval may be necessary for gores, tapers, and sharp horizontal and vertical curves or superelevation transitions. Set fine grade hubs on a suitable offset from the edge of paved shoulder, but no less than 5 feet (1.5 meters). (See *Figure 12.1* and *12.2*.) Set an intermediate stake at the centerline if the fine grade hubs span more than 60 feet (20 meters) of proposed pavement. Reestablish this intermediate stake after each layer of pavement structure, excluding the final layer of surface course.

Retain and, if necessary, reinstall all fine grade hubs until the completion of the first layer of surface course.

12.3 Type of Stake

Recommended Stake Size: 1 ¾" x 1 ¾" x 12"-24" hub ¾" x 1 ¾" x 18" reference stake
Recommended Flagging: Orange
Precision: Horz. 0.1', Vert. 0.01'
Stake Use: Alignment, Finished Grade and Pavement Slope

12.4 Stake Information

The information described below is detailed in *Figure 12.3*.

1. Offset
2. Cut or fill from reference hub to the proposed projected finished grade, excluding Case III B (cut or fill to proposed grade or crown point elevation)
3. Superelevation
4. Station number
5. Distance to Grade Point or Crown Point
6. Build up (Optional - Case III A)

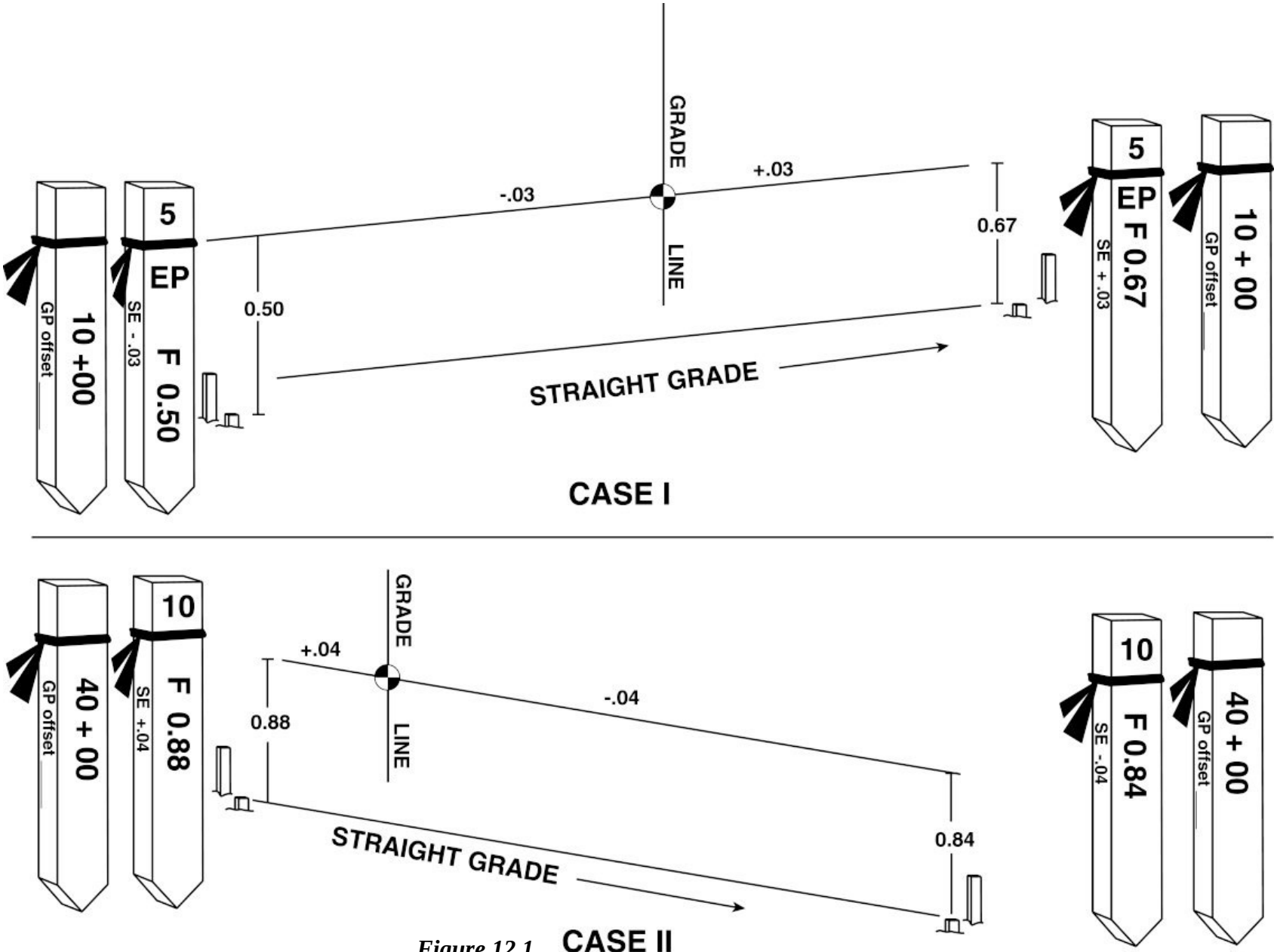

GRADE
LINE
-.03
+.03
0.50
0.67
STRAIGHT GRADE
5
EP
F 0.50
SE - .03
10 +00
GP offset
5
EP
F 0.67
SE + .03
10 + 00
GP offset
CASE I
GRADE
LINE
+.04
-.04
0.88
0.84
STRAIGHT GRADE
10
F 0.88
SE +.04
40 + 00
GP offset
10
F 0.84
SE -.04
40 + 00
GP offset
CASE II

Figure 12.1

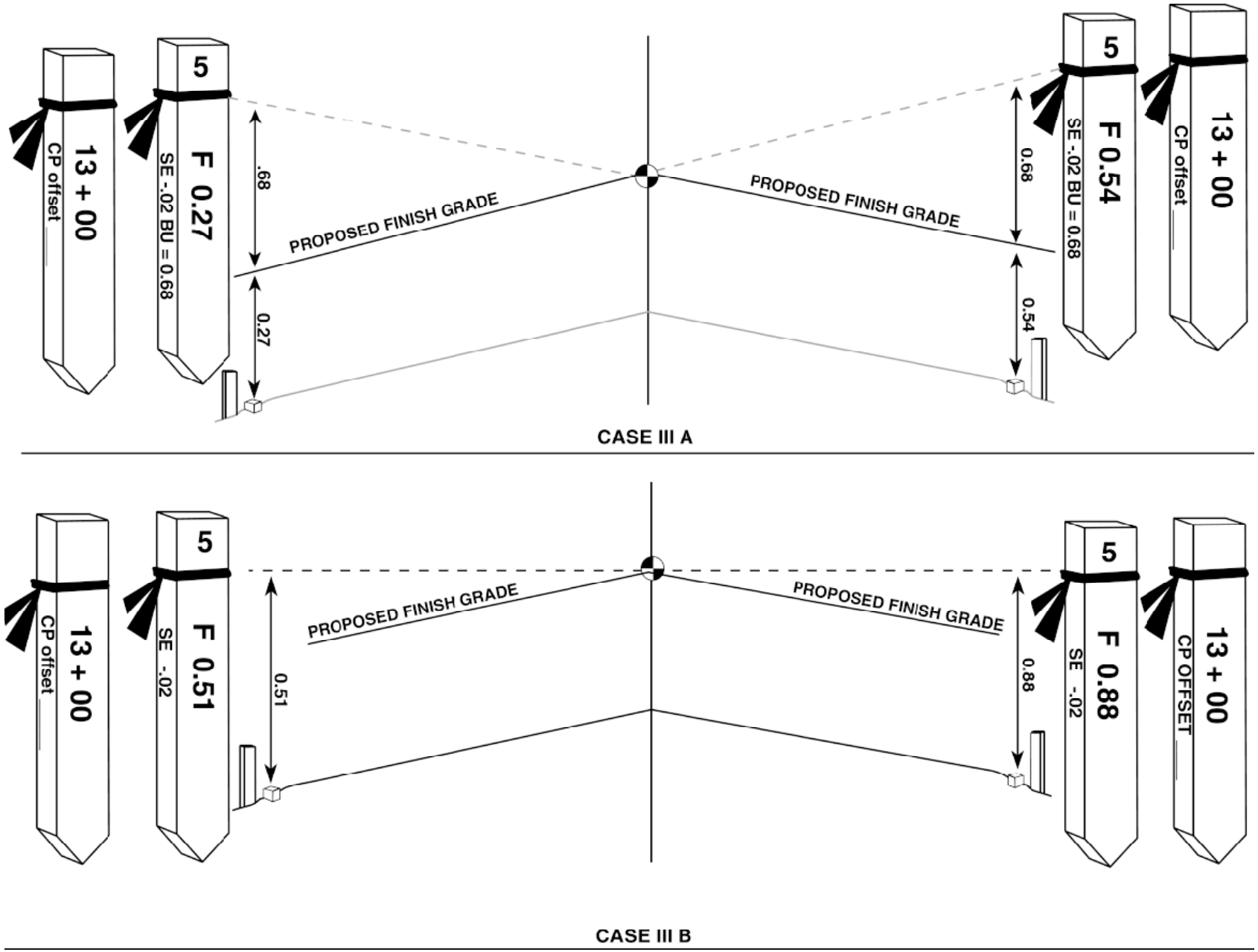

13 + 00
CP offset
5
F 0.27
SE -.02 BU = 0.68
.68
0.27
PROPOSED FINISH GRADE
PROPOSED FINISH GRADE
0.68
0.54
5
F 0.54
SE -.02 BU = 0.68
13 + 00
CP offset
CASE III A
13 + 00
CP offset
5
F 0.51
SE -.02
0.51
PROPOSED FINISH GRADE
PROPOSED FINISH GRADE
0.88
5
F 0.88
SE -.02
13 + 00
CP OFFSET
CASE III B

Figure 12.2

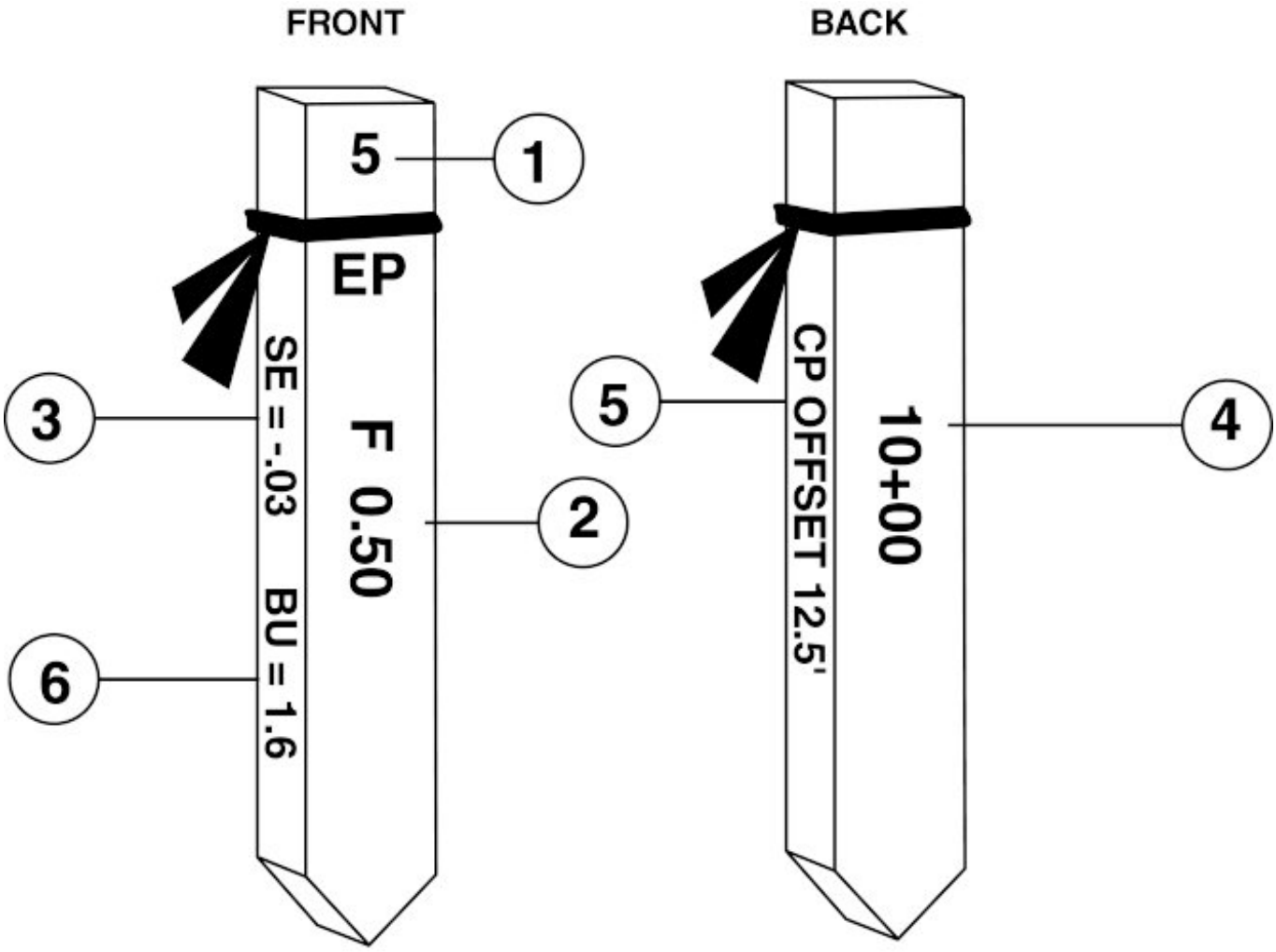


Figure 12.3

Chapter 13
Right-of-Way Markers

13.1 Guideline Information

Reference the location of all proposed Right-of-Way monuments within the construction limits. Submit reference information to the Engineer for review. Submit any Right-of-Way discrepancies between the roadway plans, including any applicable revisions, and the location established by the Department. Unless concrete Right-of-Way markers are specified in the Contract, install a Right-of-Way monument cap and a carsonite witness stake at each proposed location. Mount the monument cap on an 18" long #5 reinforcing bar, which has been driven flush with the top of the ground. Using a hammer, snugly secure the monument cap to the top of the bar. Install a carsonite witness stake adjacent to the Right-of-Way monument, and drive it approximately 12 inches (30 centimeters) into the ground. Avoid damaging the top of the monument cap or witness stake. The Department will provide both the Right-of-Way monument cap and witness stake.

If concrete monuments are specified, install a 60D nail or hub with tack at the proposed monument locations. The Contractor should install additional reference line stakes on opposing sides of the proposed monument location to reference this location during concrete monument installation.

13.2 Type of Stake

Recommended Stake Size: ¾" x 1 ¾" x 18"
Recommended Flagging: White
Precision: ————————
Stake Use: Information and Guard

Recommended Stake Size: 1 ¾" x 1 ¾" x 12" with tack or 60D Nail
Recommended Flagging: White
Precision: Horz. 0.01'
Stake Use: Location

13.3 Stake Information

The information described below is detailed in *Figure 13.1*.

1. Denotes type of stake (Right-of-Way)
2. Alignment
3. Offset from survey line
4. Station
5. Monument cap
6. 18" long #5 reinforcing bar
7. Carsonite witness stake

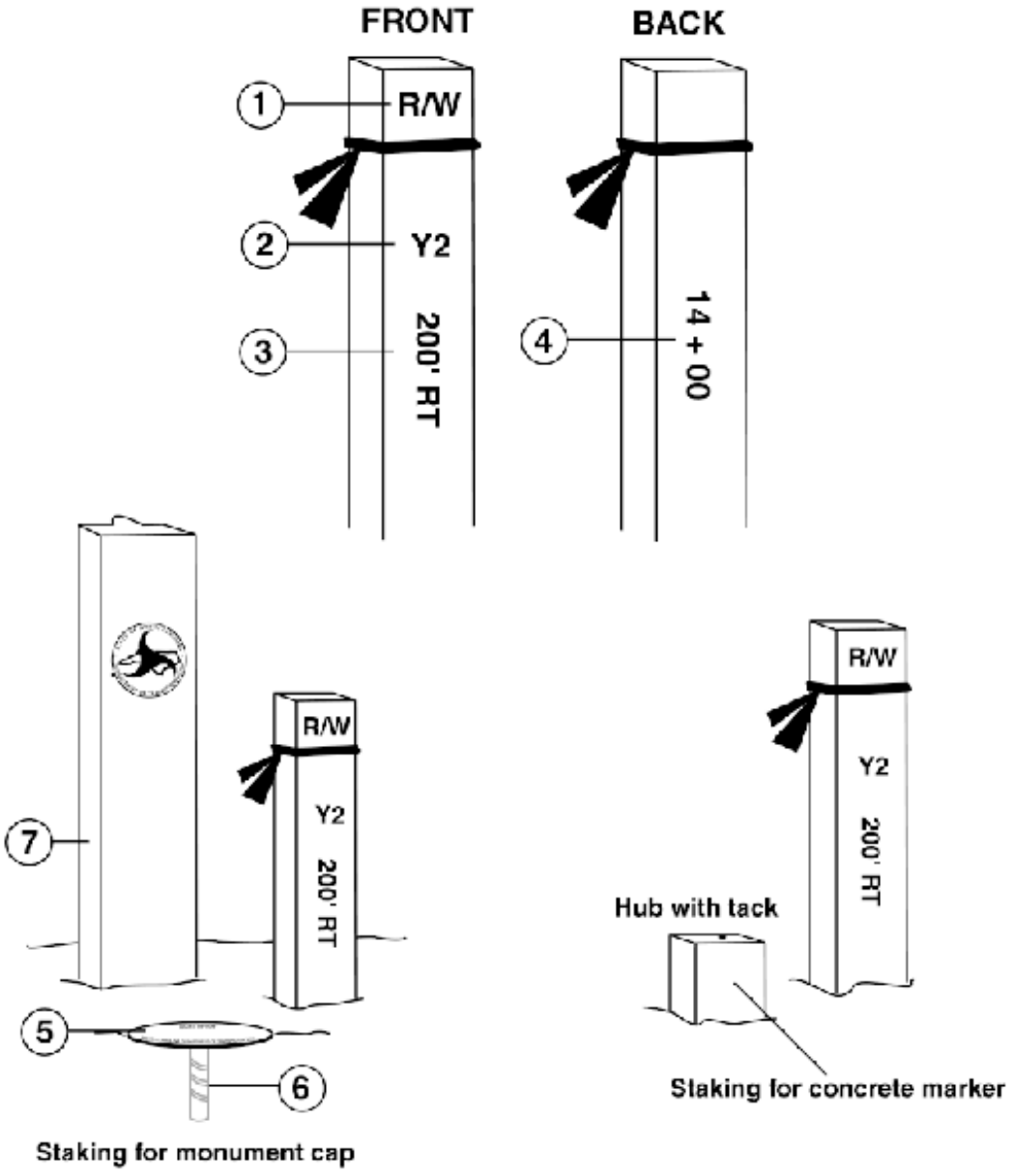


Figure 13.1

35

Chapter 14
Signs

14.1 General Information

The s-dimensions and support lengths detailed in the plans are used for estimating purposes only and are not intended for fabricating supports. Prior to sign support fabrication, the s-dimensions should be verified by either theoretical calculation or field measurement and should be submitted to Traffic Engineering for review. Once verified by the Contractor and reviewed by the Department, sign plan revisions will be provided to the Contractor for the fabrication of ground mounted supports and design of overhead sign structures.

14.2 Guideline Information

Prior to establishing the s-dimensions, stake the horizontal location of the proposed signs for the Engineer's review. Perform a thorough investigation of the proposed sign locations, or revised locations established during the Engineer's review. Identify any obstruction, either existing or proposed, which may interfere with the proposed sign installation. Such items may include, but are not limited to, existing or proposed drainage systems, underground and/or aboveground utilities, and drainage ditches. If adjustments in the sign locations are warranted to avoid obstacles, advise the Engineer in writing. Include a detailed sketch of the proposed sign location, the obstruction and the new location recommended to avoid the obstruction. Do not revise any sign locations without the written direction of the Engineer.

Once proposed overhead sign locations are confirmed, use the roadway plans to calculate the theoretical finished elevations at that station. Consider the following in calculating the theoretical finished section:

- Proposed lane and shoulder widths, including any tapers or widening for guardrail roadway
- Superelevations
- Shoulder rollovers
- Side ditches
- Barrier rail sections
- Slope gradients
- Any other items which may affect the span length or elevation of the proposed sign

14.3 Overhead Sign Assemblies

Layout the overhead sign assemblies as detailed in the Contractor's approved shop drawings. Provide reference line for the footings, which consists of a minimum of two hubs with corresponding reference stakes. Reference the center of the sign footing. The first reference hub shall be a minimum of 10 feet (3 meters) from the reference point with the second hub installed at an equal distance from the first hub. Grades should be set and referenced from the hubs to a known or calculated elevation of the proposed footing. (See *Figure 14.2*)

14.4 Ground Mounted Signs (Type A and B)

The s-dimension for ground mounted signs represents an increase (+) or decrease (-) in support length relative to the elevation of the edge of the outside travel lane, not the outside edge of the paved shoulder. (See *Figure 14.1*.) Reference the *Typical Elevation Ground Mounted Sign* detail located within the project Signing Plans. Submit to the Engineer, in tabular format, the s-dimensions for each support within the proposed Type A and B ground mounted signs. Provide reference line for the footings, which consists of a minimum of two hubs with corresponding reference stakes. Reference the center of the sign footing. The first reference hub shall be a minimum of 10 feet (3 meters) from the reference point with the second hub installed at an equal distance from the first hub. Grade information is typically not required. (See *Figure 14.3.*)

14.5 Ground Mounted Signs (Type D, E and F)

S-dimensions are not required for Type D, E and F Ground Mounted Signs.
Provide location of ground mounted signs. Install an information stake at the proposed sign location. (See *Figure 14.4*.)

14.6 Type of Stake

Recommended Stake Size: 1 ¾" x 1 ¾" x 12" hub
Precision: Horz. 0.01', Vert. 0.01'
Stake Use: Grade and/or Alignment

Recommended Stake Size: ¾" x 1 ¾" x 18"
Recommended Flagging: Pink
Stake Use: Information and Location

14.7 Stake Information

The information described below is detailed in *Figure 14.5*.

1. Offset to center of footing
2. Grade to known or calculated elevation of footing (typically not required for ground mounted signs)
3. Distance to centerline
4. Station
5. Alignment

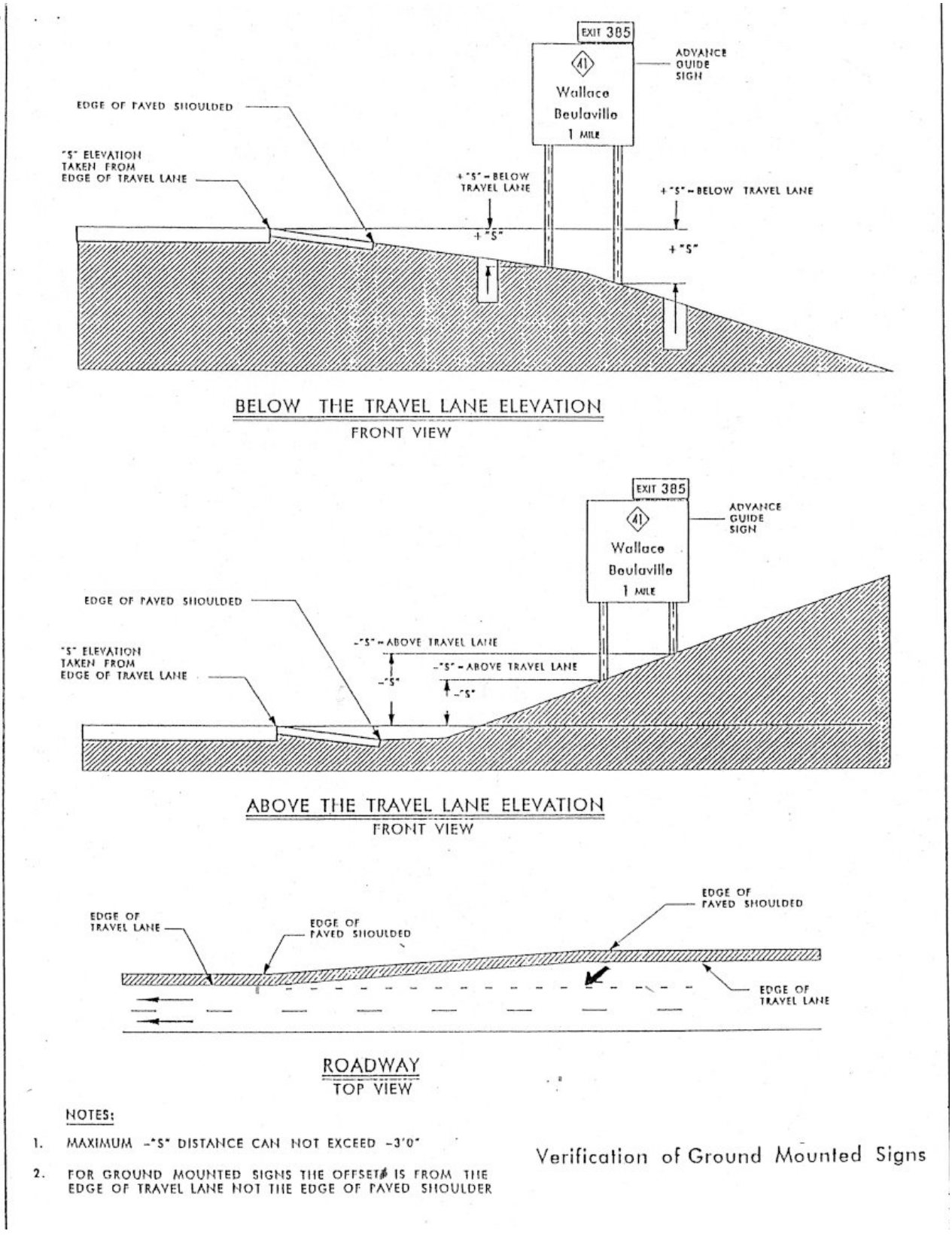

EXIT 385
41
Wallace
Beulaville
1 MILE
ADVANCE GUIDE SIGN
EDGE OF PAVED SHOULDED
"S" ELEVATION TAKEN FROM EDGE OF TRAVEL LANE
+"S" - BELOW TRAVEL LANE
+"S"
+"S" - BELOW TRAVEL LANE
+"S"
BELOW THE TRAVEL LANE ELEVATION
FRONT VIEW
EXIT 385
41
Wallace
Beulaville
1 MILE
ADVANCE GUIDE SIGN
EDGE OF PAVED SHOULDED
"S" ELEVATION TAKEN FROM EDGE OF TRAVEL LANE
-"S" - ABOVE TRAVEL LANE
-"S"
-"S" - ABOVE TRAVEL LANE
-"S"
ABOVE THE TRAVEL LANE ELEVATION
FRONT VIEW
EDGE OF TRAVEL LANE
EDGE OF PAVED SHOULDED
EDGE OF PAVED SHOULDED
EDGE OF TRAVEL LANE
ROADWAY
TOP VIEW
NOTES:
1. MAXIMUM -"S" DISTANCE CAN NOT EXCEED -3'0"
2. FOR GROUND MOUNTED SIGNS THE OFFSET IS FROM THE EDGE OF TRAVEL LANE NOT THE EDGE OF PAVED SHOULDER
Verification of Ground Mounted Signs

Figure 14.1

Overhead Signs

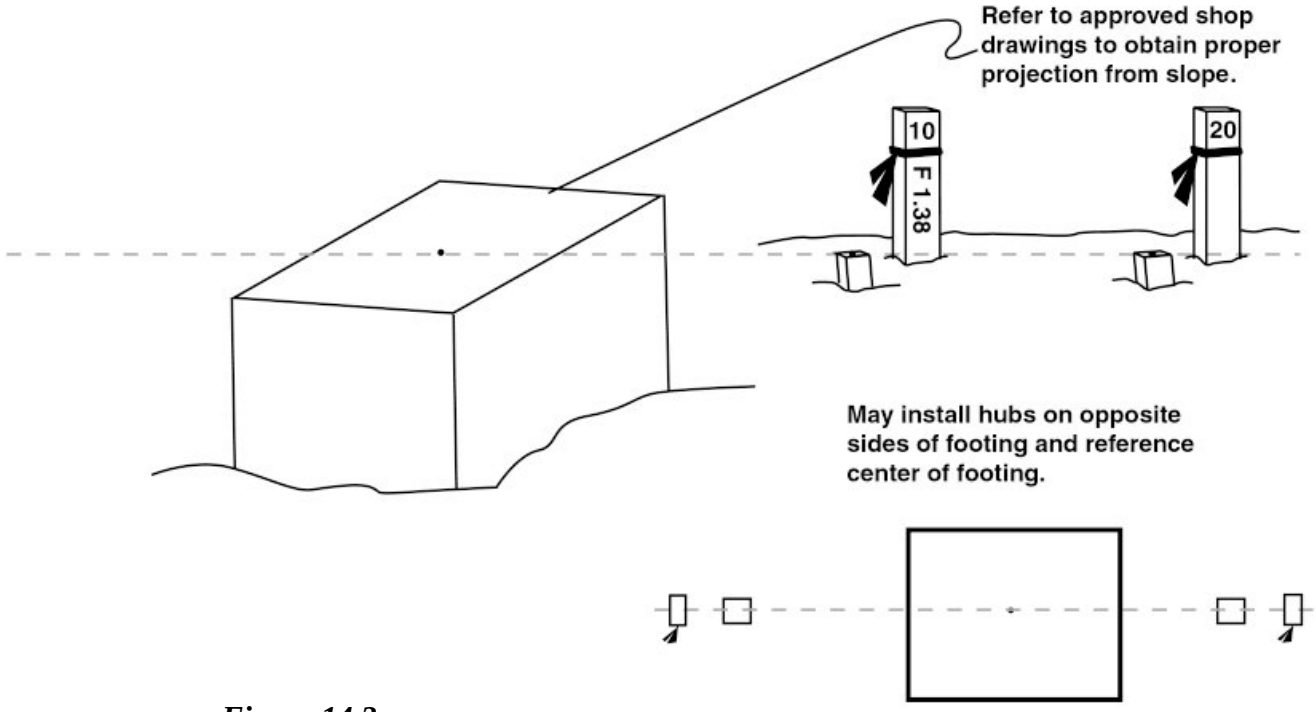


Figure 14.2

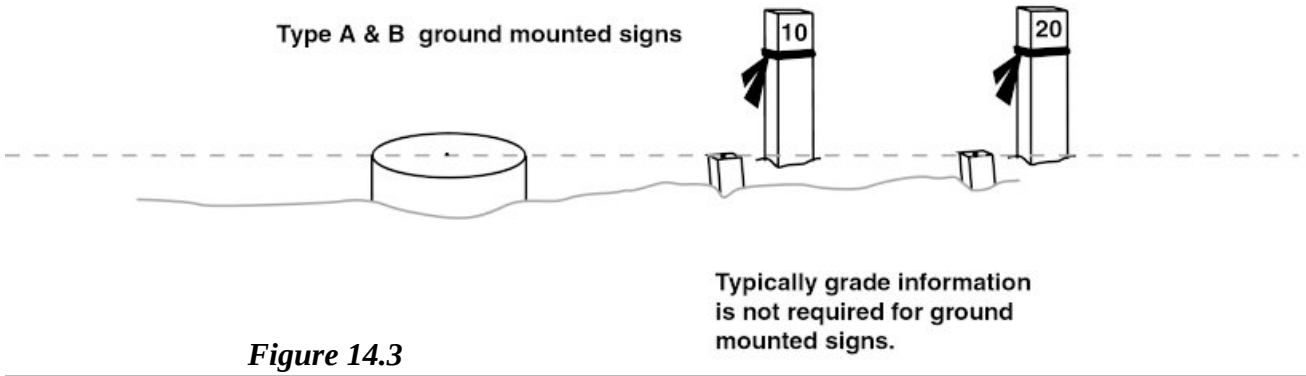


Figure 14.3

Type D, E and F Ground mounted signs

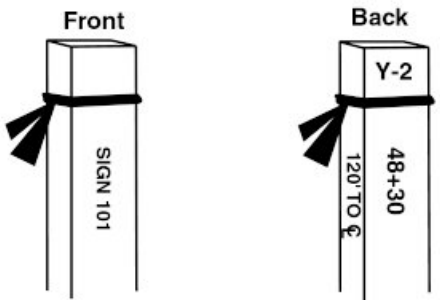


Figure 14.4

Sign Stakes

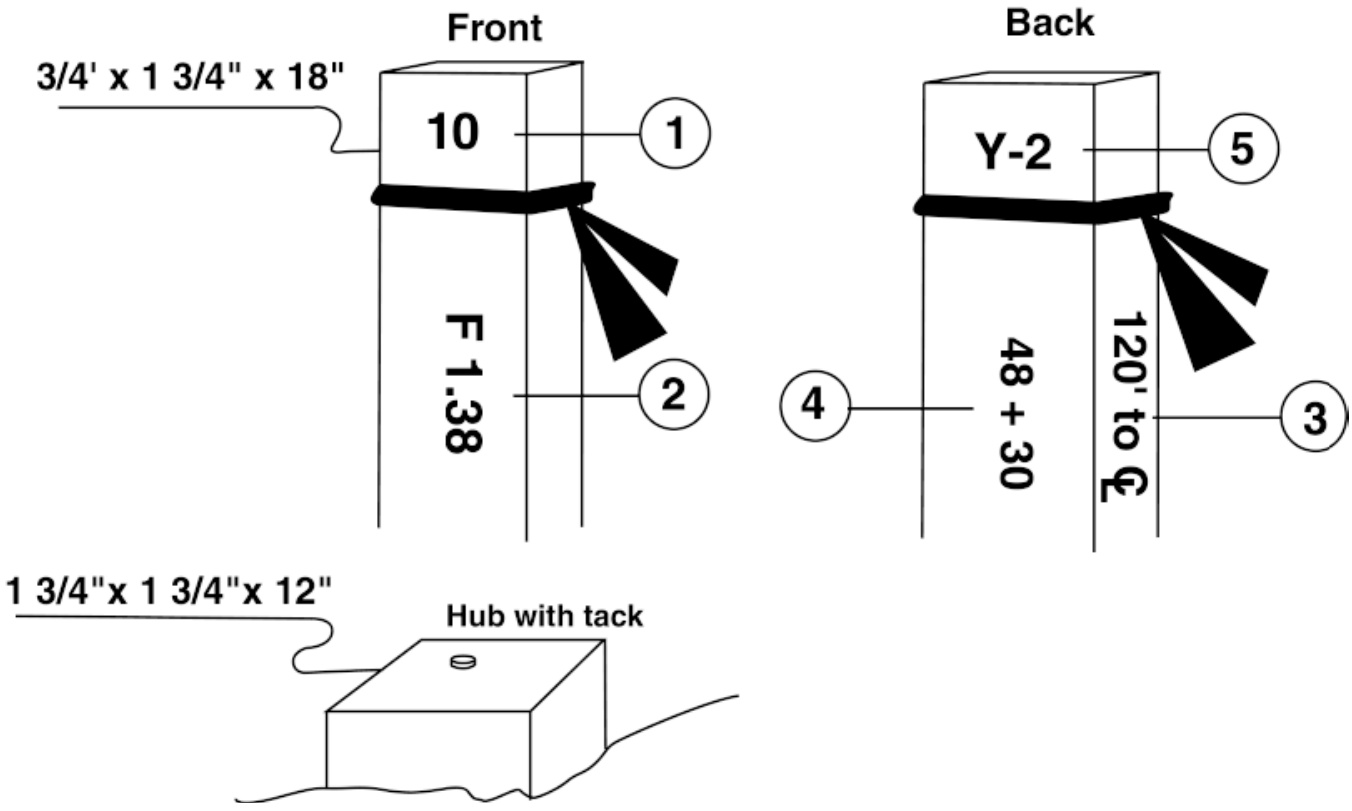


Figure 14.5

Chapter 15
Major Structure Stakes

15.1 Guideline Information

All major structures will be staked with reference lines which contain at least three (3) reference hubs on each side with tacks. These hubs should be spaced equally apart at adequate intervals. Reference hubs shall be checked for accuracy after sitting all winter. If two structures are side by side, then the reference hubs for each bridge should be color coordinated to eliminate confusion.

Bridge Stake Out

Bridge stake out will contain two reference lines for each end bent, interior bent, and the long chord line. (See *Figures 15.1a* and *15.1b*.) Set a minimum of one (1) temporary benchmark to remain in place throughout the entire bridge construction. One benchmark is to be used for substructure and one for superstructure.

Construction elevations are furnished from Structure Design for all bridges except cored slabs and should be used as follows:

> **Bottom of slab grades** will be used to determine build ups at tenth points along each girder of each span. (See *Figure 15.2*.) The build up will be the difference between 1) the theoretical bottom of slab grade plus the dead load deflection due to weight of deck and rail, and 2) the actual in field elevation of the respective tenth point on each girder.
>
> **Overhang grades** are given for every 4' interval along the lower outer most point of the proposed overhang. (See *Figure 15.3*.) These grades are given in respect to centerline stations. In order to locate these overhang locations correctly, a reference point on each of the proposed overhangs must be determined according to centerline station, from which the other overhang points can be laid off.
>
> **Header grades** are given along the skew of the proposed header, to the finished top of slab grade. (See *Figure 15.4*.)
>
> **Drilled shafts** should be staked only after bridge stake out is complete. Each drilled shaft should be referenced individually so that casing and reinforcing steel alignment can be checked during drilling and casting operations. Each drilled shaft stake out will contain two reference lines with two reference points on either side. If field conditions do not permit this type of referencing, then the Contractor should consult the Resident Engineer with a proposed method of referencing and receive approval.

Approach slab grades also are given to the finished slab grade. (See *Figure 15.4*.) It is important to check a point on the actual deck, at either end of the structure, which is relative to a given approach slab elevation in order to determine any necessary minor adjustment to the approach slab.

Culvert Stake Out

The grade that is provided on the structural plans is referenced to the centerline invert of the culvert. The length of the culvert should be checked to ensure that it intercepts the roadway slope properly. Culvert stake out will contain a reference line for the centerline of barrel and for each culvert headwall face. Each reference point should refer to the intersection point of the centerline of the barrel reference line and the face of the culvert headwall reference line. Grades set on the hubs referencing the face of the culvert headwall will be set in reference to the top of the headwall or curtain wall. Intermediate hubs for culverts over 100' in length will be set at even intervals no greater than 50'+/- apart or at the construction joints. (See *Figure 15.5*.) Grades set on the centerline offset hubs shall reference the proposed elevation of the culvert invert. For deep fills camber should be taken into consideration and compensated in accordance with the camber table detailed in the Appendix. Plan inverts should not be adjusted without consulting the Engineer due to environmental permit requirements.

Wall Stake Out

Noise walls, reinforced earth walls and retaining walls will be staked with a reference line to the face of the wall or as noted in the structure plans or as otherwise needed for construction. Existing ground elevations shown in the plans shall be verified for accuracy. For pile/panel type walls three (3) offsets shall be provided for each pile. All critical elevations shall be referenced, including, but not limited to, top of wall/ coping, bottom of shaft/pile, etc.

15.2 Type of Stake

Recommended Stake Size: ¾" x 1 ¾" x 18"
Recommended Flagging: Color Coordinated
Precision: ——————
Stake Use: Information

Recommended Stake Size: 1 ¾" x 1 ¾" x 12"
Recommended Flagging: Color Coordinated
Precision: Horz. 0.01', Vert. 0.01'
Stake Use: Alignment and Grade

Recommended Stake Size: ¾" x 1 ¾" x 48"
Recommended Flagging: Color Coordinated
Precision: ——————-
Stake Use: Guard

TYPICAL BRIDGE - TANGENT SURVEY LAYOUT

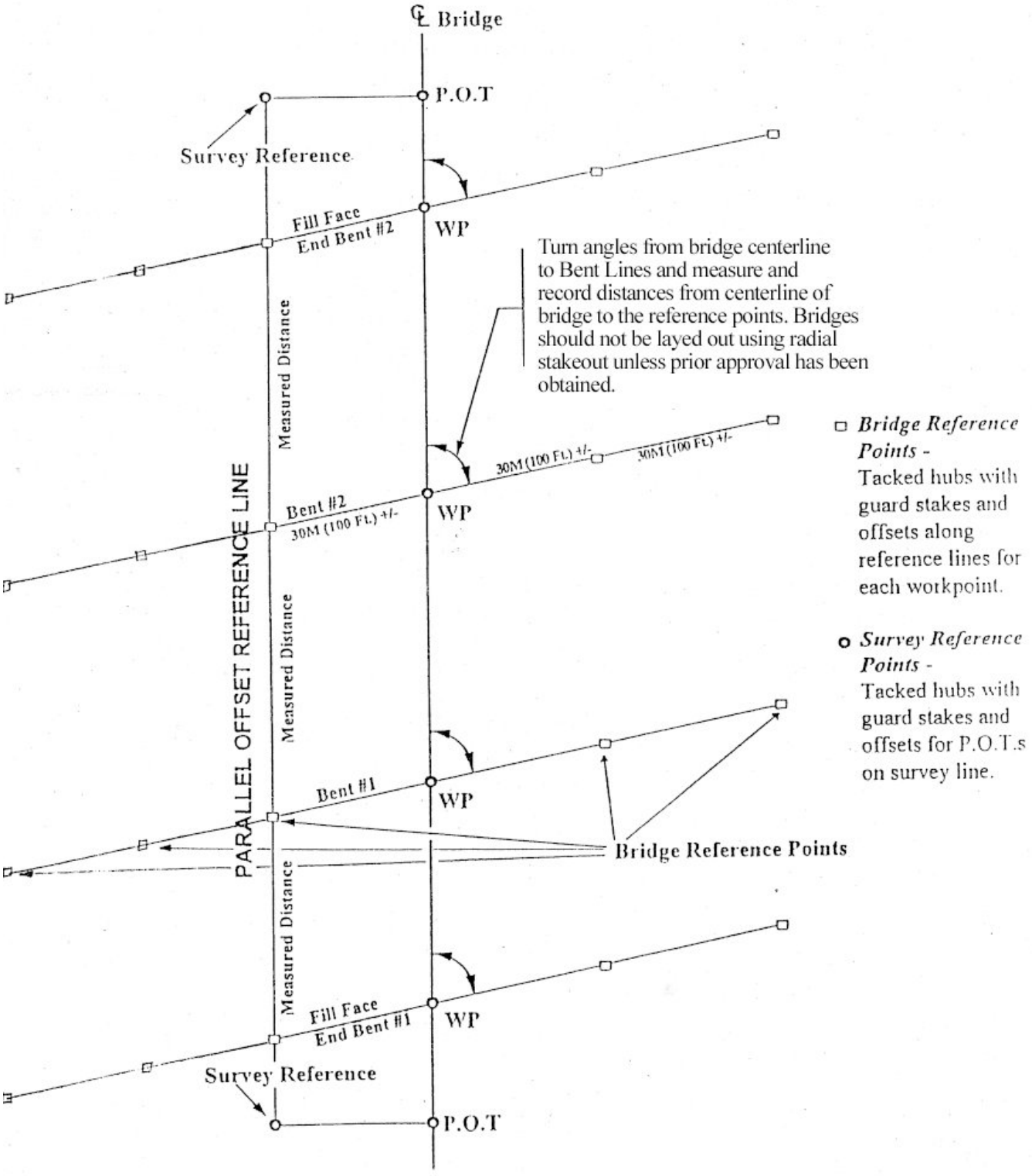


Figure 15.1a

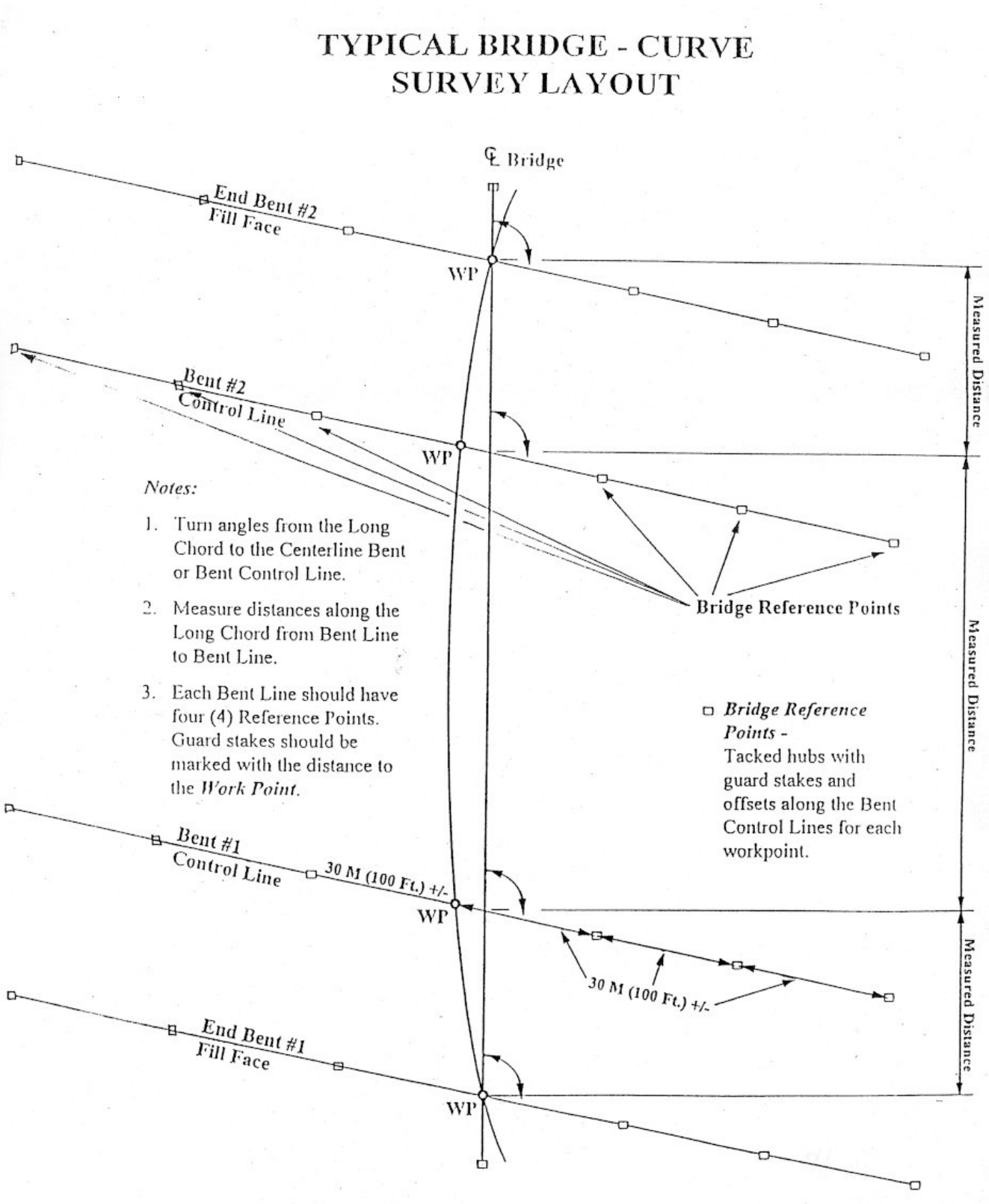
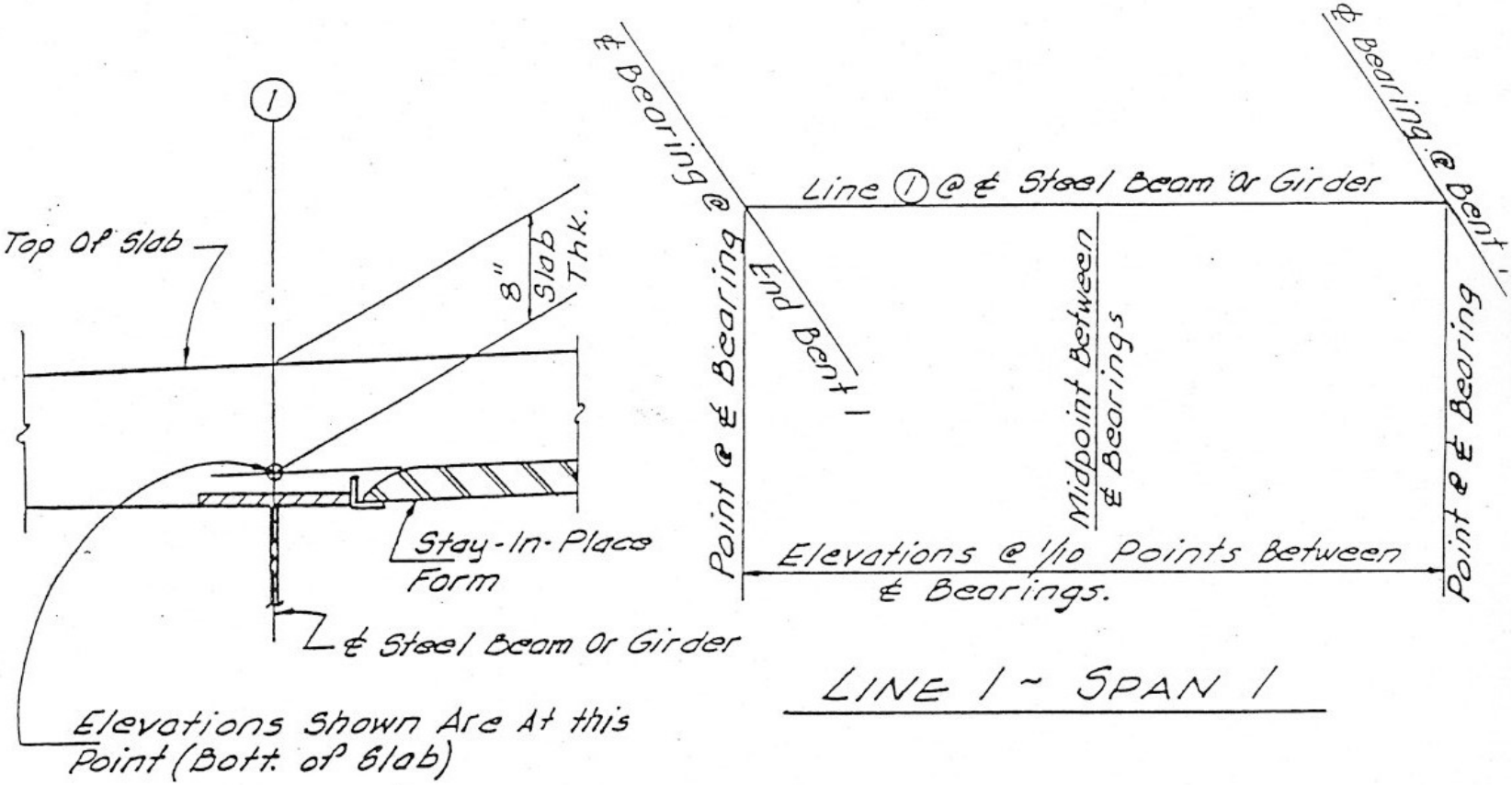

TYPICAL BRIDGE - CURVE
SURVEY LAYOUT
℄ Bridge
End Bent #2
Fill Face
WP
Measured Distance
Bent #2
Control Line
WP
Notes:
1. Turn angles from the Long Chord to the Centerline Bent or Bent Control Line.
2. Measure distances along the Long Chord from Bent Line to Bent Line.
3. Each Bent Line should have four (4) Reference Points. Guard stakes should be marked with the distance to the Work Point.
Bridge Reference Points
Measured Distance
Bridge Reference Points -
Tacked hubs with guard stakes and offsets along the Bent Control Lines for each workpoint.
Bent #1
Control Line
30 M (100 Ft.) +/-
WP
30 M (100 Ft.) +/-
Measured Distance
End Bent #1
Fill Face
WP

Figure 15.1b



CONSTRUCTION ELEVATIONS

SPAN 1, BEAM 1 OR GIRDER 1 SHOWN

OTHER SPANS AND BEAMS OR GIRDERS SIMILAR

PROJECT NO.: 8.1414607 COUNTY: DURHAM

STATION: 166+62.40-L-REV. ASSEMBLED BY D.B. SIMPSON, JR.

Figure 15.2

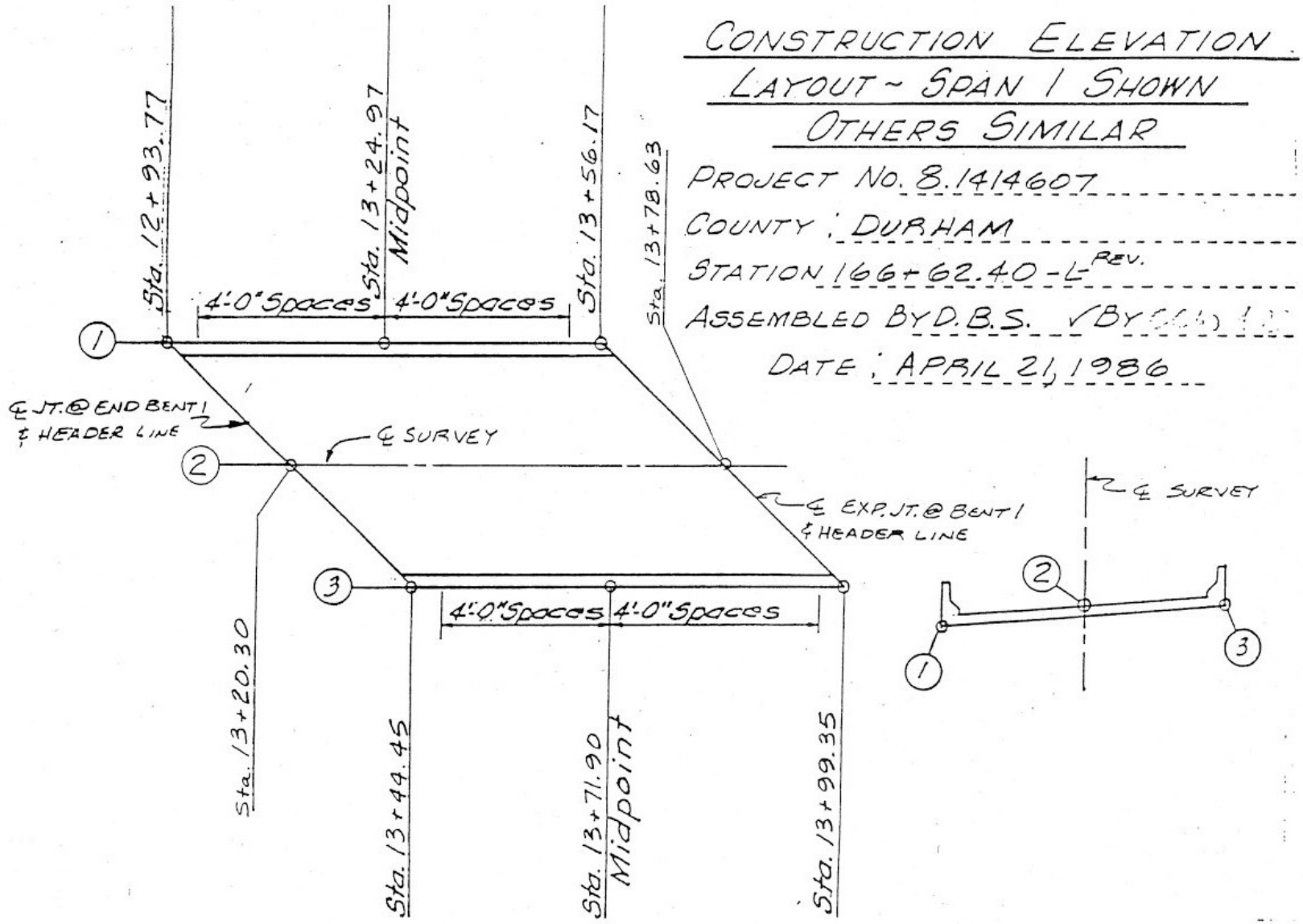

CONSTRUCTION ELEVATION
LAYOUT ~ SPAN 1 SHOWN
OTHERS SIMILAR
PROJECT NO. 8.1414607
COUNTY : DURHAM
STATION 166+62.40 -L- REV.
ASSEMBLED BY D.B.S. √BY
DATE : APRIL 21, 1986
Sta. 12+93.77
Sta. 13+24.97 Midpoint
Sta. 13+56.17
Sta. 13+78.63
4'-0" Spaces
4'-0" Spaces
℄ JT. @ END BENT 1 & HEADER LINE
℄ SURVEY
℄ EXP. JT. @ BENT 1 & HEADER LINE
4'-0" Spaces
4'-0" Spaces
Sta. 13+20.30
Sta. 13+44.45
Sta. 13+71.90 Midpoint
Sta. 13+99.35
℄ SURVEY
1
2
3

Figure 15.3

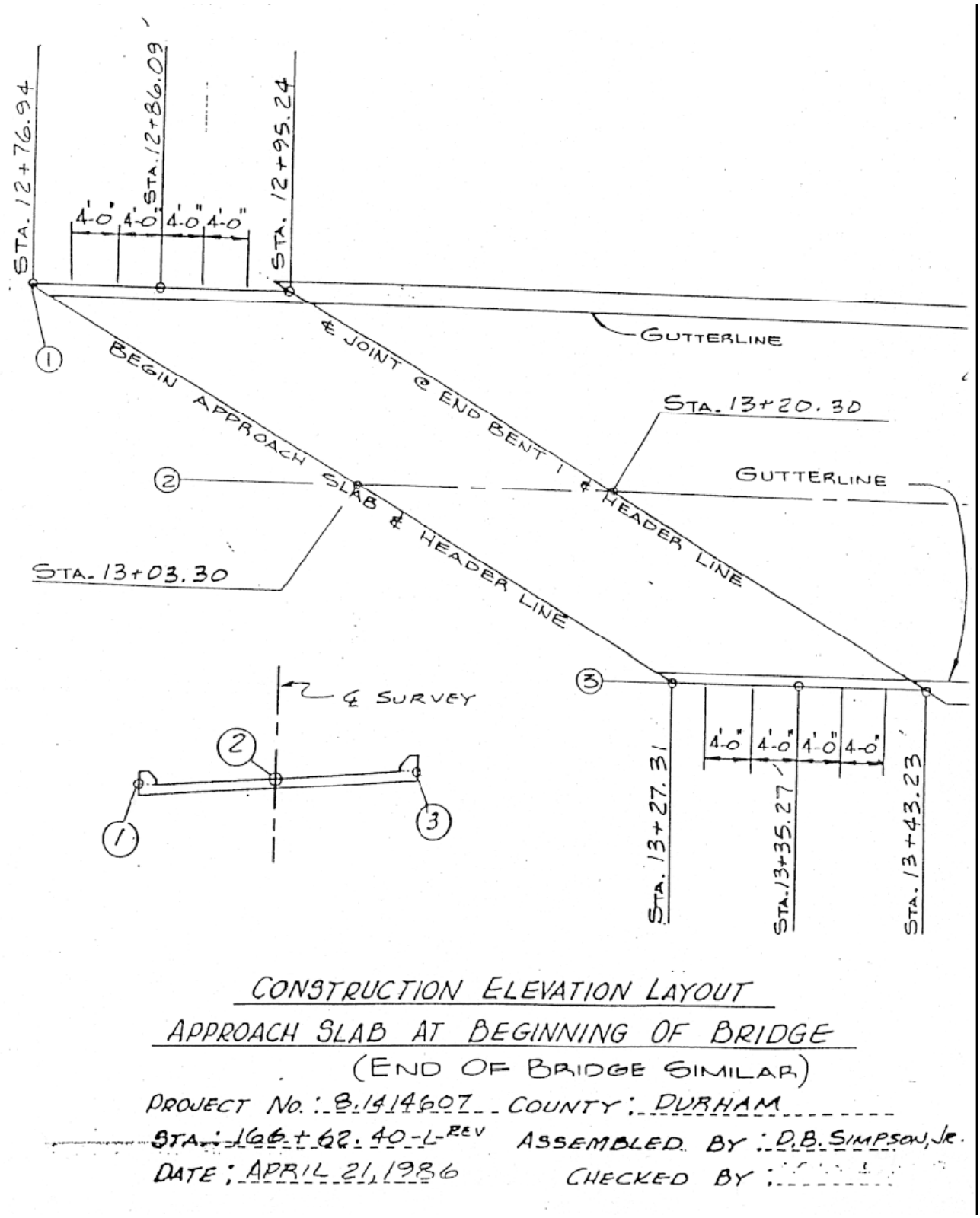
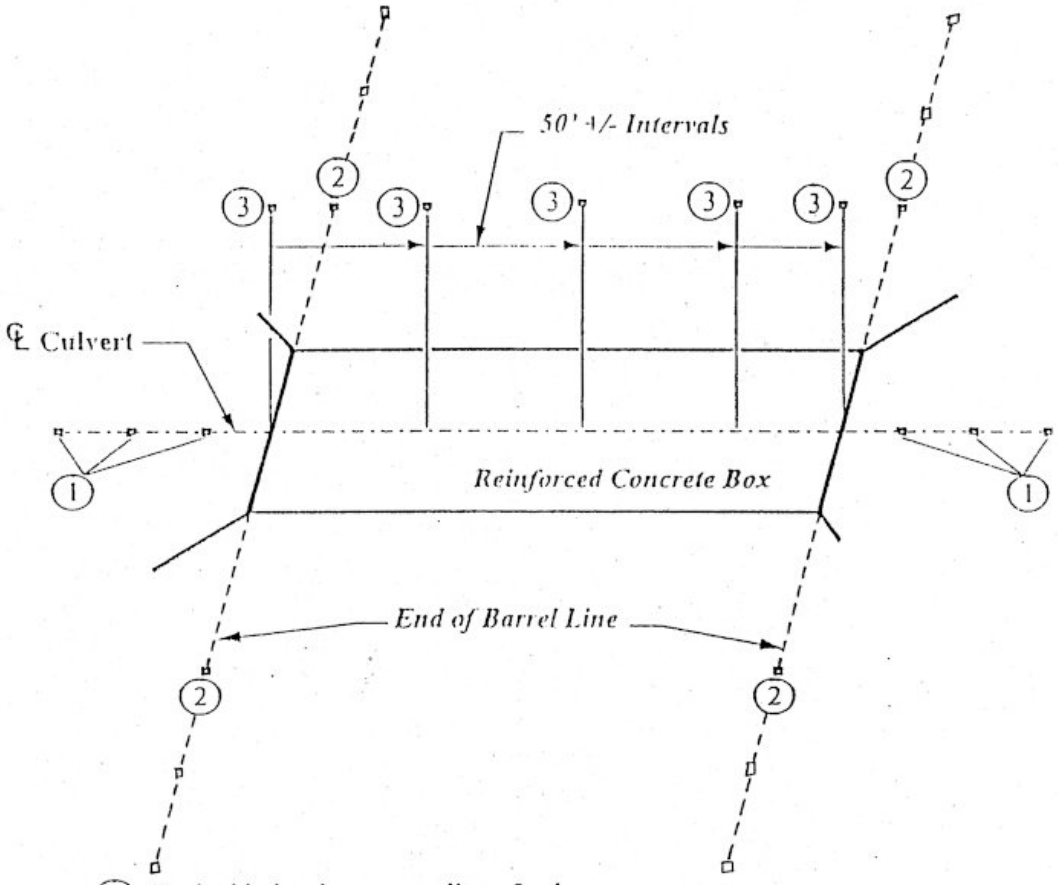

STA. 12+76.94
STA. 12+86.09
STA. 12+95.24
4'-0"
4'-0"
4'-0"
4'-0"
GUTTERLINE
℄ JOINT @ END BENT 1
BEGIN APPROACH SLAB
STA. 13+20.30
GUTTERLINE
℄ HEADER LINE
STA. 13+03.30
℄ HEADER LINE
℄ SURVEY
STA. 13+27.31
STA. 13+35.27
STA. 13+43.23
CONSTRUCTION ELEVATION LAYOUT
APPROACH SLAB AT BEGINNING OF BRIDGE
(END OF BRIDGE SIMILAR)
PROJECT No.: B-1414607 COUNTY: DURHAM
STA.: 166+62.40-L-REV ASSEMBLED BY: D.B. SIMPSON, JR.
DATE: APRIL 21, 1986 CHECKED BY:

Figure 15.4

TYPICAL REINFORCED CONCRETE BOX CULVERT SURVEY LAYOUT



(1) Tacked hubs along centerline of culvert.

(2) Tacked hubs along end of barrel with distance marked to centerline of culvert and cut/fill to top of bottom slab on guard stakes.

(3) Hubs with marked guard stakes giving offset and cut/fill to top of bottom of slab - including camber.

Figure 15.5

Chapter 16
Cross Sections for Earthwork Quantities

16.1 General Information

The Engineer may elect to obtain cross-sections by using either hand or aerial methods depending on the typography, vegetative cover, and size of the project or borrow sites. The Department often utilizes aerial photography to obtain cross-sections for calculation of earthwork quantities. Aerial photography requires the installation of photogrammetric control panels. Once panels are installed, the Photogrammetry Unit can orient the film both horizontally and vertically and obtain a correct scale.

16.2 Guideline Information

If the Engineer elects to hand section the project, set centerline stakes for all alignments on 50 foot (20 meter) intervals as detailed in Chapter 3. Offset alignments also may be required.

If the Engineer elects to obtain cross-sections by aerial methods, and a panel plan has not been provided, establish the survey line and install photogrammetric panels as detailed below:

Photogrammetric Control Panels

Either install photogrammetric panels on 5 foot x 5 foot sheets of black plastic or paint them on the roadway surface. An oil based exterior paint is recommended to mark the panel arrows. Panel arrows should have legs approximately 5 feet in length and six inches in width. (See *Figure 16.1*.) The point of the arrow represents the photogrammetric control point. Photogrammetric panels should be oriented so that their arrows point towards increasing stations.

Horizontal Control Stakes and Panels

After the survey line has been established perform the following:

- Set centerline stakes for all alignments on 50 foot (20 meter) intervals as detailed in Chapter 3.
- Set panels at 300 foot (100 meter) intervals on alignments where construction occurs.
- Set additional panels at beginning and ending stations, all cardinal points, equalities and intersections of alignments. If a control point exceeds the 300 foot (100 meter) interval by less than 50 feet (15 meters), then place a panel only on the control point. The following control point will continue on the original 300 foot (100 meter) interval.

Vertical Control

Vertical control panels shall be set at the following locations:

- At 90° angles from each horizontal control panel, preferably on a level surface along the construction limits.
- Panels are to be numbered consecutively with odd numbers on the left side of the alignment and even numbers on the right side. The panel numbers should be painted on the top right hand corner of each panel.
- Each ramp, loop, -Y- line, and service road should have a separate alphabetic suffix. Panels should be labeled 1A, 2A, 1B, 2B, 1C, etc.
- When more than one flight is necessary, the panel numbers should be continued from the previous flight. The last station of the previous flight should be paneled again and the panels should be labeled with the number preceding your last panel flown. Example: Flight 1 ended at Station 79+00, Panel number 13 on the left and 14 on the right. Flight 2 would begin at station 79+00, Panel number 15 on the left and 16 on the right.
- If the interchange does not exceed 1500 feet (500 meters) in width, then only one vertical control panel is necessary within each quadrant.
- If the interchange exceeds 1500 feet (300 meters) in width, then vertical control points should be installed on 300 foot (100 meter) intervals, as described herein.

Panel Field Book

Provide a panel book detailing the location of all horizontal and vertical control panels. Panels may be offset right or left due of traffic congestion or vegetative cover. However, do not exceed 50 feet (15 meters) from the original panel location. The offset distance must be noted in the panel book. The engineer will obtain the vertical elevations for each panel.

If the Engineer elects to obtain cross-sections by aerial methods, and a panel plan has been developed, the Engineer will provide the photogrammetric panel locations. The staking of the survey line is typically not required when setting photogrammetric panels at the predetermined locations. Set panels at these locations, and provide a panel book detailing the locations, coordinates and offsets if required.

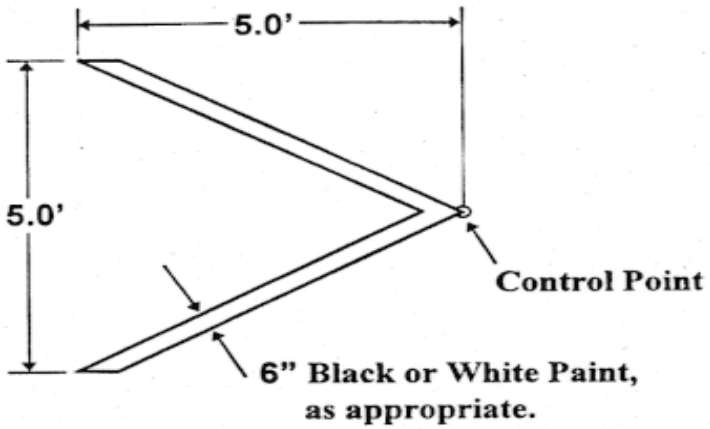
The Engineer will obtain the vertical elevations for each panel.

Maintain the photogrammetric panels until a successful aerial photograph has been obtained. Photogrammetric panels must be clearly visible on the scheduled flight day.

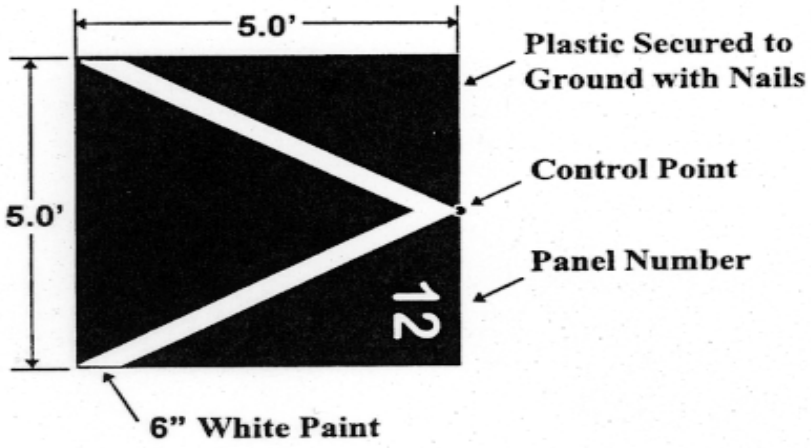
16.3 Type of Stake

Panel Size: 60" x 60" sheet of black plastic with arrow
Precision: Horz. 0.01'
Stake Use: Location

AERIAL FLIGHT PANEL CONFIGURATION



Typical configuration for asphalt or concrete surfaces.

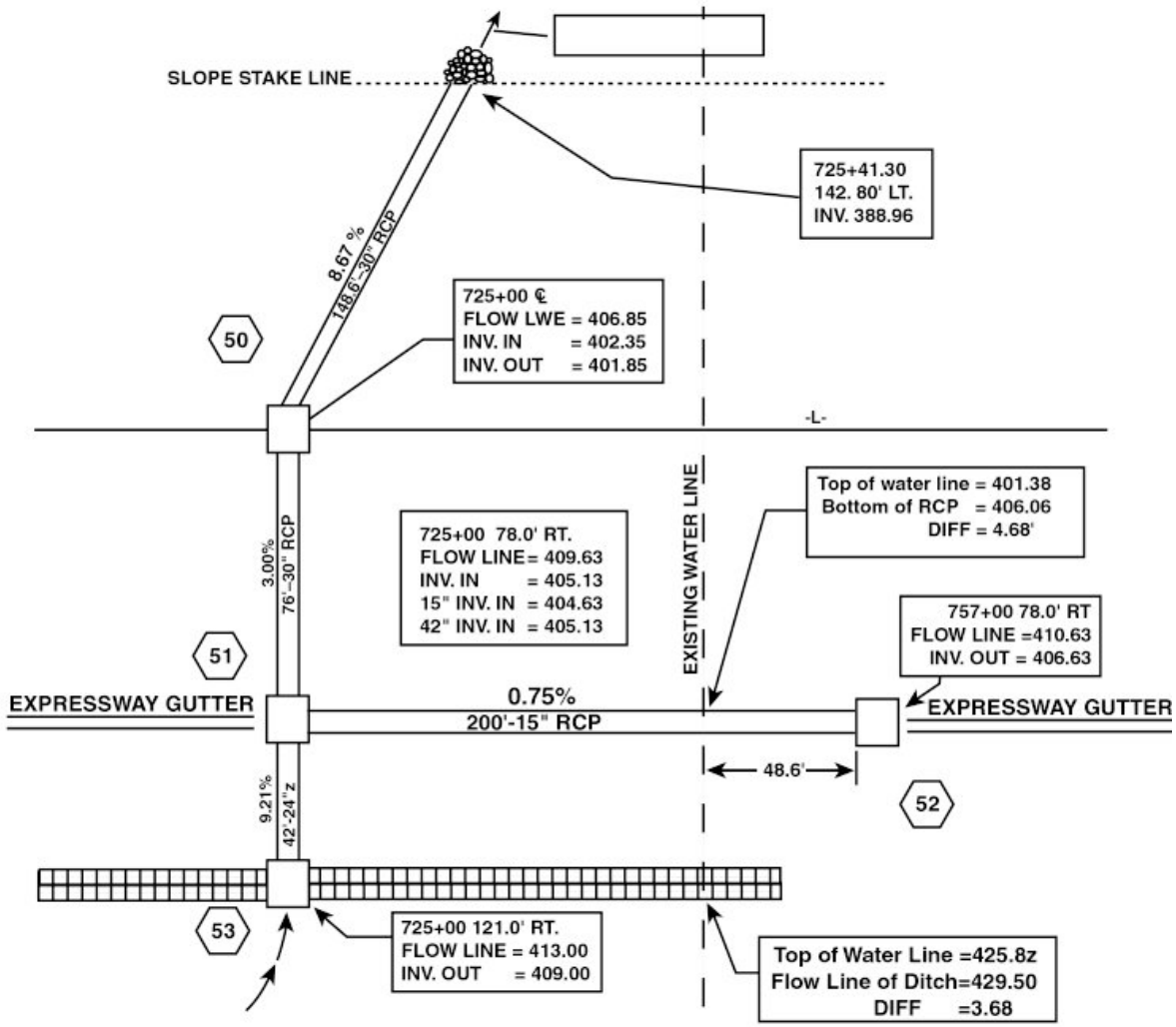


Typical configuration for earth or other surfaces.

Figure 16.1

Appendix

TYPICAL DRAINAGE SUBMITTAL



OUTLET PIPE

EXISTING STREAM = 388.46
+0.50
INV. OUT = 388.96

142.80' LT. SLOPE STAKE
INTERCEPT POINT

STR# 51

GRADE POINT GRADE = 410.35
12' x .021 = +0.24
410.59
26' x .021 = -0.54
410.05
10' x .042 = -0.42
FLOW LINE OF GRATE = 409.63
-5.00
INV. OUT = 404.63
+0.50
INV. IN = 405.13

STR# 52

GRADE POINT GRADE = 411.35
12' x 0.21 = +0.24
411.59
26' x .021 = -0.54
411.05
10' x .042 = -0.42
FLOW LINE OF GRATE = 410.63
-4.00
INV. OUT = 406.63

STR# 50

GRADE POINT GRADE = 410.35
TYPICAL — 12' x .042 = -0.50
409.85
18' x 0.167 = -3.00
FLOW LINE OF GRATE = 406.85
HEIGHT OF BOX = -5.00
INV. OUT = 401.85
+0.50
INV. IN = 402.35

STR# 53

Flow line of ditch elevation
from cross sections at
STA. 725 + 00 121' RT.
is 413.00 after setting slope
stake using ditch detail "Q"
this elevation checks.

Flow line of grade = 413.00
-4.00
INV. OUT = 409.00

CHECKLIST FOR PIPE LAYOUT DRAWING SUBMITTALS

VERIFY THE FOLLOWING IS CONTAINED WITHIN YOUR LAYOUT DRAWING SUBMITTAL:

STRUCTURE NUMBER _____
STATION AND DISTANCE FROM CENTERLINE _____
SIZE OF PIPE _____
PLAN INVERTS (IF PROVIDED) _____
PROPOSED INVERT _____
FLOW LINE AT GRATE _____
ELBOW _____
COLLAR _____
CAMBER _____
% GRADE OF PIPE _____

EXPLANATION IF LENGTH OF PIPE VARIES FROM THE PLAN QUANTITY _____

IS THERE A DITCH AT THE BEGINNING OR END OF PIPE? _____
- FIELD VERIFICATION OF DITCH LOCATION AND ELEVATION _____
- OR EXISTING DITCH LOCATION AND ELEVATION _____

DOES PIPE EMPTY INTO CREEK? _____
- ELEVATION OF SHOT TAKEN IN EXISTING CREEK AT INTERVALS TO ENSURE DRAINAGE _____
- WAS THE TOE OF FILL AT THE CREEK INVESTIGATED? _____

EXTRA DEPTH BOXES _____
- DETAIL THE EXTRA DEPTH DRAINAGE STRUCTURE SPECIFIED IN PLANS _____
- IF A DRAINAGE STRUCTURE IS NOT SHOWN ON PLANS, REASON FOR EXTRA DEPTH _____

IS THERE A HEADWALL? _____
- PROVIDE DETAIL DRAWING NUMBER _____
  - TOP OF HEADWALL ELEVATION _____
  - INVERT ELEVTION _____
  - SHOULDER ELEVATION _____
  - SHOW SLOPE CONNECTION TO BACK OF HEADWALL _____
  - DISTANCE FROM DIRT SHOULDER TO BACK OF HEADWALL _____

CAMBER FOR PIPE AND BOX CULVERTS

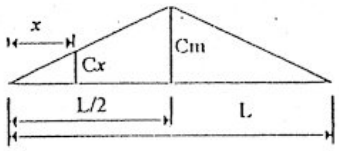
When pipes or box culverts are founded on compressible material, camber should be placed in the grade to compensate for the settlement. The amount of camber to be used depends on the load imposed on the foundation material and the compressibility of the material. Since these factors vary, judgment is required in selecting the amount of camber to be used. Unless provided in the plans, the camber is determined as follows for pipe culverts.

The table below includes camber factors based on the load imposed (fill height) and the compressibility (soil type) of the material. Using the fill height and soil type, a corresponding factor is selected from the table. For continuous culverts beneath the entire width of the embankment, multiply the selected factor by the length of the culvert (L) to determine the midpoint camber.

CAMBER TABLE

Fill Height		Soil Type Factors		
(meters)	(feet)	medium	soft	very soft
0 to 3	0 to 10	0.0008	0.0013	0.0017
3 to 9	10 to 30	0.0017	0.0025	0.0033
9 to 15	30 to 50	0.0025	0.0038	0.0050

The mid point camber for pipe culverts shall be limited to one-half of the available fall in the pipe culvert or, (L/2) x (% grade), where L is the length of the culvert in meters and shall be limited to 0.6 m (2 ft). The proposed grade for the culvert at the midpoint (L/2 from the end of the culvert) should be adjusted upward by Cm where Cm is the smaller of the calculated camber and the two limits stated above. The amount of camber (Cx) at any distance (*x*) along the length of the culvert that can be determined by (Cm) (*x* / (L/2)), where *x* is any distance along the length of the culvert L.



Example 1: Assume 75 m (246.1 ft) pipe culvert on 1.5 % grade under 8 m (26.2 ft) fill with soft foundation material.

Table Camber: factor = 0.0025 (no units), L = 75 m (246.1 ft)
75 m x 0.0025 = 0.1875 m (0.615 ft)

Limit checks: L = 75 m (246.1 ft), % grade = 0.015
(75/2) x 0.015 = 0.5625 m
or (246.1/2) x 0.015 = 1.846 ft

Compare 0.1875 m to 0.5625 m.; therefore Cm = 0.1875 m

Example 2: Assume 75 m (246.1 ft) pipe culvert on 0.4 % grade under 7.6 m (25 ft) fill with soft foundation material.

Table Camber: factor = 0.0025 (no units), L = 75 m (246.1 ft)
75 m x 0.0025 = 0.1875 m (0.615 ft)

Limit checks: L = 75 m (246.1 ft), % grade = 0.004
(75/2) x 0.004 = 0.15 m
or (246.1/2) x 0.004 = 0.492 ft

Compare 0.1875 m to 0.15 m.; therefore Cm = 0.15 m (0.492 ft)

Example 3: For Example 1 above, determine the camber 10 m from the end of the culvert.

From Example 1: L = 75 m, Cm = 0.1875 m

$$Cx = (Cm)\,(x / (L/2)) = (0.1875\text{ m})(10\text{ m}/(75\text{ m}/2)) = 0.05\text{ m}$$