CONTRACT PLANS READING

A training course developed by the

FLORIDA DEPARTMENT OF TRANSPORTATION

**This 2009 revision was carried out under the direction of
Ralph Ellis, P. E., Associate Professor of Civil Engineering**

**The Office of Construction
Florida Department of Transportation**

Yvonne Collins, State Construction Training Administrator

CONTRACT PLAN READING

TEXTBOOK

FLORIDA

STATE OF FLORIDA DEPARTMENT OF TRANSPORTATION

DEPARTMENT OF TRANSPORTATION

SUBJECT INDEX

TABLE OF CONTENTS

DIRECTIONS TO COURSE USERS

INTRODUCTION

This is CONTRACT PLAN READING. It is a course of training in reading and interpreting typical highway and bridge plans. The course will be used in the following ways:

1. As a course for training department personnel in reading and interpreting contract plans.

2. As a course for training consultant design personnel in the standard terms, symbols, layout, content and organization of contract plans used by the Department.

The course contains two different parts:

1. The TEXT you are reading.

2. The PLAN BOOK.

You will be given directions in the TEXT to look at specific sheets and projects in the PLAN BOOK.

Follow all directions.

TRAINING TECHNIQUE

This course has been designed for self-instructional training:

- You can work alone.
- You can correct your mistakes.
- You can finish the training at your own speed.

The basic information is taught, simply and clearly, in a series of steps -- each step adding to your knowledge. When you complete the last step, you will be able to read and interpret plans.

This method of instruction teaches by asking you questions. It gives you some information and then asks a question or series of questions about that information. All questions must be answered. Answers are to be written in the spaces provided, and then compared with the correct answers following each chapter.

EXAMINATION

An examination will be given to you after completing the course. The results of the examination will indicate how well you have learned to read and interpret plans. You should reread any training sections that give you trouble in the examination.

Go on to Chapter One.

CHAPTER ONE
Information Basic to Reading Plans

CONTENTS

CONTENTS, continued

1

INFORMATION BASIC TO READING PLANS

This is a preparation chapter. Instead of studying plan sheets in detail, we will get acquainted with some basic information and procedures used on most plan sheets.

MEANINGS OF DIFFERENT VIEWS

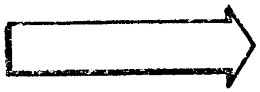
Most objects have different appearances when viewed from different angles. A top view usually is quite different from a side view. Because objects on highway plans are shown from several different views, you should be able to recognize each view and know what it means. As an example, we will study the views of a chair.

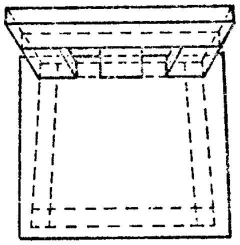
PLAN VIEW

This is a PLAN VIEW of a chair.

A PLAN VIEW is a view from directly above an object -- you are looking down at the object.

Dashed lines indicate parts of the object which CANNOT BE SEEN from your viewpoint -- such as the legs and the cross braces of the chair.





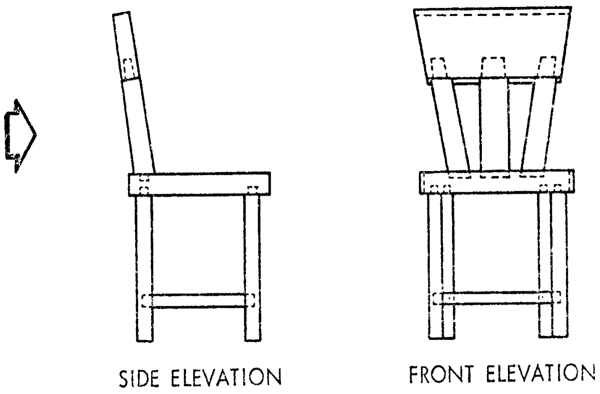
PLAN

ELEVATION VIEW

An ELEVATION VIEW shows the height of an object.

Two elevation views of a chair are shown here.

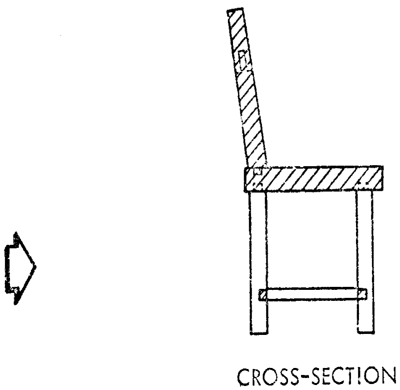
The elevation may be shown from the front, the rear or either side.



CROSS-SECTION VIEW

A CROSS-SECTION VIEW shows the inside of an object -- as if the object had been cut open.

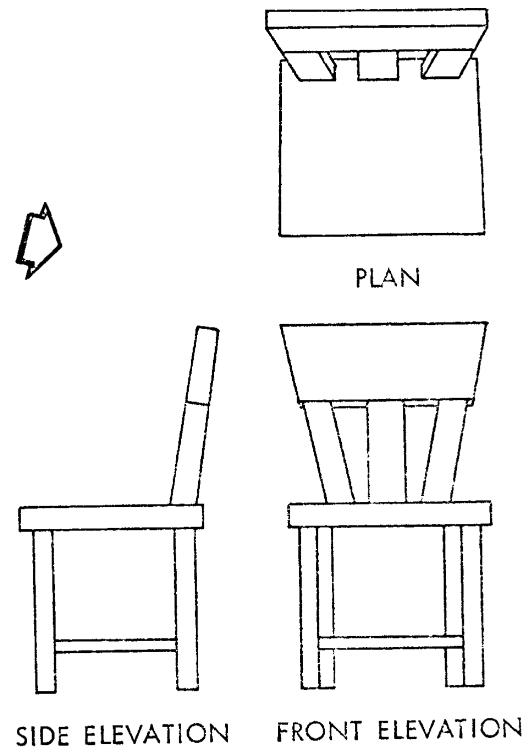
This is a cross-section view of a chair. As you face the side of this chair, a piece of it has been "sliced" away. You can see the insides of the seat, the back and the cross braces.



SUMMARY

Sometimes different views are drawn close together in this relationship:

Sometimes it is necessary to shown only one view.



REMEMBER--

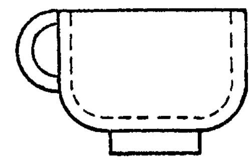
A view from above is a PLAN VIEW.

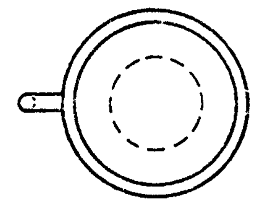
A view from the front or side is an ELEVATION VIEW.

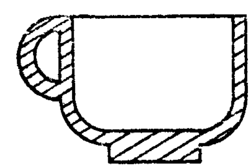
An inside view, as if the object had been cut open, is a CROSS-SECTION VIEW.

QUIZ

List the views of this coffee cup:







TYPES OF HIGHWAY PLAN SHEETS

There are several types of plan sheets. Most of them show different views of things to be built -- plan views, elevations and cross sections. Some sheets have notes or listings of materials needed. Standard symbols are used to help you recognize objects.

Let's take a quick look at the main types of roadway plan sheets. Don't spend too much time trying to learn the details -- we will learn them later.

PLAN AND PROFILE SHEETS

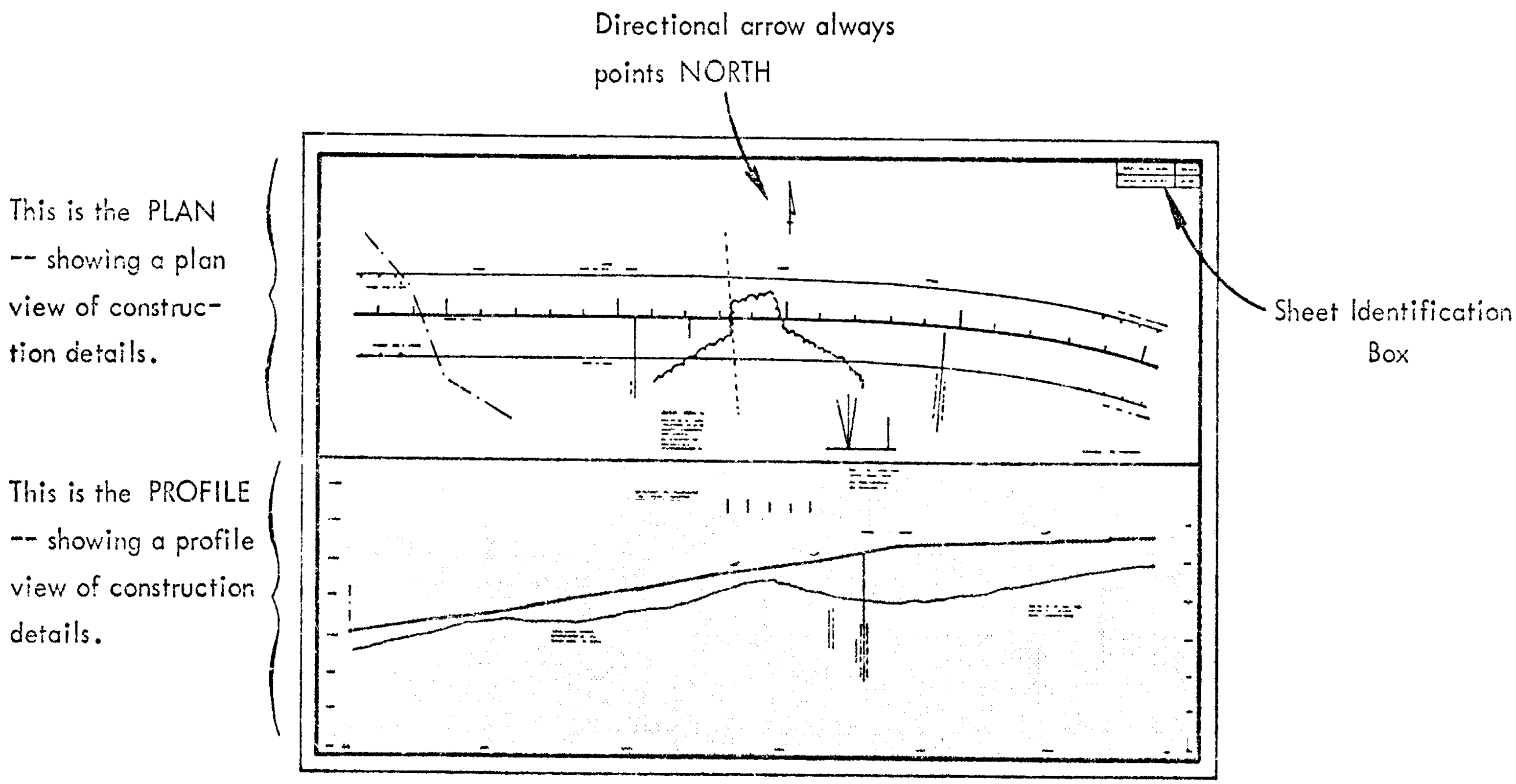
Plan and Profile Sheets show construction details of the highway from two views. The top half of the sheet shows a PLAN view -- looking down from above. The bottom half shows a PROFILE view -- similar to a side elevation view.

Sometimes, as in the case of highway interchanges, a whole sheet may be required just to show the plan view, and a separate sheet may be required for the profile views.

Sheet No. 4, Project 56520-3602 (Plan Book – page 6) is an example of a Plan and Profile Sheet. Compare it with the figure on the next page.

Can you find the directional arrow in the plan view? Directional arrows always point NORTH. It's good plan reading practice to determine directions immediately -- you can avoid much confusion by doing so.

This is a Plan and Profile Sheet:



TYPICAL SECTION SHEETS

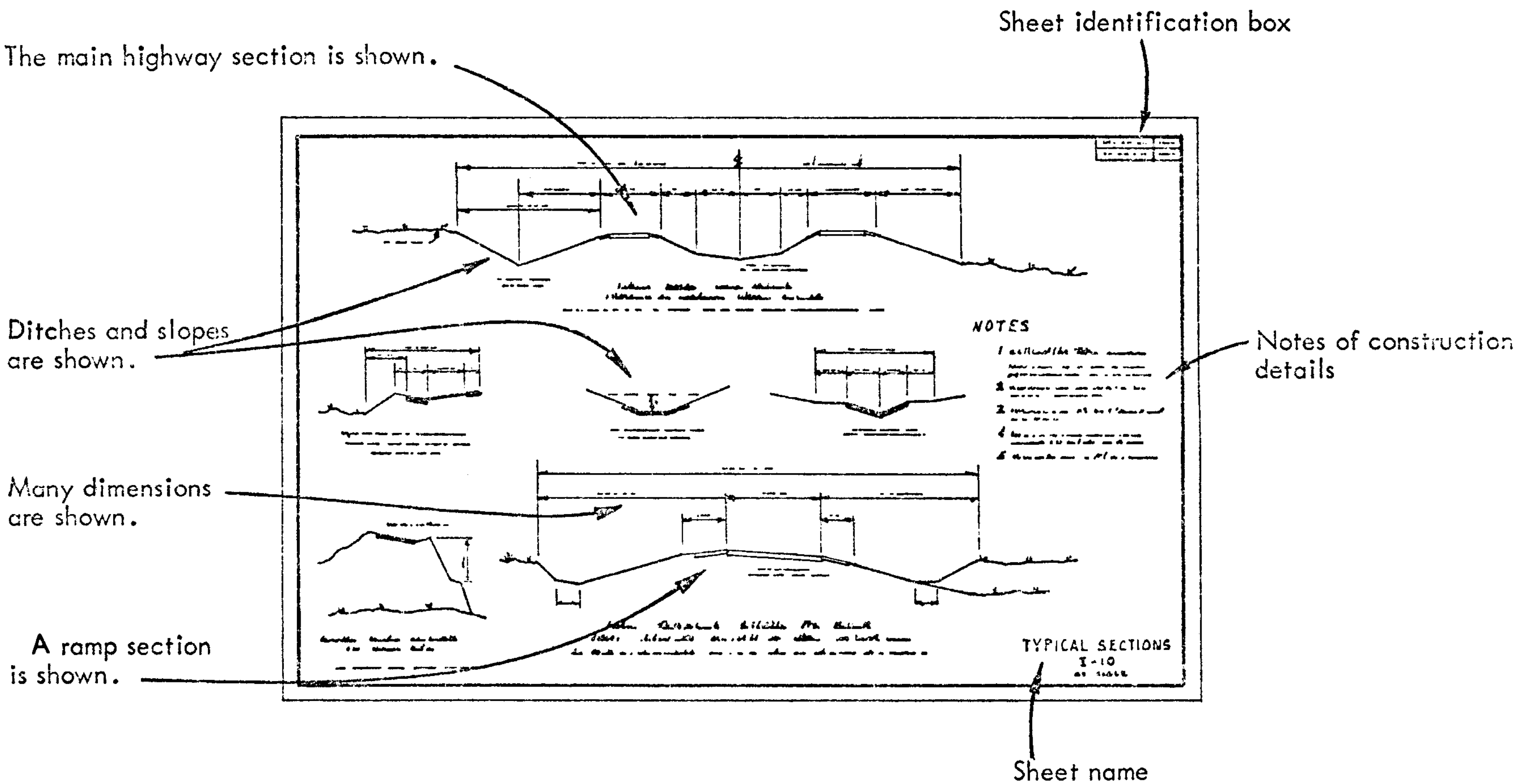
Remember the cross-section view of the chair? It is what you would see if the half of the chair nearest you were sliced off. A cross section of a highway is the view you would have if you cut through the road crosswise. Typical Section Sheets show typical cross sections of the road to be built. They show the different layers of the road and the shapes of the side slopes and ditches.

A very simple road, like a straight, level, monotonous road through a desert, would need only one typical section, because the road would be the same everywhere. Most roads, though, have several typical sections.

In the Plan Book, Sheet No. 2, Project 56520-3602(Plan Book – page 5) and Sheet No. 9, 10 and 11,
Project 79040-3544(Plan Book – page 38,39,40) are typical sections. Look at them. The sheets name in the lower right corners tell you that they are Typical Sections.

You should be able to distinguish Typical Section Sheets from other types of sheets.

This is a Typical Section Sheet:



QUIZ

Do Typical Section Sheets show elevation views of the proposed road? _______________

The directional arrow is found on the _______________ view of a Plan and Profile Sheet.

Which sheet shows the shape of the road's side slopes and ditches? ______________

ABOUT LEARNING

Most persons learn best, and retain learned information best, by taking the time necessary to answer quiz-type questions in writing. No one will know if you skip this part of the training -- but tests consistently indicate that persons who do skip the quiz work gain little time and learn less.

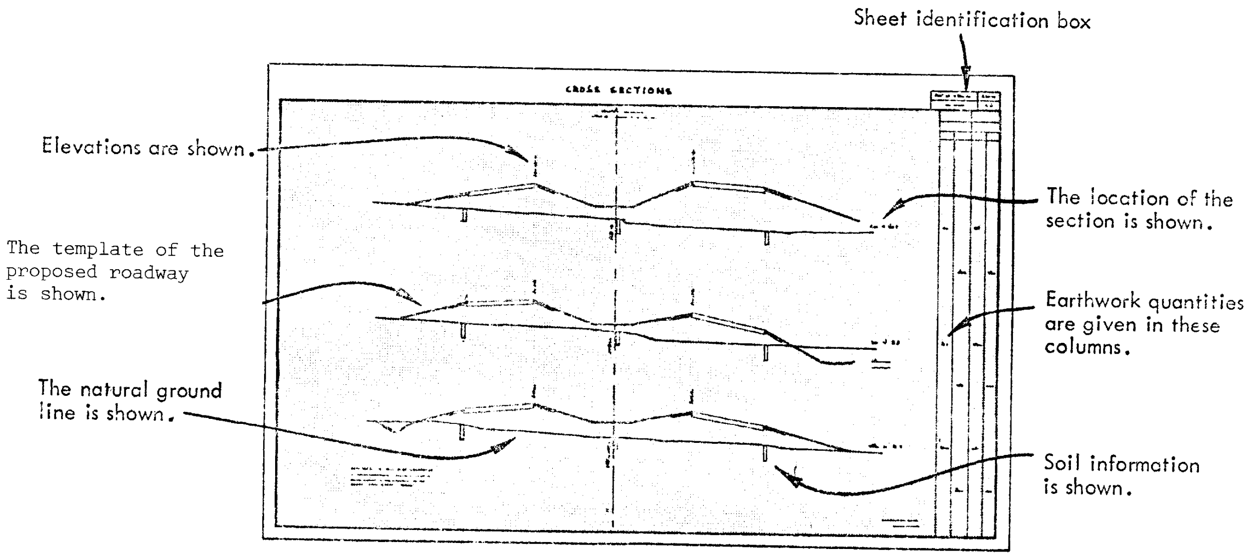
Learn at your own pace. If you miss answers, reread the material and answer the questions correctly before going on. This course becomes more advanced later on, so it is best to clear up difficulties as you go.

CROSS-SECTION SHEETS

Cross-Section Sheets show cross-section views at frequent points along the proposed roadway. They show the natural ground line and the template -- shape -- of the proposed roadway. Cross-Section Sheets provide a picture of what the roadway will look like. Find Sheet No. 8, Project No. 56520-3602 (Plan Book – page 10) and compare it with the figure below.

As you already may know, the shape of the road on Cross-Section Sheets is the same shape shown on Typical Section Sheets.

This is a Cross-Section Sheet:



ROADWAY AND TRAFFIC DESIGN STANDARDS

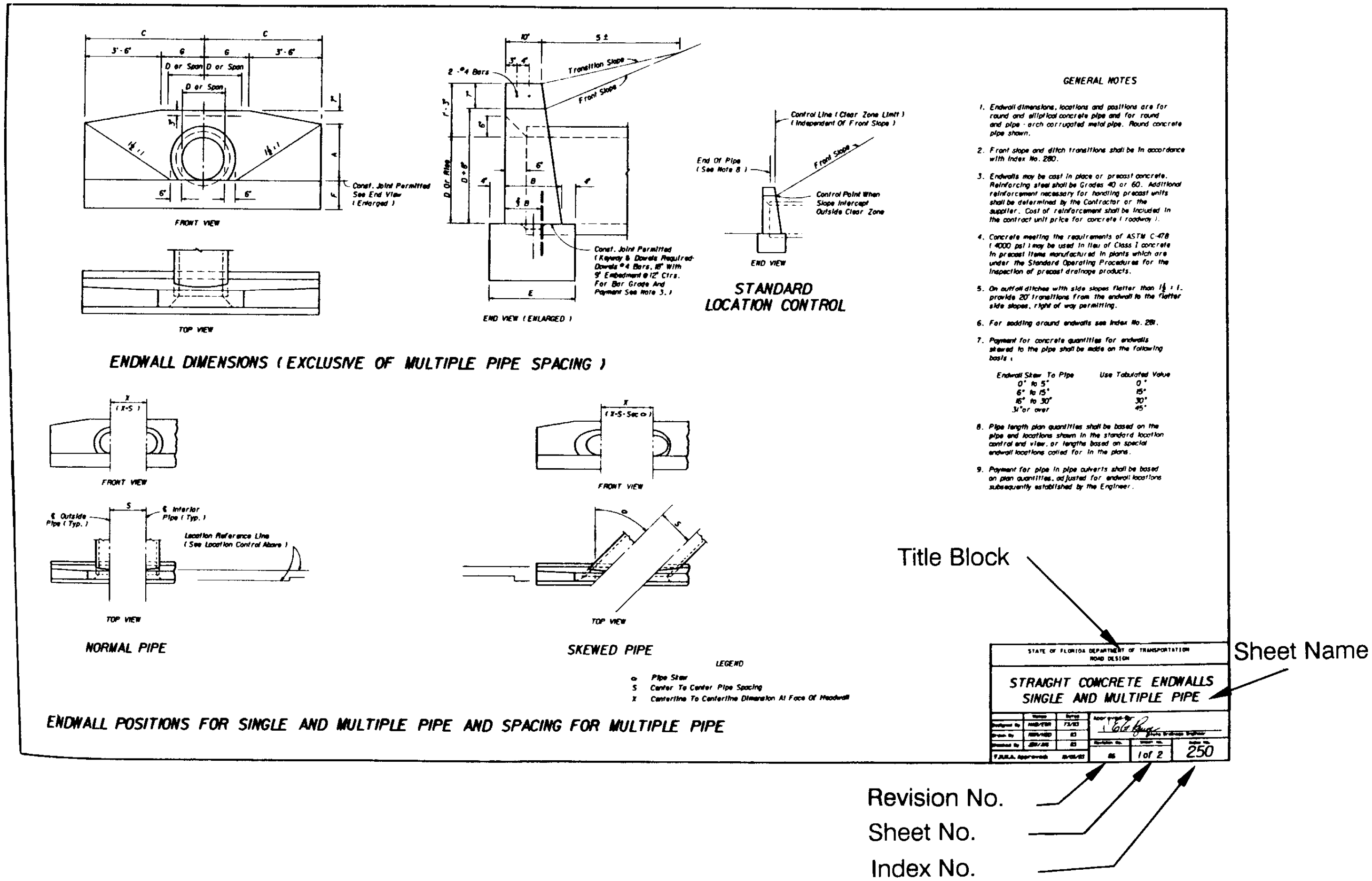
Roadway and Traffic Design Standards show details of standard items that can be used on many projects. For example, signs and fences are often standard items on many different highways. Sign and fence details, then, are included in the plans as Roadway and Traffic Design Standards.

The Roadway and Traffic Design Standards are published in a book separate from the contract plans. They are, however, considered part of the plans.

Roadway and Traffic Design Standards do not have sheet numbers. Instead, they have Index Numbers in their lower right corners. Find the drawing with Index No. 250 (Plan Book – page 108) in your Plan book and compare it with the next figure. It shows details of endwalls.

Occasionally Roadway and Traffic Design Standards are revised. The revision numbers (years of last revision) are recorded in the lower right corners. These dates are important in identifying the Standards -- as drawings with different dates will differ.

This is a Standard Roadway Drawing:



QUIZ

Which sheets show a cross-section view of the road superimposed on the natural ground line?

____

Name the other sheet that shows the shape of the road from a cross-section view.

____

Which of these sheets show more dimensions and slope data?

____

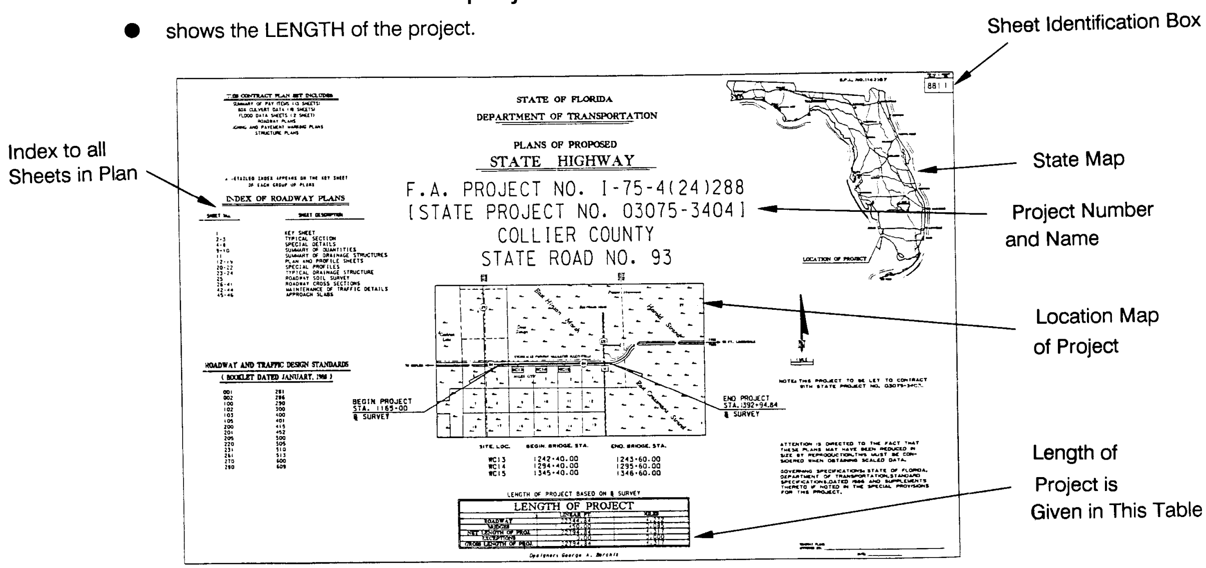
Revision numbers to Roadway and Traffic Design Standards appear in the _________ corner of that sheet.

Right? Go on to KEY SHEET.

KEY SHEET

The Key Sheet is the front cover of a set of plans. Find the Key Sheet , Sheet No.1, Project 56520-3602 (Plan Book – page 1). Compare it with the figure on this page. The Key Sheet:

- IDENTIFIES the project with a name and number,
- shows the LOCATION of the project on the State Map and in more detail on the Location Map,
- gives an INDEX to all sheets in the plan set, and
- shows the LENGTH of the project.



SUMMARY OF ROADWAY PAY ITEMS

Summary of Roadway Pay Items shows the quantities of work items that the contractor is to perform. It is a computer printout included in your Plan Book. Look at it.

Several other sheets show quantities. These include:

- Summary of Signing Pay Items, and
- Summary of Quantities

QUIZ

To find where in Florida the project is located, you would look at the ________________ in the __________________ corner of the ____________________.

An index to all sheets in the plan set is given on the _____________________.

Right? Go on to SUMMARY OF SHEET TYPES.
Wrong? Review KEY SHEET and SUMMARY OF ROADWAY PAY ITEMS before going on.

SUMMARY OF ROADWAY PLAN SHEET TYPES

We have seen nine major types of roadway plan sheets. They are listed below.

- KEY SHEET,
- TYPICAL SECTION SHEET,
- SUMMARY OF PAY ITEMS,
- SUMMARY OF QUANTITIES SHEET,
- PLAN AND PROFILE SHEETS,
- CROSS-SECTION SHEETS, and
- ROADWAY AND TRAFFIC DESIGN STANDARDS.

Remember that the Roadway and Traffic Design Standards are in a book separate from the contract plans. The computer printouts -- Summary of Pay Items -- are not numbered plan sheets and may appear in a different order than indicated above.

QUIZ

Name the sheets, or groups of sheets, which best fit these descriptions:

Shows cross-section view with typical shape and dimensions of the proposed road ______________________________

Cover sheet which identifies the project and shows its location

____

Shows details of roadway items usable on many projects

____

Shows tabulated quantities of all materials and work required for construction

____

Shows two views of the roadway -- a plan view and an elevation view

____

Shows the natural ground line and the template of the proposed roadway at frequent points along the roadway

____

Right? Go to OTHER GROUPS OF PLAN SHEETS.
Mistakes? Write down the correct answers and memorize as many types of sheets as you can. You will become familiar with the different sheets as we move along.

OTHER GROUPS OF PLAN SHEETS

All the sheets we have discussed so far appear in the Roadway Plans group. Each set of Contract Plans may contain one or more of these other plan sheet groups:

- SIGNING AND PAVEMENT MARKING PLANS -- contain details of the estimated quantities, method of construction, and location of road signs to be erected and pavement markings to be placed along the project.
- SIGNALIZATION PLANS -- contain details of the location and wiring of electrical traffic signals.
- LIGHTING PLANS -- contain estimated quantities, and details of construction, erection, and wiring of roadway lighting systems.
- STRUCTURES PLANS -- contain estimates for, and details of, bridges and other major structures to be built on the project.
- LANDSCAPE PLANS -- contain plan quantities and details of tree removal, tree placement and other landscaping work.
- UTILITY PLANS -- contain plan quantities and details of utility relocation and removal and proposed utilities.

Try the quiz on the next page.

QUIZ

In which group of plan sheets would you find:

details of road signs to be erected? ______________________________

details of the electrical wiring of traffic signals? ________________________

details of bridges to be constructed on the project? ____________________

cross-section views of the proposed roadway? ________________________

No mistakes? Go on to SYMBOLS AND ABBREVIATIONS.

SYMBOLS AND ABBREVIATIONS

Numerous symbols are used on plan sheets to represent existing topography, property lines and objects to be built. These are uniform from one set of plans to the next, making it easier to read and understand different sets of plans.

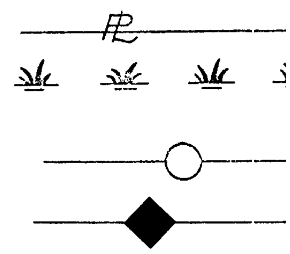
Examples of symbols and their meanings are:

Property Line

Marsh

Existing Telephone Pole

Proposed Power Pole



Frequently it is necessary to abbreviate words on the plan sheets. For uniformity and clear understanding, standard abbreviations have been adopted. Some examples are shown below:

Ah.	=	Ahead
Blvd.	=	Boulevard
Ch.Ch.	=	Channel Change
I.P.	=	Iron Pipe
R.R.	=	Railroad
Esmt.	=	Easement

Lists of standard abbreviations and symbols are provided in two Roadway and Traffic Design Standards, Index Numbers 001 and 002 (Plan Book – pages 96-100). Find them in your Plan Book and remember their locations so that you can refer to them easily.

QUIZ

What do these symbols and abbreviations mean?

——/—/—/——	____________________
℄	____________________
Exc.	____________________
G.R.	____________________
W.B.	____________________
	____________________

Did you get the correct answers without looking at the Roadway and Traffic Design Standards? If you did, good! If you didn't, don't worry about it. You are not expected to memorize all symbols and abbreviations at this time.

As you find symbols and abbreviations on the plans that don't make sense, look them up. Learn them as you go.

Go on to SHEET IDENTIFICATION.

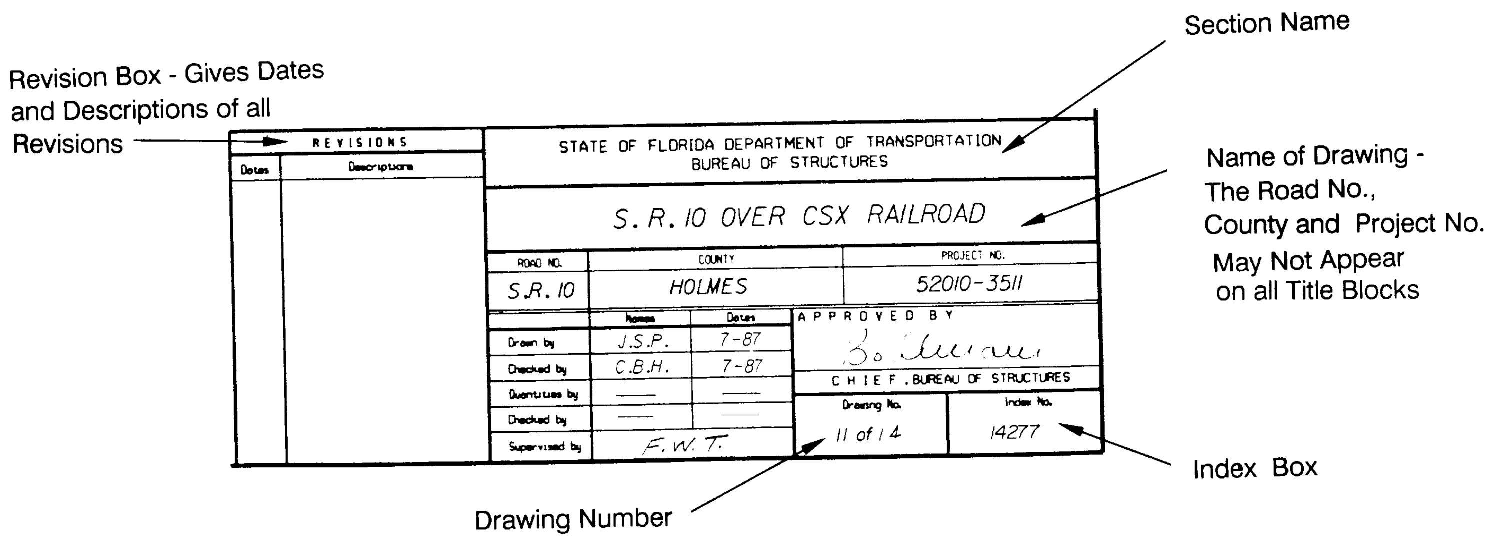
SHEET IDENTIFICATION

Each sheet contains information describing the sheet by name, number or other means. We will look at some of this information now.

TITLE BLOCKS

Title blocks appear in the lower right corners of Roadway and Traffic Design Standards, Signing and Pavement Marking Plans, Signalization Plans, and Structures Plans. Although there are small differences in these types of title blocks, the major items of information appear on them all.

A typical Title Block look like this:



SHEET NAMES

Most Roadway Plans are labeled with the names of the sheets -- corresponding to the names listed in the index. The sheet names usually appear in the lower right corners along with revision dates and scale information.

SHEET IDENTIFICATION BOXES

Sheet Identification Boxes appear in the upper right corners of all sheets except Roadway and Traffic Design Standards. There are two types:

STATE	STATE PROJ. NO.	FISCAL YEAR	SHEET NO.
Fla.			

This box appears on key sheets for the major groups of plans.

STATE PROJ. NO.	SHEET NO.

This box appears on all other sheets EXCEPT Roadway and Traffic Design Standards.

SHEET NUMBERS AND PROJECT NUMBERS

Sheet numbers and project numbers appear in the sheet identification boxes on all sheets -- except Roadway and Traffic Design Standards. The major groups of plans -- Roadway Plans, Signing and Pavement Marking Plans, Signalization Plans, and Structure Plans -- are numbered separately as follows:

Roadway Plans -- numbered sequentially, beginning with Sheet No. 1, Sheet No. 2, etc.

Signing and pavement Marking Plans -- numbered sequentially -- but with an S prefix -- beginning with Sheet No. S-1, S-2, etc.

Signalization Plans -- numbered sequentially -- but with a T prefix -- beginning with Sheet No. T-1, T-2, etc.

Lighting Plans -- numbered sequentially -- but with an L prefix -- beginning with Sheet No. L-1, L-2, etc.

Structure Plans -- Also numbered sequentially -- but with separate letter prefixes beginning with A. For example:

Key Sheet -- Sheet No. A-1
Standard Structure Drawings -- Sheet No. A-2, A-3, etc.
Sheets for individual structure -- Sheet No. B-1, B-2, etc.
Sheets for next structure -- Sheet No. C-1, C-2, etc.
And so on, excluding the letter prefixes E, I, L, O, Q, S and T.*

Roadway and Traffic Design Standards have no sheet numbers or project numbers. Instead, they have index numbers. More about that later.

* E is used for existing structures. I, O, and Q are not used because of possible misinterpretations.

QUIZ

Which groups of plans are represented by these sheet number prefixes?

L ____

S ____

T ____

any letter except I, L, O, Q, S or T _________________________

Sheet numbers without prefixes are in the _______________________________.

Which sheets do not have sheet identification boxes in their upper right corners? ________________

Sheet names appear in the ____________ corners of most types of sheets.

Project numbers and sheet numbers appear in the upper right corners of all sheets except _______________.

On which sheet would you find an "Index of Structure Plans?" _________________

Right? Go on to ROADWAY AND TRAFFIC DESIGN STANDARD NUMBERS.
Wrong? Review the last three pages. Write the correct answers before, going on.

ROADWAY AND TRAFFIC DESIGN STANDARD NUMBERS

Roadway and Traffic Design Standards have no sheet numbers or project numbers -- but they do have INDEX numbers, REVISION numbers and SHEET numbers in their lower right corners.

The index number identifies the standard drawing, or group of drawings.

The revision number indicates the year that the drawing was last revised.

The sheet number tells us how many drawings are in the group, and which one of these we are looking at.

INDEX NUMBERS ON OTHER PLAN GROUPS

Lighting Plans do not have index numbers, only sheet numbers. Signing and Pavement Marking Plans, Signalization Plans, and Structures Plans do have index numbers -- but they have sheet numbers as well. Sheets in all these Plan Groups are arranged in the order of their sheet numbers.

QUIZ

All sheets except __________________ have sheet numbers.

Do Structures Plans have both index numbers and sheet numbers? ___________________

In the upper right corners of most sheets are shown _______________ numbers.

In the lower right corners of some sheets are shown ____________________ numbers and ______________________numbers.

Which sheets have index numbers only? ______________

All correct? Go to SCALES OF DRAWINGS.

SCALES OF DRAWINGS

Many things on plan sheets are drawn to SCALE. This means that lines on the plans are drawn an exact length so they represent a real distance on the ground or a dimension of real objects.

If we measured a line on a drawing, and knew the scale, we could compute the real length; BUT -- many Plan Sheets, including those in your Plan Book, are reduced by the Department to approximately HALF their original size. This means that a line which is exactly one inch long on a full-size original will be <u>approximately one-half</u> inch long on a reduced sheet.

AVOID trying to measure distances on plan sheets with a ruler: look for a written dimension, or calculate from written figures.

Scales of drawings often are noted on the North Arrow of the plan view sheet. For example, look at the North Arrow of the plan view of Sheet No. 1, Project 56520-3602 (Plan Book – page 1). It shows this note:

SCALE ½ " = 1 mile

The note (1/2" = 1 mile) means that every one-half inch on the plan view represents 1 mile on the ground. Two inches represents 4 miles, five inches represents 4 1/2 miles.

If the note were 1" = 200', it would mean that every inch on the plan view represents 200', 2" represents 400', and so on.

QUIZ

Let's make sure we understand how scales work. Fill in the blanks.

Scale	Map Distance	Ground Distance
1 in. = 1000 ft.	1/2 inch	________
1 in. = 100 ft.	3 inches	________
1 in. = 100 ft.	4 3/4 inches	________
1 in. = 200 ft.	1/2 inch	________
1 in. = 200 ft.	2 1/2 inches	________
1 in. = 10 ft.	1/2 inch	________
1 in. = 4000 ft.	2 1/4 inches	________

Right? Let's look at scales on some types of plan sheets. Go on to the discussion on SCALES OF PLAN AND PROFILE SHEETS.

SCALES OF PLAN AND PROFILE SHEETS -- PLAN VIEWS

Plan views on plan and profile sheets usually are shown with a 1" = 100' scale. The scale is shown on North Arrow of the plan view: 1" = 100'.

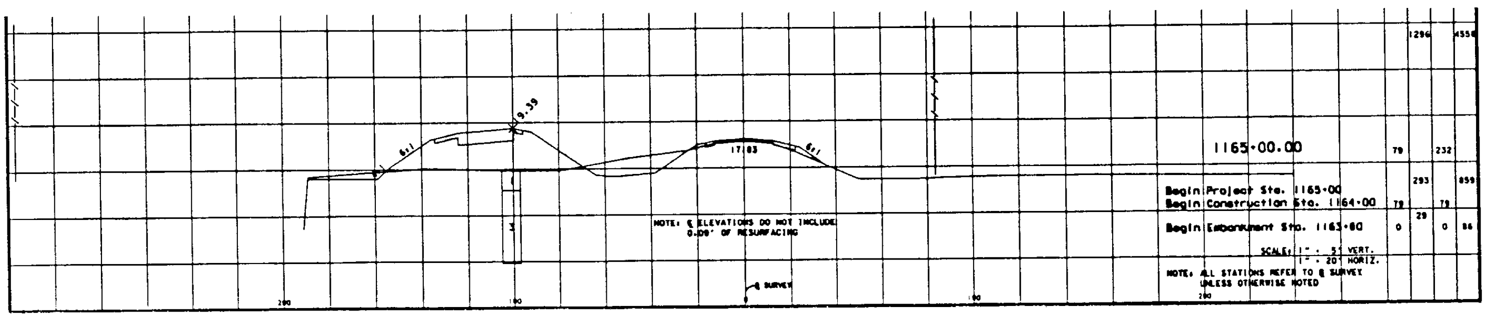
Sometimes plan views are drawn larger to show more detail. For instance, in urban or other congested areas, plan views are drawn to a scale of 1" = 40'. Look at Sheet No.18, Project 79040-3544(Plan Book – page 45) for an example.

SCALES OF PLAN AND PROFILE SHEETS -- PROFILE VIEWS

Scales for plan and profile sheets may vary depending on the type of project. The reason for this is to exaggerate small differences of elevation so you can see them more clearly.

SCALES OF CROSS-SECTION SHEETS

Cross sections, like profile views, are drawn on a grid and usually have different scales for vertical and horizontal measurements. Sheet No. 7, Project 56520-3602 (Plan Book – pages 9) is a Cross-Section Sheet -- find it now and compare it with this figure:



Horizontal distances are measured right or left of a labeled reference line, which usually is the centerline of the highway, but may be a survey baseline. The bottoms of Cross-Section Sheets are labeled with these distances.

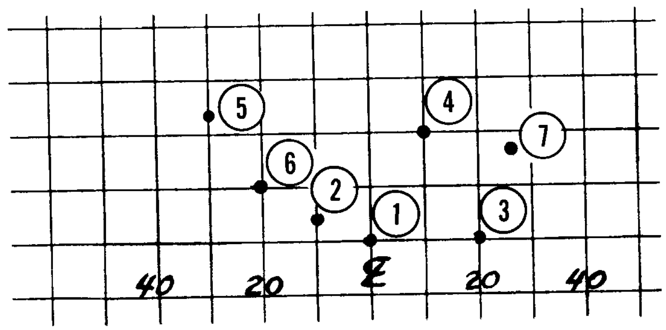
Elevations are shown at some points on the cross sections.

The vertical scale is usually 1" = 5 feet. The horizontal scale usually is 1" = 10 feet, but when the cross section is very wide, as when approaching an interchange, the horizontal scale may be 1" = 20 feet. Sheet No.6, Project 56520-3602 (Plan Book – page 8) shows a horizontal scale of 1" = 20 feet.

Go to the next page.

QUIZ

A typical piece of cross-section paper is shown below. The scale is 1" = 5 feet vertically and 1" = 10 feet horizontally. The heavy vertical line in the center represents the centerline (℄) of construction. The elevation of point 1 is 120.0 feet.



Fill in the blanks.

Point 2 has an elevation of 122.0 feet and is 10 feet left of centerline.
Point 3 has an elevation of ________ feet and is _________ feet _______ of centerline.
Point 4 has an elevation of ________ feet and is _________ feet _______ of centerline.
Point 5 has an elevation of ________ feet and is _________ feet _______ of centerline.
Point 6 has an elevation of ________ feet and is _________ feet _______ of centerline.
Point 7 has an elevation of ________ feet and is _________ feet _______ of centerline.

SURVEY DATA

Much of the information shown on the plan sheets is based on surveys made in the field. It will help you to understand the plans if you learn a little about survey data. We will discuss survey data next.

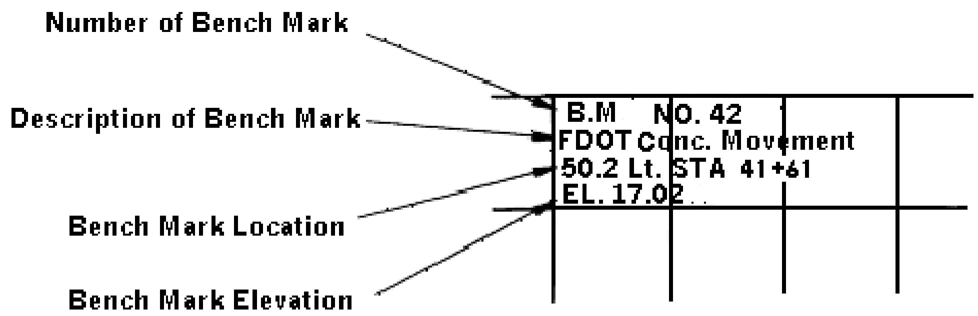
BENCH MARKS

Bench marks -- B.M. -- are markers, such as spikes in trees or concrete monuments, which have known elevations. Bench-mark elevations usually are referenced from mean sea level. There are many bench marks throughout Florida.

Most surveys start from NGVD '29 (National Geodetic Vertical Datum of 1929) bench marks -- which are usually concrete monuments. During the surveys, additional bench marks are established and recorded by the Department. They are used during construction to establish accurate elevations. Bench marks often are established by placing spikes in trees or by marking walls and bridges. Bench marks are established about every 1000 feet along the project.

The important thing is that each bench mark gives us a point of known elevation and the location of that point.

Bench mark notes are shown along the top of profile views on plan and profile sheets. Here is an example from Sheet No. 20, Project 79040-3544(Plan Book – page 47).



QUIZ

Bench marks give precise ________________________.

Bench mark notes are found in the ________________________ views of plan and profile sheets.

Refer to Sheet No. 20, Project 79040-3544(Plan Book – page 47).

How many bench marks are noted on this sheet? ________________

What does bench mark No. 42 look like? _________________

What is the elevation of bench mark No. 42? ______________

Correct? Go to the discussion on MEASURING DISTANCES.

MEASURING DISTANCES

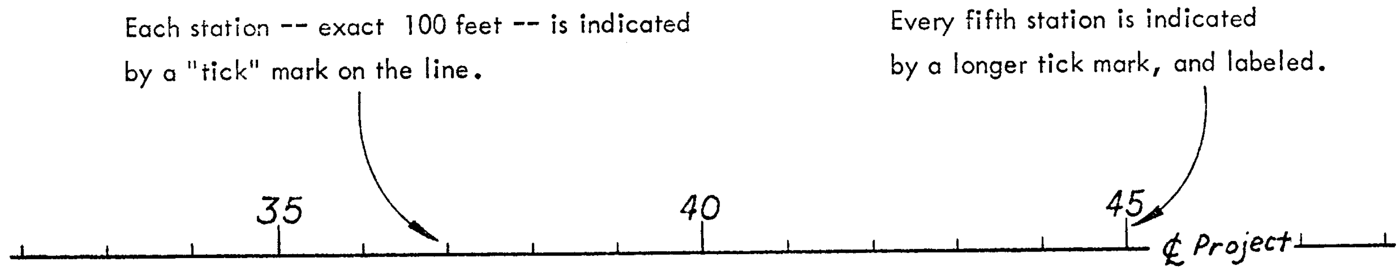
STATIONS

On nearly all plan sheets you will see reference to "stations." This is a term used for measuring distances and identifying points on the ground along a surveyed line. In surveying, a "station" is equal to 100 feet of distance. Think of it like this:

1 foot = 12 inches
1 station = 100 feet

Surveyors also use the station to identify points along a surveyed line. For example, if the beginning of a line is station O, a point 500 feet from station O is station 5, and station 12 represents a point 1200 feet from station O. Another example: station 37 is 8 stations (800 feet) ahead of station 29. So -- the word "station" is used in two ways: twenty-five stations is a distance of 2500 feet, and station 25 is a point 2500 feet from station O. (Projects, however, rarely begin at station O -- for example, the location map on the Key Sheet, Sheet No.1, Project 56520-3602 (Plan Book – page 1) shows the note "Begin Project station 23+00.")

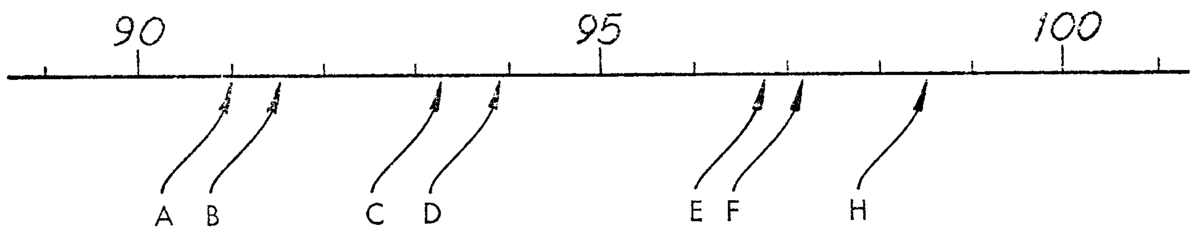
Plan sheets show stationing on the centerlines of proposed projects, like this:



When a specific construction item is described in the plans, the exact location is defined by a station number. If the item is exactly on a station you will see + 00 after the number. A point half-way between two stations would be shown with + 50 after the lower station number. The location of any point is always shown as a plus distance in feet beyond the last station -- for example, Sta. 345 + 67 would mean a point 67 feet ahead of station 345 + 00. Sta. 98 + 76.54 would mean a point 76.54 feet ahead of station 98 + 00.

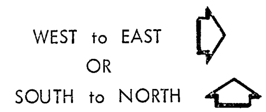
QUIZ

Fill in the blanks below with the letters that best describe the stationing:

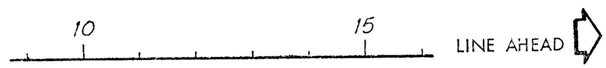


Station 91 + 00 ____________________
Station 98 + 50 ____________________
Station 93 + 25 ____________________
Station 97 + 15 ____________________
Station 91 + 50 ____________________
Station 96 + 75 ____________________
Station 93 + 90 ____________________

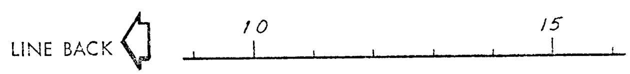
Generally, station numbers get larger as you go from:



Station numbers usually get larger when you look in this direction. When you look in that direction, you are looking at the LINE AHEAD.



Station numbers usually get smaller when you look in this direction. When you look in that direction, you are looking at the LINE BACK.



To find the distance between two points along a centerline, you subtract the lower station number from the higher station number. Ignore the PLUS SIGN when calculating the answer.

EXAMPLE: Distance between stations 20 + 60 and 12 + 80.

Ignore the plus sign.	2060
Subtract smaller station.	- 1280
Answer	780 feet

Here is a way to check the answer on the previous page:

The distance from station 12 + 80 to station 13 + 00 is:	20 feet
The distance from station 13 + 00 to station 20 + 00 is:	700 feet
The distance from station 20 + 00 to station 20 + 60 is:	60 feet
ADD and the total distance is:	780 feet

QUIZ

Find the distances between these stations:

Stations 29 + 10 and 34 + 30 ______________________________

Stations 93 + 40 and 116 + 20 ______________________________

Stations 450 + 00 and 455 + 10 ______________________________

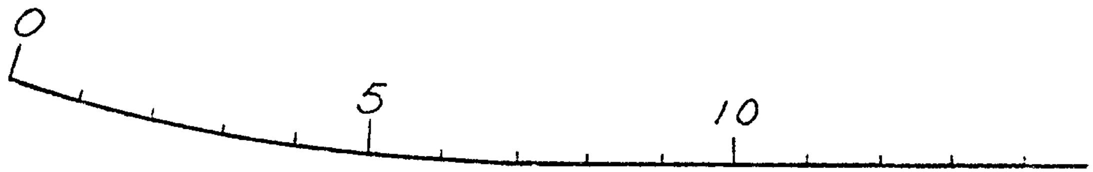
Stations 23 + 28 and 245 + 50 ______________________________

Some measurements shown on the plans need to be more exact than others. The stations and distances we talked about were shown to the nearest foot. However, in Florida, stations normally are written to the nearest one-hundredth of a foot -- like this: 148 + 35.08. Go on to EQUATIONS.

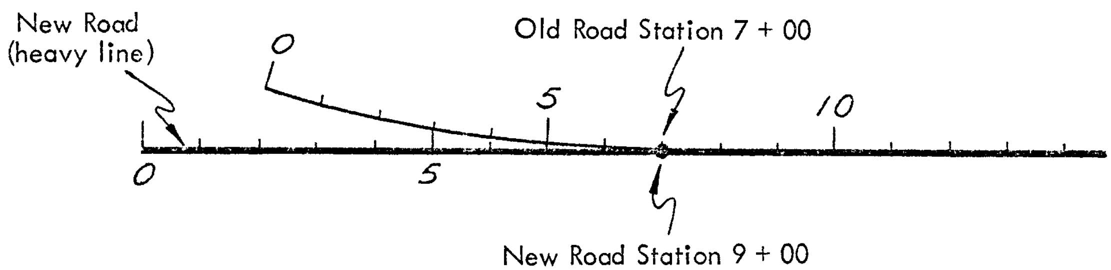
EQUATIONS

You just learned that the distance between two stations is found by subtracting the smaller station from the larger station. BUT WAIT A MINUTE! This isn't always the case. Let's see why.

Suppose the stationing on an old road looks like this:



Then suppose a new road is built partly over the old road like this:



Station 9 + 00 on the new road is the same point as station 7 + 00 on the old road -- right? Sure it is. Check it for yourself.

The stationing on the new road doesn't have to be continuous. Lots of time can be saved by using the old-road stationing for the new road.

All we have to be concerned about is WHERE the stationing for the new road CHANGES. The point where the stationing changes is station 9 + 00 on the new road OR station 7 + 00 on the old road -- both stations represent the same point.

Since they are the same point, we can say that station 9 + 00 = station 7 + 00. THAT IS, station 9 + 00 on the line back of station-change point equals station 7 + 00 on the line ahead of the station-change point.

In abbreviated form, you can say it like this:

Sta. 9 + 00 Bk. = Sta. 7 + 00 Ah.

When you say it like that, it is an EQUATION.

You know, then, that an equation means the station numbering is changed. The point of the equation has two station numbers -- one that is correct when measuring on the line BACK of the equation, and the other when measuring AHEAD of the equation.

Now we're going to see why the distance between two stations sometimes can't be determined by subtracting the smaller station number from the larger station number. Refer to the figure on page 1-42. On the new road, look at the distance between stations 5 + 00 and 10 + 00. It's more than 500 feet -- it's 700 feet!

Kind of tricky, isn't it? You can't subtract station 5 + 00 from station 10 + 00 to find the actual distance. You have to do more than that.

This is what you have to do:

First, subtract station 5 + 00 from station 10 + 00.

```
 1000 feet
 -500 feet
  500 feet
```

This is only the APPARENT LENGTH -- not actual length.

Then, find the difference between the station numbers at the equation.

```
  900 feet
 -700 feet
  200 feet
```

This is the EQUATION LENGTH.

If the back station number in the equation is larger than the ahead station number, add the EQUATION LENGTH to the APPARENT LENGTH to find the actual length.

```
  500 feet
+ 200 feet
  700 feet
```

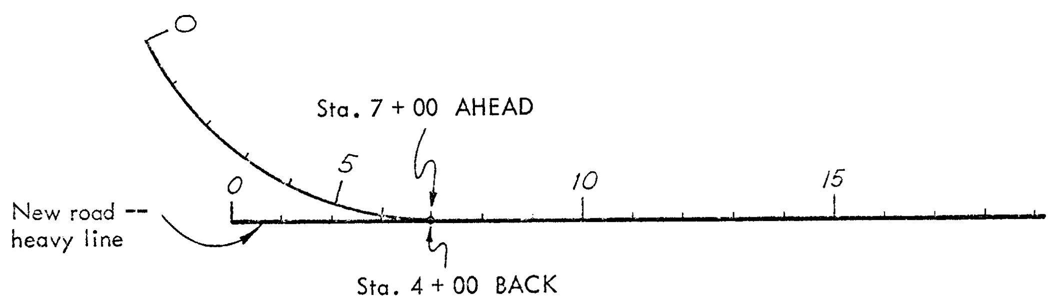
This is the ACTUAL LENGTH.

How about that?

REMEMBER: If the back station number in the equation is larger than the ahead station number, add the EQUATION LENGTH to the APPARENT LENGTH to find the actual length.

What do you do if the back station number is SMALLER? We haven't talked about that. Let's do it now.

Suppose a new road is built over an old road like this:



In this case, the EQUATION looks like this:

Sta. 4 + 00 Bk. = Sta. 7 + 00 Ah.

On the new road, the length between stations 0 + 00 and 10 + 00 appears to be 1000 feet. But it's not. The actual length is 700 feet.

Here's what you do to find the actual length:

Since the back station number in the equation is SMALLER than the ahead station number, SUBTRACT the equation length from the apparent length to find the actual length.

First, find the apparent length.

1000 feet
- 000 feet
1000 feet

Then find the equation length.

700 feet
-400 feet
300 feet

Subtract the equation length from the apparent length.

1000 feet
- 300 feet
700 feet

This is the ACTUAL LENGTH

The important thing to remember is this:

WHEN YOU WANT TO KNOW THE ACTUAL DISTANCE BETWEEN ANY TWO STATIONS, AND THERE IS AN EQUATION BETWEEN THEM,

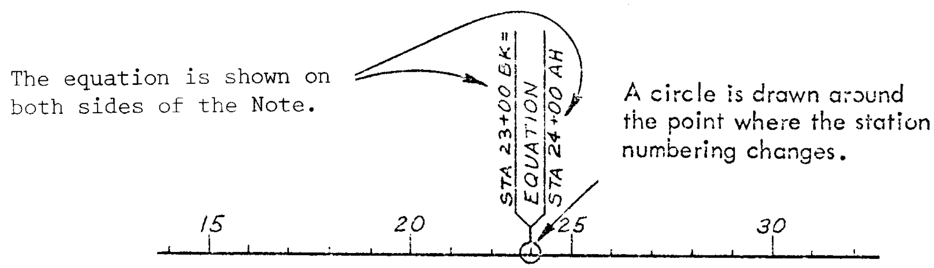
- ADD THE EQUATION LENGTH TO THE APPARENT LENGTH -- if the back station is larger
- SUBTRACT THE EQUATION LENGTH FROM THE APPARENT LENGTH -- if the back station is smaller

If you do these things, you'll always find your answer.

Equations are easy to find on the plans. They are shown on:

- the Location Map on the Key Sheet, and
- Plan and Profile Sheets.

Equation notes show the location of equations, like this:



QUIZ

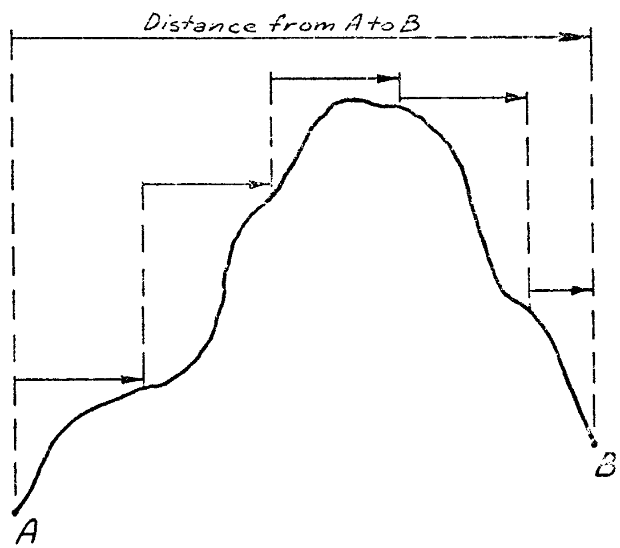
Can you determine the actual distance between two stations by subtracting the smaller station from the larger station:

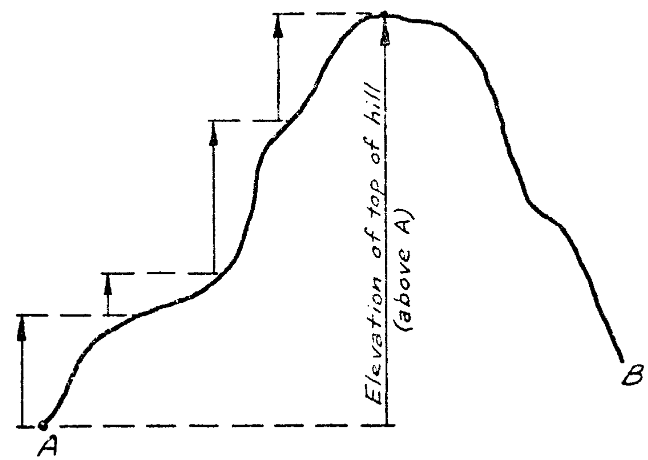
if there is no equation between them? ______________________
if there is an equation between them? ________________________

Does the stationing of a project have to be continuous? ____________________

At the point where the stationing of a project changes, there is an ______________________.

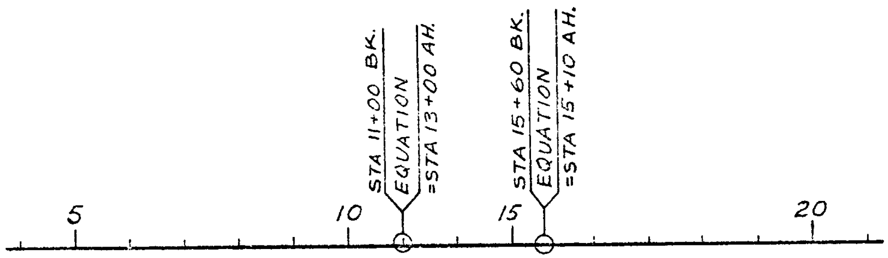
One more thing to remember about distances shown <u>on the plans</u> -- they always are measured either HORIZONTALLY or VERTICALLY, never along the slope of the ground. The profile views below show how the surveyor makes a series of short level measurements to find the total distance from A to B and several vertical measurements to find the elevation of the top of the hill.





QUIZ

All questions on this page refer to the figure below:



What are the APPARENT lengths between these stations?

5 + 00 and 10 + 00 ______________________________
10 + 00 and 15 + 00 ______________________________
15 + 00 and 20 + 00 ______________________________

What are the ACTUAL lengths between these stations?

5 + 00 and 10 + 00 ______________________________
10 + 00 and 15 + 00 ______________________________
15 + 00 and 20 + 00 ______________________________
5 + 00 and 20 + 00 ______________________________

QUIZ, continued

Answer the questions below for the equation Sta. 269 + 80.61 Bk. = Sta. 269 + 94.74 Ah.

What is the length of this equation? _____________

What is the APPARENT distance between stations 265 + 00 and 275 + 00? ________________

What is the ACTUAL distance between these stations? _____________________

Did you get the right answers? Remember:
ADD the equation length if the back station is LARGER.
SUBTRACT the equation length if the back station is SMALLER.

A station is equal to _____________ feet of distance.

Thirteen stations is a distance of ____________feet.

With no equations to consider, a point 600 feet ahead of station 100 + 00 is station ____________.

Generally, station numbers get larger as you go from _______ to _________, or ________ to _________.

Are distances shown on the plans measured along the slope of the ground? ____________

If you had trouble getting the right answers, carefully review the discussion on MEASURING DISTANCES.
Next we will study MEASURING GRADES, SLOPES AND CROSS SLOPES.

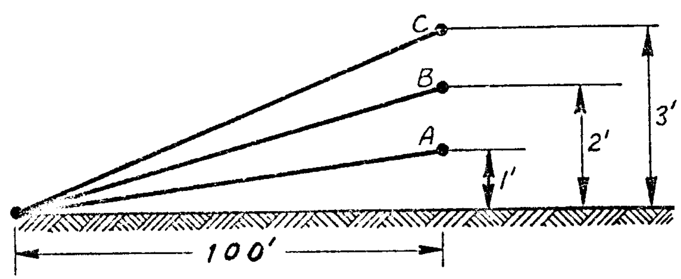
MEASURING GRADES, SLOPES AND CROSS SLOPES

If distances are always measured vertically or horizontally, how do we express the rise and fall of the ground? It is expressed in one of three ways -- as a GRADE, a SLOPE or a CROSS SLOPE.

GRADES

GRADES are written as a PERCENT of vertical rise or fall, based on horizontal distance.

The figure below shows how grades are computed. The three heavy lines represent profiles or proposed roads.

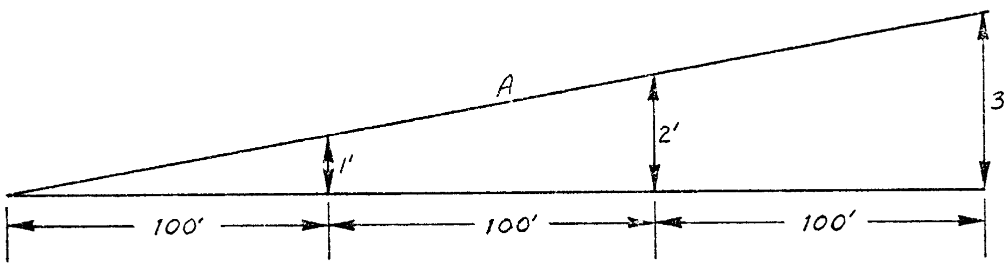


Line A rises 1' vertically in 100' horizontal distance.
The grade is 1/100 or 0.01 or 1%.
Line B rises 2' vertically in 100' horizontal distance.
The grade is 2/100 or 0.02 or 2%.
Line C rises 3' vertically in 100' horizontal distance.
The grade is 3/100 or 0.03 or 3%.

A single formula that can be used to determine percent of grade as shown below:

$$\%Grade = \frac{\text{Vertical distance}}{\text{Horizontal distance}} \times 100$$

Look at line A extended out farther. No matter how far you go, the percent of rise to distance is always the same.



$$\% \text{ Grade} = \frac{\text{Vertical distance}}{\text{Horizontal distance}} \times 100$$

$$\% \text{ Grade} = \frac{1'}{100'} = 0.01 \times 100 = 1\%$$

OR --

$$\% \text{ Grade} = \frac{2'}{200'} = 0.01 \times 100 = 1\%$$

OR --

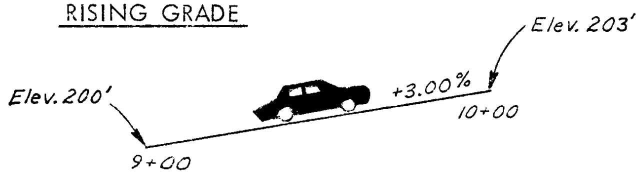
$$\% \text{ Grade} = \frac{3'}{300'} = 0.01 \times 100 = 1\%$$

Grades not only go up, they also go down -- and the computation is made the same way. The plans show a PLUS SIGN (+) in front of the percent for an UP grade and MINUS SIGN (-) in front of the percent for a DOWN grade.

If a grade does not go up or down, it is a level grade -- shown without a plus or minus sign. A level grade always is shown as 0.00%.

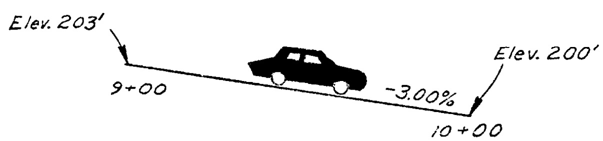
REMEMBER these three ways of showing

RISING GRADE



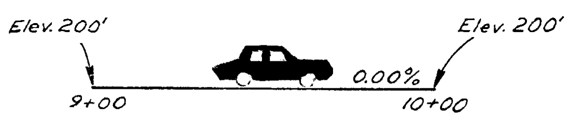
The roadway rises 3' in 100' of horizontal travel. The grade is +3.00%.

FALLING GRADE



The roadway falls 3' in 100' of horizontal travel. The grade is -3.00%.

LEVEL GRADE



The roadway does not rise or fall. It is level. The grade is 0.00%.

QUIZ

Fill in the blanks to show the percents of grade for the changes of elevation shown below:

Horizontal Distance	Elevation Change	Percent Grade
100'	5.00' rise	____________
100'	6.50' fall	____________
200'	4.00' rise	____________
300'	7.50' rise	____________
400'	2.00' fall	____________
500'	1.25' fall	____________
700'	0.00'	____________

Now, try it another way. For each distance and grade that is given, compute the elevation change:

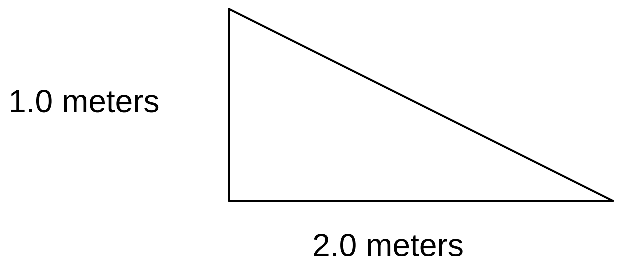
Horizontal Distance	Percent Grade	Elevation Change
100'	+ 2.50%	____________
150'	- 4.00%	____________
225'	+ 3.00%	____________
450'	+ 0.50%	____________
200'	0.00%	____________
1000'	+ 1.42%	____________

Go on to SLOPES.

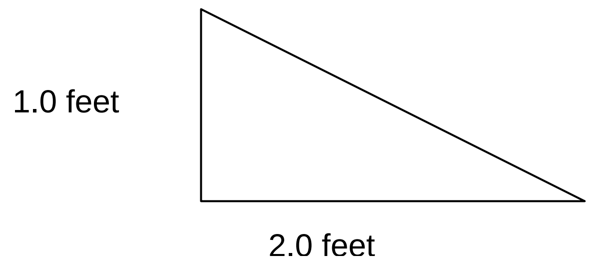
SLOPES

Slope is defined as the RATIO of vertical length over horizontal length. Even though you, as an inspector may encounter both the Metric and the English system of measurement, the definition of slope will remain the same.

For example:



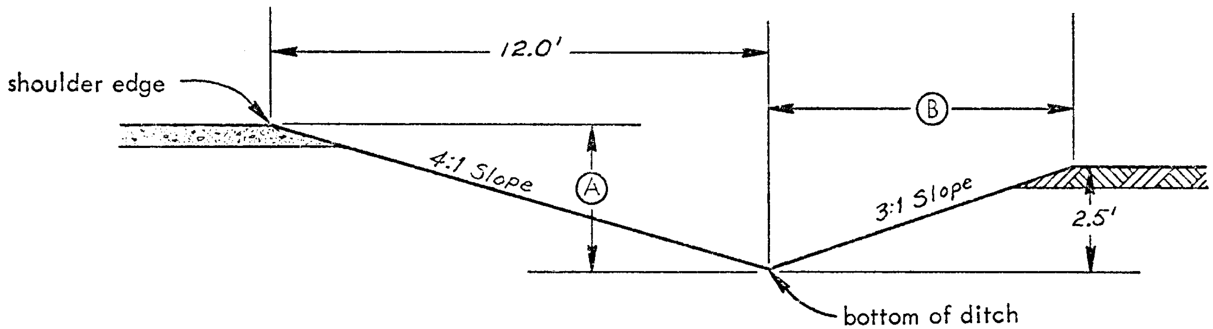
Slope = 1.0 meters/2.0 meters or **1:2**



Slope = 1.0 feet/2.0 feet or **1:2**

Notice that when slope ratios are given, the vertical distance is always given first, and is always 1. The second figure in the slope ratio is the horizontal distance. You can see that this gives you a measure of steepness. The second number is large for flat slopes and small for steep slopes.

Here are some examples of how slope ratio measurements are used.



Note: The slope ratios in the above figure should read 1:4 and 1:3 (not 4:1 and 3:1).

What is the vertical distance **A**, from the shoulder edge to the bottom of the ditch? The 1:4 slope goes down 1 foot for every 4 feet horizontally. Since the bottom of the ditch is 12.0 feet from the shoulder, it will be 3.0 feet (12.0' ÷ 4.0') below the shoulder.

What is the horizontal distance **B**, from the bottom of the ditch to the top of the backslope? For each 1 foot of rise, the slope goes out horizontally 3 feet. Therefore, for the slope to rise 2.5 feet, the horizontal distance will have to be 7.5 feet (3' x 2.5').

An easy way to see this relationship is shown by this formula: Slope ratio = $\frac{\text{Vertical distance}}{\text{Horizontal distance}}$

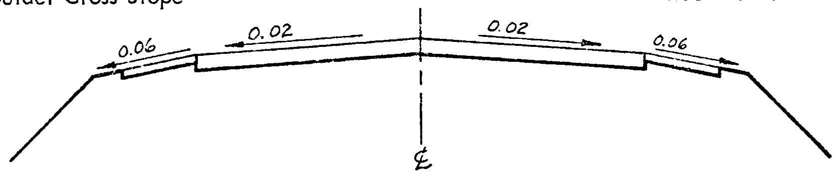
QUIZ

Fill in the blanks to show the relationships between slope ratios, vertical distances and horizontal distances. If you know two of these, you can always figure the third.

Vertical Distance	Horizontal Distance	Slope
2.0'	4.0'	-----
-----	6.0'	1:3
3.0'	-----	1:5
30.0'	45.0'	-----
-----	20.0'	1:10
4.0'	-----	1:4

CROSS SLOPES

Cross slopes of highway surfaces are shown differently. The figure below shows the slopes of the pavement away from the centerline -- the pavement cross slopes -- to be 0.02 feet per foot. Cross slopes allow water to drain from the pavement surface.



A cross slope of 0.02 ft./ft. means that the pavement elevation drops 0.02 feet vertically for each foot horizontally away from the centerline. If the outside edge of the pavement is 20.0 feet from the centerline, it would be 0.4 feet (0.02 x 20.0 = 0.4) below the centerline elevation.

Another way of seeing this relationship is by solving the problem using the cross slope rate formula as follows:

$$\text{Cross slope rate} = \frac{\text{Vertical distance}}{\text{Horizontal distance}}$$

$$\frac{0.02}{1.00'} = \frac{\text{Vertical distance}}{20'}$$

Vertical distance = 20' x 0.02
Vertical distance = 0.4 ft.

When working with <u>cross slopes,</u> the formula used for determining the slope is reversed. While slope <u>ratios</u> are expressed in horizontal distance to vertical distance, cross slope rates are expressed as vertical distance to horizontal distance.

QUIZ

Fill in the blank spaces.

Cross Slope	Horizontal Distance	Vertical Distance
0.02 ft. per ft.	24.0'	____________
0.02 ft. per ft.	36.0'	____________
0.03 ft. per ft.	48.0'	____________
0.06 ft. per ft.	10.0'	____________
0.045 ft. per ft.	50.0'	____________
0.01 ft. per ft.	15.0'	____________

This chapter taught you many basic things -- things you must know in order to read plans and understand the chapters that are yet to come.

A view from the top is a ________________ view.

A view from the front or side is a ____________________ view.

An inside view, as if the object had been cut open, is a __________________ view.

An index to the sheets included in a set of plans will be found on the ________________ sheet.

Do revision dates help identify Roadway and Traffic Design Standards? _______________

What two kinds of numbers identify plan and profile sheets? _____________ and _______________.

QUIZ, continued

What do these symbols and abbreviations mean? Look them up if you have to -- don't guess.

R.R.	____________
Rt.	____________
Sta.	____________
——X——X——	____________
---10" WM---	____________
⅊	____________
℄	____________

QUIZ, continued

Distance on Scale	Ground Plan View	Distance
1 in. = 100 ft.	4 3/4 inches	___________
1 in. = 10 ft.	3 1/2 inches	___________
1 in. = 2000 ft.	2 1/4 inches	___________

Full Size Plans	1/2 Size Plans
1 in. = 200 ft. →	1 in. = ___ ft.
1 in. = 10 ft. →	1 in. = ___ ft.

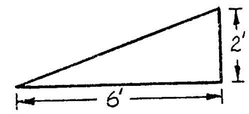
Find bench mark No. 42 at station 41+61 on Sheet No. 20, Project 79040-3544 (Plan Book – page 47).

The elevation of the bench mark is _________________.

What does the bench mark look like? _____________

Where is the bench mark located? ______________

QUIZ, continued



What is the slope ratio here? ______________

What is the percent grade of a line, which falls 5.00 feet in a horizontal distance of 100 feet?

____

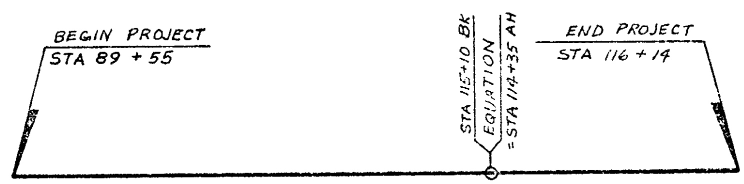
If the grade of a line is + 2.50%, what is the elevation change of the line in a horizontal distance of 100 feet? _________

If the slope of a line is 0.02 ft. per ft., what is the vertical distance between the beginning and the end of the line 48.0 feet long? ____________

What is the percent grade of a roadway, which neither rises nor falls? __________

A distance of 18.5 stations is equal to _____________ feet.

What is the actual length of the project below?___________ feet



Did you make less than three mistakes? If so, go to Chapter Two.
Three or more mistakes? Stop. Review the sections giving you trouble; then go to Chapter Two.

ANSWERS TO QUESTIONS

Page 1-6

- Elevation view
- Plan view
- Cross-section view
- Plan view

Page 1 -11

- No
- Plan
- Typical Section Sheet

Page 1-15

- Cross-Section Sheets
- Typical Section Sheet
- Typical Section Sheet
- Lower right

Page 1-17

- State map; upper right; Key Sheet
- Key Sheet

Page 1-19

- Typical Section Sheet
- Key Sheet
- Roadway and Traffic Design Standards
- Summary of Pay Items
- Plan and Profile Sheet
- Cross-Section Sheet

Page 1-21

- Signing and Pavement Marking Plans
- Signalization Plans
- Structures Plans
- Roadway Plans

ANSWERS TO QUESTIONS, continued

Page 1-23

- Limited Access Line
- Center Line
- Excavation
- Guardrail
- Westbound
- Proposed fire hydrant

Page 1-27

- Lighting Plans
  Signing and Pavement Marking Plans
  Signalization Plans
  Structures Plans
- Roadway Plans
- Roadway and Traffic Design Standards
- lower right
- Roadway and Traffic Design Standards
- Structures Key Sheet, or Sheet No. A-1

Page 1-29

- Roadway and Traffic Design Standards
- Yes
- project
- drawing; index
- Roadway and Traffic Design Standards

Page 1-31

- 500 ft.
- 300 ft.
- 475 ft.
- 100 ft.
- 500 ft.
- 5 ft.
- 9000 ft.

Page 1-34

- 120.0; 20; right
- 130.0; 10; right
- 132.0; 30; left
- 125.0; 20; left
- 128.0; 26; right

ANSWERS TO QUESTIONS, continued

Page 1-37

- elevations
- profile
- 1
- FDOT Conc. Monument
- 17.02

Page 1-39

- A
- H
- C
- F
- B
- E
- D

Page 1-41

- 520 feet
- 2,280 feet
- 510 feet
- 22,222 feet

Page 1-47

- Yes
- No
- No
- equation

Page 1-49

- 500'
  500'
  500'
- 500'
  300'
  550'
  1,350'

Page 1-50

- 14.13'
- 1000'
- 985.87'
- 100
- 1300
- 106 + 00
- West; East; South; North
- No

ANSWERS TO QUESTIONS, continued

Page 1-54

- + 5.00%
  - 6.50%
  + 2.00%
  + 2.50%
  - 0.50%
  - 0.25%
  0.00%
- 2.50'; rise
  6.00'; fall
  6.75'; rise
  2.25'; rise
  0.00'
  14.20'; rise

Page 1 -57

- 1:2
- 2.0'
- 15.0'
- 1:1.5
- 2.0'
- 16.0'

Page 1-59

- 0.48'
  0.72'
  1.44'
  0.60'
  2.25'
  0.15'
- plan
- elevation
- cross-section
- Key
- Yes
- Sheet numbers;
  Project numbers

Page 1-60

- Railroad
- Right
- Station
- Fence
- Existing 10" Water Main
- Property line
- Centerline

Page 1-61

- 475 ft.
  35 ft.
  4500 ft.
- 400, approximately
  20, approximately
- 17.02
- FDOT Conc. Monument
- 50.2ft. Lt. Sta. 41+61

Page 1-62

- 1:3
- -5.00%
- 2.50' rise
- 0.96'
- 0.00%
- 1850
- 2734 ft.

CHAPTER TWO

Roadway Alignment

CONTENTS

2

ROADWAY ALIGNMENT

In Chapter One you learned about horizontal distances elevation, stations, equations, bearings, grades, slopes and cross slopes. All of these things are important to defining roadway alignment. This chapter will describe in detail how to read and understand plan and profile views of roadway alignment.

Contract plans show two views of alignment -- a plan view showing HORIZONTAL alignment and a profile view showing VERTICAL alignment. Usually these views are shown one above the other on plan and profile sheets. This way the roadway can be better visualized. Sometimes a plan view is shown on one sheet and an elevation view on another. Examine Sheet No. 17, Project 79040-3544 (Plan Book – page 44) -- it is a plan and profile sheet.

QUIZ

What two views usually are shown on plan and profile sheets? ___________________________

Normally, the top half of a plan and profile sheet shows a __________________________ view.

Which view shows horizontal alignment? _________________________________

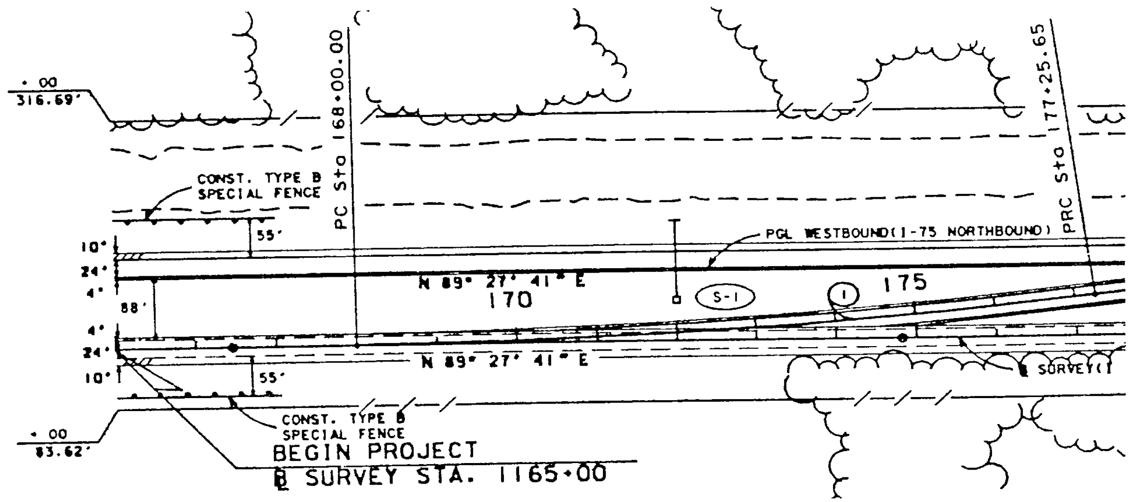
HORIZONTAL ALIGNMENT

The horizontal alignment of the proposed road is found in the top halves of plan and profile sheets. The alignment is shown in relation to buildings, utility poles, fences, trees, property lines and other topography.

POINTS OF BEGINNING AND ENDING

The beginning of each project is shown on the first plan and profile sheet. Find the beginning of the project, Sheet No.17, Project 79040-3544 (Plan Book – page 44).

Note: Drawing below is not from Project 79040-3544, it is intended as an example only.



We know exactly where the project starts. The end of the project is shown with a similar note on the last plan and profile sheet.

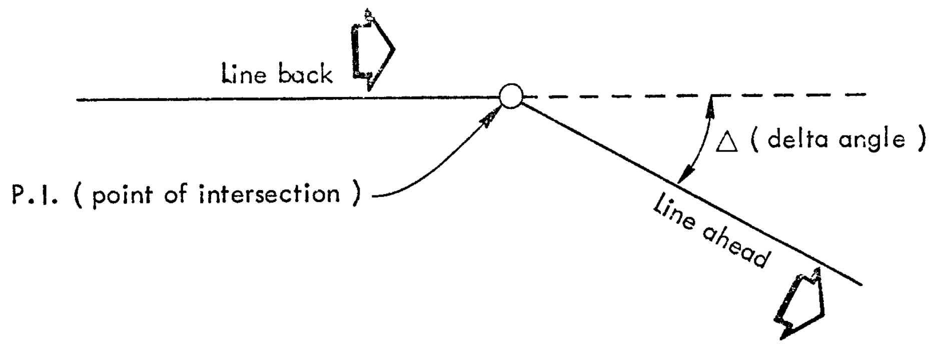
DISTANCES

In Chapter One you learned how distances along the project are measured by STATIONS -- represented by small "tick" marks on the centerline. Each "tick" mark represents 100 feet of distance on the ground -- as they are spaced 100 feet apart.

The stations on the plans describe the exact locations of proposed roadways.

CHANGES OF DIRECTION

What happens when it is necessary for the roadway to change direction? Simple enough, the surveyor drives a stake in the ground, turns his transit in the direction he wants to go and measures the angle of the change. This angle is called the DELTA ANGLE and is identified with the symbol Δ. The point where the stake is driven is called the POINT OF INTERSECTION -- P.I. -- because the line back and the line ahead intersect at this point. The figure below shows this relationship:

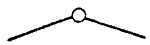

Line back
P.I. (point of intersection)
△ (delta angle)
Line ahead

QUIZ

What does Δ represent? ______________________________

The point at which Δ occurs -- where the stake is driven -- is called the ____________________.

The abbreviation for the answer above is ________________.



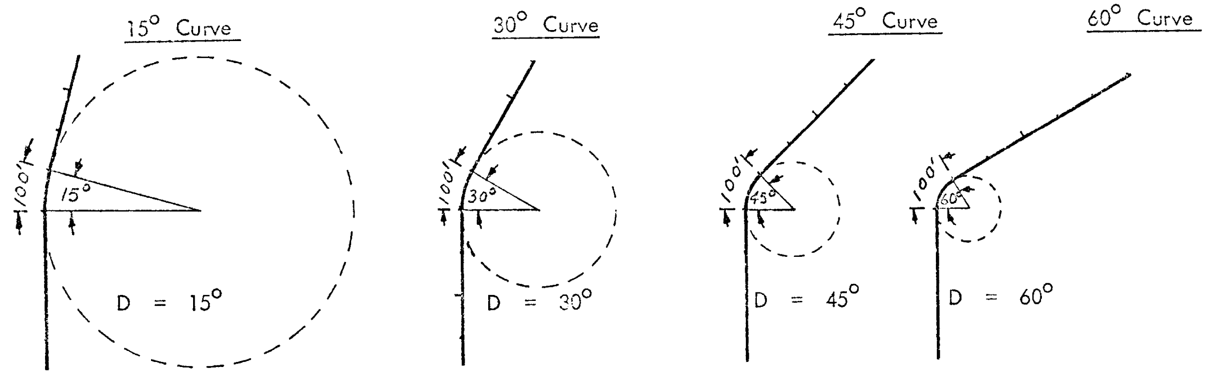
This is the symbol for ____________________.

HORIZONTAL CURVES

We have seen how we can describe horizontal alignment with a series of straight lines. But we can't build the road that way -- cars can't make the sharp turn at the P.I., so a horizontal curve is surveyed between the straight lines to permit the cars to change direction easily. Let's look at some of the elements of horizontal curves.

DEGREES OF CURVATURE

If the road is for high-speed traffic, the curve must be "flat" and extend a considerable distance each side of the P.I. For low design speeds, the curves may be sharper. The plans tell you how "sharp" the curve is by identifying the DEGREE OF CURVATURE -- D. The degree of curvature is measured by the angle at the center of a circle -- between two radii -- extending to points 100 feet apart on the circumference of the circle. The figures below show increasing D values, exaggerated for clarity -- in practice D values larger than 20° are rare.



You can see that small D values represent "flat" curves with large radii, and large D values represent "sharp" curves with small radii. Remember, the letter D always is used to identify degrees of curvature.

QUIZ

If you have two radii extending 100 feet apart on the circumference of a circle, the angle at the center represents the ______________________.

D is the abbreviation for ___________________.

Do large D values represent sharp curves? ___________________

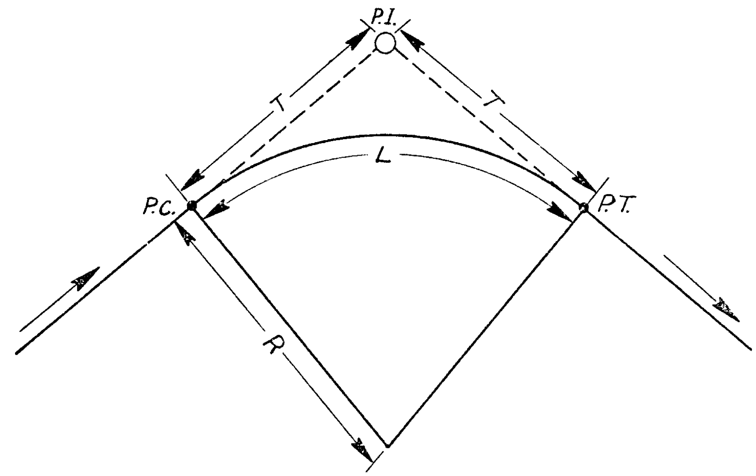
The degree of curvature is the directional change along ___________ feet of a curve.

OTHER CURVE ELEMENTS

Other parts of a curve are identified with symbols and abbreviations. Some of these are:

- P.C. -- Point of Curvature
- P.T. -- Point of Tangency
- T -- Tangent Length
- L -- Curve Length
- R -- Radius

These parts are identified on the figure at the right:



Point P.C. is where the horizontal curve begins. Point P.T. is where the horizontal curve ends. The curve length, (L), is the distance measured along the curve from point P.C. to point P.T. The tangent lengths (T) represent equal distances from point P.C. to P.I. and from point P.I. to P.T. The radius (R) of the curve, as you recall, represents the distance from the center of the imaginary circle -- used to draw the curve -- to the edge of the circle. The radius (R) is always perpendicular -- 90°-- to the tangent (T).

Plan views on plan and profile sheets list horizontal curve elements with their values. These data are located near the curve to which they apply. Turn to Sheet No. 22, 23, and 26, Project 79040-3544

(Plan Book – pages 49-51) and find the curve between stations 54 + 45.01 and 78 + 70.43.

QUIZ

Refer to the curve beginning at station 54 + 45.01 on Sheet No. 22, Project 79040-3544 (Plan Book – page 49).

The P.I. is located at station ________________.

The delta angle is ______________.

The degree of curvature is ____________.

Each tangent Is _______________ long.

The total length of the curve is ______________.

The P.C. is at station ______________.

The P.T. at the end of the curve is located at station ______________.

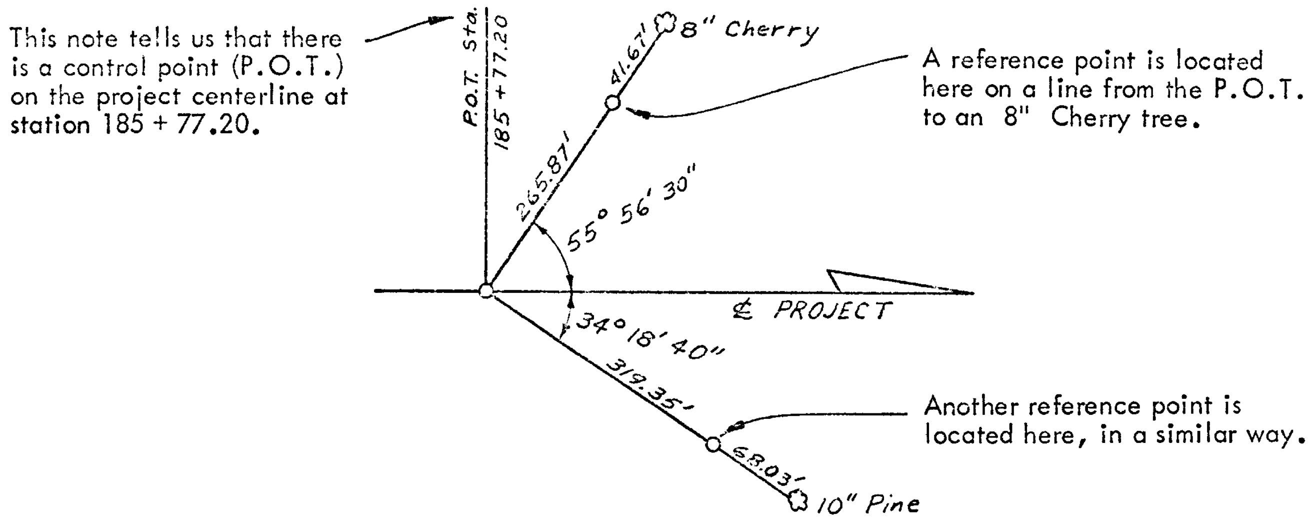
Refer to the list of abbreviations to answer these:

P.C. means ________________________.
P.T. means ________________________.

CONTROL POINTS AND REFERENCE POINTS

Points on curves (P.O.C.'s) and points on tangents (P.O.T.'s) are control points to help assure that the roadway is constructed exactly where it is supposed to be. The locations of each control point are identified by reference points.

For example, compare the figure below with the diagram on the upper right side of Sheet No. 26, Project 79040-3544(Plan Book – page 51):



The P.O.T. is the control point. The markers and trees are reference points that can be used to establish the exact location of the P.O.T.

There are many similar control points with their reference points on other plan and profile sheets. Another example is on Sheet No. 22 of Project 79040-3544 (Plan Book – page 49).

QUIZ

Answer these questions about the P.O.T. at station 78 + 70.43 on Sheet No. 23, Project 79040-3544
(Plan Book – page 51):

The P.O.T. is located on the ___________________________of the project.

There is a reference point 45.22' from the P.O.T., on a line between the P.O.T. and an ________. This line makes an angle of ________________with the ℄ Survey.

The other reference point is _______________ feet from the P.O.T.

Refer to the P.I. at station 54 + 45.01 on the upper right side of Sheet No. 22, Project 79040-3544
(Plan Book – page 49):

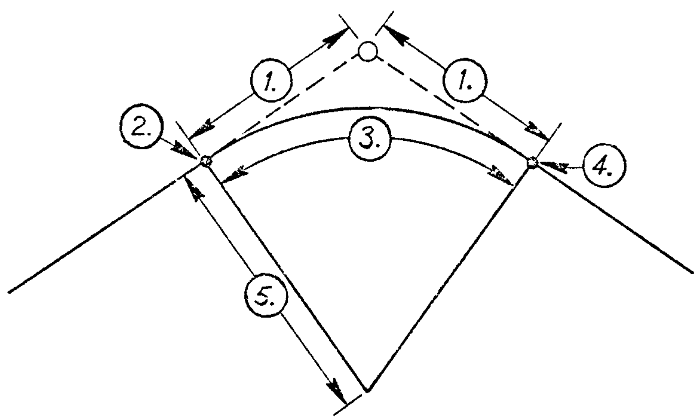
One of the lines makes an angle of 90°with the survey line back.

What is used as a reference on this line? _______________________

How far is the reference from the P.I.? _______________________

QUIZ, continued

Label the curve elements:



1. ____________________

2. ____________________

3. ____________________

4. ____________________

5. ____________________

D represents
Δ represents
P.O.T. = ____________________
T = ____________________
L = ____________________
R = ____________________
P.I. = ____________________
P.C. = ____________________
P.T. = ____________________

QUIZ, continued

Find the curve whose P.I. is at station 66 + 76.16 on Sheet No. 22, Project 79040-3544 (Plan Book – page 49). From the list labeled "CURVE DATA" find the following information:

Location of P.C. = ______________________

Location of P.T. = ______________________

Delta Angle = _________________________

Degree of Curvature = ___________________

Tangent Length = ______________________

Length of Curve = ______________________

Do not go on until you fully understand the material presented -- and can answer the questions easily.

If you answered all the questions correctly, congratulations! -- Go on to VERTICAL ALIGNMENT.

VERTICAL ALIGNMENT

Vertical alignment is the relationship of roadway elevations along the project. A roadway changes elevations at various points along the way. It rises and falls.

Vertical alignment control points are defined by stations and elevations. Stations and elevations form a "grid" for measuring and plotting vertical alignment. Vertical alignment data are shown in profile views on plan and profile sheets.

Turn to Sheet No. 18, Project 79040-3544 (Plan Book – page 45). First, notice the difference between the top and bottom halves of the sheet. The top half shows a plan view -- the bottom half shows a profile view.*

Go to ELEVATIONS OF THE PROPOSED ROADWAY.

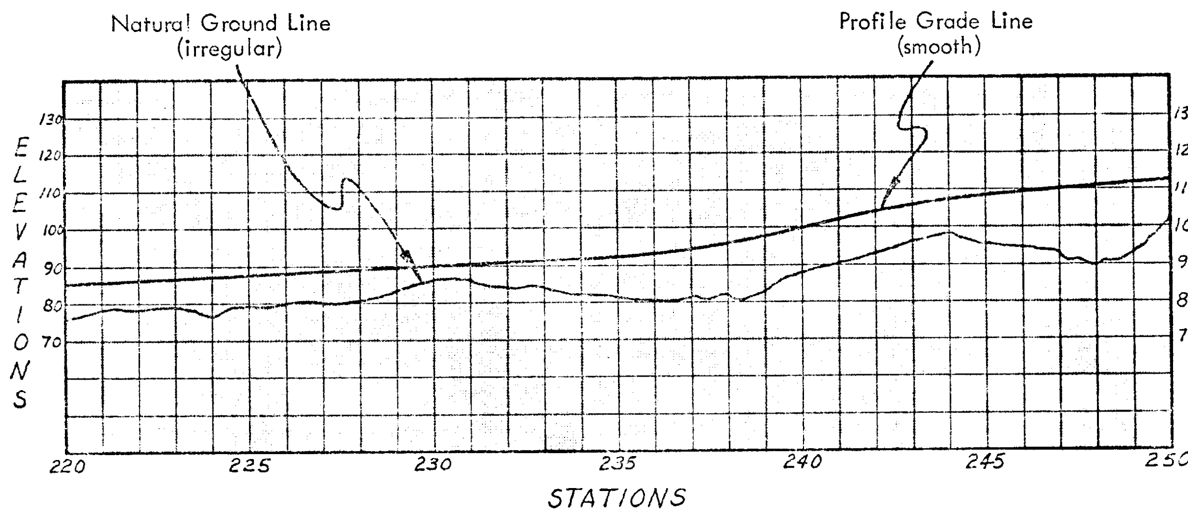
---

* Profile views sometimes are shown on separate sheets. They are not always shown together with plan views.

ELEVATIONS OF THE PROPOSED ROADWAY

The elevations of the proposed roadway are represented by the "profile grade line" shown on profile views.

The profile view (or profile) shows both the natural ground line and the profile grade line. The natural ground line and the profile grade line are shown below. Each line is plotted on a profile grid according to elevations and stations:



The natural ground line usually is an irregular line. It represents a profile view of the original ground, before construction. The profile grade line is a smooth, continuous line. It represents a profile view of the proposed roadway.

Elevations of the profile grade line serve as control points for construction of the proposed roadway. Many elements of the roadway are based on -- or constructed in relation to -- profile grade elevations.

Refer again to Sheet No. 18, Project 79040-3544 (Plan Book – page 45). Vertical lines are drawn every 100 feet to provide horizontal reference points. Also, horizontal lines every two feet provide vertical reference points. On the left and right sides of the profile grid you will find the elevations of the project written in feet. Along the bottom of the grid are station numbers. Station numbers and elevations are similarly located on all profile views. Elevation lines and station-number lines form "grids" upon which profile views are shown.

Notice particularly the differences in horizontal and vertical scales. On your reduced sheets, 100 feet of horizontal distance -- or one station -- equals approximately 1/2 inch. However, only 2 feet of vertical distance -- or elevation -- equals approximately 1/2 inch. The vertical scale is fifty times larger than the horizontal scale.

Changes of grade can easily be seen by looking at the profiles -- as the changes are exaggerated twenty times.

QUIZ

Vertical alignment of a roadway is based on elevation and ______________________.

The bottom halves of most plan and profile sheets show ______________ views of the proposed highway.

Are roadway elevations represented by the profile grade line? _____________________

Profile grade elevations serve as _______________ points for highway construction.

The irregular line in the profile view is the ______________________.

QUIZ, continued

Refer to Sheet No. 19, Project 79040-3544 (Plan Book – page 46).

What is the elevation of the natural ground line at station 32 + 00? ________________________

What is the elevation of the natural ground line at station 38 + 00? ________________________

What is the approximate difference in elevation of the natural ground line and the profile grade line at station 38 + 00? __________________________

What is the profile grade elevation at station 26 + 00? ____________________________

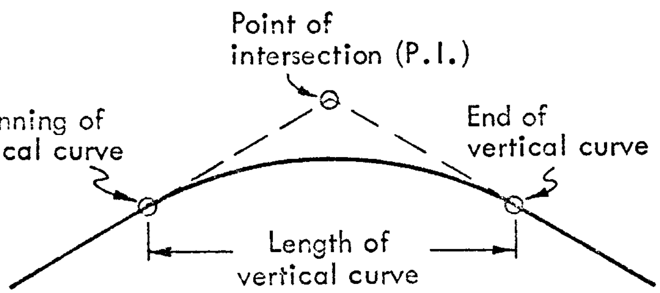
What is the profile grade elevation at station 27 + 00? ____________________________

At station 29 +00, is the natural ground higher than the profile grade line? _______________________

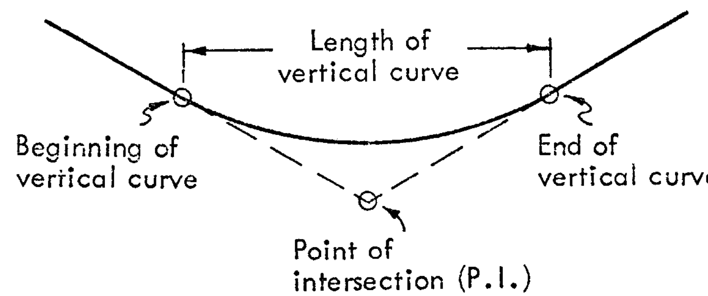
If you answered the questions correctly, go to VERTICAL CURVES.
If not, first review the last three pages, then find your mistakes.

VERTICAL CURVES

Vertical curves are the curved portions on the profile -- as shown below:



Crest Vertical Curve

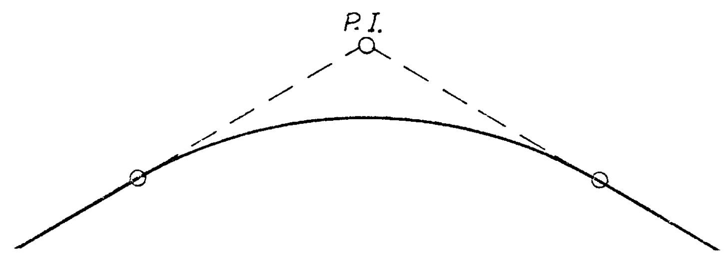


Sag Vertical Curve

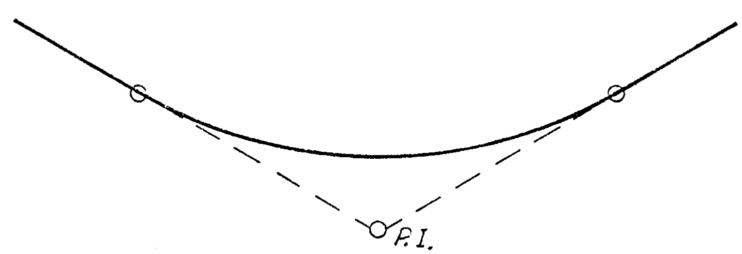
Grades change in the same way bearings change. In other words, roads go "uphill" and "downhill" as well as "left" and "right." For each grade change, there is a point of intersection (P.I.) -- just as there are P.I.'s for changes in horizontal direction.

The length of a vertical curve is the horizontal distance between the beginning and the end of the curve.

When a road goes over a hill or mountain, it may curve over the top. The term "crest" describes the vertical curve shown at the right:



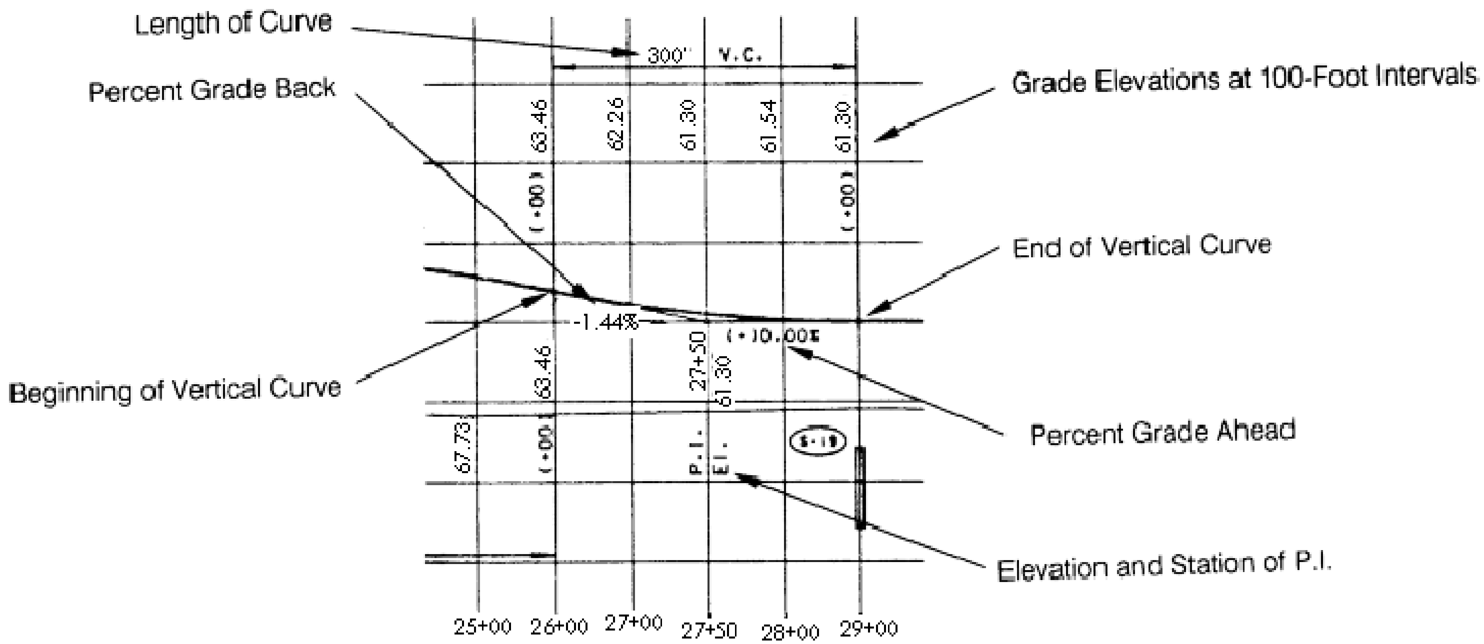
When a roadway goes down in a valley or other depression, it might "sag" as shown below:



Vertical curves form "transitions" between two different profile tangents. Without vertical curves to provide smooth grade changes, there would be sharp breaks in the profile.

VERTICAL CURVE DATA

For each vertical curve, the station and elevation of the P.I. is written on the profile. The vertical curve length also is shown. For example, refer to Sheet No. 4, Project 56520-3602 (Plan Book – page 6). Locate the vertical curve whose P.I. is at station 27 + 50. The curve data are shown as follows:



Stations and elevations of vertical curve points usually are written vertically. Vertical curve lengths are written horizontally between the beginning and the end of the curve. In the example above, "300' V.C." means "300 foot vertical curve." In other words, the vertical curve is 300 feet long, measured horizontally.

QUIZ

Refer to Sheet No. 4, Project 56520-3602 (Plan Book – page 6) and answer these questions about the vertical curve beginning at station 26 + 00.

The P.I. elevation is ________________.

The P.I. station is _______________.

The length of the vertical curve is ______________.

The percent grade preceding the curve is _____________.

The percent grade ahead of the curve is _____________.

What is the profile grade elevation at station 28 + 00? ________________

REMEMBER: There is NO relationship between a horizontal curve -- as shown on the plan -- and a vertical curve -- as shown on the profile. A road may have a horizontal curve where there is a vertical curve, or it may not.

Review any sections you need to review. Then go to Chapter Three.

ANSWERS TO QUESTIONS

Page 2-2

- plan and profile views
- plan
- plan view

Page 2-6

- delta angle
- point of intersection
- P.I.
- point of intersection

Page 2-9

- degree of curvature
- degree of curvature
- yes
- 100

Page 2-12

- 66+76.16
- 24°15′ 14.10" Rt.
- 0°59' 59.96"
- 1, 231, 15'
- 2, 425, 42'
- 54+ 45.01
- 78+ 70.43
- point on curve
  point on tangent

Page 2-14

- centerline of survey
- stake; 77°
- 124.50'
- stake
- 53.68'

ANSWERS TO QUESTIONS, continued

Page 2-15

- 1. T
  2. P.C.
  3. L
  4. P.T.
  5. R
- degree of curvature
- delta angle
- point on tangent
  tangent length
  length of curve
  radius
  point of intersection
  point of curvature
  point of tangency

Page 2-16

- Sta. 54+45.01
- 78 + 70.43
- 24°15'14.10" Rt.
- 0°59' 59.96"
- 1,231.15
- 2,425.42

Page 2-19

- horizontal distances
- profile
- yes
- control
- natural ground line

Page 2-20

- 17.98'
- 18.68'
- 0.49'
- 16.92'
- 16.48'
- yes

Page 2-24

- 61.30
- 27 + 50
- 300'
- 1.44%
- 0+00%
- 61.54

CHAPTER THREE

Cross Sections and Superelevation

CONTENTS

3

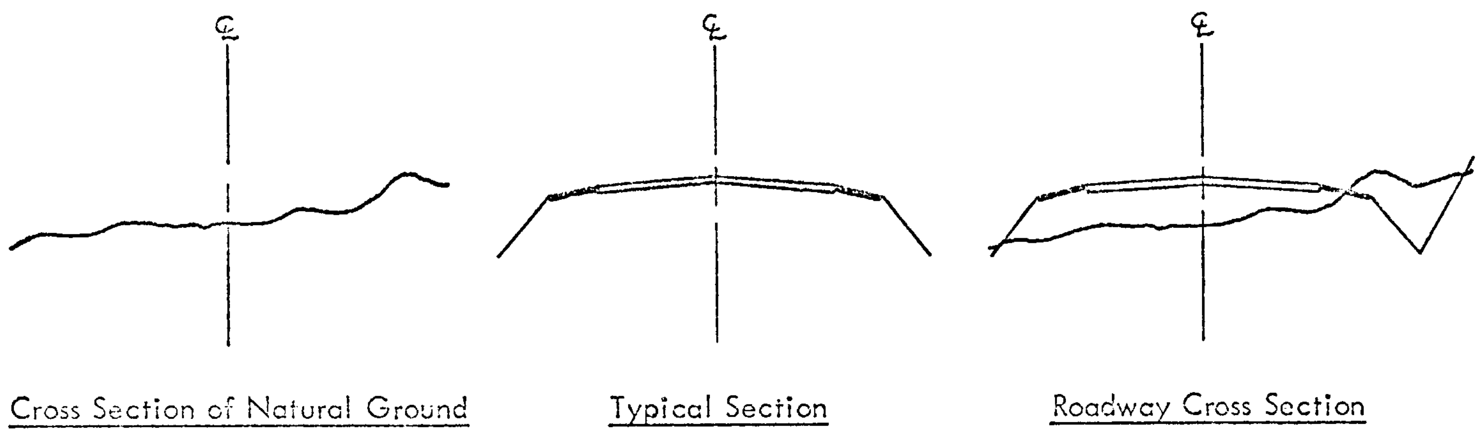
CROSS SECTIONS AND SUPERELEVATION

CROSS SECTIONS

Remember when we learned about the meanings of different views? We said that a cross section was a view of the inside of an object -- as if the object had been cut open.

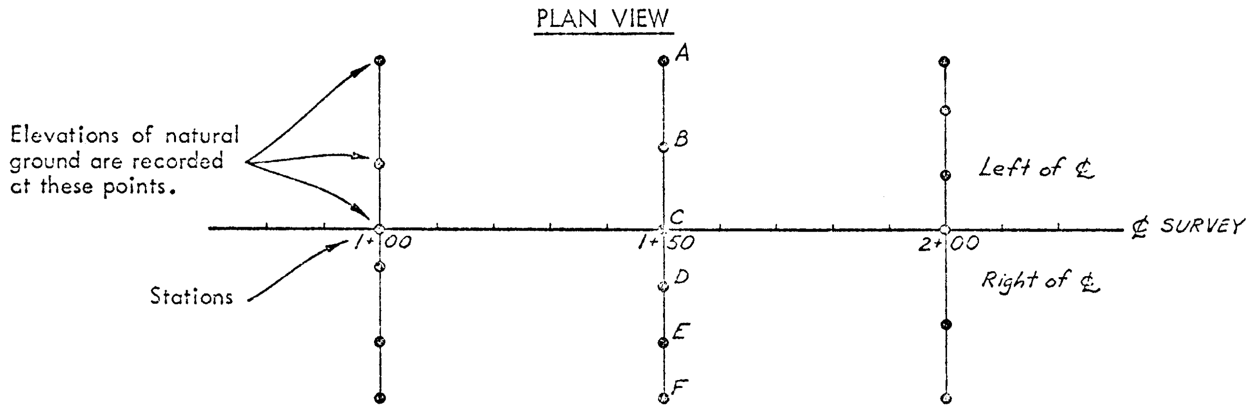
Well, a cross section of a highway project is a view of the inside of the project cut open at right angles to the survey centerline (℄).

In this section, we will discuss three types of cross sections: Cross Sections of the Natural Ground, Typical Sections and Roadway Cross Sections. The median width of a highway can also be found on the roadway cross-section sheet.

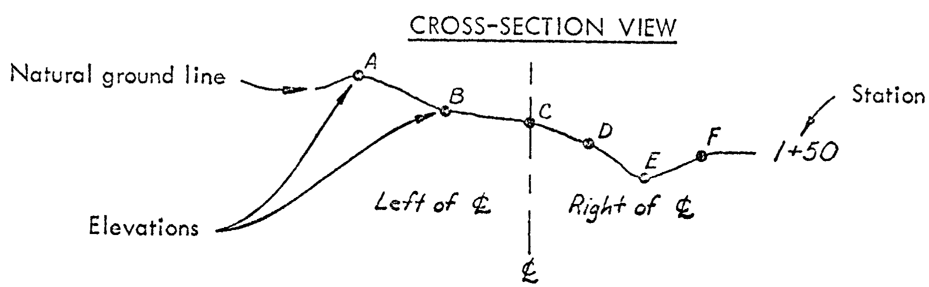


CROSS SECTIONS OF THE NATURAL GROUND

Before highway construction begins, a field survey is made along the proposed highway centerline. Elevations of the natural ground at various points on, and on either side of, the ℄ are recorded, like this:



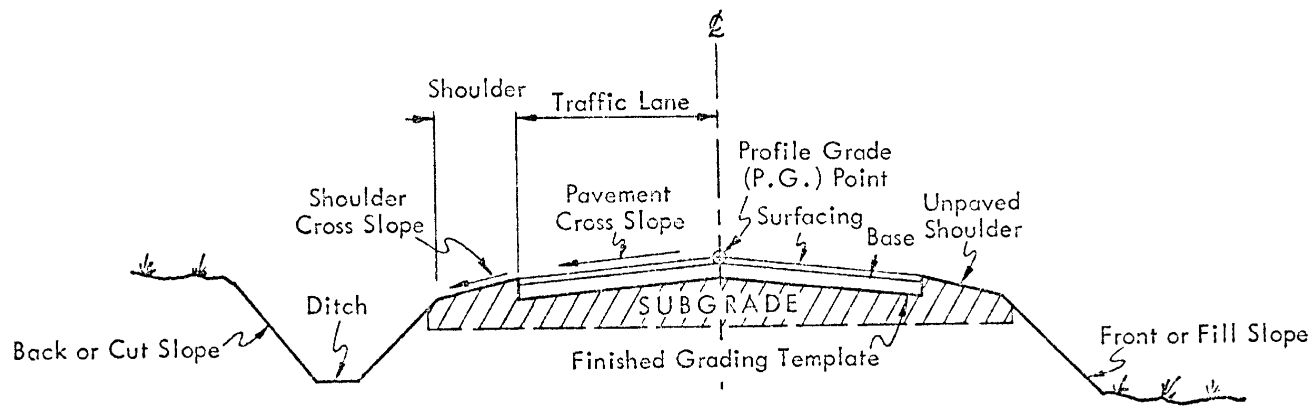
These elevations are plotted for each station to give "cross sections" of the natural ground. A sample cross section might look like this:



TYPICAL SECTIONS

One other type of cross section is important to reading plans -- the typical section. A typical section is nothing more than a typical cross section of the road to be built. A project where the shape or width of the roadway changes will require more than one typical section.

Study the terminology used in the typical section of a 2-lane highway below:



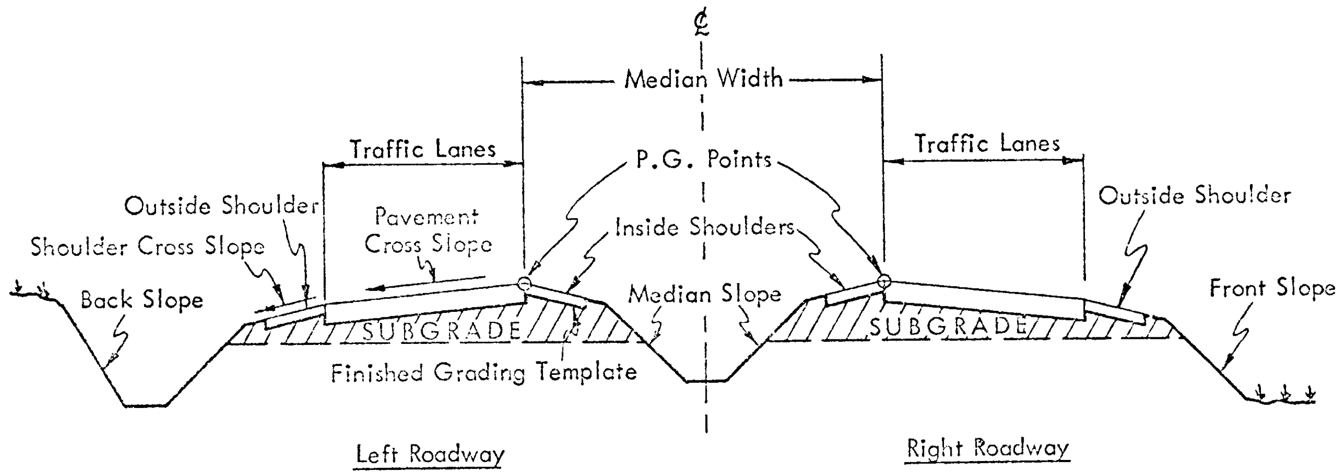
The finished grading template is the final shape of the roadway before paving materials are placed.

The subgrade is the portion of the roadbed immediately below the finished grading template. Usually, it is about 12" thick.

Notice that the shoulder cross slopes are steeper than the pavement cross slopes. These cross slope differences are usual in Florida.

An important word about the profile grade point: it is the point plotted on profile views to form the smooth, continuous, profile grade line.

The typical section on the previous page is for a single roadway. A typical section for a divided highway might look like this:



Nearly the same terms apply to both single roadways and divided highways. The only differences are these: (1) on divided highways, a distinction is made between inside and outside shoulders, but there is no such distinction between shoulders on single roadways, and (2) divided highways have medians, but single roadways, of course, do not.

QUIZ

The region below the finished grading template on which the paving materials rest is called the ________________.

A road's horizontal alignment is shown on _______________views.

Let's say that you plotted the natural ground elevations found at a certain station -- on both sides of the ℄ . You would then see a ____________of the ______________at that station.

Right? Continue with the quiz.
Mistakes? Reread the correct answers before going on.

Refer to Sheet No. 2, Project 56520-3602 (Plan Book – page 5). What are these values?

Pavement cross slope __________

Cross slope of outside shoulders ________

Width of each roadway _________

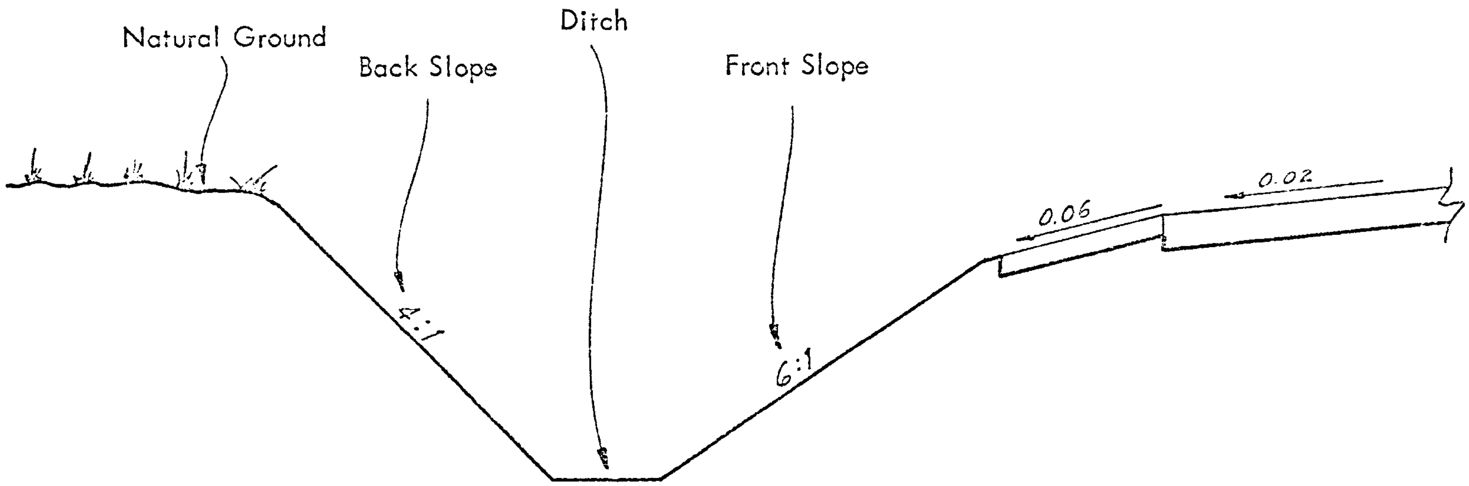
Width of pavement on each outside shoulder _______

If you made mistakes, review page 3-5 now.

CUT SECTIONS

Cut sections are areas where the existing ground must be "cut" -- or excavated -- in order to shape the roadway.

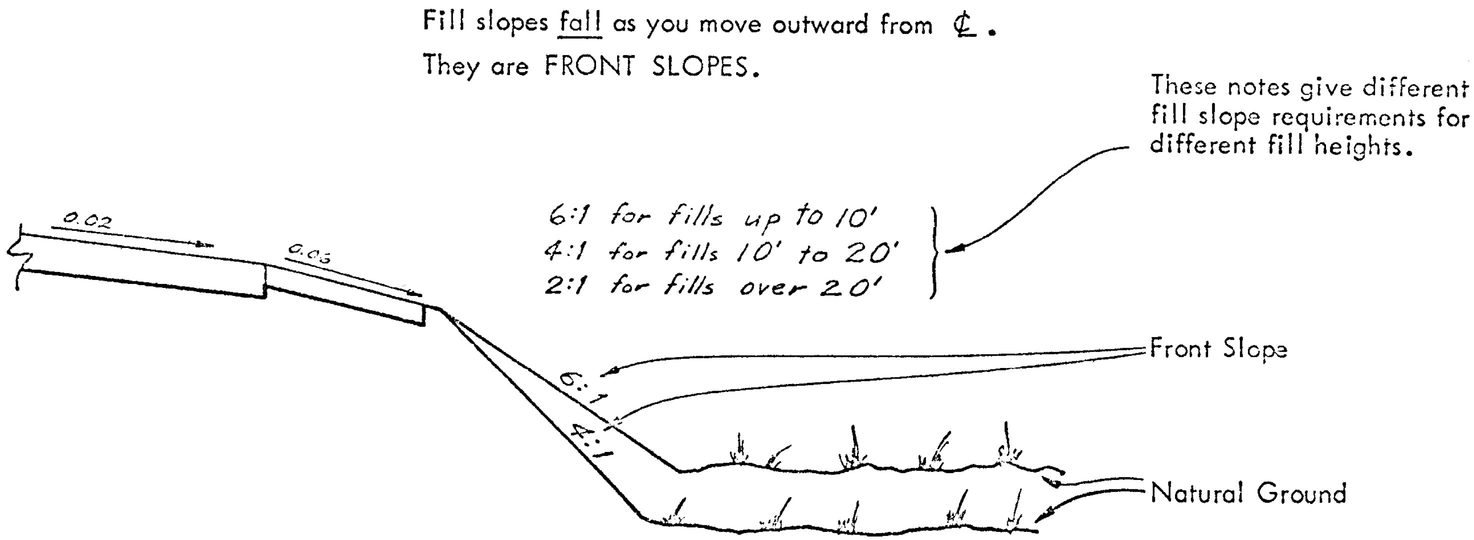
The details on the left side of this typical section show how the slopes will be graded in CUT sections. In cut sections, the road is built below the existing ground. Some of the cut section details are explained in this figure:



On this typical section, cut section details are on the left side of the typical section. This does not mean that all cuts will be made on the left side of the road. The same details apply to the right side of the road where the natural ground is higher than the road.

FILL SECTIONS

The details on the right side of this typical section show how the slopes will be graded to FILL sections. In fill sections, the road is built above the natural ground. The fill-section details are explained in this figure:

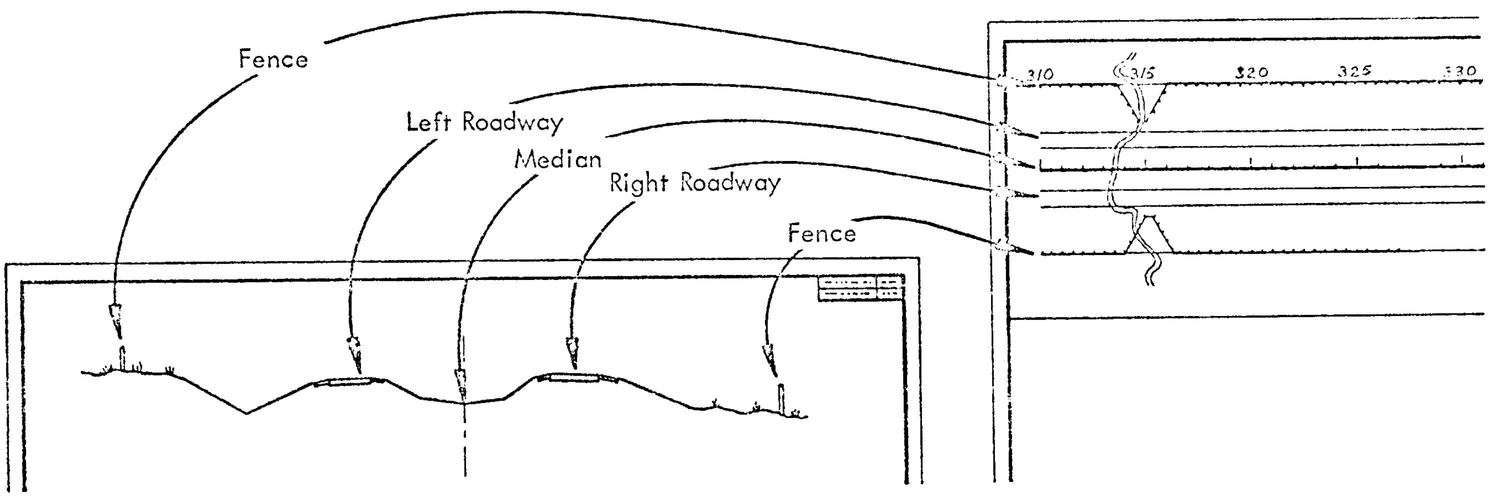


Even though fill-section details are shown on the right side of this typical section, they also apply to the left side where the natural ground is lower than the road.

RELATING TYPICAL SECTIONS TO PLAN AND PROFILE SHEETS

There are several similarities between typical sections and plan and profile sheets. Let's study those concerning plan views first.

TYPICAL SECTIONS AND PLAN VIEWS

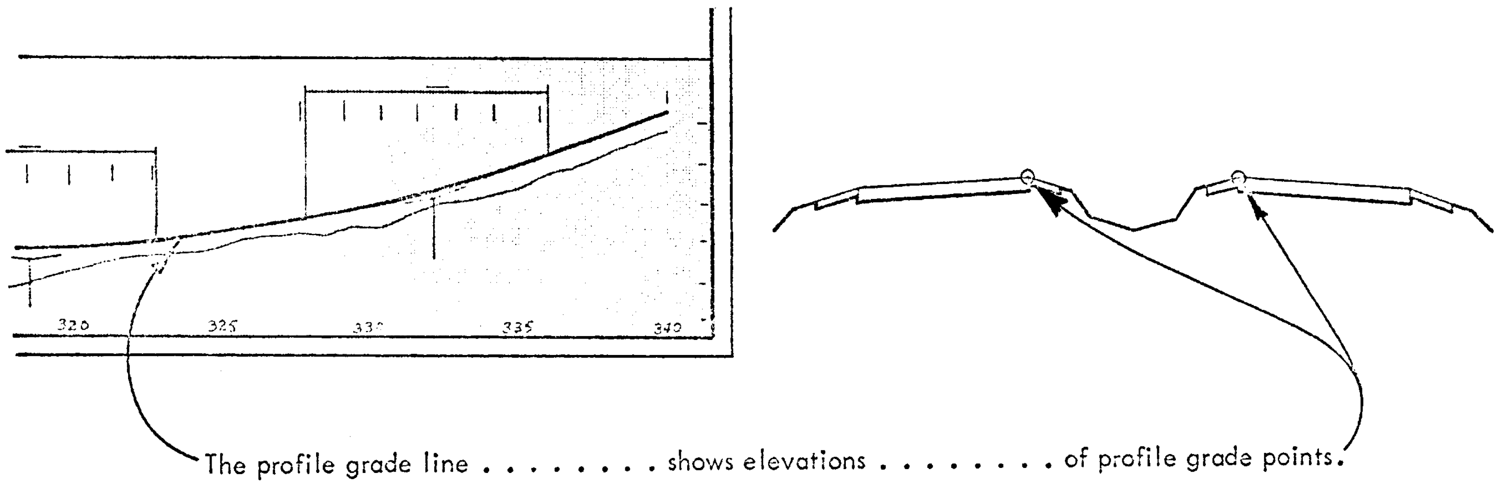


In both views you can see the two limited access/right-of-way fences, two roadways and a median.

TYPICAL SECTIONS AND PROFILE VIEWS

Now compare the same typical section with the profile view.

The profile grade line shows the elevations of the profile grade point (in the typical section). To see how this works, study the figure below:



Where the roadways have different elevations, two profile grade lines are shown in the profile view.

QUIZ

Answer these questions about the typical section on Sheet No. 2, Project 56520-3602 (Plan Book – page 5).

What is the shoulder slope rate? ________________

Each shoulder is __________ feet wide.

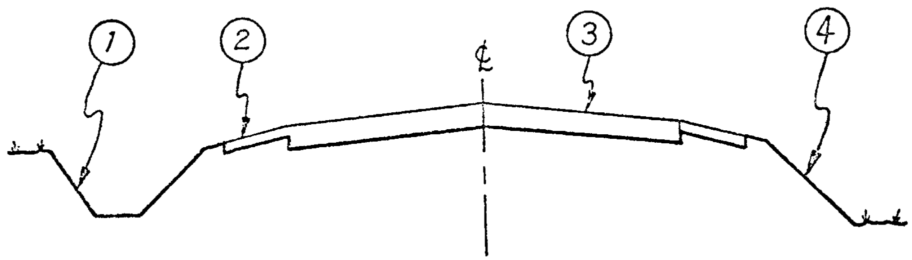
The fill has two slope ratios. The slope has a fill slope ratio of __________ for fills to 20 feet.

The other slope ratio is ____________for fills over 20'.

QUIZ, continued

Name the marked and numbered slopes:

1.____________ 2.____________ 3._____________ 4. _____________



The profile grade point is represented on three types of sheets. Can you name them?

____

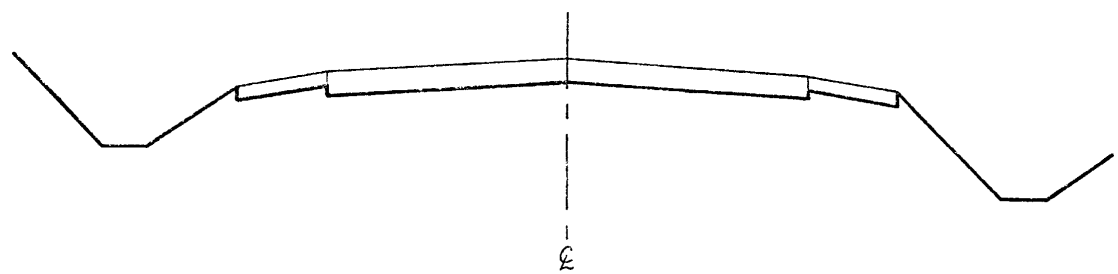
____

____

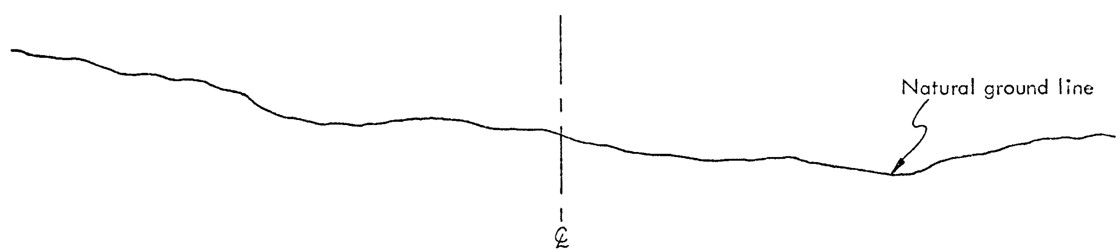
If you included "roadway cross-section sheet" in the last answer, you are way ahead. Go on to ROADWAY CROSS SECTIONS.

ROADWAY CROSS SECTIONS

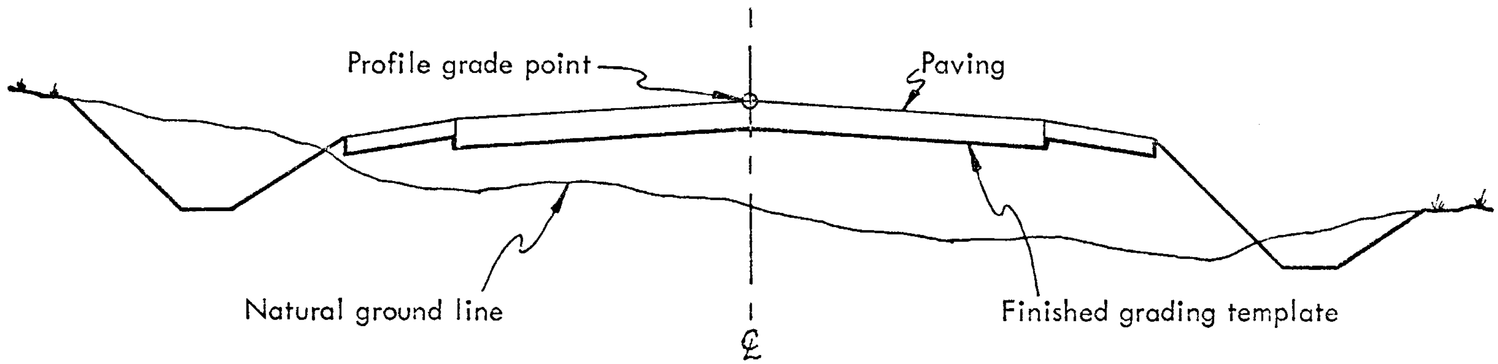
Roadway cross sections show typical sections superimposed on cross sections of the natural ground line. This is a typical section:



This is a cross section of the natural ground line:



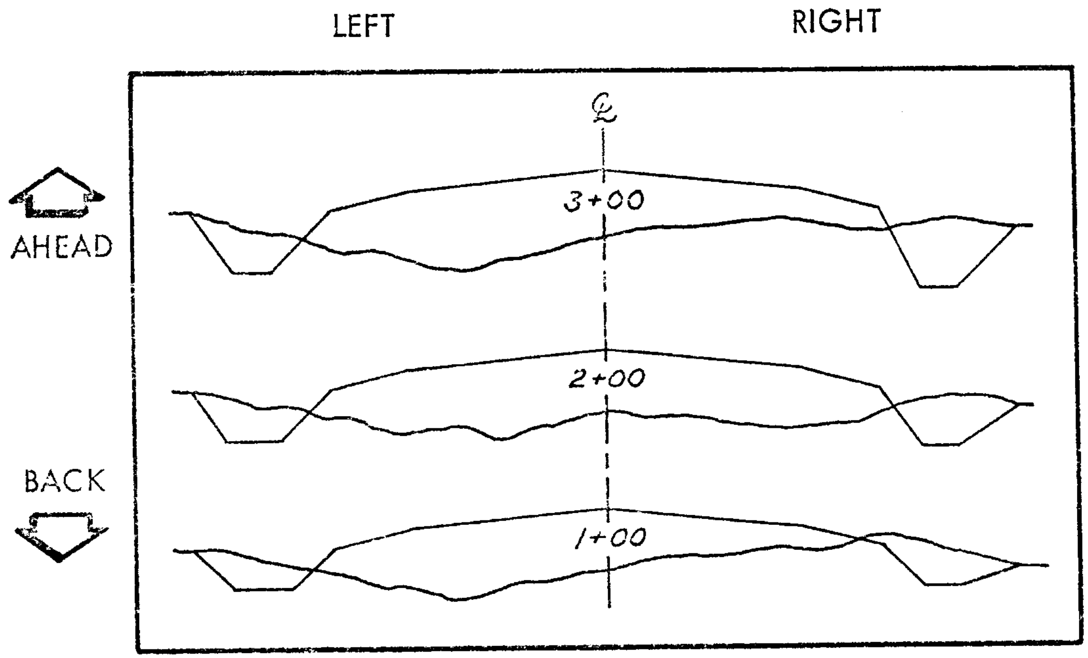
This is a typical section superimposed on the existing ground line -- called a roadway cross section:



Now turn to Sheet No. 8, Project 56520-3602 (Plan Book – page 10) . This sheet -- a roadway cross-section sheet -- shows roadway cross sections at these stations: 28 + 50, 29 + 00, 29 + 50 and 30 + 00.

The cross section at the bottom of the sheet is taken at station 28 + 50. Reading upwards, the next cross section is taken at station 29 + 00. The next is taken at station 29 + 50.

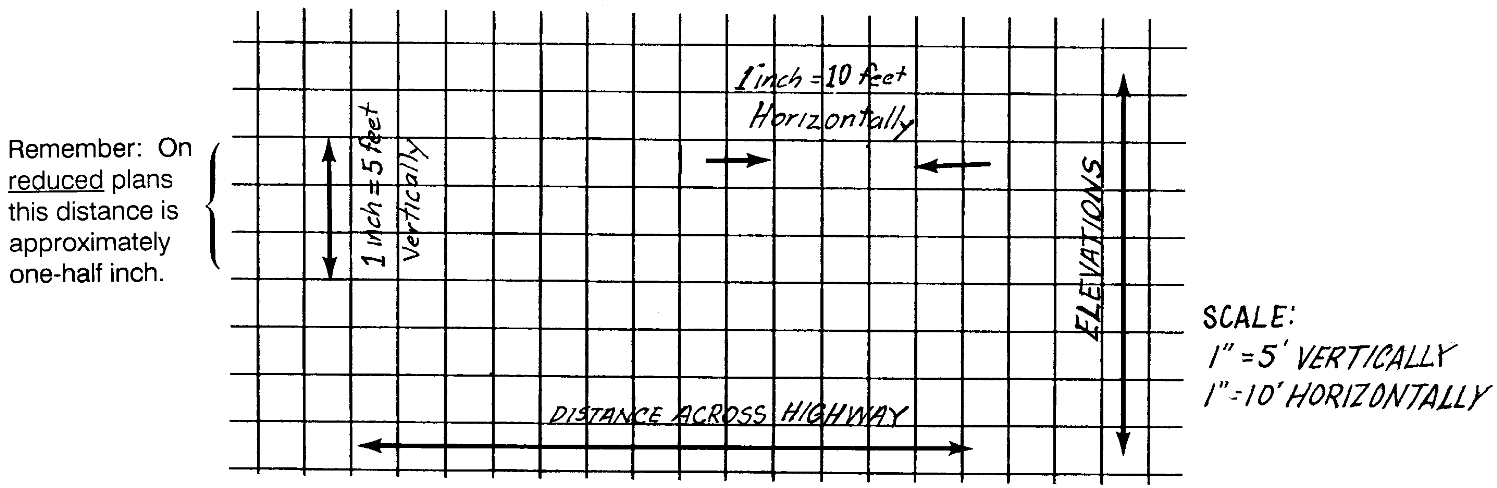
As you can see, you read roadway cross-section sheets from BOTTOM to TOP. As you read UP, you are going AHEAD on the highway. Examine the figure below:



Remember -- on all cross sections, the left side of the section is the left side of the highway. The right side of the section is the right side of the highway.

It's as if you were standing on the ℄ looking ahead -- up the sheet.

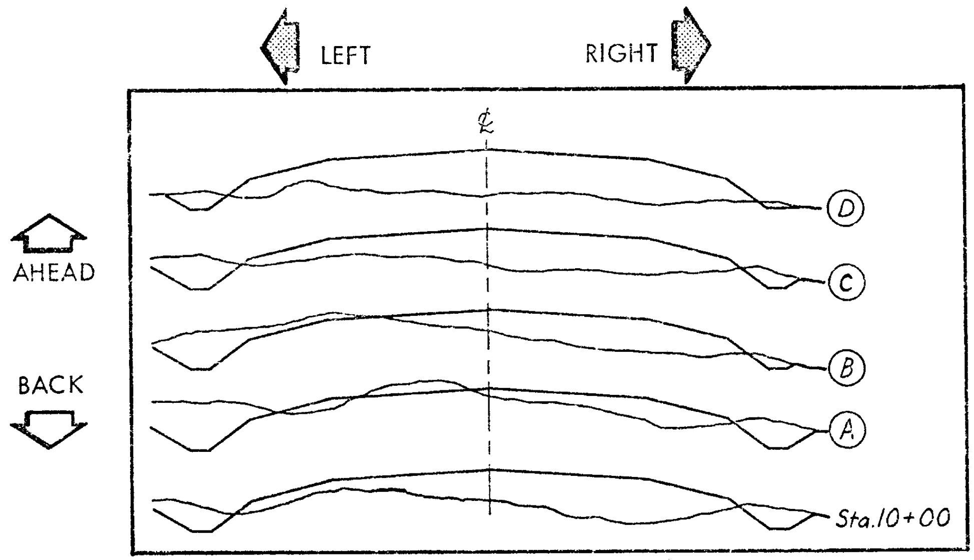
Now let's take a closer look at the vertical and horizontal lines on a roadway cross-section sheet:



The most usual scales on Roadway Cross Section sheets in Florida are 1" = 5 feet vertically and 1" = 10 feet horizontally, as shown above. Occasionally, where the roadway is unusually wide, the horizontal scale is 1" = 20 feet. When the roadway is narrow, the horizontal scale may be 1" = 5 feet.

QUIZ

If we are taking cross sections at every station along the project, and the first station is 10 + 00, what are the station numbers for the cross sections shown below?



Cross Section	Station Number
A	____________
B	____________
C	____________
D	____________

QUIZ, continued

Below is a small part of a Roadway Cross-Section Sheet, with scales, an elevation, and six points marked on it.

Point 1 is at an elevation of 40.00' and is located on the centerline.

Point 2 is at an elevation of 41.00' and is 6 feet right of centerline.

Point 3 is at an elevation of __________ and is _____________ feet _______________ of centerline.

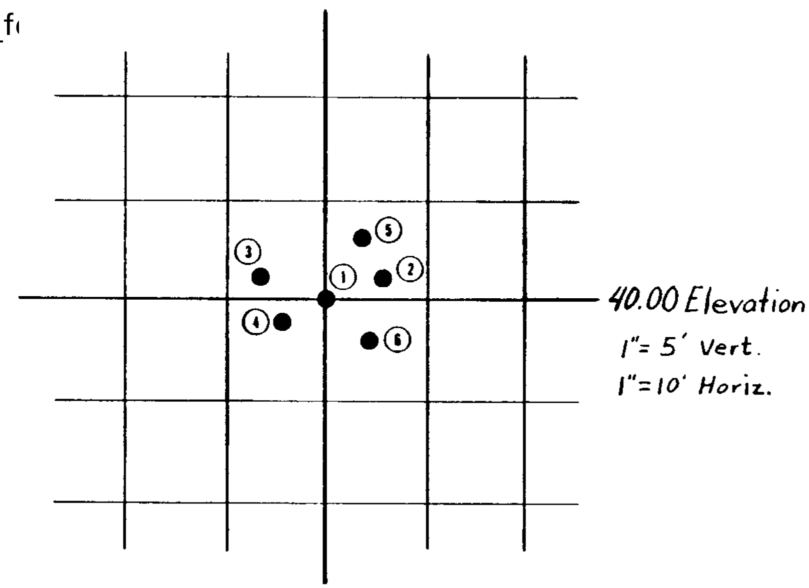
Point 4 is at an elevation of __________ and is_____________ feet _______________ of centerline.

Point 5 is at an elevation of __________ and is _____________ feet _______________ of centerline.

Point 6 is at an elevation of __________ and is _____________ feet _______________ of centerline.

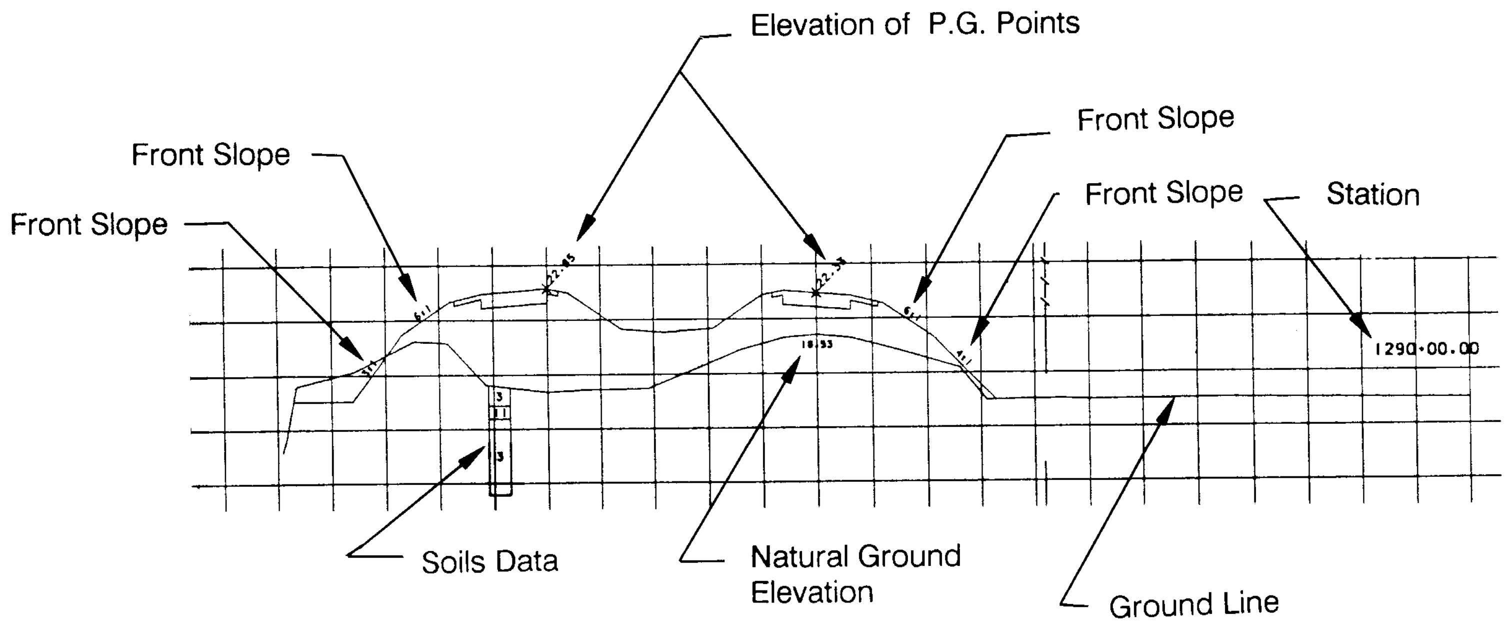
Point 5 is __________ feet __________ point 6.

The horizontal distance between point 2 and point 3 is _____f



Refer to Sheet No.8, 56520-3602 (Plan Book – page 10). Interpret the top cross section as shown below:

Note: Drawing below is not from project 56520-3602, it is intended as an example only.



QUIZ

Refer to the roadway cross-sections, Sheet No.8, Project 56520-3602 (Plan Book – page 10).

What are the elevations of these points at station 29 + 00?

Profile grade point of left roadway ____________ of right roadway _______________

Natural ground on center of survey __________________

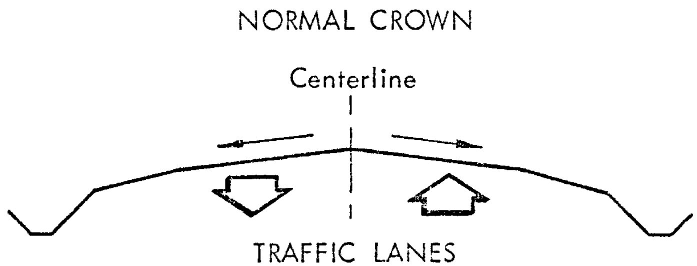
What is the elevation of the profile grade point at station 29 + 50? ______________

Going from station 28 + 50 to station 30 + 00, is the profile grade rising or falling? _____________

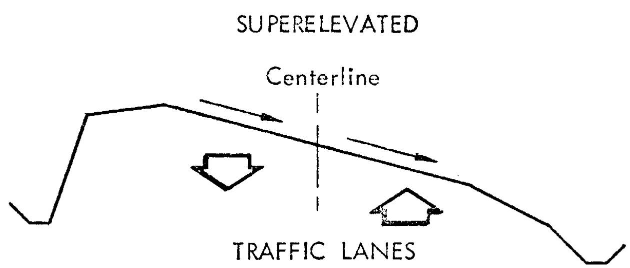
SUPERELEVATION

Roadways on most horizontal curves are superelevated. If a roadway is superelevated, the edge of the roadway on the outside of the curve is higher than the edge of the inside. The roadway surface slopes down from the outside to the inside of the curve.

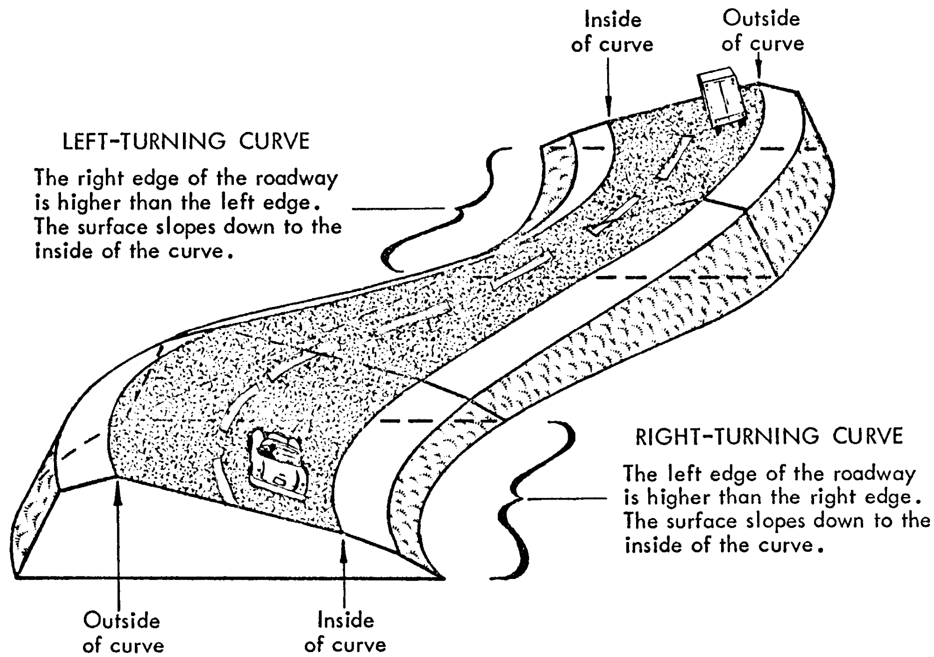
Where a roadway is NOT SUPERELEVATED, the cross slopes are just like that of any tangent segment of the roadway -- we say the roadway is at Normal Crown. The slope usually falls on each side of centerline as shown below.



Where a roadway is SUPERELEVATED, the outside edge is higher than the inside edge. The whole roadway slopes down toward the inside of the curve as shown below.



This diagram shows the outside edge of the roadway raised -- superelevated -- in relation to the inside edge.



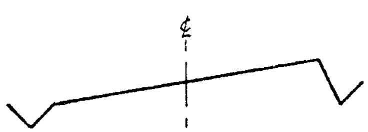
Study the above figure carefully -- so you will understand how superelevation affects roadways on horizontal curves, and the difference between right- and left-turning curves.

QUIZ

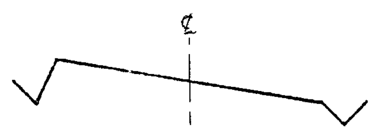
If a horizontal curve on a 2-lane road were to turn to the left, which of the following statements would be true?

__ A. Only the outside lane would slope down to the right.
__ B. Both the outside and inside lanes would slope down to the left.
__ C. Only the inside lane would slope down to the left.
__ D. Both the outside and inside lanes would slope down to the right.

Label the cross sections below as "left turn" or "right turn":

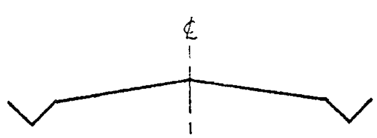


A ____________

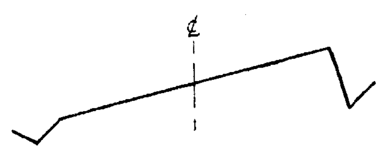


B ______________

Label the cross sections below as "superelevated" or "normal crown":



A ______________



B ______________

SUPERELEVATION TRANSITIONS

When constructing a horizontal curve in a roadway, the change from normal crown to full superelevation is not made all at once. Instead, there is a gradual transition. Superelevation is built up gradually at the beginning of the curve -- then taken down gradually at the end of the curve.

SUPERELEVATION OF UNDIVIDED HIGHWAYS

Let's see what happens to the cross section view of a two-lane, undivided highway as superelevation is being applied. Refer to the figure on the next page:

(1) -- is a cross-section of the roadway on a tangent section -- the roadway is at Normal crown. Both lanes fall from the profile grade point, at the normal cross slope rate. When transition begins ....

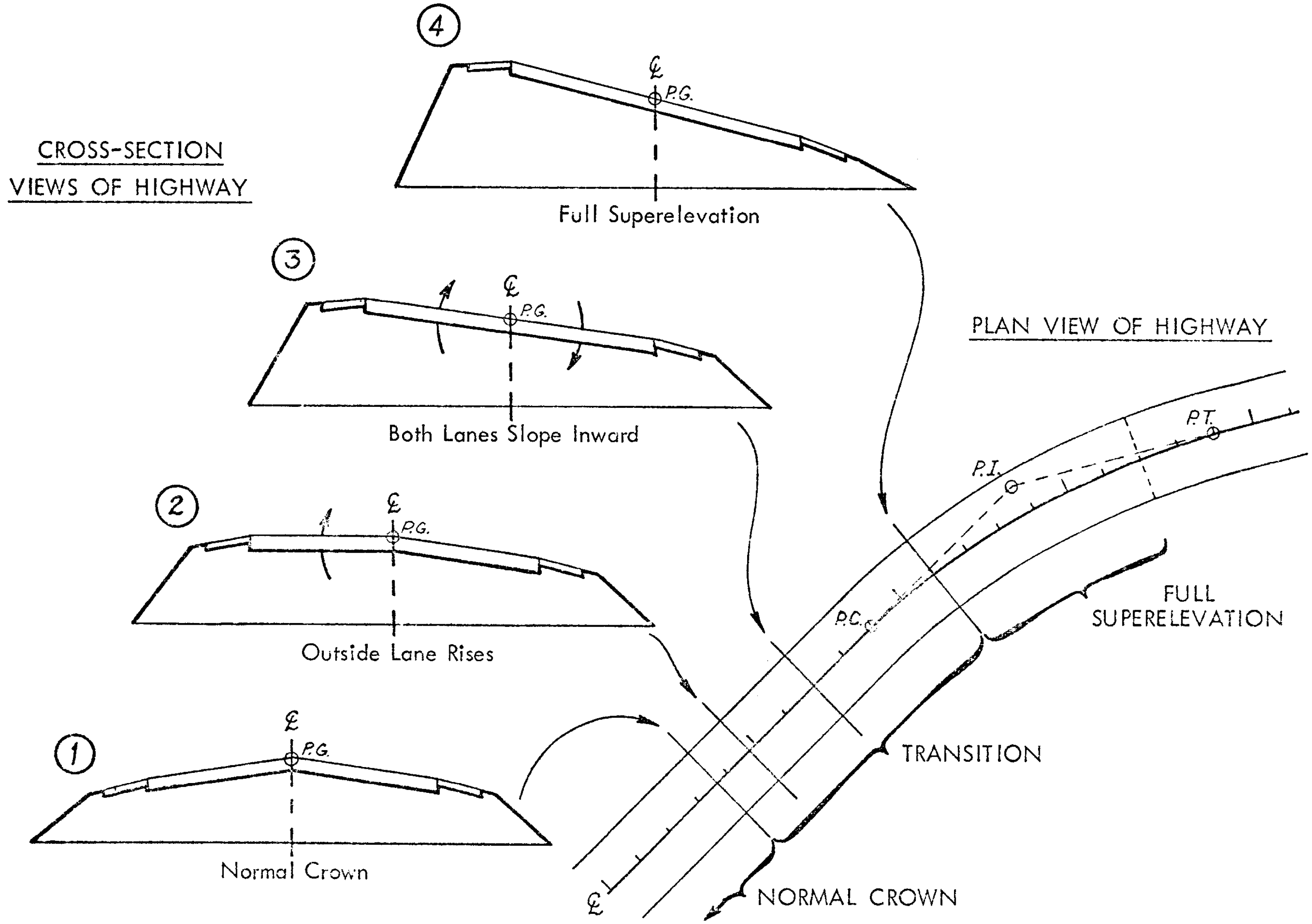
(2) -- the outside lane rotates upwards about the profile grade point. The inside lane holds its normal slope until ....

(3) -- the outside lane rises to the normal cross slope rate of the inside lane. Both lanes then rotate about the P.G. point until...

(4) -- full superelevation is reached.

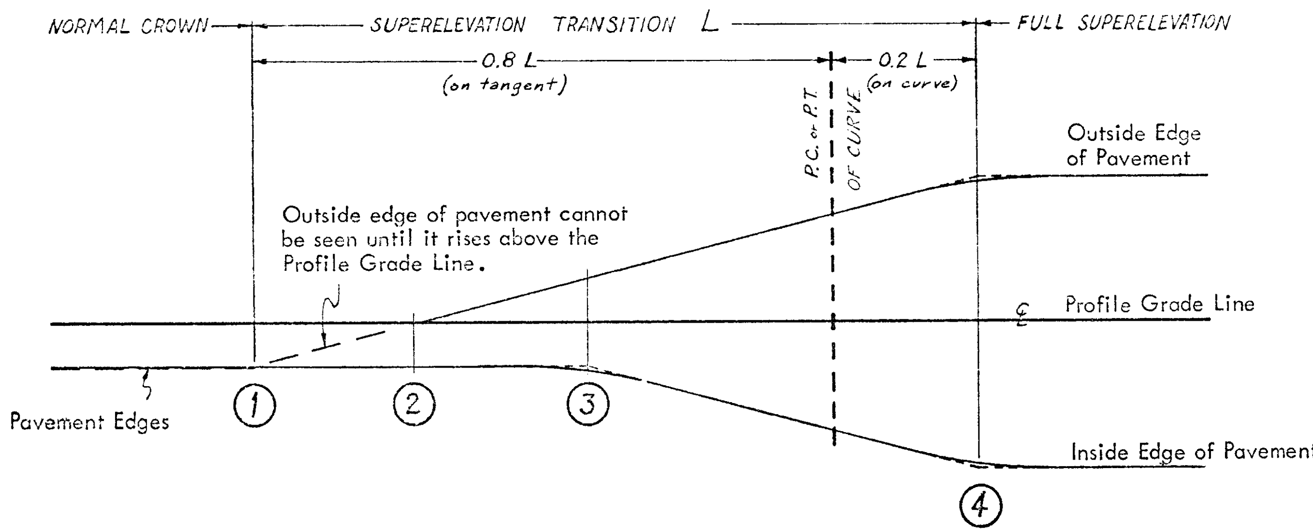
Superelevation is taken down gradually at the end of the curve by reversing these steps.

You will remember that when profile grade points are plotted on profile views, they form a smooth line called the profile grade line. During superelevation transitions, the profile grade line is the AXIS OF ROTATION about which the pavement lanes rotate.


CROSS-SECTION
VIEWS OF HIGHWAY
4
℄
P.G.
Full Superelevation
3
℄
P.G.
Both Lanes Slope Inward
2
℄
P.G.
Outside Lane Rises
1
℄
P.G.
Normal Crown
PLAN VIEW OF HIGHWAY
P.T.
P.I.
P.C.
℄
FULL
SUPERELEVATION
TRANSITION
NORMAL CROWN

PROFILE VIEWS -- UNDIVIDED HIGHWAYS WITH SUPERELEVATION

In order to understand and calculate transitions, we will look at a profile view of the superelevation transition. The circled numbers refer to the previous two pages.



Compare the above figure with the diagram on the previous page and on Roadway and Traffic Design Standard Index No. 510 (Plan Book – pages 116-117). Study the profile and cross sections in this test and on the Standard carefully, then try the quiz on the next page.

QUIZ

Here are some of the things which happen during transition from normal crown to full superelevation. Put them in their correct order:

__ A. Full superelevation reached.
__ B. Roadway at normal crown.
__ C. Both lanes rotate about axis of rotation.
__ D. Outside edge of pavement rises, inside lane holds normal crown slope.

Refer to Roadway and Traffic Design Standard Index No. 510 (Plan Book – pg.116).

Of the total superelevation transition, L, 0.8 L is on the __________and _________L is on the curve.

To avoid angular breaks in edge profiles, short ___________are constructed.

The slope ratio of the pavement edges is shown on the Roadway and Traffic Design Standard as _____________.

All correct? Go to TRANSITION LENGTH CALCULATIONS -- UNDIVIDED HIGHWAYS.

TRANSITION LENGTH CALCULATIONS -- UNDIVIDED HIGHWAYS

In order to calculate L, the transition length, you have to know several facts about the curve. These are as follows (the symbols refer to the formula at the foot of this page):

1. The TYPE of highway -- divided/undivided, how many lanes. We are dealing now with undivided highways -- the calculations for divided highways are slightly different and will be dealt with later in this chapter.
2. The WIDTH (W) and NORMAL CROSS SLOPE RATE (N ft. per ft.) of the pavement.
3. The DESIGN SPEED of the highway.

These three facts can be found on typical section sheets.

4. The SUPERELEVATION RATE (e ft./ft.) for the curve.

Fact 4 is found in the curve data on plan and profile sheets. (It is obtained by the designer from the chart in the upper right corner of Standard Index No. 510 (Plan Book – page 116).

5. The PAVEMENT EDGE SLOPE RATIO (1:d).

This fact is found in the table at the top in the center of Standard Index No. 510 (Plan Book – page 116). There are three standard slope ratios, corresponding to different design speeds -- which is why you need fact 3.

When you know all these facts about a curve, the transition length is found using the formula:

$$L = \frac{W}{2} \times d \times (e + n)$$

SAMPLE CALCULATION

Let's work out the transition length for a specific curve -- the curve at station 20 + 21.85 on Sheet No. 4, Project 56520-3602 (Plan Book – page 6).

From the typical section on Sheet No. 2, Project 56520-3602 (Plan Book – page 5) we find:

1. Undivided, two-lane highway
2. Width of pavement, W = 24 feet
   Normal crown cross slope rate, n = 0.02 ft./ft.
3. Design speed is 55 mph.

From the curve data on Plan and Profile Sheet No. 4, Project 56520-3602 (Plan Book – page 6), we find:

4. Superelevation rate, e = 0 ft./ft.

From Standard Index No. 510 we find:

5. For a design speed of 55 mph, 1:d = 1:225.

Using all these facts, we calculate: $L = \frac{W}{2} \times d \times (e + n) = \frac{24}{2} \times 225 \times (0+0.02)$

L = Superelevation transition $= 12 \times 225 \times 0.02$

$= 54$ ft. use 100 ft.

Note: The minimum transition length is 100 feet. This minimum length should be used if the calculated value of L comes out less than 100 feet.

QUIZ

A two-lane, undivided highway has a pavement width of 24 feet, with normal crown cross slopes of 0.02 ft./ft., and a design speed of 50 mph. A certain curve on this highway is to be superelevated at a rate of 0.06 ft./ft.

Calculate the length of the superelevation transition. ____________ ft.

Calculate also how much of this transition will occur ahead of the P.C. -- i.e., on the curve.
______________ ft.

Note: The minimum transition length is 100 feet. This minimum length should be used if the calculated value of L comes out less than 100 feet.

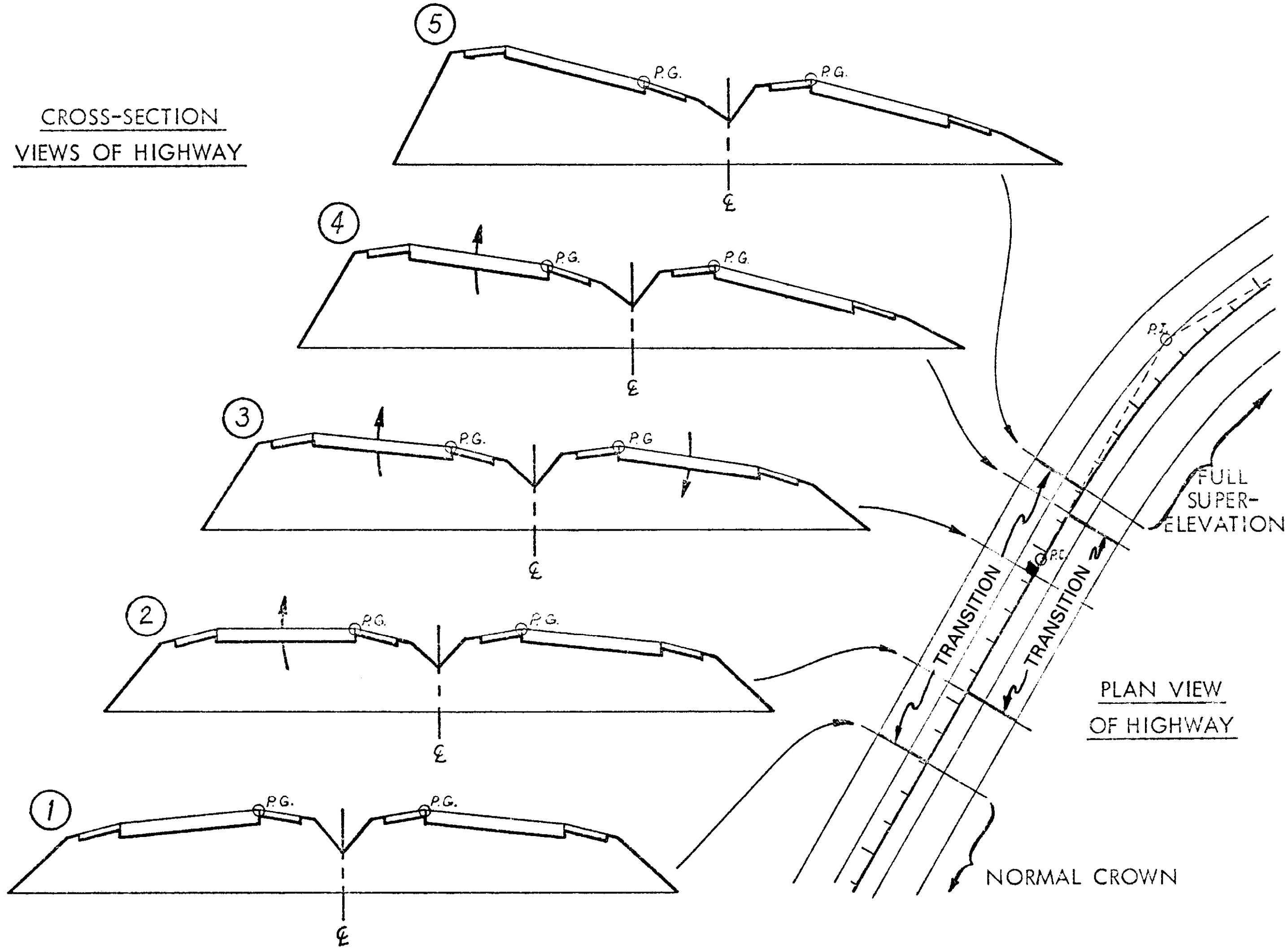
SUPERELEVATION OF DIVIDED HIGHWAYS

Much of the information you have already learned about superelevation as applied to undivided highways also applies to divided highways. However, there are several differences in the calculation of transition lengths.

The transition lengths for the outer and inner roadways of a divided highway are independent of each other. The next two pages will show how transition is applied.

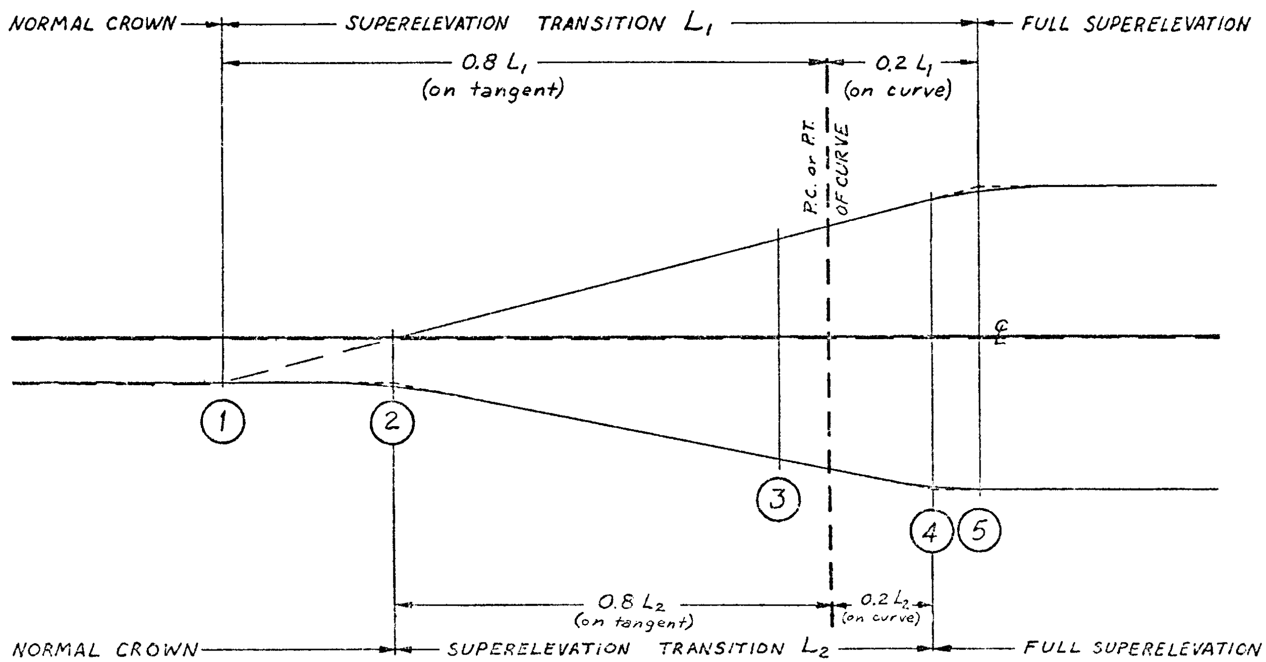
Let's see what happens to the cross-section view of a divided highway as superelevation is being applied. Refer to the diagram on the next page.

	Outer Roadway	Inner Roadway
①	Normal crown. Transition begins....	Normal crown.
②	Pavement rotates about profile grade point....	Normal crown. Transition begins...
③	Pavement rotates about profile grade point....	Pavement rotates about profile grade point...
④	Pavement rotates about profile grade point...	Full superelevation is reached.
⑤	Full superelevation is reached.	Full superelevation.


CROSS-SECTION
VIEWS OF HIGHWAY
5
P.G.
P.G.
4
P.G.
P.G.
3
P.G.
P.G
2
P.G.
P.G.
1
P.G.
P.G.
P.T.
P.C.
FULL
SUPER-
ELEVATION
TRANSITION
TRANSITION
PLAN VIEW
OF HIGHWAY
NORMAL CROWN

PROFILE VIEWS -- DIVIDED HIGHWAYS WITH SUPERELEVATION

In the case of divided highways, there are two axes of rotation -- the profile grade lines for each roadway. Here is the profile view:



Compare the above figure with the diagram on Standard Index No. 510 (Plan Book – page 117). Notice the two superelevation transitions, L1 and L2. L1 is for the outer roadway, while L2 is for the inner roadway. These two transition lengths are calculated independently of each other, and are not related in any way except in their positions relative to the P.C. or P.T.

CALCULATING TRANSITION LENGTHS -- DIVIDED HIGHWAYS

In order to calculate L1 and L2, the transition lengths, you have to know the same facts that you found for undivided highways, on page 3-28. Remember them?

1. TYPE of highway, and number of lanes.

2. WIDTH (W ft.) of each roadway, and NORMAL CROSS SLOPE RATE (n ft./ft.).

3. DESIGN SPEED.

These three facts are found on the appropriate typical section sheet.

4. SUPERELEVATION RATE (e ft./ft.) for the curve.

Found at the end of the curve data on the appropriate Plan and Profile sheet (or by the designer on Standard Drawing 510(Plan Book – page 116)).

5. The PAVEMENT EDGE SLOPE RATIO (1:d)

Found in the table in the bottom right corner of Standard Index 510.

When you know all these facts, the transition lengths are calculated using the formulas:

$$L_1 = W \times d \times (e + n) \qquad L_2 = W \times d \times (e - n)$$

SAMPLE CALCULATION

Now we will work out the transition lengths for a specific curve.

From the typical section, we find:

1. Divided, 4-lane highway.
2. Width of each roadway, W = 24 feet
   Normal cross slope n = 0.02 ft./ft.
3. Design speed = 70 mph.

From the curve data on the plan and profile sheet, we find:

4. Superelevation rate, e = 0.039 ft./ft.

From the table at the top in the center of Standard Index No. 510 (Plan Book – page 116) we find:

5. Pavement edge slope ratio for design speed of 70 mph, 1:d = 1:250.

Using all these facts, we calculate:

L1 = w x d(e + n)
= 24 x 250 x (0.039 + 0.02)
= 24 x 250 x 0.059
= 354 feet

Superelevation transition, outer roadway.

L2 = w x d(e - n)
= 24 x 250 x (0.039 - 0.02)
= 24 x 250 x 0.019
= 114 feet

Superelevation transition, inner roadway.

QUIZ

A four-lane highway has each roadway 24 feet wide, with normal cross slopes of 0.02 ft./ft., and design speed 60 mph. A curve on this highway is to be superelevated at a rate of 0.045 ft./ft.

Calculate the transition lengths for

(a) the outer roadway ___________________

(b) the inner roadway ___________________

SHOULDER CONSTRUCTION WITH SUPERELEVATION

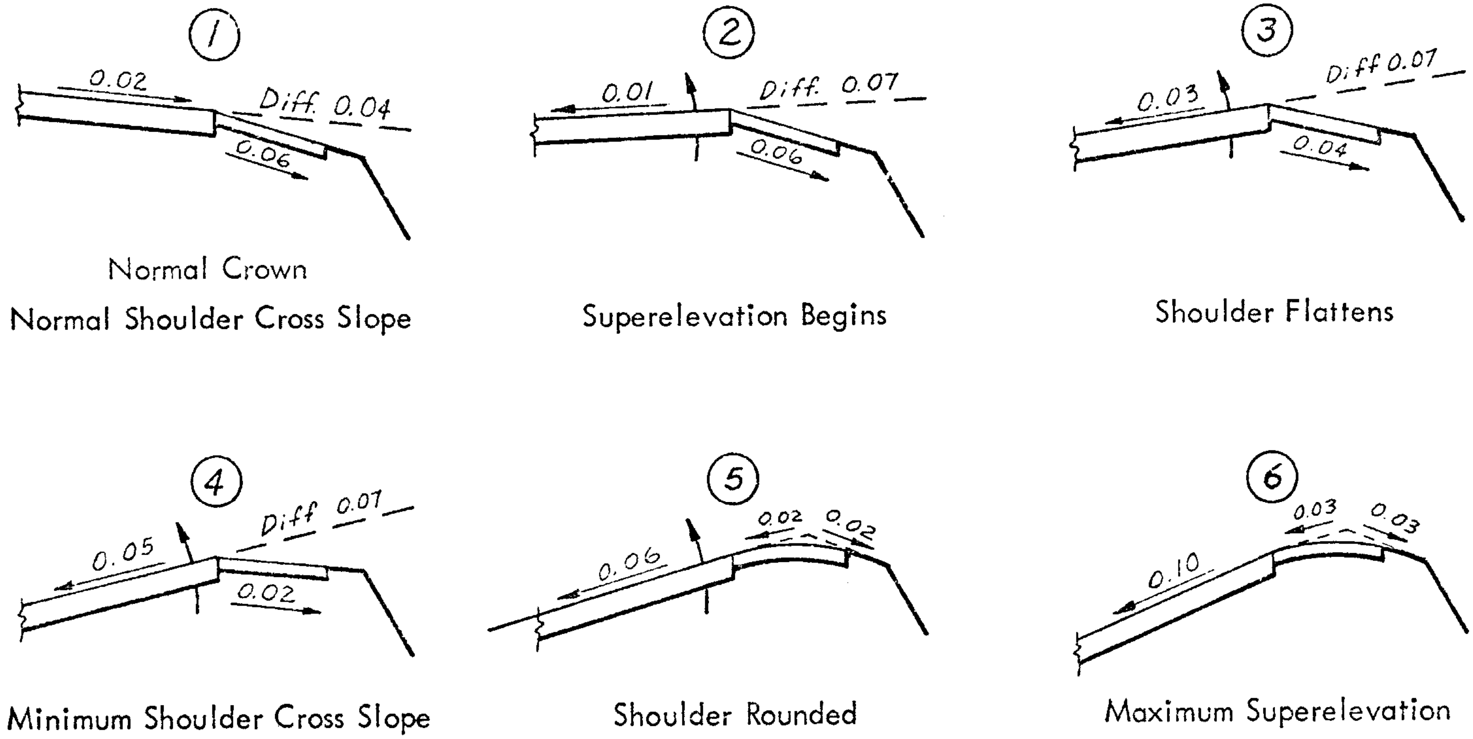
On most highways, the outside shoulders have a cross slope of 0.06 ft./ft.: the inside (median) shoulders on divided highways have a cross slope of 0.05 ft./ft. When the highway is superelevated, the shoulder slopes must be changed to avoid sharp angular breaks in the roadway cross section. The maximum permissible break is an algebraic difference of 0.07 ft./ft. between the shoulder slope and the pavement cross slope.

Study the part of Standard Index No. 510 (Plan Book – page 116) labeled "Shoulder Construction with Superelevation."

You will notice that when the shoulder is on the low side, all that is required is that the 0.06 ft./ft. shoulder cross slope be maintained until the pavement cross slope reaches 0.06 ft./ft. If the pavement cross slope is greater than 0.06 ft./ft., the shoulder has the same slope as the pavement.

When the shoulder is on the high side, the details are more complex. Read the note on Standard Index No. 510 (Plan Book – page 116) again, then compare it with the figure on the next page.

This figure shows the changes made in the high side shoulder slopes as the pavement is being superelevated.



Read the notes under "Shoulder Construction with Superelevation" on Standard Index No. 510 (Plan Book – page 116), then take the review quiz on the next page.

QUIZ

The control point on a finished roadway surface is the __________________.

On a divided highway, the median width is measured between the _________________.

A project where the shape or width of the roadway changes will require more than one ______________section.

The median width of a highway can be found on three kinds of sheets -- these are:

1. ___________________________________
2. ___________________________________
3. ___________________________________

Roadway Cross-Section Sheets are read from the ____________to the ___________of the sheet.

Vertical measurements on roadway cross-section sheets give ________________.

If both the inside and outside lanes on a superelevated horizontal curve slope down to the left, then it is a _____________-turning curve.

QUIZ, continued

A highway having four 12 feet wide pavement lanes, with median, normal cross slope 0.02 ft./ft. and a design speed of 65 mph is to be superelevated on a right-turning curve at a rate of 0.045 ft./ft.

Calculate:

1. The superelevation transition length, left roadway ____________.

2. The superelevation transition length, right roadway ___________.

3. The shoulder slope at full superelevation, left roadway: outside __________, inside __________.

4. The shoulder slope at full superelevation, right roadway: outside _________, inside __________.

Where would you find superelevation details for municipal areas? ____________________
(Hint: look at the general notes on Standard Index No. 510 (Plan Book – page 116))

What is the minimum permissible transition length? _______________

Did you get all the answers?
If so, congratulations! This has been a hard chapter. Take a break -- then go on to Chapter Four.

Trouble with superelevation calculations? Review pages 3-21 through 3-37.

If you still feel uncertain about Cross Sections, review pages 1-3 through 1-12 in Chapter One, then review this chapter.

ANSWERS TO QUESTIONS

Page 3-6

- subgrade
- plan
- cross section;
  natural ground line
- 0.02 ft./ft.
  0.06 ft./ft.
  24'0"
  8'0"

Page 3-11

- 0.06 ft./ft
- 8
- 6:1
- 2:1

Page 3-12

- 1. Back Slope
  2. Shoulder Cross Slope
  3. Pavement Cross Slope
  4. Front Slope
- typical section sheet
  plan and profile sheet
  roadway cross-section sheet

Page 3-17

- 11 + 00
- 12 + 00
- 13 + 00
- 14 + 00

Page 3-18

- 41'; 6; left
- 39'; 4; left
- 43'; 4; right
- 38'; 4; right
- 4; above
- 12

Page 3-20

- 61.30; 59.00
- 60.30
- 61.30;
  falling

Page 3-23

- B
- A. left turn
  B. right turn
- A. normal crown
  B. superelevated

Page 3-27

- B, D, C, A
- tangent; 0.2
- vertical curves
- 1:d

Page 3-30

- 192
- 153.6

Page 3-36

- 351 ft.
- 135 ft.

Page 3-38

- profile grade point
- profile grade points
- typical
- 1. typical section sheets
  2. plan and profile sheets
  3. roadway cross-section sheets
- bottom; top
- elevations
- left

Page 3-39

- 390.0
- 150.0
- 0.025 ft./ft.; 0.05 ft./ft.
- 0.06 ft./ft.; 0.025 ft./ft.
- Standard Index 511
- 100 ft.

CHAPTER FOUR

The Construction Contract

CONTENTS

4

THE CONSTRUCTION CONTRACT

In the previous three chapters you have studied and learned the basics of plan reading. When you study contract plans in greater detail you will encounter repeated reference to the construction contract. Therefore, right now is a good time to stop and learn about construction contracts. Let's find out how plans are developed and get acquainted with the other contract documents needed to build highways and bridges.

CONTRACT PLANS

TRAFFIC AND PLANNING INFORMATION

Long before contract plans are prepared the Department gathers information on the kinds and amounts of traffic using the roads. Estimates are made on what the future traffic will be. This information helps to plan the right kind of roads and guides designers in determining the standards to be used.

SURVEYS

When it has been decided to build a certain highway, it is necessary to perform a field survey to gather information needed by the designer. The survey establishes the highway location and records precise measurements of distance and elevation. Topographical features such as buildings, fences, telephone poles and drainage areas are recorded, together with many other features that will be important in designing the road.

PROJECT DESIGN

In the office, the survey information is compiled and designs are developed for building the new road or bridge.

Decisions are made about the shape of the road -- width, elevations, grades, ditches, intersections and sometimes very complicated interchanges.

Decisions are made about drainage -- the sizes of culverts and how best to take care of surface water.

Decisions are made about the strength of the road -- the types of soils used and the types and amounts of surfacing material.

These and other decisions establish a design for the highway, which is most effective and most economical.

CONTRACT PLANS

In order for a contractor and the Department's project engineers and inspectors to know how the road or bridge is to be built, it is necessary to put these design decisions down on paper in the form of illustrative drawings, notes and instructions.

In addition to showing how the project is to be built, the contract plans show an estimate of the amount of work to be done -- the cubic yards of earth to be moved, the tons of surfacing materials, the linear feet of pipe, etc. This serves as a basis for estimating the cost of the work and for paying the contractor for work performed.

Contract plans are one of the most important documents used by project engineers and inspectors. The meaning and intent of the plans must be understood thoroughly.

QUIZ

What is used to determine the exact location and measurements needed to design a highway?

____

Decisions about the drainage requirements, and shape and strength of the road are made in the ___________________ process.

The design of a road is based on planning and data collection showing kinds and amounts of ________________ using the road.

Road and bridge designs in the form of notes, drawings and instructions are included in the _______________________.

Now, let's look at some of the other documents needed to build highways.

OTHER CONTRACT DOCUMENTS

STANDARD SPECIFICATIONS

The book of Florida Standard Specifications for Road and Bridge Construction sets forth the directions, provisions and requirements that apply to all contractors on all projects. These include legal requirements for bidding and for performing the work, construction details about how work should be done, specifications for materials and criteria for testing materials, and methods of measurement and bases of payment for work performed.

SUPPLEMENTAL SPECIFICATIONS

Sometimes it is necessary to revise the standard specifications, but it is not convenient or practical to publish a new specification book each time this happens. To take care of this situation, special provisions are written and included with each project. The special provisions supersede the standard specifications and are used until they can be included in a new publication of the book of standard specifications.

SPECIAL PROVISIONS

Frequently some unusual problems or conditions arise during the design or construction of a project, and special instructions are needed. For this situation, special provisions are written that apply only to one particular project. Special provisions supersede both the standard specifications and the supplemental specifications if there happen to be any discrepancies.

DISCREPANCIES

In case there are discrepancies between the contract plans and the various sources of specifications, the special provisions are the highest level of authority. The contract plans are the next highest level of authority, then supplemental specifications and the standard specifications.

QUIZ

Which document applies to all projects? ______________________________________

Which document modifies the one above? ____________________________________

Which documents are prepared for a specific project? ______________________________________

In cases of discrepancy, the governing order of the documents shall be as follows:

_______ Special Provisions

_______ Standard Specifications

_______ Supplemental Specifications

_______ Contract Plans

You've just learned about four contract documents. This course teaches you to read one of them -- the contract plans.

The contract plans often refer you to the other three documents. For example, the summary of pay items makes many references to pay item numbers. The pay item numbers represent sections in the Standard Specifications.

Go to Chapter Five.

ANSWERS TO QUESTIONS

Page 4-4

- field surveys
- design
- traffic
- Contract Plans

Page 4-6

- Standard Specifications
- Supplemental Specifications
- Contract Plans; Special Provisions
- 1,4,3,2

CHAPTER FIVE

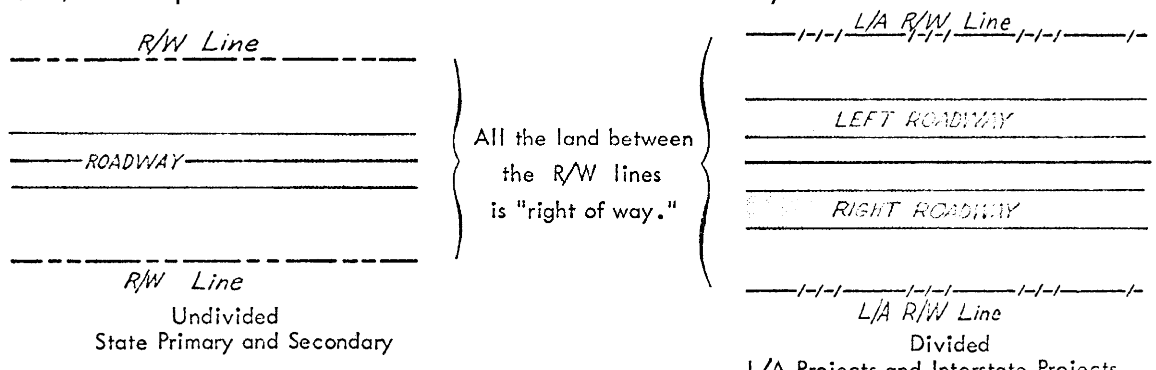
Right-of-Way

CONTENTS

5

RIGHT-OF-WAY

Right of Way (R/W) is the public-owned land used to build roadways.



All the land between the R/W lines is "right of way."

All the land between the R/W lines is "right of way."

R/W land is used for the paved roadway -- and for the shoulders, ditches and slopes. Information concerning R/W land is found in:

- the contract plans -- plan and profile and typical section sheets, and
- special maps called RIGHT-OF-WAY MAPS.

Inspectors work mostly with contract plans, but sometimes it is necessary to refer to right-of-way maps. Right-of-way maps are NOT normally part of the contract plans -- they ARE part of the legal description of the project.

QUIZ

R/W means ____.

Highways are constructed within the _________________________________.

Who owns the R/W? ___________________________

Information about right-of-way can be found in the _______________________ and in

_______________________.

Are right-of-way maps normally part of the contract plans? _________________________

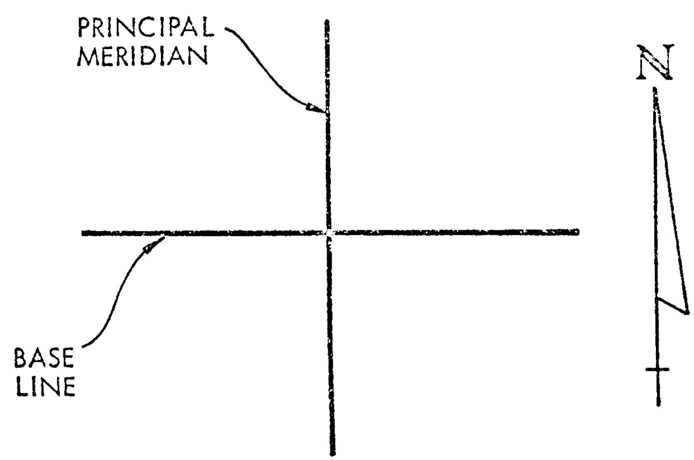
Go on to RIGHT-OF-WAY MAPS.

RIGHT-OF-WAY MAPS

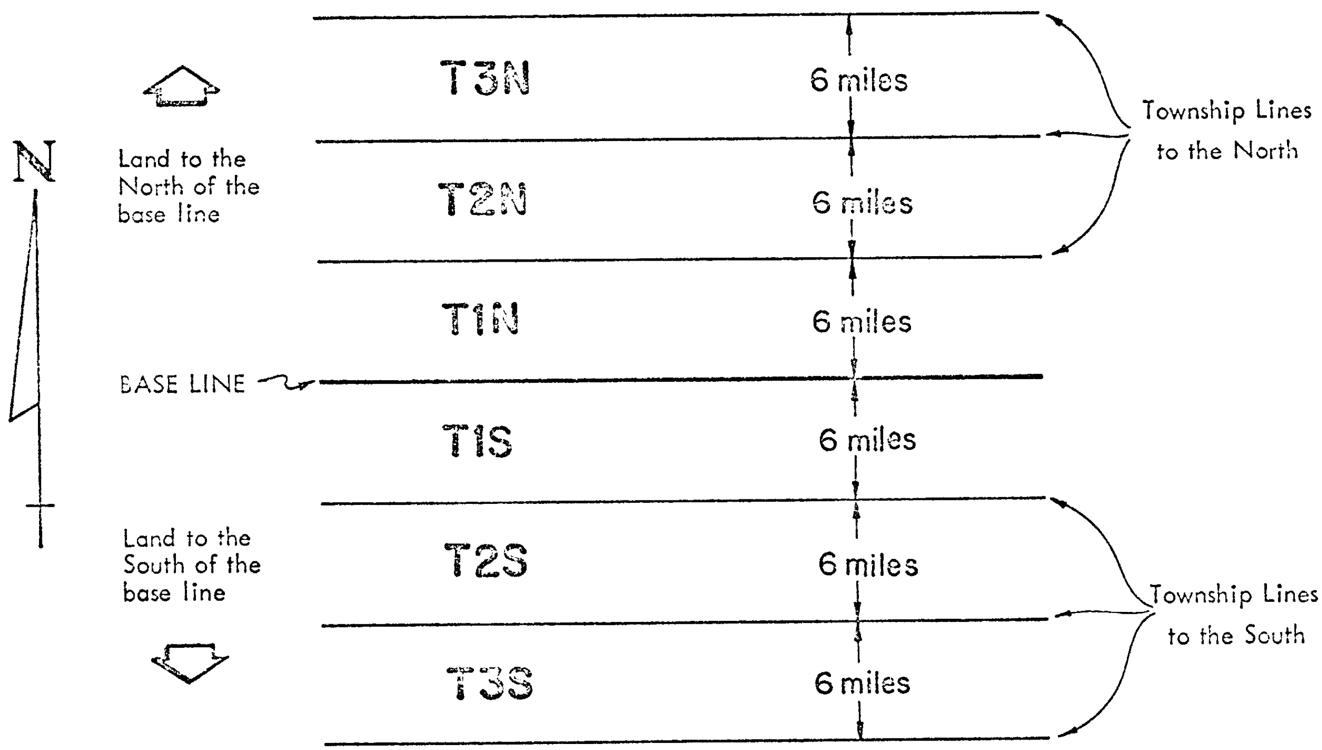
Before we look at the right-of-way maps, let's learn about the grid system used on right-of-way maps.

GRID SYSTEMS

Land survey grid systems are often used to identify property. The grid system established by the United States Coast and Geodetic Survey (USC&GS) is based on several lines running North-South and East-West. The lines running North and South are PRINCIPAL MERIDIANS. Those running East and West are BASE LINES.

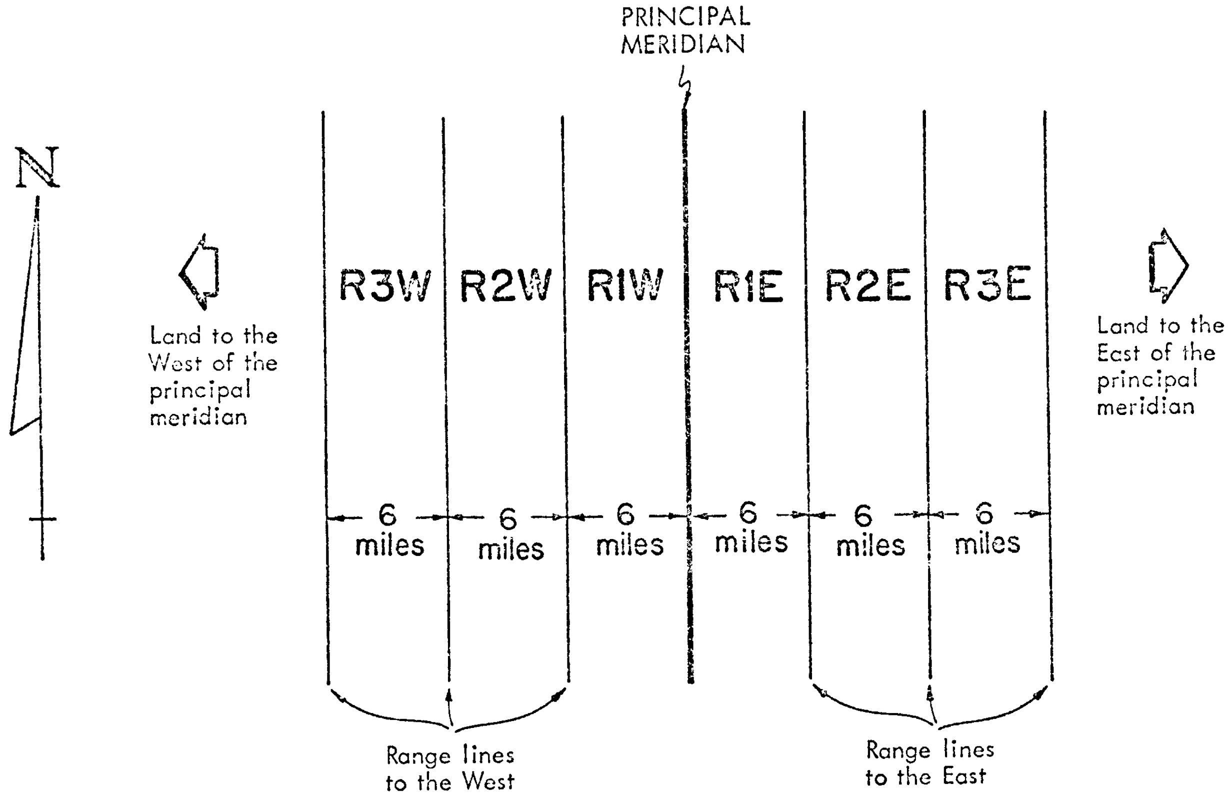


TOWNSHIP LINES are established on each side of the base lines and parallel to them at six-mile intervals as shown below:



The "rows" of land between the lines are identified as Township 1 North (T1N), Township 2 South (T2S), etc.

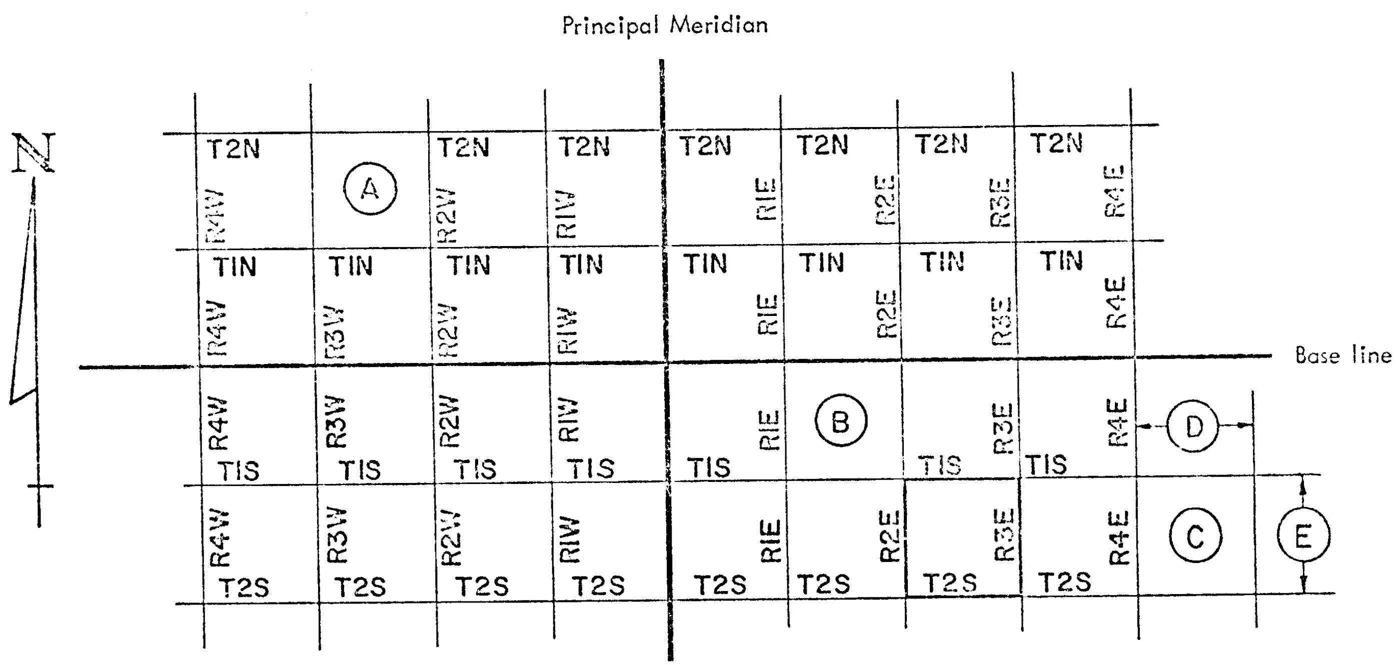
Then RANGE lines are established parallel to the principal meridians at six-mile intervals as shown below:



The "column" of land between these lines is identified as Range 1 West (R1W), Range 2 East (R2E), etc.

When these lines are combined, you can see a grid system. Each block is 6 miles square. Look carefully at the figure below and notice how you can identify the exact location of any square by telling:

- which row it is in, North or South of the Base line, and
- which column it is in, East or West of the Principal Meridian.



For example, if we describe a square as Township 2 South and Range 3 East (T2S-R3E) we would know it is in the second row South of the base line and the third column East of the principal meridian.

QUIZ

Refer to the last figure and fill in these blanks:

The description for square A is ______________________________.

The description for square B is ______________________________.

The description for square C is ______________________________.

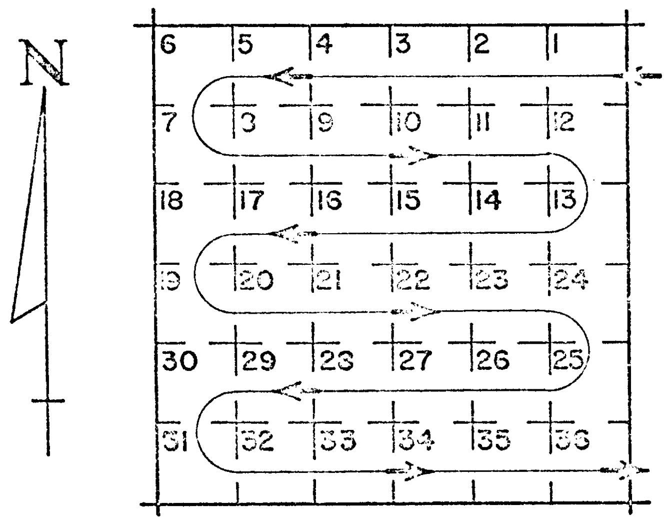
Dimension D is ____________________________ miles.

Dimension E is ____________________________ miles.

The area of square C is _______________________ square miles.

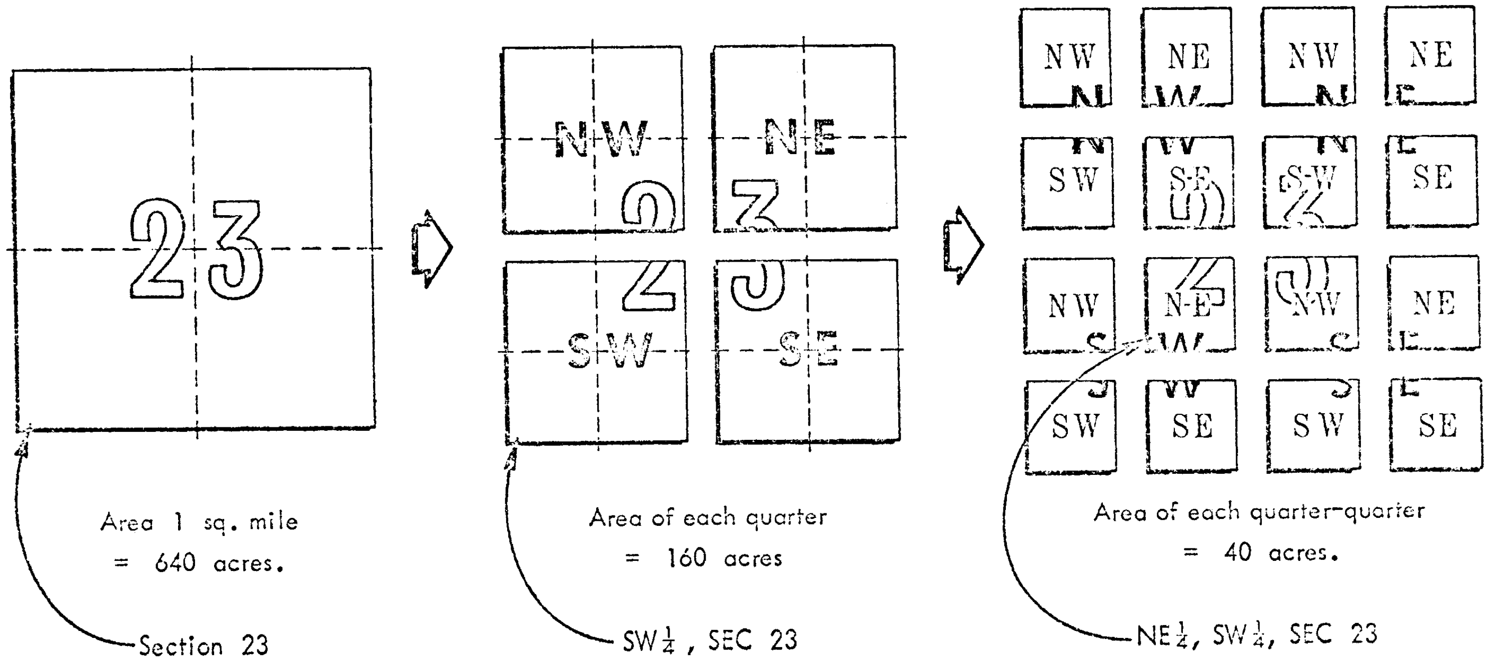
Each of the squares in the previous figure is called a TOWNSHIP. Don't confuse this with Township Lines, which are the dividing lines. From here on, when we say TOWNSHIP, we mean the square area of land, six miles on each side.

Usually it is necessary to describe areas of land much smaller than a Township. Since a township is six miles square, a logical division is 36 one-mile squares. Each of these one-mile squares is called a SECTION, and the Sections within a township are numbered like this:



Often a Section of land must be divided into smaller pieces. The standard way of doing this is to divide the section into four quarters (quarter-sections) and if necessary each quarter is divided into four smaller quarters (quarter-quarter sections).

The figure on the next page shows how this is done, and how the quarters are named.



Land areas usually are measured in acres. A standard section contains 640 acres (1 sq.mi. = 640 acres). Generally, each quarter contains 160 acres, and each quarter-quarter contains 40 acres. However, since some section lines are not exact, or may not have been exactly marked, this is not always true.

QUIZ

Two lines are established as starting points for land survey grids.

The East-West line is the___________________.
The North-South line is the __________________.

Lines six miles apart and parallel to the base line are ____________lines.

Lines six miles apart and parallel to the principal meridian are ____________lines.

The areas defined by township and range lines are called __________________.

The area of each township is ______________ square miles.

Townships are divided into 36 areas called ______________________.

The area of each section is ___________acres.

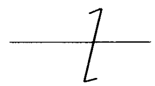
Sections are divided into ____________sections and _______________________ sections.

All right? Go to READING RIGHT-OF-WAY MAPS.
Mistakes? Review pages 5-4 through 5-10.

READING RIGHT-OF-WAY MAPS

You will see a plan view of the proposed highway superimposed on a plan view of the property.

Look for:

- the property lines that are labeled with the symbol PL .
- the symbol  which means that property on both sides of a line belongs to the same owner.
- the section lines and section numbers.
- the township location.

Distances on right-of-way maps are often followed by letters C, D, F or P, which tell us how the distance was obtained.

C means computed distance was not measured on the ground, but calculated from this or other plans.

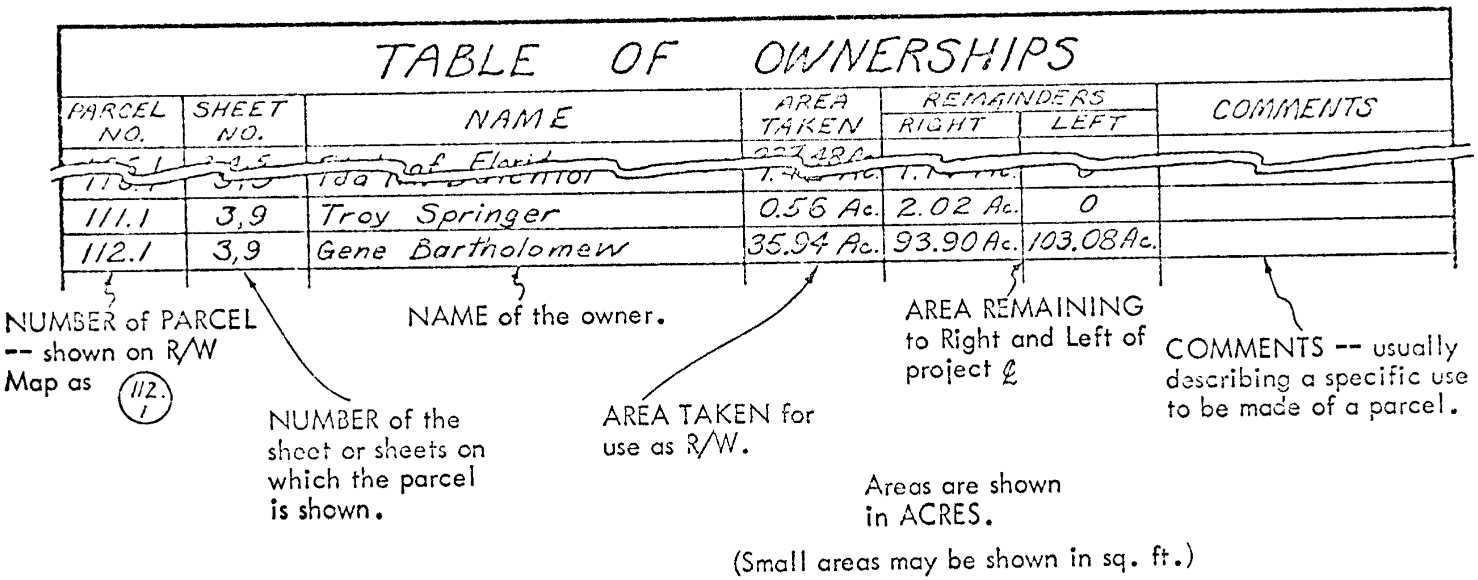
D means deed -- the distance was obtained from the legal records of the property.

F means field -- the distance was measured by a survey party in the field.

P means plat -- the distance was obtained from a filed plat or map.

PARCELS

Land used for right-of-way is secured in parcels -- small parts -- from the property owners. On Federal-Aid and L/A projects the parcels required are numbered on the R/W Map and tabulated in the table at the foot of the map. Look at the Table of Ownership below.



Occasionally, in the part of the table where the owner's name is shown, you will see the abbreviations "et.al." and "et.ux." These are legal terms, in Latin. "Et.al." means "and others." "Et.Ux." means "and wife."

EASEMENTS

Easements sometimes are acquired by the Department from parcel owners, when land is required outside the R/W for a specific purpose, such as drainage, detour construction or slope construction.

RIGHT-OF-WAY DATA IN THE CONTRACT PLANS

You can find data concerning the limits of R/W in the contract plans, on:

- Typical Section Sheets -- the boundaries of the R/W are found at the edges of a typical section.

- Plan Views on Plan and Profile Sheets -- show the boundaries and the details of easements.

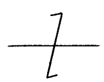
QUIZ

The land acquired by the public for highway construction is called ____________________.

R/W data is found mainly on _________________, but can also be found on _____________________sheets and ________________sheets in contract plans.

A square of land between two township lines and two range lines is called a ______________. It's area is _________________ square miles.

Townships are divided into 36 __________________, each with ______________acres.

The symbol  indicates that land on both sides of a line belongs to the ____________.

Match up these distances with how they were found:

74.35	(D)	________	1. in the field, by survey
1361.85	(F)	________	2. from a filed plat.
7809.31	(C)	________	3. in the legal records of the property.
688.79	(P)	________	4. by calculation

What does "et.ux., et.al." mean? ____________________________

Correct? Well done. Go on to the next page.
Mistakes? Don't go on until you have found the correct answers. They are all there on the R/W Map.

You have just completed five chapters of Contract Plan Reading. There are a total of ten chapters, so you are halfway through the course. How much do you remember from Chapter One? Quite likely, more than you realize. For a refresher, take the quiz beginning on the next page -- it covers Chapters One through Five. You will be surprised at how much you have mastered. Take a short break, then begin.

QUIZ ON CHAPTERS ONE THROUGH FIVE

Which of the following is a bird's eye view?

___A. Elevation view
___B. Plan view
___C. Cross-section view

Which sheets are bound in a separate set and can be used on other projects? ____________________

Which sheets show profiles of the proposed roadway? ______________________

Refer to Sheet No.4, Project 56520-3602 (Plan Book – page 6).

How many feet of the project are shown on the plan view of Sheet No. 4 (Plan Book – page 6)?

____

Is the right-of-way of the proposed project shown on Sheet No. 4 (Plan Book – page 6)?

____

What is the percent of grade of the profile grade line between stations 38+ 25.81and 42 + 00?

____

What is the elevation of the bench mark located at 49' Rt of 28 + 08.10? ____________________

On these reduced sheets, one horizontal inch on a profile view represents approximately ________feet.

A vertical curve begins at station 36 + 25.81 and ends at station ________________.

The point of intersection for this curve is at station __________________.

This vertical curve is ______________long.

The elevation of the point of intersection is _________________.

The elevation of the profile grade points at station 33 + 00 are _____________ and _____________.

The elevation of the existing ground at centerline of survey, Sta. 33 + 00 is ________________.

After resurfacing, the elevation will be _________________.

The sheet from which you obtained your last answer is a ____________sheet.

Refer to the horizontal curve on Sheet No. 4, Project 56520-3502 (Plan Book – page 6), whose P.I. is at station 20+21.85.

For each 100 feet along the curve, the directional change is ________________.

Throughout the curve, the total change in direction is ____________ to the _____________.

Each tangent is ____________ long.

The length of the curve is _____________.

The P.C. is at station _______________.

The rate of full S.E. for this curve is ________________.

What is the transition distance from normal crown to full S.E. on this curve? _____________________

For this curve, does the transition on the inside roadway have any length? ____________________

The contract plans and the standard specifications do not agree. Which document do you use?
____

Go to Chapter Six.

ANSWERS TO QUESTIONS

Page 5-3

- right-of-way
- right-of-way
- the public
- contract plans; right-of-way maps
- no

Page 5-8

- T2N - R3W
- T1S - R2E
- T2S - R5E
- 6
- 6
- 36

Page 5-11

- base line; principal meridian
- township
- range
- townships
- 36
- sections
- 640
- quarter; quarter-quarter

Page 5-15

- right-of-way
- R/W maps; typical sections; plan and profile
- township; 36
- sections; 640
- same owner
- D; 3
  F; 1
  C; 4
  P; 2
- wife, others

ANSWERS TO QUESTIONS, continued

Page 5-17

- B
- Roadway and Traffic Design Standards
- Plan and profile sheets
- 1900 feet
- Yes
- +2.79%

Page 5-18

- 56.60'
- 200'
- 40+25.81
- 38+25.81
- 400'
- 61.30
- 61.30; 60.07
- 60.07
- 61.30
- roadway cross-section

Page 5-19

- 4°-00'-00"
- 22°-00-'00"- left
- 278.48'
- 550 .00'
- 17 + 43.37
- None
- 229.5 feet
- No (superelevation rate equals normal cross slope)
- Contract plans

CHAPTER SIX

Preparation for Construction

CONTENTS

6

PREPARATION FOR CONSTRUCTION

Before roadway construction begins, a preconstruction conference will be held to discuss, among other things, the adjustment and/or relocation of utilities, clearing and grubbing and maintenance of traffic.

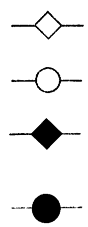
UTILITY ADJUSTMENTS

Certain public utilities -- such as power lines, telephone lines, water lines, sewer lines and gas lines -- must be removed from the project right-of-way. Our concern is where these utilities are and how they are to be removed.

First, let's find out where the utilities are. Utilities are shown with symbols on utility adjustments sheets. To understand utility adjustment sheets, you need to know the meanings of the various symbols for utilities.

QUIZ

What do these symbols mean?



____

____

____

____

Closed or solid symbols represent ___________________ utilities, while open or dashed symbols ________________________ represent utilities.

Do plan and profile sheets list obstructions to be removed from the right-of-way? ___________________

Would you expect utility adjustment sheets to be the main source of information on utility relocation? _______________

Refer to Sheet No. 16, Project 56520-3602 (Plan Book – page 18). This is a _________________ sheet.

Describe the line crossing the survey ---- OT ---- between Stations 24 and 25+50 CR 267? _______________________________

Will the overhead telephone lines that crosses CR 267 between Station 24 and 25+50 be removed? ________________________

If you answered the questions correctly, go to CLEARING AND GRUBBING. If you make mistakes, go to the next page.

UTILITY ADJUSTMENT SHEETS

Utility adjustment sheets are the main source of information on utility adjustments. They show plan views -and some profile views -- of existing and proposed utilities. Unlike plan and profile sheets, utility adjustment sheets usually do not show a continuous view of the project. Instead, only the segments affected by utility adjustments are shown. The segments are conveniently shown in the order of increasing stations.

UTILITY SYMBOLS

Many utility symbols are used on utility adjustments sheets. If you are not familiar with them now, don't worry about it. They will become familiar with more plan-reading practice. Until then, use the key to the symbols.

Here is a rule of thumb that may be helpful in interpreting the symbols. The symbol for each object is nearly the same for both the existing and the proposed object. The only difference is that existing-utility symbols tend to be open (not shaded) with dashed lines; proposed-utility symbols tend to be darkened (shaded) with solid lines. With this rule of thumb in mind, compare some of the symbols in the utility-symbols key.

Go to the next page.

CLEARING AND GRUBBING

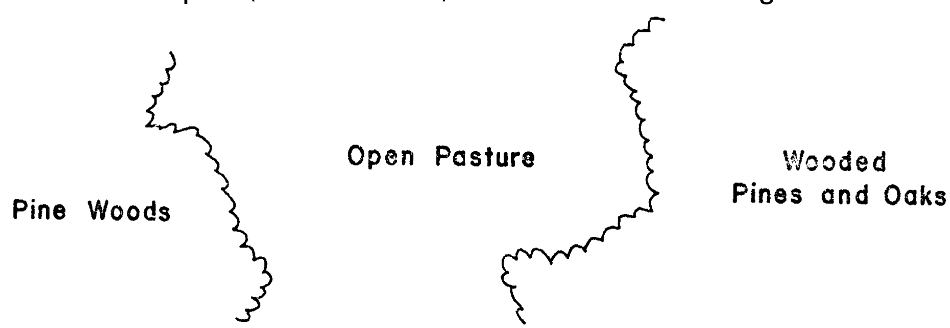
Clearing and grubbing is the process of removing trees, brush and other obstructing vegetation and debris and flexible pavement from the construction site. Building removal is not included in the category of clearing and grubbing.

The contractor will clear and grub all vegetation not designated by the engineer to remain for ornamental purposes. You should be aware of the arrangements, which have been made to clear and grub the right-of-way. Since the amount of work to be done in clearing and grubbing varies from one project to the next, clearing and grubbing is usually a special pay item in each construction contract. The following discussion shows how to read clearing and grubbing details.

PLAN AND PROFILE SHEETS

Since plan and profile sheets show existing topography, many of the items to be cleared and grubbed are shown on those sheets. Most information regarding removal of obstructions from the R/W is found in the standard specifications. You find additional information about interchanges on the interchange detail sheets.

The wooded and open (non-wooded) areas look something like this:



SUMMARY OF QUANTITIES SHEETS

Clearing and grubbing is a pay item (the contractor is paid for the work). All pay items are listed on Summary of Pay Items.

MAINTENANCE OF TRAFFIC

While highway construction is in progress on public roads, provisions must be made to allow some or all of the regular traffic to use the highway. References include the Manual on Uniform Traffic Control Devices and Roadway and Traffic Design Standards in the 600 series.

MANUAL AND STANDARDS

Look at the first note in the lower right corner of the Maintenance of Traffic sheet for project 56520-3602. It reads: "Maintenance of Traffic shall conform to the Manual on Uniform Traffic Control Devices." The manual sets out the methods, construction details, and signing whereby traffic is maintained during highway construction. The Design Standards are used for additional details.

PLANS

If necessary, traffic control plans are included in the contract plans. Sheet No.15, Project 56520-3602 (Plan Book – page 17) is an example of a crossover detail sheet.

Go on to the quiz.

QUIZ

Most information regarding removal of obstructions from the R/W is found in the ___________________ .

Where would you find additional information about:

Moving a power line? __________________________

Existing buildings on or near the R/W? ___________________________

Removing underbrush? ____________________________

Construction of a detour road at a large, complex interchange? ____________________________

Signing that detour? _______________________________

Go on to Chapter Seven.

ANSWERS TO QUESTIONS

Page 6-3

- Existing power pole
- Existing telephone pole
- Proposed power pole
- Proposed telephone pole
- proposed; existing
- No
- Yes, they are
- utility adjustment
- overhead telephone line
- No

Page 6-7

- standard specifications
- Utility Adjustment Sheets
- Plan and Profile Sheets
- Clearing and Grubbing Sheets
- Interchange Detail Sheets
- Traffic Control Manual

CHAPTER SEVEN

Earthwork

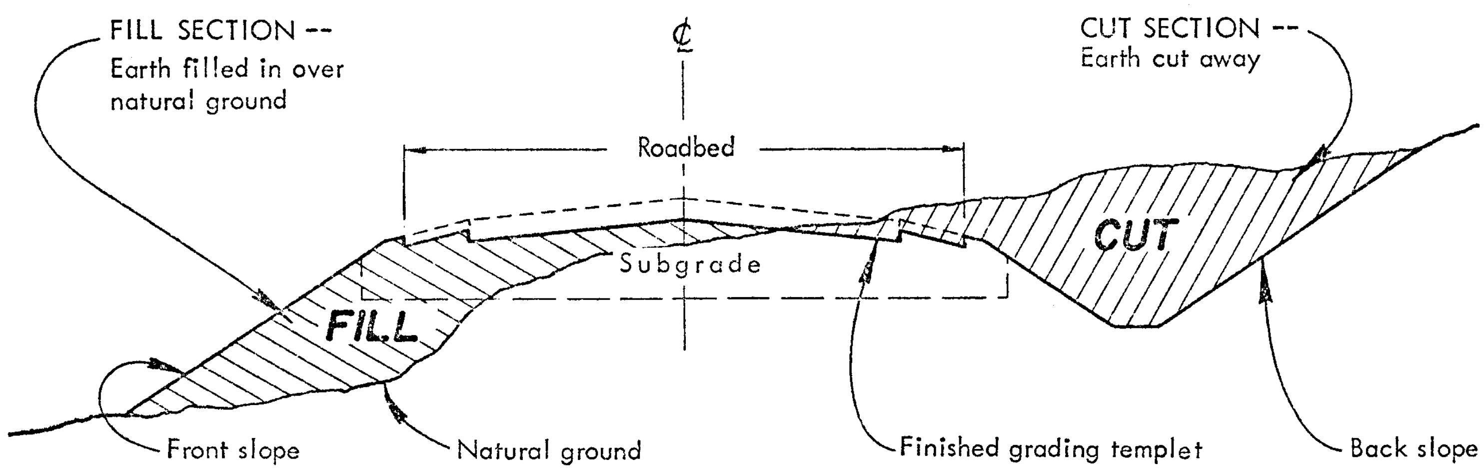
CONTENTS

7

EARTHWORK

BASIC PROCESS

The most important operation involving earthwork is constructing the roadbed. The roadbed is constructed by excavating soil from CUT sections -- and placing soil as embankments in FILL sections. In cut sections, the roadbed is built below the natural ground -- the natural ground is excavated to the elevation of the proposed roadbed. In fill sections, the roadbed is built above the natural ground -- the earth fill is an embankment.



QUIZ

The top of the graded roadbed is the _________________.

Is the roadbed constructed by excavating from fill sections? _______________________

Does the finished grading templet appear above the natural ground line in fill sections?
____

In cut sections, where is the finished grading template in relation to the natural ground line?
____

Constructing the roadbed consists of several different operations. Before we can understand these operations, we must first know something about the kinds of soil encountered on a project. Go to SOILS CLASSIFICATION.

SOILS CLASSIFICATION

ROADWAY SOILS DATA

Part of the preliminary survey of a project concerns the location and classification of the various soil types encountered below ground level along the project. The information collected is shown on Roadway Soil Survey Sheets and Roadway Cross Section Sheets. Find Sheet Nos. 5-13, Project 56520-3602
(Plan Book – pages 7-15). Sheet No. 5, Project 56520-3602 (Plan Book – page 7) is the Cover Sheet, and gives descriptions of the various layers -- strata -- of soil encountered when test borings were made. Notice the small columns beneath each cross section on Sheet Nos. 6 and 13, Project 56520-3602
(Plan Book – pages 8, 15); the numbers in these columns refer to the descriptions on Sheet No.5, Project 56520-3602 (Plan Book – page 7). For example, at Sta. 29+ 50, the layer nearest the surface is stratum No. 1 -- silty sand. The next layer is stratum No. 4 - uniform fine sand with organic -- and below that is stratum No. 3 -- silty sand with organic. Stratum No. 4 – uniform fine sand with organic material is suitable for use in an embankment.

Samples from each of these layers are analyzed by the Materials Testing Laboratory, and are classified according to their suitability for use in building the road. The classifications run from A-1 (Excellent) through A-8 (Unsatisfactory). Sheet No. 5, Project 56520-3602 (Plan Book – page 7) shows the results of this laboratory analysis.

Try the quiz on the next page.

QUIZ

Roadway Soils Data are found on ____________________ sheets.

Refer to Sheets Nos. 5-13, Project 56520-3602 (Plan Book – pages 7-15).

The soil encountered at the surface of the natural ground 60 feet Lt. of at station 37+50 is stratum No. ___________.

The description of stratum No. 2 is __________________________.

Material from stratum No. 4 is classified on Sheet No. 5 as being in group A-___________.

Is material from stratum No. 4 satisfactory for use in the embankment? ________________

Did you find all the answers? If so, go to the next page.
If not, look again at Sheets Nos. 5-13, Project 56520-3602 (Plan Book – pages 7-15), find all the answers, then go on.

TYPES OF EARTHWORK

On many projects, several types of earthwork are required. The type of earthwork usually depends on its location or its purpose. Information on earthwork is found on three kinds of sheets:

- Summary of Quantities Sheets
- Roadway Cross-Section Sheets
- Mass Diagram Sheets for projects that do not pay for earthwork using the embankment pay item.

SUMMARY OF QUANTITIES SHEETS

Summary of quantities sheets give capsule estimates of each type of earthwork to be done. For example, turn to Sheet No. 12, Project 36070-3501 (Plan Book – page 37). Near the bottom is a Summary of Earthwork that shows quantities for various types of earthwork -- embankment, borrow excavation, subsoil excavation and roadway excavation.

GRADING (ROADWAY EXCAVATION AND EMBANKMENT)

Grading consists of making <u>cuts</u> -- excavation of all types of materials (sand, clay, rock, muck, etc.) from inside the right-of-way and above the finished grading templet; and fills -- the placement and shaping of suitable materials to form an embankment.

BORROW EXCAVATION

Borrow excavation is excavation from selected areas -- borrow pits -- outside the right-of-way; it is necessary when roadway excavation does not supply sufficient suitable materials to construct the embankment.

SUBSOIL EXCAVATION

If the results of the roadway soils analysis show unsatisfactory material at any point beneath the finished grading templet, subsoil excavation is carried out to remove the unsatisfactory material. The holes are then filled with suitable material obtained by either roadway or borrow excavation.

QUIZ

Grading consists of excavation ___________________ the R/W and _____________________the finished grading templet, together with the placement and shaping of the __________________.

Borrow excavation is excavation outside the _______________________.

Go on to Chapter Eight.

ANSWERS TO QUESTIONS

Page 7-3

- Finished grading templet
- No
- Yes
- Below the natural ground line

Page 7-5

- Roadway Cross-Section
- 1
- uniform fine sand
- 3
- Yes

Page 7-7

- inside; above; embankment
- R/W

CHAPTER EIGHT

Drainage

CONTENTS

8

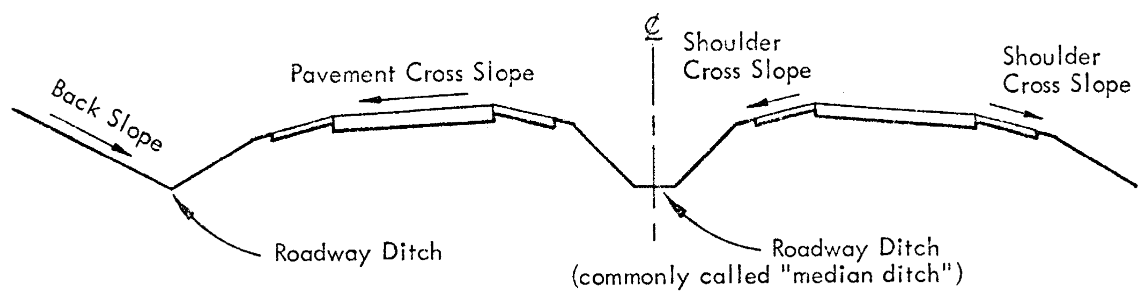
DRAINAGE

A major concern of highway construction is water drainage. Water must be kept from standing on or washing over the road. Also, the side slopes must be protected from erosion. To handle these drainage problems, the natural flow of water in the area is studied, and a drainage system of slopes, ditches, pipes, and culverts is devised. These are shown on plan and profile sheets, typical section sheets, drainage structure sheets and roadway cross-section sheets.

DITCHES AND CHANNELS

ROADWAY DITCHES

Roadway ditches are formed along roadways in cut sections and in the median strips of divided roadways. They collect and drain water from back slopes and cross slopes.



Roadway ditches often are sodded or paved to prevent erosion. Ditch pavement and sodding requirements are found on the quantity sheets for the project -- typical sections of roadway ditches are found on the typical sections sheets.

DISCUSSION ON DITCH REQUIREMENTS

Information about roadway ditches is found on:

- summary of quantities sheets -- station locations and sodding and paving requirements.

- typical section sheets -- general details of width, height, side slopes and thickness of sodding or paving.

- plan and profile sheets -- length of ditches, and their location relative to the roadway.

- roadway cross-section sheets -- specific details of width and height.

SPECIAL DITCHES

Special ditches are different from roadway ditches -- they are different in grade, elevation or location. Special ditches usually are labeled and described on plan and profile sheets -- any sodding or paving requirements are found on summary of quantities sheets.

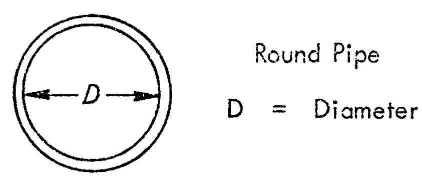
PIPE CULVERTS

A culvert is a structure, which provides an opening under the roadway.

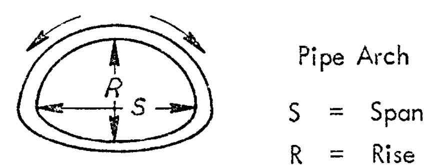
When an opening under the roadway is provided with a pipe, the pipe is called a pipe culvert. A pipe culvert can be a corrugated metal pipe (C.M.P.) or a concrete pipe.

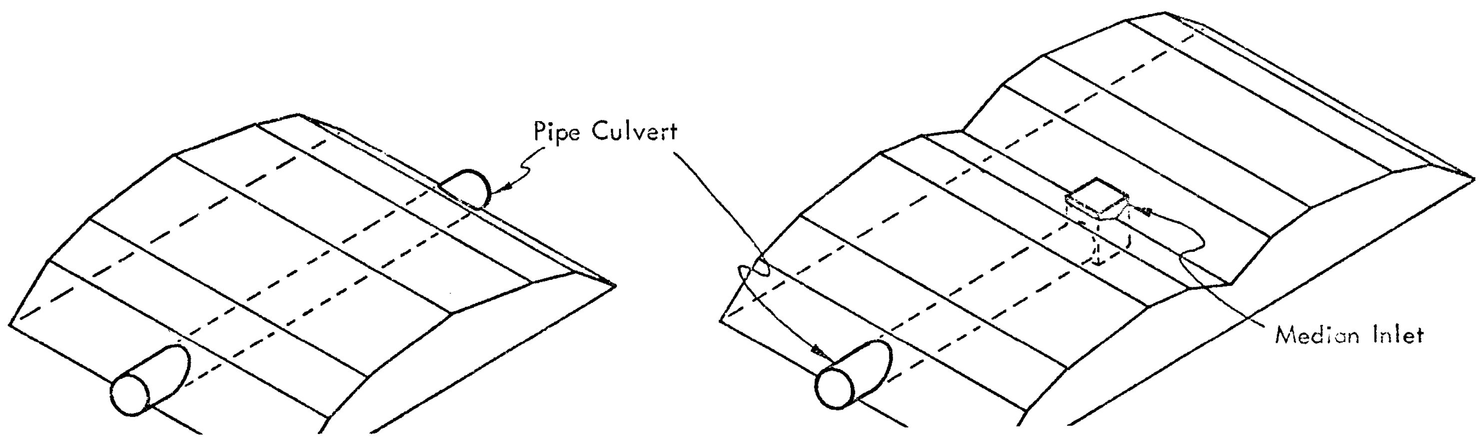
Pipe culverts may have several different shapes. End views of the more common pipes are shown below.

ROUND SHAPE



ARCHED SHAPE

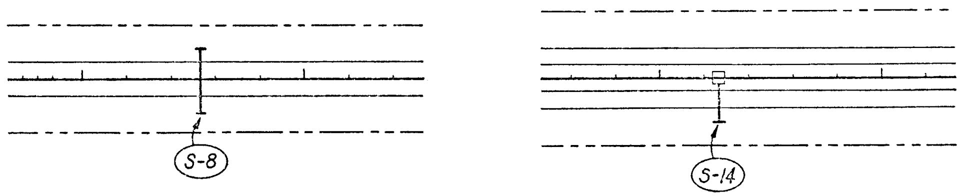




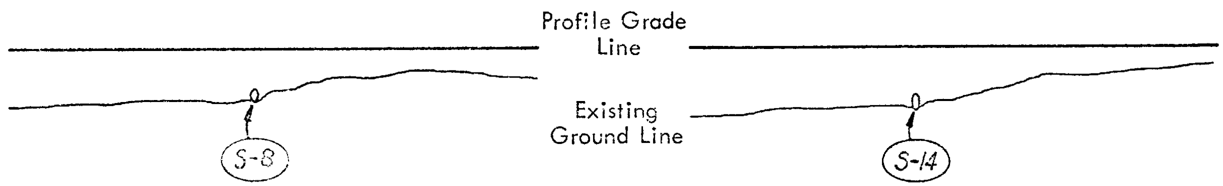
Pipe culverts may go under an entire highway --

-- or under one roadway only, with an inlet from the median

Pipe culverts are shown on plan and profile sheets. On plan views, like this:



and on profile views like this:



All drainage structures (except bridges built on piles) are given a structure number, like those above.

Construction details of drainage structures -- such as pipe culverts -- are shown on Drainage Structure Sheets, where they are referred to by the same structure numbers.

For example, on plan and profile Sheet No. 18, Project 79040-3544 (Plan Book – page 45) locate the pipe culvert under the left roadway at station 27 + 00. The structure number, S-4 and S-5 is shown on the plan view.

Now turn to Sheet No. 14, Project 79040-3544 (Plan Book – page 41) of the same project. This is a Summary of Drainage Structures sheet, and on it we find that S-4 is 45 feet of 18" pipe, with suitable inlet and end section. Inlets and end sections will be discussed later.

FLOW LINE

In any drainage structure, the lowest line along which water can flow is called the Flow Line (F.L.).

QUIZ

The inside dimension representing the longest vertical distance across the end of a pipe arch is called the ________________________________.

The inside dimension representing the longest horizontal distance across the end of a pipe arch is called the ________________________________.

Refer to Sheet No. 14, Project 79040-3544 (Plan Book – page 41). Locate the pipe culvert at station 28 + 07.

Which roadway does it lie under? ______________________

What is its structure number? ____________

What is the inside diameter of the pipe? _________________

What is the length of the pipe? ___________________

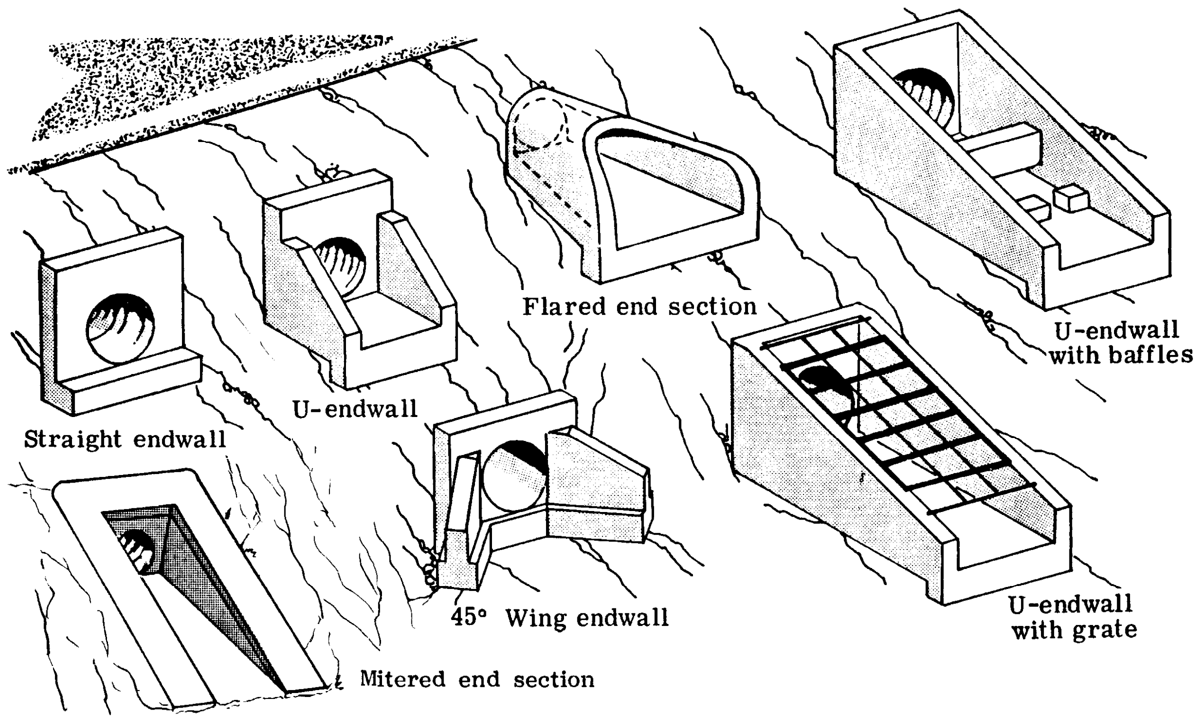
End views of two of the more common pipes are shown below. What do the letters represent?

D = ________ S = __________ R = ____________

Details of proposed pipe culverts are found on ________________ sheets.

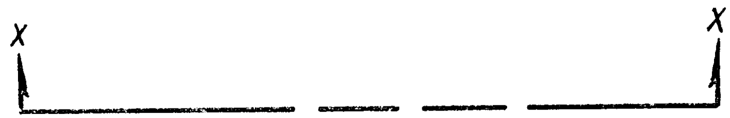
END TREATMENT

Endwalls or other end treatments give culverts pleasing appearances and help prevent erosion of surrounding embankments. Special end treatments also increase the efficiency of water flow. See the figures below:

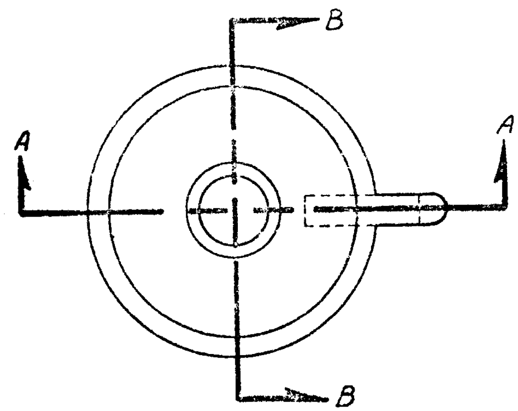


Roadway and Traffic Design Standards give details of endwalls. The index numbers are given on the appropriate drainage structures sheet.

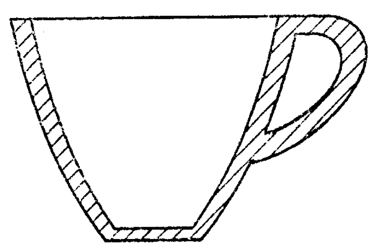
Turn to Standard Index No. 270 (Plan Book – page 110). Notice that the plan view has marks like this:



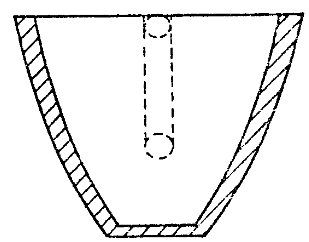
Alongside such a plan view is a view labeled "Section X-X." This is a cross-section view. Marks like those above show where the figure was sliced to give the cross section labeled section X-X. The arrows show the direction in which you are looking when you view Section X-X. Examine these figures:



Plan view of cup



Section A-A

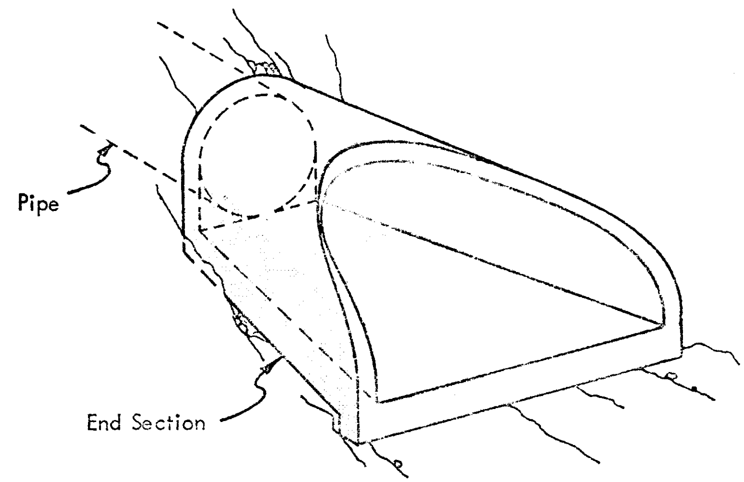


Section B-B

These are drawings of a cup. First you see a plan view. The second view is section A-A, the view of the cup sliced along the line indicated in the plan view. Section B-B is a cross-section view of the cup sliced along a different line. These cross-section views are common on detail sheets and standard drawings.

Look again at Standard Index 270 (Plan Book – page 110). It shows details of construction of a flared-end section for pipe culverts -- which looks like this:

Note: Drawing below is not from Standard Index 270 (Plan Book – page 110), it is intended as an example only.



The dimensions of endwalls, as shown on standard drawings, are letters. Usually the letters are related to each other in such a way that if you know the diameter of the pipe culvert you can calculate -- or find from a table -- all the dimensions of the structure.

QUIZ

Locate the drainage structure at station 34 + 60 on Sheet No. 19, Project 79040-3544 (Plan Book – page 46).

What is its structure number? ________________________

What is the pipe diameter? ______________________

What kind of end treatment is specified for this structure? ___________________

Refer to Standard Index No. 270 (Plan Book – page 110): Flared End Section.

For an 18" pipe, what are the dimensions "D" and "E?" ____________________

How thick are the walls when the end section is constructed to fit a 36" pipe? ______________

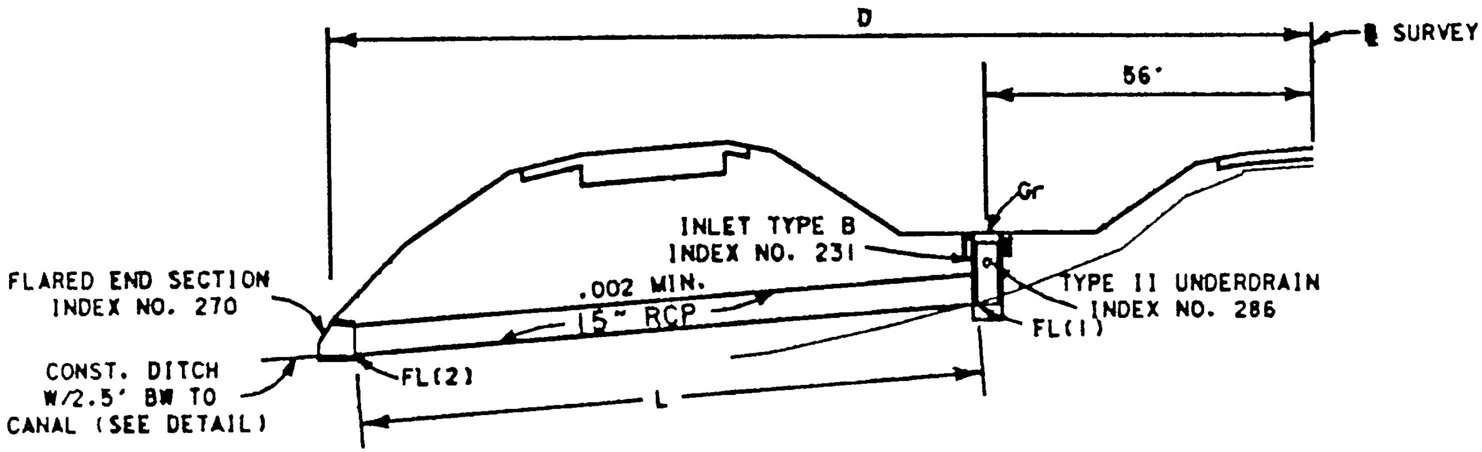
If you had any trouble finding the information asked in the QUIZ, remember to look first on the Plan and Profile Sheet, then on the Drainage Structure Sheet, then at the Standard Drawing.

No problems? Go on to INLETS AND MANHOLES.

INLETS AND MANHOLES

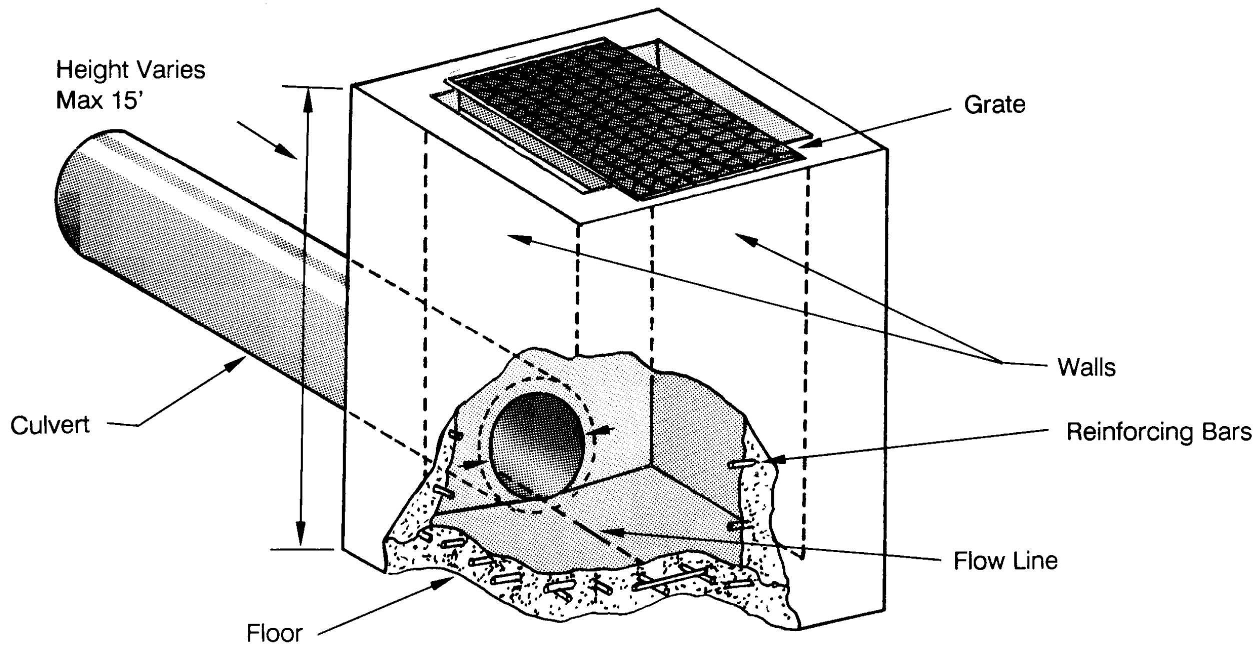
INLETS

Inlets often are used in conjunction with pipe culverts. Inlets permit surface water to fall into culverts or other underground pipes.



Locate structure S-9 of Sheet No. 18, Project 79040-3544 (Plan Book – page 45). It is at station 31 + 00. The Typical Drainage Structure sheet tells us that an inlet, Type "C" is required. Details of the construction of this inlet are on Standard Index No. 232 (Plan Book – page 103). Turn to that Standard Index now.

Standard Index No. 231(Plan Book – pages 101-102) shows various views and details of Inlet Type "B." Study the drawing, and this figure carefully.



Notice:

- the cross-section views on Standard Index No. 231(Plan Book – pages 101-102) -- more detail can be shown using such views.
- the reinforcing steel bars placed in the concrete to add strength.

QUIZ

Refer to Standard Index No. 231(Plan Book – pages 101-102), and Standard Index No. -- Inlet Type "B"

How thick is the floor of the inlet?__________

The outside dimensions of the inlet in plan view are __________ x _________.

How wide is the sodded area around the inlet? _________

Bottom type B is recommended for pipes with diameters larger than ____________.

Supplementary details for the inlet can be found on Standard Index No. __________.

MANHOLES

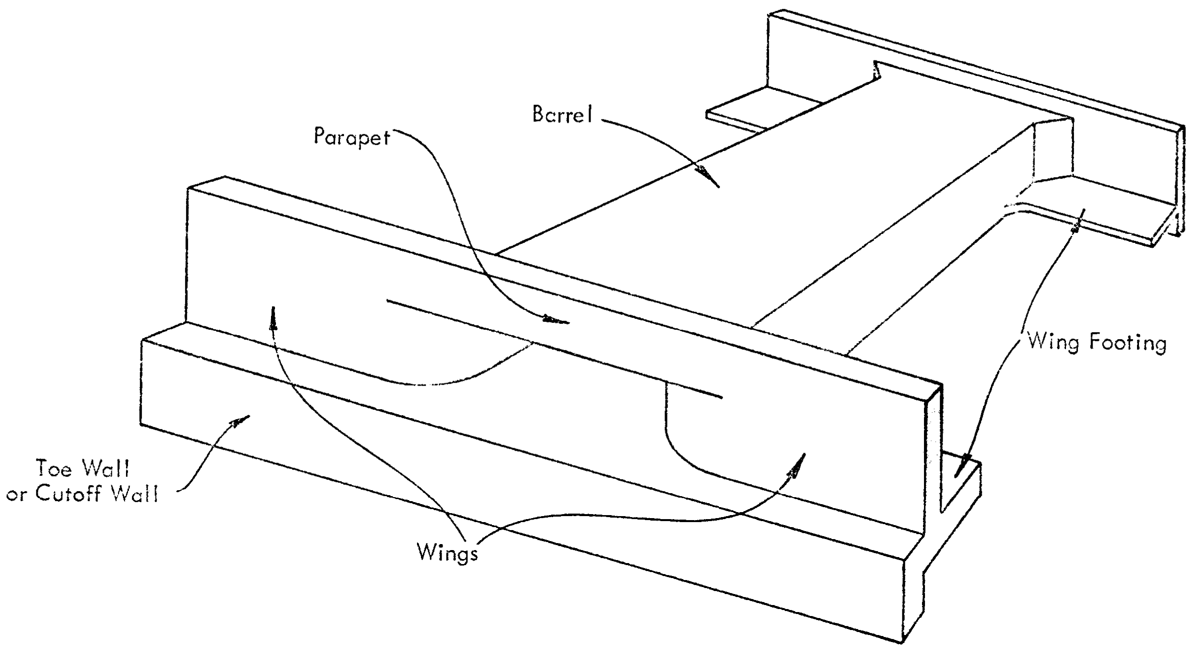
Manholes usually are found in urban projects. Manholes are brick or concrete shafts situated so as to allow maintenance and inspection personnel access to culverts, storm sewers and other underground structures. The location of manholes is shown on plan and profile sheets -- various Standard Indexes give details of their construction.

BOX CULVERTS

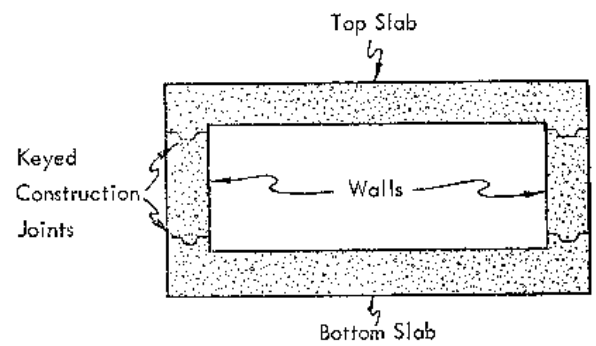
Box-shaped culverts are called box culverts. They are constructed with reinforced concrete. Before reading box culvert data sheets, let's become familiar with some terms.

TERMINOLOGY

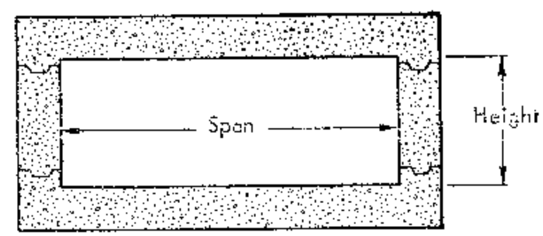
A box culvert is shown below -- study the names of its parts:



The barrel has these parts



Culvert barrel dimensions are
measured like this



Dimensions of box culverts often are written as 8' x 4', 10' x 8', etc. The first number always refers to the span and the second number always refers to the height.

QUIZ

The major part of the culvert, the part between the two ends, is called the ________________.

The part which projects above the top slab is called a _______________.

The part which "hangs down" from the end of the barrel is called a ________________.

The top and the bottom of the culvert barrel are referred to as _____________.

The distance from the inside of one wall to the inside of the other wall is the _____________.

The height is the distance between the inside surfaces of the _____________.

Locate the culvert required at station 1366 + 16.06 on Sheet No. 17, Project 55050-3544 (Plan Book – page 57).

What is its structure number? _________________

What kind of culvert is required? _________________

What length of culvert is required? __________________

What are the required span and height of this culvert? ________________

Which standard index is referenced for this culvert? _________________

The answers to all these questions can be found on drainage structures Sheet Nos. 5 & 17,Project 55050-3544 (Plan Book – pages 53, 57). Before we can fully understand box culvert plans, we must learn about reinforcing bars in concrete structures. Go to REINFORCING BARS on the next page.

REINFORCING BARS

Any concrete structure can be made stronger by placing steel reinforcing bars throughout the structure before pouring the concrete. Larger highway concrete structures are almost always of reinforced concrete.

Turn to the box culvert data sheet for the structure at station 1366+ 16. The table on the Sheet No. 7,
Project 55050-3544 (Plan Book – pages 55) contains reinforcing-steel data. Also look at Standard Index 290 (Plan Book – pages 111-115), for drawings that show the positions of the steel bars.

Most of the items in the drawings may be new to you. Some of them -- bar sizes, bar bending, bar dimensions, bar spacing and bar clearances -- are explained on the following pages.

BAR SIZES

There are two main types of reinforcing bars: smooth bars and deformed bars. As the methods of showing the sizes of these two bar types are slightly different, let's look at them one at a time.

Smooth Bars

Smooth bars, as their name suggests, are plain round bars with a smooth outer surface, like this:

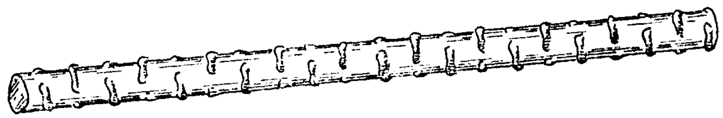
When called for in the plans, these bars are referred to as "smooth round bars" and generally are used as dowels that allow slippage.The sizes of smooth round bars are given in inches: for example, 3/4".

NOTE

As you become familar with drawings showing reinforcing bars, you will find that different bars in a structure are designated by a letter: for example, bars A, bars K, V1-bars, etc. These letters have NOTHING to do with the bar sizes or shapes-- they are there only to help differentiate bars in one part to a structure from those in another.

Deformed Bars

Deformed bars, which generally are used for reinforcing purposes nowadays, are round bars with their surface deformed, or pressed, into ridges by the manufacturer, like this:



The ridged surface provides a better "grip" onto the concrete than a smooth surface. Bar sizes are shown as numbers like this: #3, #8, #11. The number is a measure of the diameter -- the diameter in inches is roughly equal to the bar number divided by 8. For example, a #4 bar would have a diameter of 4/8" or 1/2". The smallest deformed bar is a #3 bar, with a diameter of 3/8". Study this table:

Bar Size Number	#3	#4	#5	#6	#7	#8	#9	#10	#11	#14	#18
Diameter In Inches	$\frac{3}{8}$"	$\frac{1}{2}$"	$\frac{5}{8}$"	$\frac{3}{4}$"	$\frac{7}{8}$"	1"	$1\frac{1}{8}$"	$1\frac{1}{4}$"	$1\frac{3}{8}$"	$1\frac{3}{4}$"	$2\frac{1}{4}$"

For these bars (#9 to #18), the number is really a measure of the cross-sectional area.

Bars #14 and #18 are only used for massive structures, which bear very heavy loads -- such as bridge piers in waterways.

QUIZ

The symbol ∅ means ________________.

Suppose you know that different bars had the following diameters. Fill in the blanks with the proper bar numbers:

3/8" ______________________

3/4" ______________________

1" ______________________

1/2" ______________________

1 3/8" ______________________

You should still have your plan book open at Standard Index No. 290 (Plan Book – pages 111-115). If not, turn to that drawing now.

Go to the next page.

BAR BENDING

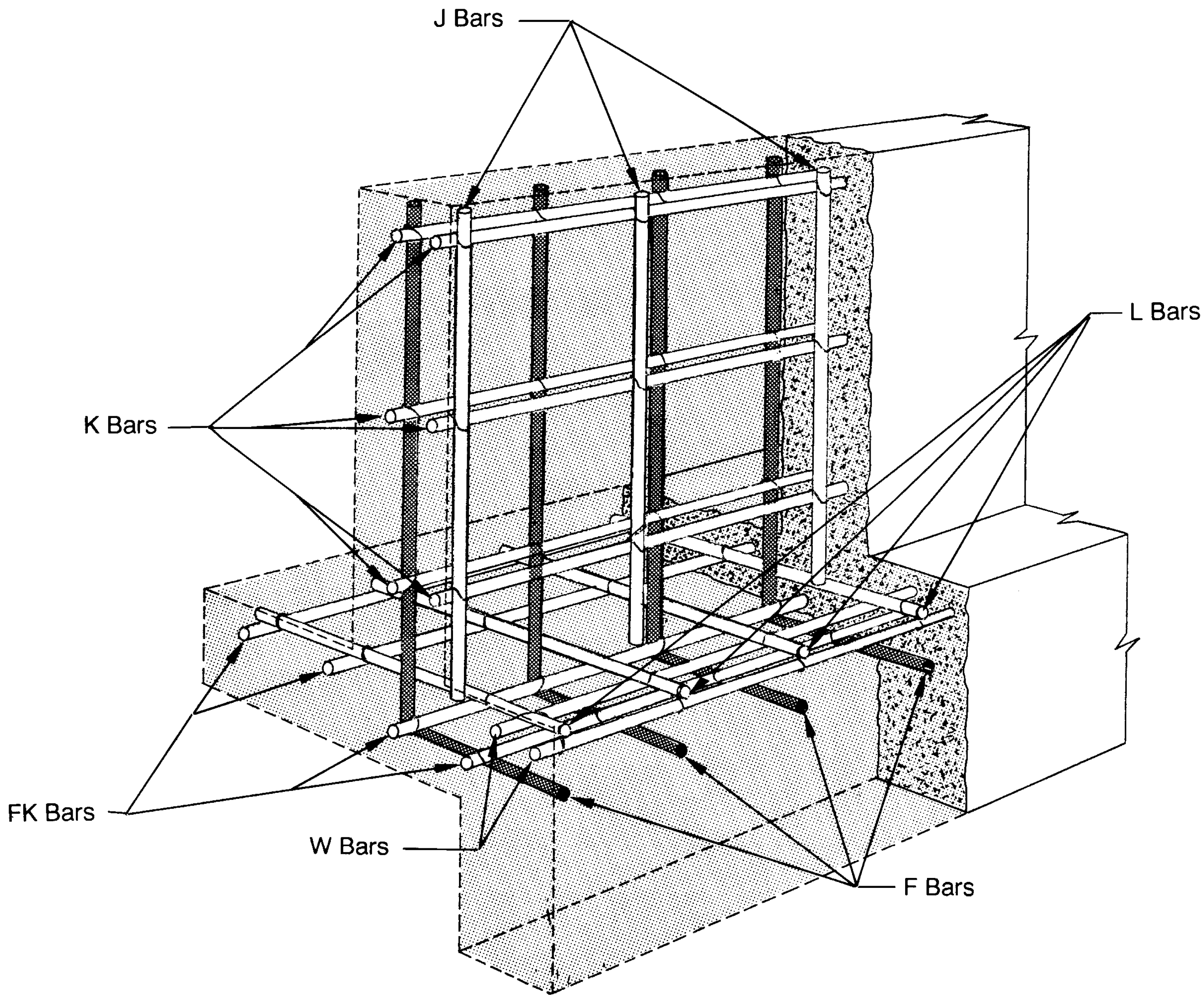
Look at the part of Standard Index 290 (Plan Book – page 112), called "Section Thru Wingwall."

On the next page is a diagram of how the end of a wing would look if the concrete was removed.

The F bars are shown shaded, with dimensions. Can you see that they are L-shaped?

NOTE

Here are two hints on interpreting bar details. First, bars usually are shown as broken lines, but actually they are continuous. Second, bars pointing straight toward the reader often appear as heavy dots.

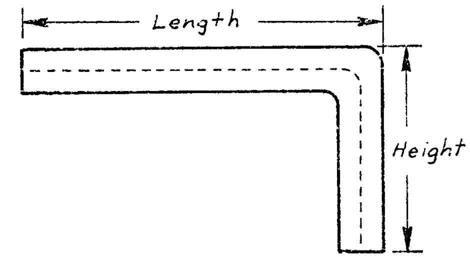

J Bars
K Bars
L Bars
FK Bars
W Bars
F Bars

BAR DIMENSIONS

For straight bars, the only dimension required -- other than the diameter, or bar size number -- is their length.

Bent bar dimensions (other than diameters) are measured from outside to outside.

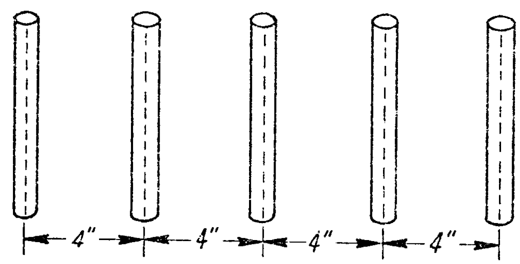
For example, study this figure:



OUT TO OUT

BAR SPACING

Bar spacings are distances between bars. Bar spacings are measured center to center as shown at the right:



SPACING

3/4" Ø BARS A at 4" Ctrs.

OR

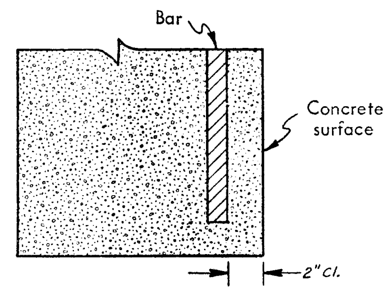
5 #6 bars A @ 4" C to C or c.c.

Spacing instructions are shown like this:

Even if C to C (or c. c.) is absent, the meaning remains -- center to center.

BAR CLEARANCES

Bar clearances are distances between concrete surfaces and the nearest edges of the bars -- as shown at the right. Where bar clearances are required, the abbreviation "Cl." appears on the plans. If "Cl." does not appear, the clearances will be defined in a general note.



CLEARANCE
(Showing 2" clearance)

Sometimes clearance is referred to as concrete cover.

QUIZ

Is a #6 bar thicker than a #3 bar? __________

When measuring the spacings of reinforcing bars, c. c. means ___________________.

Refer to Standard Index 290 (Plan Book – pages 111-115), and Sheet No. 7, Project 55050-3544 (Plan Book – page 55) for the Culvert Data for the culvert at station 1366 + 16.06.

An A1 bar is L-shaped. When bent, its dimensions are _____________ x ____________.

Are bar dimensions given center-to-center or out-to-out? ________________

Into what shape are bars F bent? ____________ How long is each F-bar? ________________

QUIZ, continued

Refer to Sheet No. 7, Project 55050-3544 (Plan Book – page 55) to answer the following questions.

A100 bars are in the_________________ slab of the culvert barrel.

A100 bars are # _________________ bars.

There are ___________ A100 bars estimated for this structure.

Each A100 bar is ________ long.

What is the total estimated quantity of reinforcing steel for this structure? _____________________

It is important that you understand reinforcing bar details before proceeding.
If you found the quiz confusing, review pages 8-17 through 8-23.

If you got the right answers, look at the next two pages for a quick review before going on.

FOR REVIEW

BAR SIZES are measurements of bar diameters.

Sizes of smooth bars are diameters in inches.

Sizes of deformed bars are numbers.

Small numbers -- small diameters
Large numbers -- large diameters

BAR DIMENSIONS are measurements -- other than diameters -- of individual bars.

Bar dimensions are measured out-to-out.

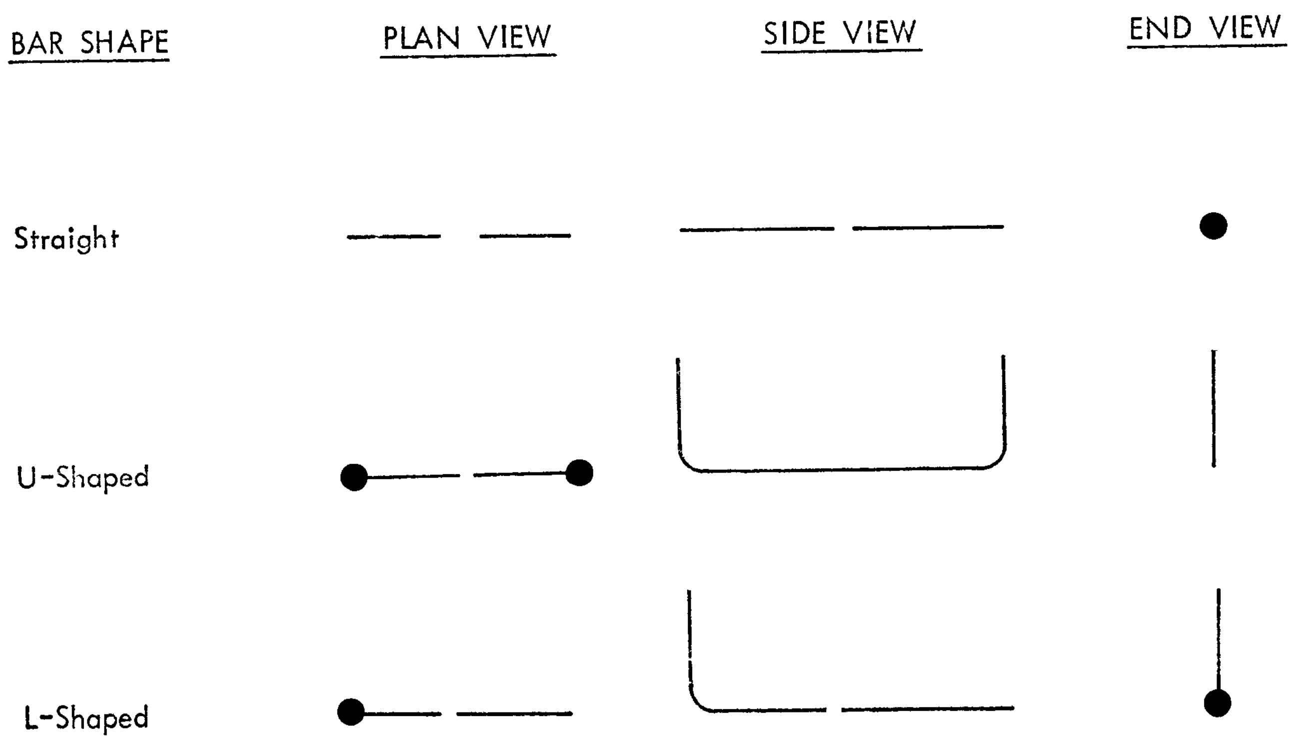
BAR SPACINGS are distances between bar centers.

Bar spacings are measured center to center.

BAR CLEARANCES are distances between concrete surfaces and the nearest edges of bars.

Bar clearances are noted with the word "cover" or the abbreviation "Cl."

The following will serve as a review of how steel reinforcing bars look inside structures -- study it carefully.



QUIZ

The following questions will serve as a review of Chapter Eight on "Drainage." If you miss answers, review accordingly.

Refer to Sheet No. 6, 7, 15, 19, 21, Project 55050-3544 (Plan Book – pages 54 - 56, 58-59).

How many feet of 18" pipe are to be laid at station 285 + 80? ___________

How much Class I concrete is estimated for structure S-140? __________

Which standard index would be used to construct the end section of structure No. S-81? ___________

How many pounds of reinforcement are required for structure No. S-174A? ___________

For the box culvert located at station 1366 + 16.06,

What is the thickness of the bottom slab of the barrel? ___________

How much concrete is required for the barrel? __________

What bar size are the A2 bars in the barrel? _________

How long is each A2 bar? ____________

The distance from the closest surface of the concrete to the side of a steel reinforcing bar is called the ____________________.

This completes the discussion on DRAINAGE. Take a break before going to Chapter Nine.

ANSWERS TO QUESTIONS

Page 8-6

- rise
- span
- Left
- S-6
- 18"
- 92'
- Diameter; Span; Rise
- Drainage
  Structure

Page 8-10

- S-12
- 24"
- End Wall
- 6'1"; 3'0"
- 4"

Page 8-13

- 8"
- 10′ 7″ X 8′ 4″
- 2'
- 36"
- 201

Page 8-16

- barrel
- parapet
- toe or cutoff wall
- slabs
- span
- top and bottom slabs
- S-85
- Concrete Box Culvert
- 166'
- 6' x 5'
- Index No.290

Page 8-21

- round
- #3
  #6
  #8
  #4
  #11

Page 8-25

- Yes
- center-to-center
- 2'-3" x 3'-11"
- Out-to-out
- L-shape
- 8'-9"

Page 8-26

- top
- # 4
- 249
- 7'2"
- 12,526 lbs.

Page 8-29

- 102'
- 2.24 CYD
- Index No. 273
- 140
- 9"
- 116.143 CYD
- # 4
- 6'2"
- clearance

CHAPTER NINE

Bridges

CONTENTS

CONTENTS, continued

9

BRIDGES

A BRIDGE is a traffic-carrying structure (including supports), with a clear span of more than 20 feet, which is constructed over an obstruction in the roadway. The obstruction may be a creek, river, railroad or even another roadway. Let's learn the names of some basic bridge parts.

TERMINOLOGY

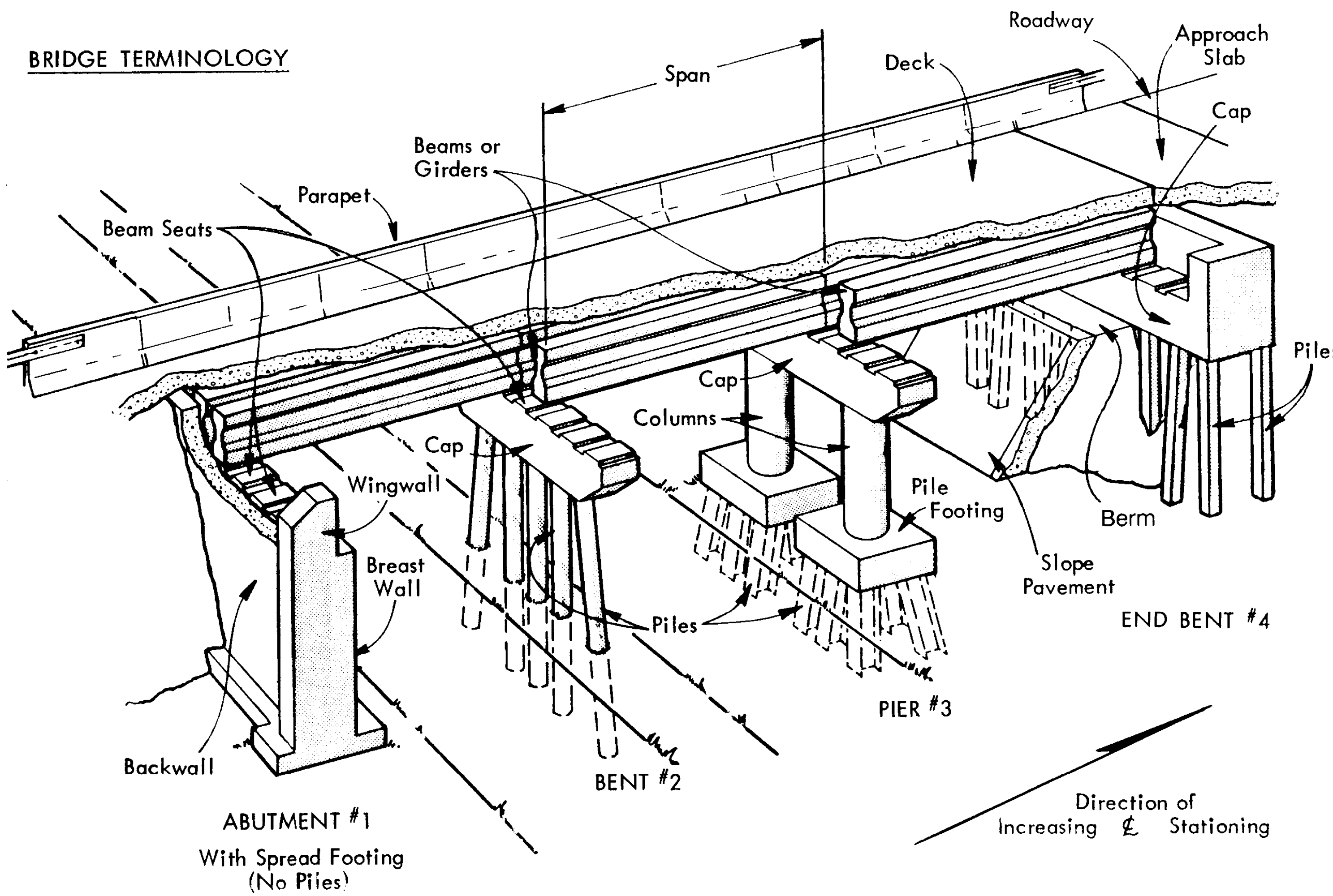
Learning basic bridge terminology is an important first step in understanding bridge plans. Several bridge terms are explained below. After reading each definition, locate the part on page 9-6.

PILES:	These are the long shafts, made of timber, steel, or reinforced concrete which are driven or drilled into the ground to form a FOUNDATION for the bridge supports. When the ground is hard rock, piles may not be required.
SUBSTRUCTURES:	This is a general term for the structure which support the bridge from below. There are four main kinds of substructures:
ABUTMENTS: and END BENTS:	These are the first and last substructures of each bridge. ABUTMENTS have vertical wall the full height of the bridge: END BENTS consist of a horizontal CAP supported by piles and surrounded by slope pavement.

BENTS and PIERS:	These are the intermediate substructures of a bridge. BENTS consist of piles, rising above ground, and supporting a horizontal CAP: PIERS consist of COLUMNS, resting on a FOOTING, and supporting a CAP. The substructures of each bridge are numbered sequentially in the direction of increasing centerline stationing.
FOOTING:	This is a reinforced concrete slab which supports the base of an abutment or pier. A footing supported by piles is a PILE FOOTING: a SPREAD FOOTING rests on a surface capable of support without piles.
COLUMNS:	These are the vertical support members of a pier.
CAP:	This is the horizontal member of a substructure. The top surface of the cap -- BEAM SEATS -- support the BEAMS or GIRDERS.
BEAMS or GIRDERS:	These are the longitudinal members resting on the caps. Beams or girders support the DECK.
DECK:	This is the reinforced concrete slab, or steel grating, placed over the beams or girders. The deck is the "roadway" of the bridge.
APPROACH SLABS:	These are the reinforced concrete slabs linking the deck and the roadway.

PARAPETS:	Parapets, consisting of either traffic barriers or curbs and handrails, are placed on the outer edges of the deck. They help control drainage and prevent vehicles from going off the bridge.
SPAN:	The distance from one substructure to the next substructure.
BERM:	The flattened portion of an earth fill -- often located near end bents or abutments.
SLOPE PAVEMENT or RIPRAP:	Material placed against the embankment to protect the bridge ends.
SUPERSTRUCTURE:	All bridge parts above the caps make up the bridge superstructure.
SUBSTRUCTURE:	All bridge parts below the beams make up the bridge substructure.

Review these terms as necessary. Then try the quiz on page 9-7.


BRIDGE TERMINOLOGY
Roadway
Approach Slab
Span
Deck
Cap
Beams or Girders
Parapet
Beam Seats
Piles
Cap
Columns
Cap
Wingwall
Pile Footing
Berm
Slope Pavement
Breast Wall
Piles
END BENT #4
PIER #3
Backwall
BENT #2
Direction of Increasing ℄ Stationing
ABUTMENT #1
With Spread Footing
(No Piles)

QUIZ

Supporting structures of the bridge are ________________________________.

Substructures include everything below the ________________________________.

The end substructures are either ________________________________, which have a vertical wall the full height of the bridge, or ________________________________.

Vertical support members of bents are _______________________________.

Columns provide _______________________________________ support in piers: They rest directly on a _________________________.

On top of caps, the ________________________________ support the beams.

The flattened portion of an earth fill is a ________________________________.

The "roadway" of the bridge is the ________________________________.

What is the distance from one substructure to the next substructure? _______________

The _____________________________ prevents vehicles from veering off the bridge.

The piles, footings, columns, walls and caps form the bridge ______________________________.

Any bridge part not in the substructure is in the ________________________________.

Linking the deck and the roadway are ________________________________ slabs.

Go to the next page when you are sure you know all these terms.

STRUCTURE PLANS

Bridge information is found in the Structure Plans. The numbering scheme for Structure Plans was explained on page 1-26 of this text. We will study structure plans by looking at a single bridge site.

Turn to Sheet No. B-1, Project 56520-3602 (Plan Book – page 20). This is the General Note Sheet for Project 56520-3602. Notice:

- the general notes, top right;
- the index of sheets, top left;
- the rip-rap details, lower left; and
- the note, upper center, referencing the applied finish detail.

QUIZ

Bridge information is found in the ________________________________.

Refer to Sheet Nos. 1A, B-1, B-7, B-8, B-10,B-14, Project 56520-3602 (Plan Book – pages 2, 20, 26, 27, 29, 33).

Which sheet shows traffic railing barrier details? _________________

How much Class IV concrete is estimated for the substructure of the bridge? ______________

What is shown on Sheet No. B-8, Project 56520-3602 (Plan Book – page 27)?

____

How many pounds of reinforcing steel are estimated for this bridge superstructure? ____________

What size of Prestressed Piling will be used on this bridge? ______________

BRIDGE LAYOUT

PLAN AND ELEVATION

Turn to Sheet No. B-2, Project 56520-3602 (Plan Book – page 21) in your Plan Book. This is a Plan and Elevation sheet for the bridge. The Plan and Elevation sheet is probably the most useful bridge plan sheet -- it shows what the bridges look like, the number and position of substructures (in this case, end bents and intermediate bents) and the location of slopes, approach slabs and traffic lanes.

QUIZ

What is the minimum vertical clearance between the design High water and the bridge superstructure?

____

At what station on the ℄ of survey is the intersection with the ℄ of Int. Bent No.4? ________________

What is the slope ratio of the end bent slope pavement? ____________________________

The overall length of the bridge is ____________________.

The angle between the ℄ of survey and the ℄ of bents is __________________________

Mistakes? Look again at Sheet No. B-2, Project 56520-3602 (Plan Book – page 21).
All correct? Go on to the next page.

BRIDGE BORING DATA SHEET

The foundations of a bridge must be firm, so it is necessary to obtain information about the earth under a proposed bridge. This information is given on Boring Data Sheets.
Sheet Nos. B-4 - B-6, Project 56520-3602 (Plan Book – pages 23-25), are examples of Bridge Boring Data Sheets. Study it now, then answer the questions about it.

QUIZ

Which boring numbers are located within the limits of the bridge? ________________

How many blows did it take for 12" penetration at elevation 25 feet in boring B-5? ______________

The soil encountered at elevation 45 feet in boring No. B-5 was ______________________________.

How deep was boring No. B-7? _____________

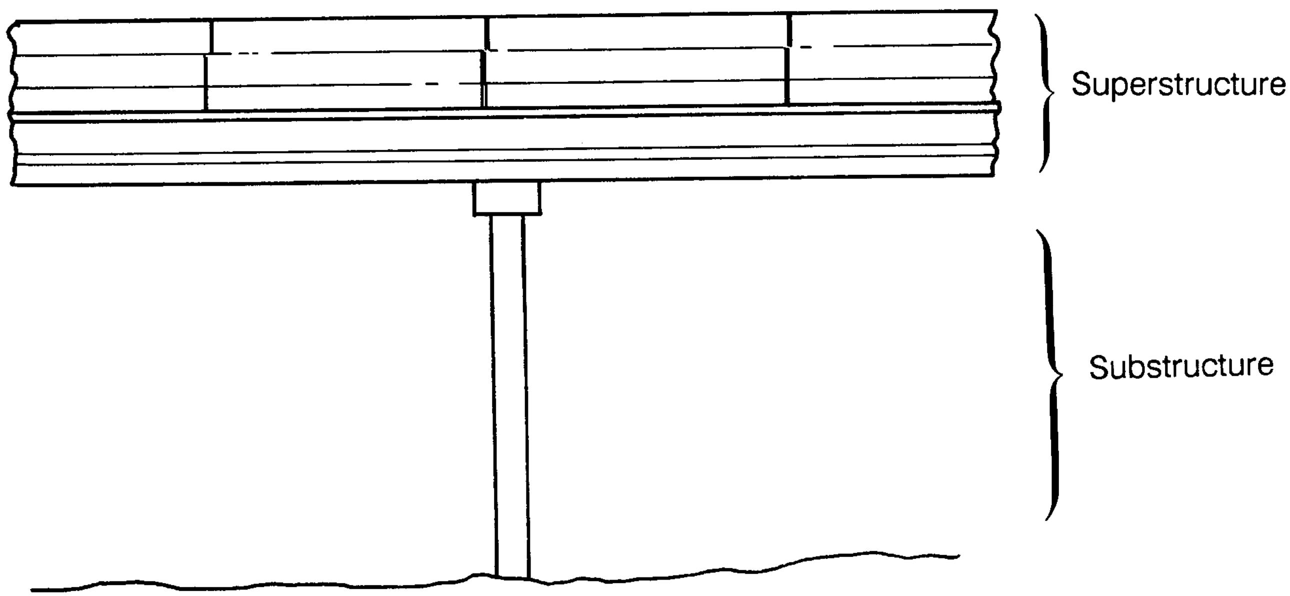
Go on to SUBSTRUCTURE.

SUBSTRUCTURE

REVIEW OF BRIDGE TERMINOLOGY

Basically, a bridge consists of two parts: a substructure and a superstructure. The substructure is made up of end bents, abutments, bents and piers.

The superstructure is everything above the substructure.



The various parts of the substructure are discussed on the following pages.

SUBSTRUCTURE NUMBERING

The bridge substructures are numbered in the direction of increasing centerline stationing. These numbers are used throughout bridge plans to identify substructures. For example, look at Sheet No. B-2, Project 56520-3602 (Plan Book – page 21). The end bent on the left is end bent #1, the intermediate bents are bent #2, #3, #4, and #5 on the right is end bent #6.

PILES

The bent caps are supported by piles. Piles are steel or reinforced concrete shafts driven through overlying material to soil or rock capable of supporting loads. What kind of piles are used on the bridges being studied? The summary of estimated bridge quantities on Sheet No. 1A, Project 56520-3602 (Plan Book – page 2) calls them "Precast concrete piles, 18" ." This means that 18" square prestressed concrete piles will be supplied by the contractor ready for use. Sheet No. B-15, Project 56520-3602 (Plan Book – page 34) (a standard structures drawing) shows details of their construction.

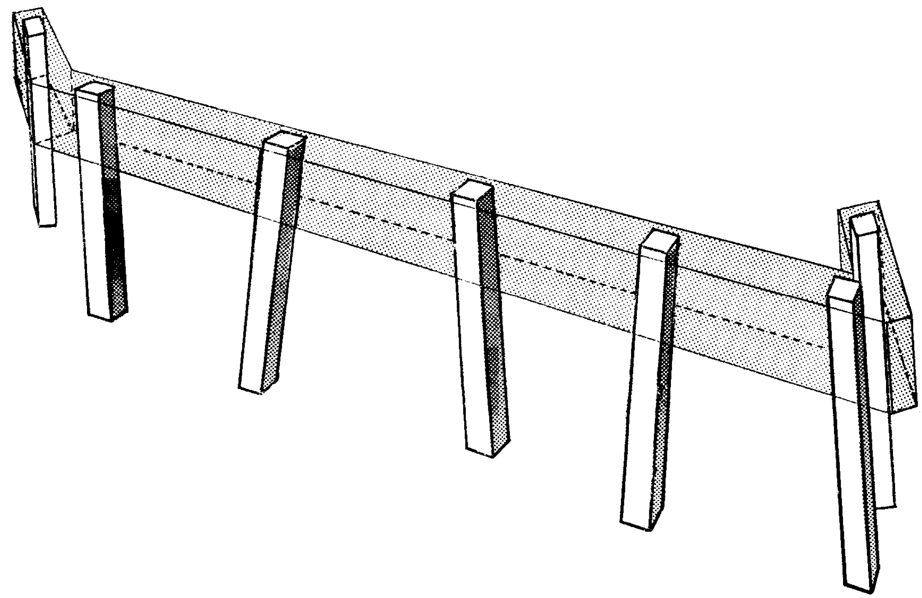
PILE LAYOUT AND NUMBERING

Look at Sheet No. B-7, Project 56520-3602 (Plan Book – page 26). This is a Pile Construction Data Sheet -- it shows the exact location of all the piles required for these bridges. Notice that the piles are numbered (a) by substructure, in the direction of increasing centerline stationing, and (b) from left to right in each substructure.

Essentially, there are two different layouts: one for end bents, the other for piers. Let us look first at the way the piles are driven for the end bents.

END BENT PILES

This diagram shows the location of the end bent piles. Notice that 2 of the piles below the main wall are battered -- driven at an angle -- outward at 2" per foot. For every foot the pile goes down, it goes outward 2". Piles often are battered to give greater resistance to forces causing longitudinal movement.



The other five piles are plumb -- driven vertically downwards.

Before the cap is poured, the tips of the piles are cut off at a specific elevation, called the cutoff elevation.

Sheet No. B-8, Project 56520-3602 (Plan Book – page 27) shows the plan and elevation of the end bents. Find it now, and locate the piles.

QUIZ

Are the piles part of the substructure? ________

If a bridge had two end bents and five piers:

-- how would the center substructure be numbered? ____________________

-- how would the last substructure be numbered? _____________________

Refer to the bridge plans.

The maximum length of an 18" prestressed concrete pile for single point pick-up is _____________.
(look at Sheet No. B-15, Project 56520-3602 (Plan Book – page 34).

What is the pile spacing in the end bent caps? ___________

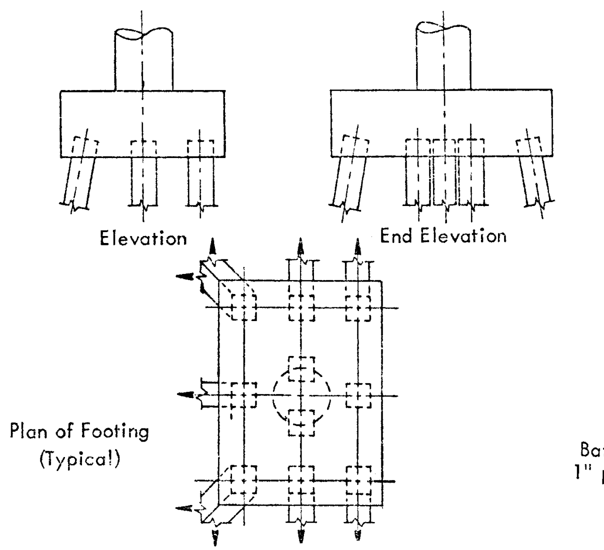
How many piles are located in Bent No. 3? ______

BENTS AND PIERS

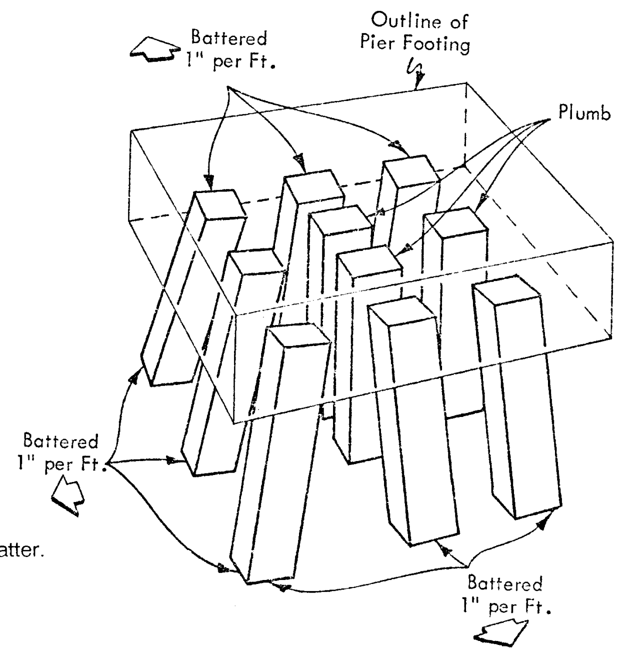
Intermediate bridge supports generally consist of pile bents when the bridge spans fresh water streams or creeks or railroads, as in our example plans, Sheet No. B-15, Project 56520-3602 (Plan Book – page 34). Larger bridges or structures more visible to the public generally incorporate piers as intermediate supports. The drawings below show a pile-supported pier footing.

Note: Drawing below is not from Project 56520-3602, it is intended as an example only.

Notice that the piles at the outside corners are battered in two directions with a slope of 1 inch per foot -- - 1:12. If piles were not used to support the footing, it would be called a spread footing.



The arrows indicate the directions for the 1:12 pile batter.

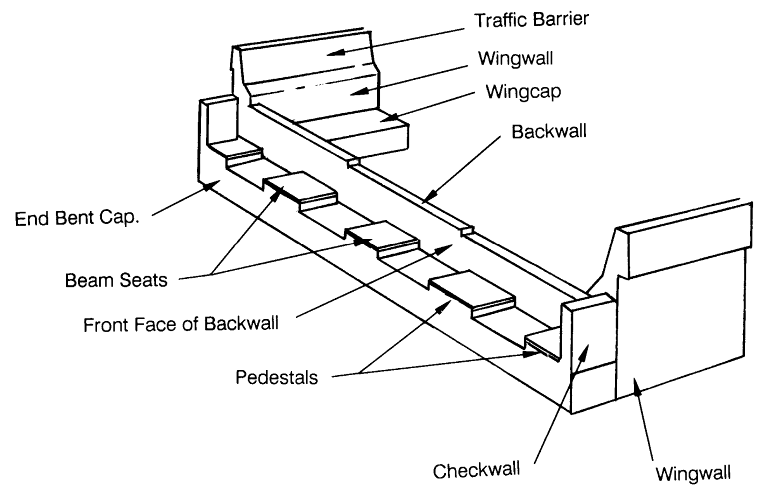


The arrows indicate the directions for the 1:12 pile batter.

END BENTS

The earth supports the piles, the piles support the substructures which in turn bear the weight of the superstructure. Later, we will see how the superstructure is supported. First, let's learn some end bent terminology.

The diagram on this page shows one of the end bents as an example on Sheet No. B-12, Project 52010-3527 (Plan Book – page 71). Study it carefully, and compare it with the drawings of the end bents on Sheet No.B-12.



On Sheet No. B-12, Project 52010-3527 (Plan Book – page 71), note the references to the Bill of Reinforcing Steel (Sheet No. B-22, Project 52010-3527(Plan Book – page 80)) and the Bar Bending Details (Sheet No. B-23, Project 52010-3527 (Plan Book – page 81)).

QUIZ

How much concrete is required to build Bent No. 4? ________________

The spacing between end bent steps is ______________________.

Bars H1 are #____________Bars.

Bars H13 have an overall length of 4'-05" feet and each bar is made by combining two bars 1'0" long with a 2'5" splice. How many bars are required in each end bent? _____________

How wide is the bent cap? __________________

The elevation of the center beam seat of End Bent No. 1 is _______________.

You need to study Sheets No. B-12 and B-13, Project 52010-3527 (Plan Book – pages 71-72) to answer most of those questions. If you missed any, reexamine these sheets and correct any mistakes. Then go on to BENTS.

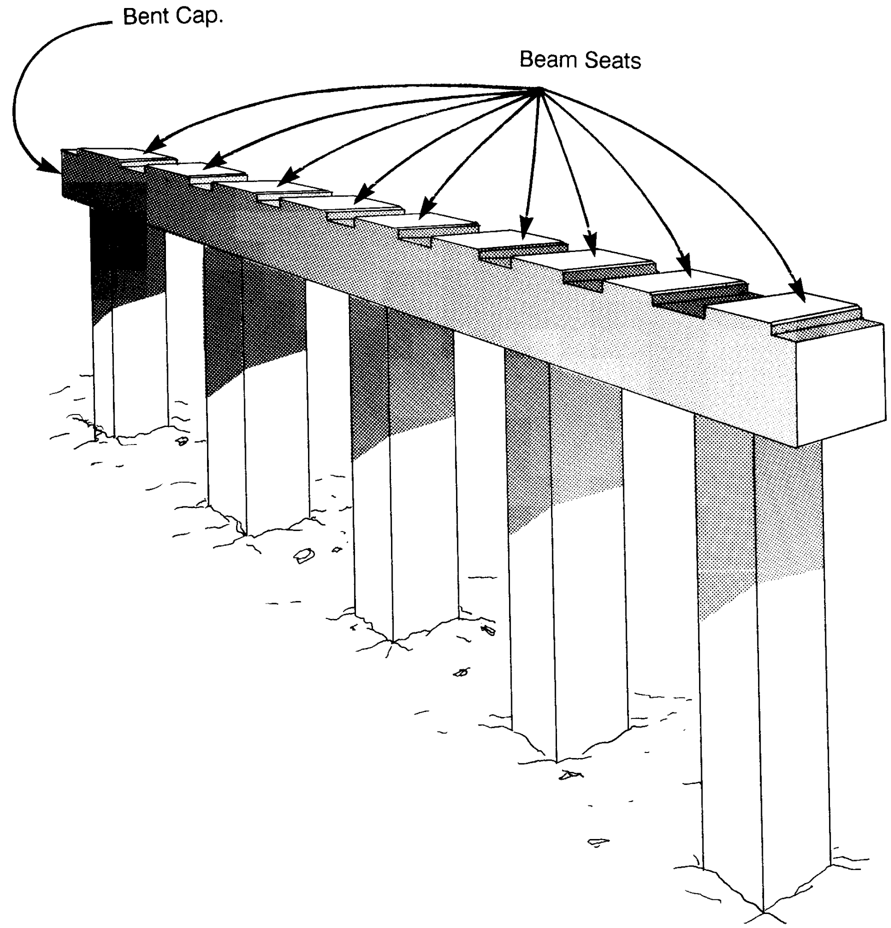
BENTS

Bents consist of:

- ➢ Piles -- columns supported by the ground that in turn supported the caps.

- ➢ Caps -- horizontal concrete members that support the superstructure beams and deck.

The figure opposite shows one of the two piers, which make up substructure #2 or #3 of project 52010-3527. Compare it with the drawings on Sheet No. B-14, Project 52010-3527 (Plan Book – page 73).



QUIZ

Refer to Sheet No. B-14, Project 52010-3527 (Plan Book – page 73), Structure Plans.

What is the overall length of the pier cap? ______________

Refer to Sheet No. B-11, Project 52010-3527 (Plan Book – page 70), Structure Plans.

What is the pile cutoff elevation of Bent No. 3? __________

Bars S are rectangular hoop bars placed vertically in the bent cap. Bars S1 are spaced 12"_________ to

___________.

Bar dimensions are measured __________________ to __________________.

W bars are found in _________________, and are #_______________ bars.

SUPERSTRUCTURE

The superstructure consists of the beams, their cross supports, the slab and pavement which make up the deck, the drainage system, the parapets and the railings -- everything above the substructure. If you need to refresh your memory about these terms, refer to the definitions and figure on pages 9-3 through 9-6 of this text.

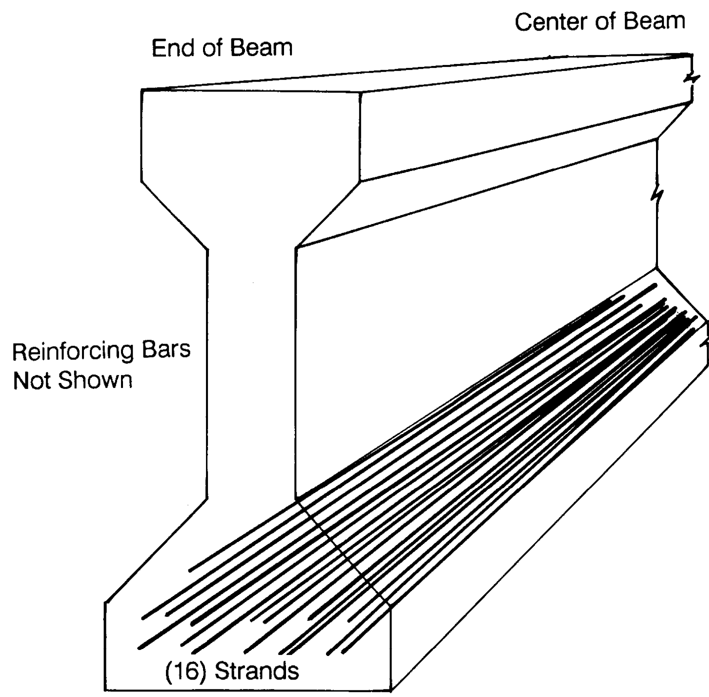
BEAMS

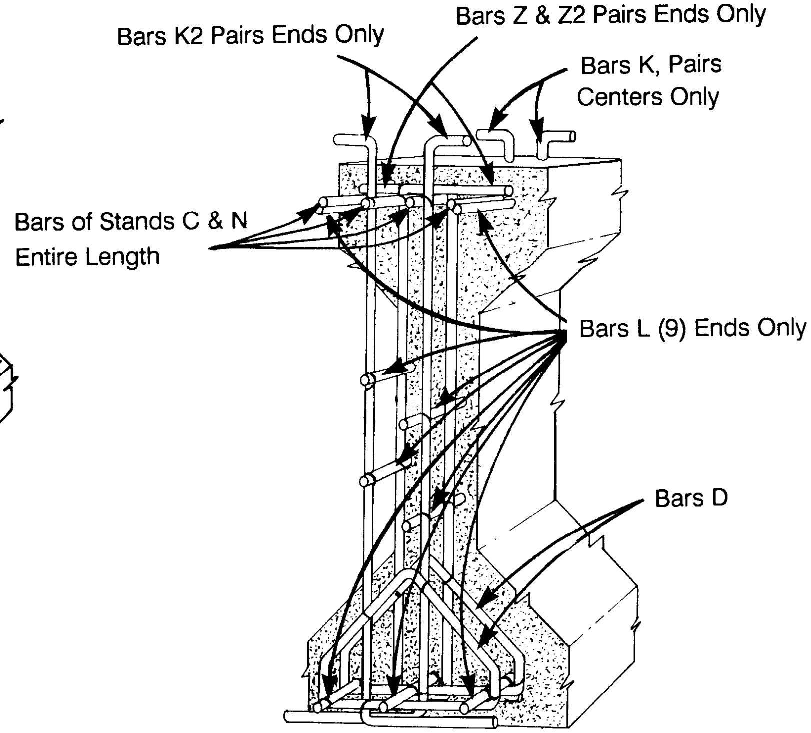
The beams run the length of each span. The bridge we are examining has three spans. All spans use five prestressed concrete beams (Type II). Sheet No. B-20, Project 52010-3527 (Plan Book – page 78) shows their construction. Use this sheet, and the figures on the opposite page, as you read on.

> Prestressing Strands: Strands of wire are placed along the beam and tensioned to the amount shown on the plans before the concrete is poured. After the concrete is poured and has developed a specified strength, the forces from the pretensioned strands are transferred to the concrete.
> Fourteen strands run along the bottom of the beam in the beams for Span 2.
>
> Reinforcing Bars: Most of the stress occurs at the ends of the beam. Bars K2, Z1, Z2, L and D occur only at the end; Bars E only in the center; Bars or Strands C and N run the whole span in the top part of the beam.

Study Sheet No. B-20, Project 52010-3527 (Plan Book – page 78) carefully, then answer the questions on page 9-22.

Half of Beam Showing Prestressing Strands





STRANDS AND REINFORCING OF TYPE II PRESTRESSED BEAMS. Compare with Sheet No. B-20, Project 52010-3527 (Plan Book – page 78)

QUIZ

What is the size of the tensioning strands? ____________________

What tension are they stressed to? ____________

How many Bars L are required for one beam? ___________

How long are Bars L? __________

Bars Z2 are size # _________, are ___________________ long before bending and have ___________ clearance (called "cover" on Sheet No. B-20, Project 52010-3527 (Plan Book – page 78)).

How far beyond the ends of beams should the strands extend? _________________

Go on to DIAPHRAGMS OR WEBS.

DIAPHRAGMS OR WEBS

After the beams have been placed in position on the bearings, they are connected by transverse vertical members called diaphragms or webs. Each span on this bridge has two end diaphragms. Long span bridges may have diaphragms at mid-span; these are called intermediate diaphragms.

Sheet No. B-17and B-18, Project 52010-3527 (Plan Book – pages 75-76) shows the location and reinforcing details of the diaphragm. Look at these sheets now.

The end webs are tied to the beams using the ends of the beam L-bars, which were left sticking out from the beam ends.

QUIZ

Refer to Sheet No. B-17and B-18, Project 52010-3527 (Plan Book – pages 75-76).

Each end web is ______________________________ thick.

How much concrete is required to pour the webs in this bridge? ____________________

Bars 6M1 are long bars because they pass across the end of the beam. Bars 6M2 are short bars because they are placed between ___________________________________.

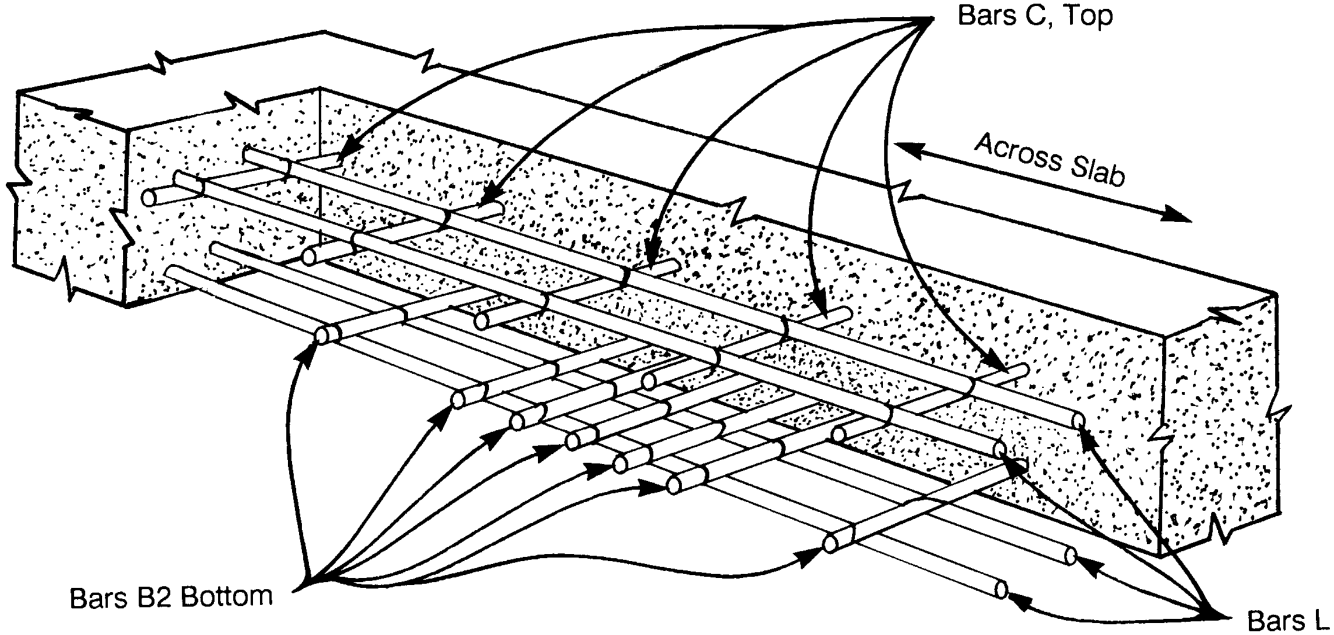
Transverse members joining the beams in a bridge superstructure are called ______________________or ______________________ .

Go on to DECK SLAB.

DECK SLAB

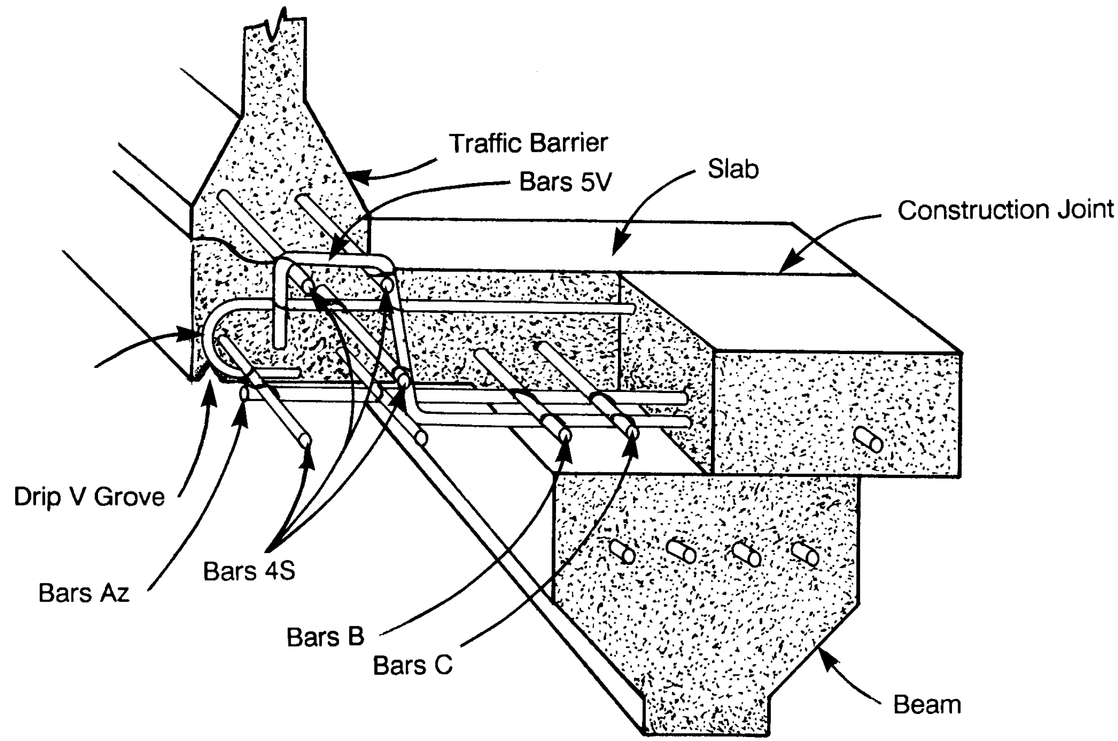
When all the diaphragms have been poured, construction of the concrete deck slab can begin.

First of all, the reinforcing steel bars are put in place. The drawing below shows the pattern of reinforcing steel over most of the slab:



Additional slab reinforcement -- Bars L -- is placed ~long the cantilevered slab to supplement the slab steel.

The drawing below shows the location of the reinforcing bars in the traffic barrier. The drip V-groove, an indentation in the bottom edge of a slab, causes drainage to drip rather than run along the bottom.



Notice the construction joints between parts of the slab, and between the slab and curb, in the figure above. Construction and other joints are explained on the next page.

CONSTRUCTION JOINTS

Usually, the concrete for the deck slab -- and similar structures -- is not all poured at once. The line between two pours is called a construction joint. Construction joints appear on the plans as either required -- the contractor must ensure that a construction joint occurs at the location indicated; or permitted -- the contractor has the option whether or not a discontinuance of work, and hence a construction joint, will occur at the location indicated. This does not mean that construction joints can be placed anywhere -- they must be located according to the plans. See Sheet No. B-16, Project 52010-3527 (Plan Book – pages 74) for the location of construction joints in the deck.

Reinforcing bars may run across construction joints.

CONTRACTION JOINTS

These are "dummy joints" formed or cut in the concrete. Contraction joints confine any cracking caused by temperature changes to one place -- the line of the joint.

EXPANSION JOINTS

Expansion joints are formed by leaving a gap between two slabs of concrete. This gap may be left open, or filled with a rubber or other resilient seal, thus preventing buckling and spalling of the concrete when increasing temperature causes the slabs to expands. Reinforcing bars do not run across expansion joints.

QUIZ

Refer to Sheet Nos. B-16- B18, and B-22, Project 52010-3527 (Plan Book – pages 74-76, 80).

How many bars C2 are required to construct the deck? ____________________

Bars C2 are #____________ bars and are located in the _________________________ of the deck.

All reinforcing steel in the deck shall have a minimum of _________________________ inch concrete cover.

How many pounds of reinforcing steel is required to construct the deck slab and diaphragms?

____

What is the clear roadway width of the deck? _________________

How many beams are required to support the bridge deck? ______________

No mistakes? Go on to FINISH GRADE ELEVATIONS.

FINISH GRADE ELEVATIONS

Before the concrete in the deck slab is set, it is screeded to ensure a smooth riding surface. The slopes of this surface are computed to allow water to drain satisfactorily from the deck -- the "roadway" of the bridge. Sheet No. B-15, Project 52010-3527 (Plan Book – page 73B) shows the finish grade elevations of the deck slab.

Look at Sheet No. B-15, Project 52010-3527 (Plan Book – page 73B) now. Finish Grade Elevations are given at frequent intervals along (a) the line of each beam in the span, (b) the gutter lines, (c) the coping line, and (d) the centerline of survey.

Try the quiz on the next page.

QUIZ

Refer to Sheet No. B-15, Project 52010-3527 (Plan Book – page 73B) and give the finish grade elevation of the following points:

Span 2, Beam 4, 30 feet from Bent No. 2. ____________________

Span 3, Beam 4, 20 feet from Bent No. 3. _____________________

Right Gutter at Bent No. 2. ___________________

Left coping at Bent No. 3. __________________

TRAFFIC BARRIER

The bridges we are studying have a reinforced concrete traffic barrier running along the length of each span, on both sides. Details of its construction are found on Sheet Nos. B4, B-12, B16, Project 52010-3527 (Plan Book – pages 63, 71, 74). Look at the drawings on this sheet now, and answer the questions below (you may need to refer to Sheet No. B-1, Project 52010-3527 (Plan Book – page 60) to answer some of them).

QUIZ

What class of concrete is used in the barrier post? ____________________

What is the barrier height above the bridge deck? ____________________

Which bars must be positioned before the slab is poured? __________________

What is the maximum spacing between open joints in the barrier? ________________

How is payment calculated for traffic railing construction? __________________

Take a short break, then go on to the Quiz on Chapter Nine.

QUIZ

Refer to the plans for Sheet Nos. B-1 to B-23, Project 52010-3527 (Plan Book – pages 60 - 81).

The minimum vertical clearance of 2'-3" between the D.H.W.S. and the bottom of beam occurs on the ____________________ side of the bridge.

Boring No. 1 is located 9 feet ____________________ of the centerline of survey.

What lines define the outside edge of the bridge deck? ________________________

All bents are skewed ___________________ from the centerline of survey.

What is the backwall elevation of the right gutter of End Bent No. 1? _________________

How thick is the end bent backwall shown in Section A-A? _______________________

What is the minimum depth of bent cap? __________________

How long is Span 2? _________________

What is the cross slope of the bridge deck? ________________

The joint seal shall be continuous from ________________ to ________________.

What is the casting length of a beam used in Span 2? _______________

How many sets of bars, listed under intermediate bents should be fabricated? ____________________

QUIZ, continued

If an 18" square pile used 7/16" diameter S.R. cables, how many would be required per pile? ___________

Is the chamfer on the head of an 18" square pile different than the chamfer on the tip? _____________

What are the dimensions of a composite neoprene bearing pad used with a Type II beam? ____________

How did you score on the quiz?
No mistakes? Well done! Go to Chapter Ten.

One or two mistakes? Check the plans to see where you went wrong; then go to Chapter Ten.

Having trouble? This is a tough chapter. Bridge construction is more precise and technical than highway construction -- which makes accuracy and attention to detail more important. Review the chapter slowly, referring to the plans as much as you can. Then go to Chapter Ten.

ANSWERS TO QUESTIONS

Page 9-7

- substructures
- beams
- abutments;
  end bents
- piles
- vertical; footing
- beam seats
- berm
- deck
- span
- parapet (traffic
  barrier)
- substructure
- superstructure
- approach

Page 9-9

- Structure Plans
- B-14
- 81.4 cy
- End Bent Details
- 58,231 lbs
- 18" Sq (Typ)

Page 9-10

- 3'-6"
- 31+95
- 2:1
- 150'
- 90°

Page 9-11

- No.5,No.6 and No.7
- 33
- dark brown clayey
  fine sand with organics
- 75.3 feet

Page 9-15

- yes
- Pier #4
  End Bent #7
- 60 feet
- 12'8"
- 4

Page 9-18

- 33.99 cy
- 7'-9"
- 8
- 4
- 2'6"
- 61.754 feet

Page 9-20

- 44'-6"
- 56.7
- center to center
- out to out
- beam seat pedestals;
  #4 bars

Page 9-23

- 1/2"
- 30,990 lbs.
- 18
- 9'0"
- 4; 3′ 7"; 2"
- 2-1/2"

ANSWERS TO QUESTIONS, continued

Page 9-24

- 9"
- 17.04 cu.yds.
- beams
- diaphragms; webs

Page 9-28

- 66
- #4; bottom
- 2"
- 37,859 lbs.
- 44'0"
- 5

Page 9-29

- 62.764'
- 62.854'
- 62.434'
- 62.523'

Page 9-30

- Class II
- 2'8"
- 4V6,4H6,6V8
- 30 feet
- per linear foot

Page 9-31

- south
- north
- sloping line
- 90°
- 62.314 feet
- 1 foot
- 2'6"
- 40'
- .02 foot per foot
- gutter to gutter
- 39'-3'1/4"
- two

Page 9-32

- 20
- yes
- 1'2" x 9' x 1-11/16"

CHAPTER TEN

Paving

CONTENTS

10

PAVING

Paving usually is one of the last phases of highway construction. It involves placing finishing materials on roadways and some bridges and slopes, and in certain ditches. Most paving data in contract plans are on typical section sheets, summary of quantities sheets and standard drawings. A few paving notes occasionally are shown on plan and profile sheets.

TYPICAL SECTIONS

Roadway paving details are shown primarily on typical sections. For example, turn to Sheet No. 2, Project 52010-3529 (Plan Book – page 83) . The typical sections show paving details as they usually appear. The paving materials -- base and surface courses -- are identified below the title of the typical section.

FLEXIBLE PAVING

The typical section for S.R. on Sheet No. 2, Project 52010-3529 (Plan Book – page 83) shows an example of flexible paving. Notice that the subgrade is prepared, a base layer is laid, and then a final surface layer of asphaltic concrete is placed and finished to profile grade.

QUIZ

Refer to Sheet No. 2, Project 52010-3529 (Plan Book – page 83).

L.B.R. stands for ______________________.

The Type S structural course is to be __________________ thick.

The existing roadway runs __________________________.

The final layer of structural course is to be __________________.

CONGRATULATIONS!

You have completed this course. Using what you have learned, you should be able to interpret the greater part of any plan sheets which you are likely to encounter in your work.

The quiz on Chapters One through Ten will help you review and prepare for the exam.

QUIZ ON CHAPTERS ONE THROUGH TEN

Questions refer to Sheet Nos. 1-5, Project 52010-3529 (Plan Book – pages 82-86) unless otherwise indicated.

What kinds of views are shown on the key sheet? ________________________

Does the locations map indicate its scale? ________

The total length of all bridges on the project is ___________________miles.

Approach slabs are shown on sheet numbers ___________________.

At which station does the project end? ________________

What is the profile grade elevation on SR 10(US90) at station 344+ 00? __________________

What is the original ground elevation on ℄ survey SR10 (US90) at station 344+00? _________________

Questions refer to Sheet No. 5,10-12,30, &33, Project 48050-3536
(Plan Book – pages 88,89-91,93-94) unless otherwise indicated.

On the first horizontal curve of the crossover at the beginning of the project, Sheet No 12, Project 48050-3536 (Plan Book – page 91), the P.I. is at station _________________.

The length of this curve is _________________.

Questions refer to Sheet Nos. 5,10-12,30, &33, Project 48050-3536 (Plan Book – pages 88,89-91,93-94) unless otherwise indicated.

The elevation of B.M. #48.92 DOI is ____________.

What is the percent of profile grade at station 29 + 19.93 North bound lanes? _____________

What is the cross slope on the finished outside shoulders of Weis Lane at Sta. 25+ 60.23 to 34+ 16.50? __________________

For a divided highway, the longer transition length of a superelevated curve applies to the roadway _______________________.

How long is the vertical curve whose P.I. is at station 45 + 30? _____________

If the contract plans and the standard specifications don't agree, which should you use? ____________________

How much 15" PVC schedule 80 pipe is planned for this project? ________________

How much reinforcing steel is needed for the U- Endwall at station 45 + 60 left? ______________

Question refers to Sheet No. 15, Project 55050-3544(Plan Book – page 56)

Structure S-23 is __________feet long.

Question refers to Sheet No. B-6, Project 56520-3602 (Plan Book – page 25)

What type of material underlies station 31 + 49, at ℄ survey? ___________________

Refer to Questions refer to Sheet Nos.B-7-B-8, B-12, B-15 Project 52010-3527
(Plan Book – pages 66-67, 71, 73B)

What does the bridge span? ______________________

What is the finished grade elevation of the ℄ of Bent No. 2? _______________

How many cubic yards of Class IV concrete is estimated for End Bent No. 1? ________

What is the length of Span 2? ____________

How thick is the deck slab? _________

This ends the quiz on Chapters One through Ten. If you missed some of the answers, be sure to review the text accordingly.

ANSWERS TO QUESTIONS

Page 10-3

- Limerock Bearing Ratio
- 3 inches
- easterly
- FC 3 (1" Thick)

Page 10-4

- Plan views
- no
- 0.113 miles
- 4,5
- 352+00.00
- 65.40'
- 48.00'
- 34+49.54
- 840.31'

Page 10-5

- 21.873
- -0.71%
- 0.06 ft./ft.
- outer
- 300'
- Contract Plans
- 121'
- 86 lbs.
- 140
- Medium to fine sand with organics

Page 10-6

- Little Reedy Creek
- 62.874
- 33.99
- 40'
- 8"