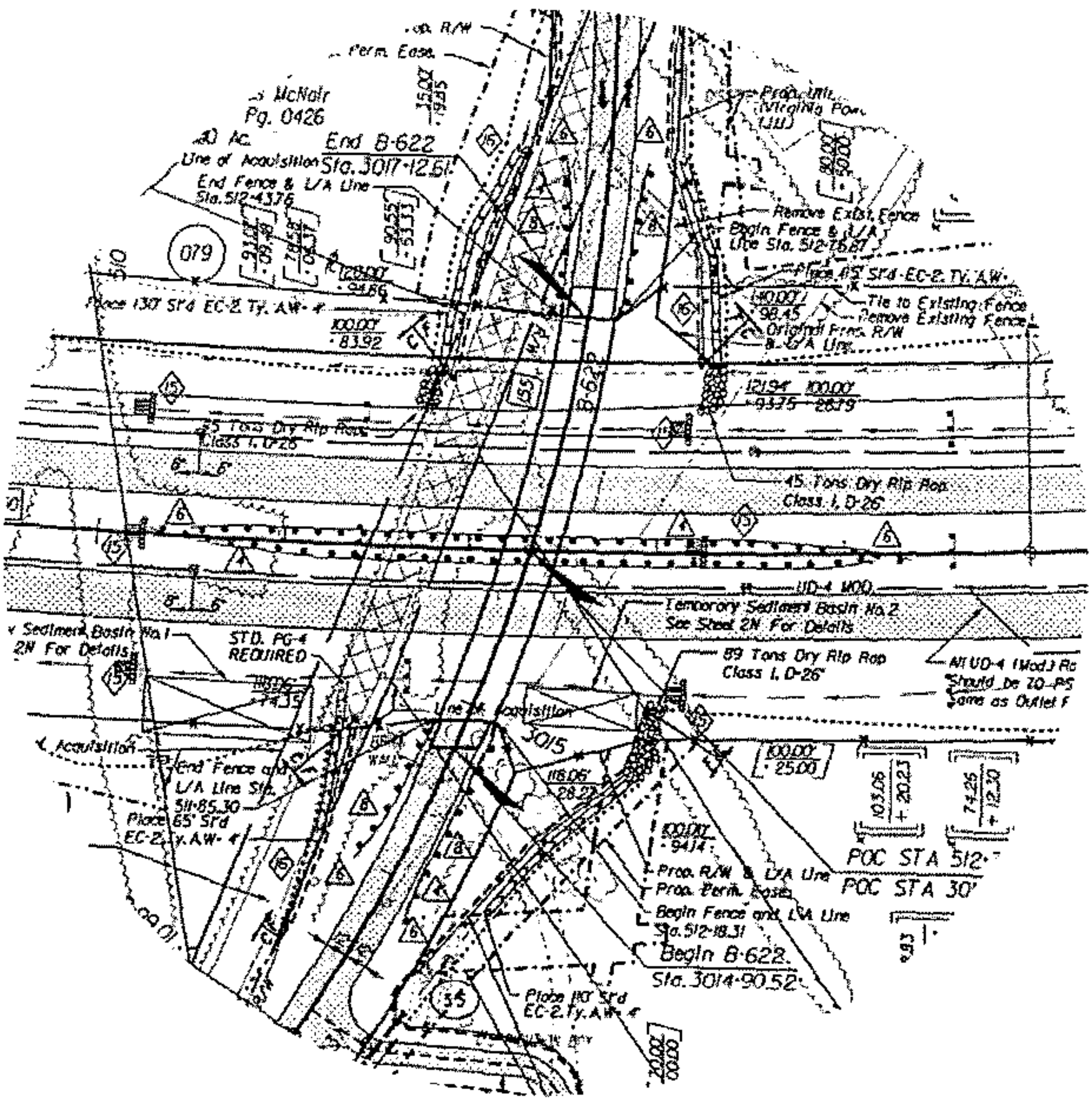
Commonwealth of Virginia
Department of Transportation

Highway Plan Reading



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February 12, 1999

Welcome to VDOT's Plan Reading Booklet. This information is in WORD97 and may be Viewed on the computer as Page Layout or printed. Paper copies are available in Engineering Services of Location and Design. The purpose of this booklet is to familiarize the reader with the information in, and the layout of, a set of highway plans. Engineering Services will provide a set of example plans at the users request, however, **this publication may be reviewed with any set of metric road plans as an example.**

The questions for the user in this publication are directed at the diagrams contained in this publication or are generic in nature and can be addressed at any set of plans. Answers to the questions may be found at the end of the publication.

Sections concerning Bridge, Traffic Signal and Utility Plans will be added to the text of this booklet in the future.

The following are a Table of Contents of Example Plans Provided by Engineering Services and a Table of Contents for the booklet:

TABLE OF CONTENTS

The first sheet in any set of plans, Sheet No. 1, is always assigned to the TITLE SHEET. This sheet identifies the project and notes the contents of the sheets that follow. Sheet No. 1A is assigned to the Project Location Map, except for Secondary Projects. Sheet No. 1B is usually assigned to the Right of Way Data Sheet.

Some plans are broken into smaller projects with two, three, or more projects using the same title sheet. Where plans are of a complex nature with several projects using a single title sheet, the index of sheets should be shown on a separate sheet and numbered 1A. The index of sheets should also be on sheet 1A when the volume of information is too large to neatly include on the title sheet. In these cases, the Project Location Map will be numbered 1B, the Right of Way Data Sheet will be numbered 1C and numbering of all sheets that follow will be adjusted accordingly.

Sheet No. 1C is assigned to the Revision Data Sheet.

Sheet No. 1D is assigned to the Stream Flow Hydrograph Sheets, as provided by the Hydraulics Designer, when applicable.

Sheet Nos. 1E, 1F, etc., are assigned to the Alignment Data Sheet, when applicable.

Sheet Nos. 1G, 1H, etc., (picking up from the last applicable number) are assigned to Maintenance of Traffic and Sequence of Construction Sheets, where applicable. (Note: Numbering in the "1" series for Secondary projects must be adjusted to allow for exclusion of the sheet for the Project Location Map).

Sheet No. 2 is assigned to the main Typical Section Sheet. General notes are to be shown on this sheet, if feasible, such as Secondary projects or other projects that do not require multiple typical sections.

Sheet Nos. 2A, 2B, etc., are assigned to other Typical Section Sheets, Detail Sheets, Summary Sheets and the Hydrologic Data Sheet, where applicable.

Sheet Nos. 3, 4, etc., are assigned to Plan Sheets.

Sheet Nos. 3A, 4A, etc., are assigned to Profile Sheets following each corresponding plan sheet.

TITLE and DESCRIPTION

On the TITLE SHEET, the TITLE and DESCRIPTION of the project are located in the top center and looks like this:

COMMONWEALTH OF VIRGINIA
DEPARTMENT OF TRANSPORTATION

PLAN AND PROFILE OF PROPOSED
STATE HIGHWAY

CHESTERFIELD COUNTY
WALTHALL INTERCHANGE

From: 0.207 mi. South Rte 620 (Woods Edge Road)
To: 0.442 mi. North Rte 620 (Woods Edge Road)

The TITLE and DESCRIPTION identifies the road to be built, and its location with reference to existing roads, intersections, counties, or towns. The project limits for this project extend from 0.207 mile South of Rte. 620 to 0.442 mile North of Rte. 620.

KEY DIAGRAM

Just below the TITLE and DESCRIPTION is located the KEY DIAGRAM. Not only does this diagram give a general plan view of the road to be constructed, but it indicates how the project is divided on each of the PLAN and PROFILE sheets in the set of plans.

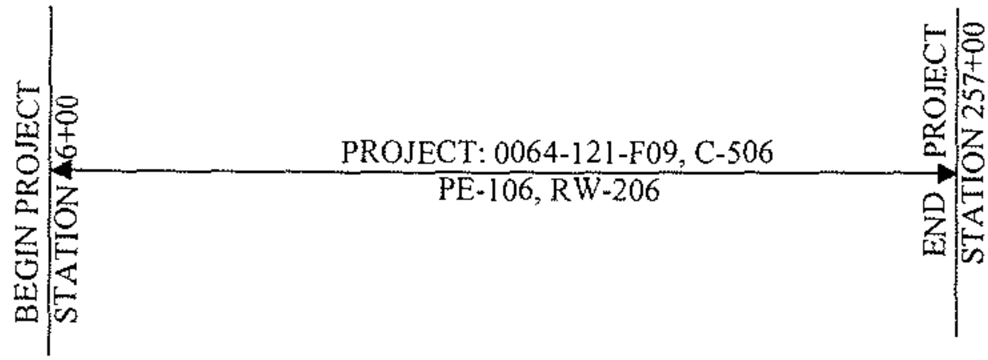
On the KEY DIAGRAM is a series of rectangular boxes with circled numbers in the lower right of each. These numbers are the sheet numbers of the sheets that show that portion of the project contained in the rectangle. Station numbers are depicted within the rectangular boxes which relate to stations on the associated plan sheets. This station information helps direct the user to the appropriate sheet.

On the KEY DIAGRAM may also be a rectangular block similar to this:

DESCRIPTION REFERENCE
P.O.T. 208+88.49 I-64
P.O.T. 528+49.22 RTE. 143

This identifies the horizontal location of a critical reference point on the project such as a road intersection.

Also found on this KEY DIAGRAM are the termini of the project. The termini are the stations where the project begins and ends. The termini stations are depicted on vertical lines which are connected by a horizontal line with the State project number on it as pictured below:



In the upper right hand corner of the TITLE SHEET is a rectangular box. This rectangular box is on each sheet of the set of plans in the upper right hand corner and looks like this:

FHWA REGION	STATE	FEDERAL AID	STATE		SHEET NO.	TOTAL SHEETS
		PROJECT	ROUTE	PROJECT		
3	VA.		95	7095-020-F08 SEE TABULATION BELOW FOR SECTION NUMBFRS	1	

This rectangular box contains the following information:

The Federal Highway Administration (FHWA) Region Number is noted as follows (The entire country is divided into regions. Virginia is in region 3.):

FHWA REGION
3

The state for which the plans are intended is noted as follows:

STATE
VA.

The Federal Aid Project Number is noted as follows (applicable only if Federal funds are used.):

FEDERAL AID PROJECT

The State Project Number is included as follows:

ROUTE	STATE PROJECT
95	7095-020-F08 SEE TABULATION BELOW FOR SECTION NUMBERS

The number of this sheet is noted as follows:

SHEET NO.
1

The total number of sheets in the set of plans is noted as follows:

TOTAL SHEETS

PROJECT NUMBERS

Project numbers are located directly under the TITLE and DESCRIPTION such as:
7095-020-F08, PE-101, RW-201
7095-020-F08, C-501
or
7095-020-F08, C-501, B-634

7095 refers to route number 95. The 7 signifies this section of road is an Alternate or Business Route. A 6 would signify an Arterial Route. Another example is 0640 which refers to route number 640. Route numbers for secondary roads are 600 and above. 600 and above route numbers are particular to a specific county, therefore Route 612 in one county will not necessarily be the same route in another county although that county may have a Route 612. Numbers below 600 are Primary routes. Route numbers for roads (other than secondary) running North and South are odd numbered and those running East and West are even numbered.

020 indicates the location and is a county/city code. 020 is the code for Chesterfield County.

F08 refers to the project section. F refers to projects with federal oversight and projects with a V signify no-federal oversight. As of June 1995, project numbers are no longer assigned an F or V. Projects which were assigned an F or V prior to June 1995 will not be changed. Instead of an F or V, an identifier is added as a prefix to the project number. The identifier is (FO) for federal projects with oversight and (NFO) for federal projects with no oversight. Federal funds are involved in NFO and FO projects. Projects with oversight are closely coordinated with the Federal Highway Administration (FHWA) by inviting them to meetings and soliciting their comments during the design process. No oversight signifies that the FHWA is not as closely involved. Examples are:

(NFO) 0060-121-101	federal project with no oversight
(FO) 0060-121-101	federal project with oversight
0060-121-101	state project

The project numbers include Job Numbers which are classified as follows:

100 - Preliminary Engineering (Coded PE)
200 - Right of Way (Coded RW)
300 - Grading & Drainage (Coded G)
400 - Paving (Coded P)
500 - Construction (Coded C)
600 Bridges (Coded B) or Major Drainage Structures (D)
700 - Flashing Light Signals (Coded FS)
800 - Landscaping (Coded L)
900 - Signing (Coded S)

These 3-digit job numbers are reserved for various phases of work to enable the various divisions of the Department of Transportation to identify and record the breakdown of charges.

The examples indicate project phases or section numbers as follows:

PE-101 signifies the preliminary engineering phase. 101 means this is the first project using 7095-020-F08. Future projects relating to this project would use 102, 103 etc.

RW-201 signifies the right of way phase. As with the PE number, 201 means this is the first right of way project using 7095-020-F08. Future right of way projects relating to this project would use 202, 203 etc.

C-501 signifies the construction phase. This number follows the same format as the PE and RW where future projects relating to this project would use 502, 503 etc.

B-634 signifies the construction of a bridge.

Other codes are:
P = paving, G = grading, L = landscaping, B = bridge, M = minimum plan, N = no plan, D = box culvert/drainage structure, FS = flashing signal (railroad crossing), S = sign plan

"No Plan" projects are used when no survey, engineering, hydraulic analysis or river mechanics studies are needed or when there will be no major structures with "B" or "D" designation numbers. Right of way may be acquired on "No Plan" projects provided it is acquired through donations and no condemnation is required. A "No Plan" project is an assembly of letter size sketches showing the location of the project with a typical cross section and estimated quantities. A "Minimum Plan" project differs in that limited survey is needed to provide the information necessary to secure right of way by the Right of Way and Utilities Division and a profile sheet is provided.

FUNCTIONAL CLASSIFICATION AND TRAFFIC DATA

In the upper right portion of the Title Sheet, directly beneath the project number box are located the FUNCTIONAL CLASSIFICATION AND TRAFFIC DATA. These are the figures that govern the design and specifications of the road to ensure that it will handle the future traffic for the design year.

FUNCTIONAL CLASSIFICATION AND TRAFFIC DATA	
INTERSTATE 95	URBAN INTERSTATE (DIVIDED – ROLLING) 70 MPH MIN. DES. SPEED
Fr: To:	0.207 mi. South Rte 620 (Woods Edge Road) 0.442 mi. North Rte 620 (Woods Edge Road)
ADT 1996	66,000
ADT 2020	110,585
DHV	11,060
D (%)	50/50
T (%)	10
V (MPH)	*

* SEE PLAN AND PROFILE SHEETS FOR HORIZONTAL AND VERTICAL CURVE DESIGN SPEEDS

For this example, through the means of traffic counts, it has been determined that the average daily traffic (ADT) in 1996 was 66,000 vehicles. Average daily traffic for the year 2020 is projected to be 110,585 vehicles.

The design hourly volume (DHV) is estimated to be 11,060 vehicles. Direction (D) of traffic at peak hours is anticipated at 50% of vehicular movement in one direction. 10% of all vehicles expected to use this road will be trucks (T), or buses. With these factors considered, an appropriate design velocity (V) (speed) is shown on the plan and profile sheet.

INDEX OF SHEETS

An Index of sheets can be listed in the upper left corner of the TITLE SHEET. If the volume of information is too large to neatly include on the TITLE SHEET, this information should be contained on sheet 1A and the location noted on the TITLE SHEET.

On the Index of sheets, Sheet 1 is followed by sheet 1A, 1B... and sheet 2 by 2A, 2B... The total number of sheets is listed in the project number block. Also notice that the Plan and Profile Sheets are referred to by station numbers of the main roadway, enabling ready reference to the sheet desired.

NOTES

In the lower left corner of the TITLE SHEET are several NOTES. One refers to "the complete paper copies of the plan assembly…" One of the notes states which SPECIFICATIONS will be adhered to on this project. STANDARDS to be applied on the project and other design criteria are also listed here. It is important to read these and any other notes on any set of plans.

Under these notes, in the lower left corner of the TITLE SHEET, is a legend with a list of conventional signs (map symbols) used on these plans. After you have familiarized yourself with these symbols, look at some of the PLAN sheets and see if you can locate and identify these on the PLAN sheets.

PROJECT LENGTH

The information found in the table at the bottom center of the TITLE SHEET describes the general length of the project or projects.

In some cases there may be several projects, such as one for preliminary engineering (PE), one for right of way acquisition (RW), and one for road construction (C). There may also be a bridge (B) or several bridge projects associated with the road project.

REVISIONS

There is a column with dates that the TITLE SHEET was revised in the bottom right corner of the sheet.

APPROVAL SIGNATURES

In the extreme lower right hand corner there is a table containing signatures of authorization. Note especially the signatures under APPROVED FOR RIGHT OF WAY ACQUISITION and APPROVED FOR CONSTRUCTION. Plans should not be used to acquire right of way or for construction without checking to make sure that the appropriate signatures are present. The absence of appropriate signatures means that the plans have not been authorized for right of way acquisition or construction and a note should be on the sheet stating that the plans are not authorized.

<u>**LOCATION MAP**</u>

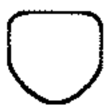
The purpose of the location map is to orient the project in relation to existing highways or to natural or man-made terrain features in the area.

As a general rule, LOCATION MAPS are always oriented to the NORTH. This will not always be the case. Locate the compass arrow; it will always indicate the northerly direction.

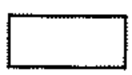
The following symbols are used on highway maps to indicate types of roads:

U.S. Routes:

State Primary Highways:



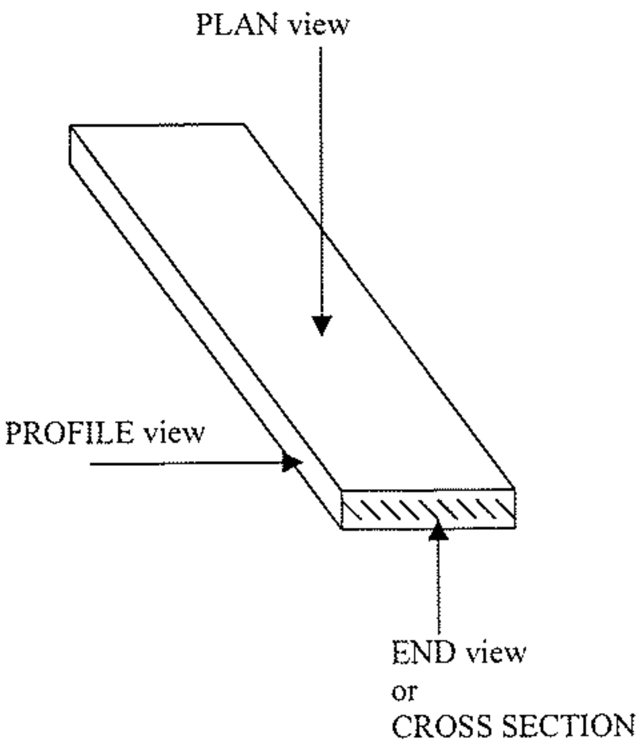
State Secondary Roads:



Interstate Highways:

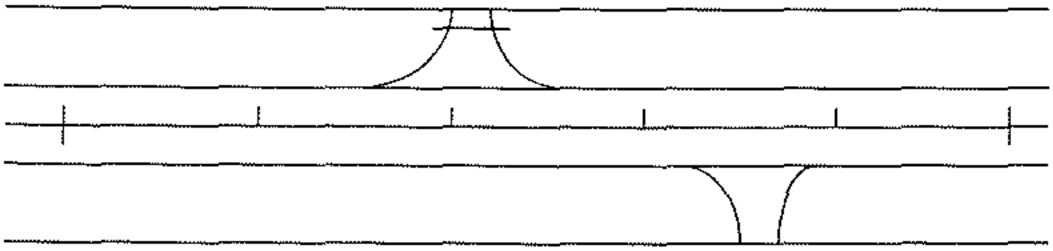
Forestry Roads:

PLAN & PROFILE

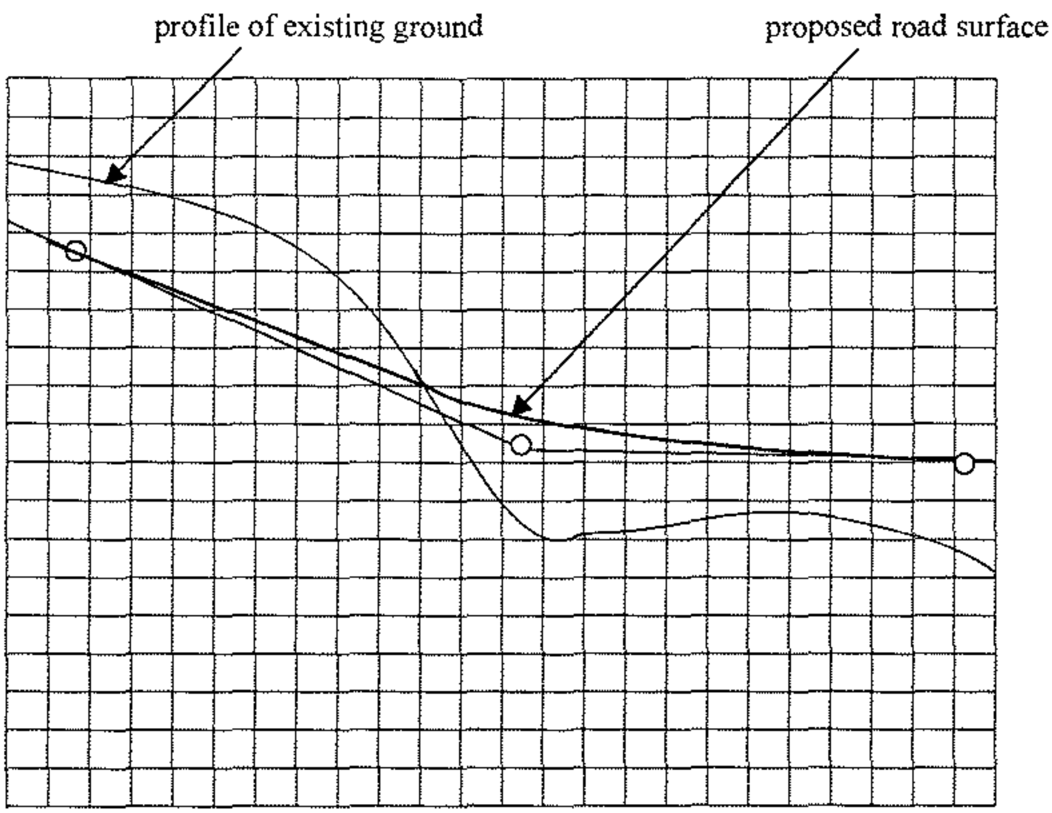


Here you see the Plan view, Profile view and the END view or CROSS SECTION.

PLAN: Looking at the PLAN VIEW, imagine looking straight down on the project from a point directly above.



PROFILE (SIDE VIEW): The PROFILE VIEW is as if you are standing off to one side of the road and looking back at the road.



STATIONING

Stationing is the process of defining locations along the project by station numbers. Highway construction projects are divided into reference points spaced along the project. These points are called STATIONS and are designated by a number such as 755+50.00. Later in the text we will show you how to translate this number into a practical reference point.

PLAN SHEETS

On the plan sheet is a line running down the center of the proposed highway. This line represents the BASELINE with the symbol:

BL

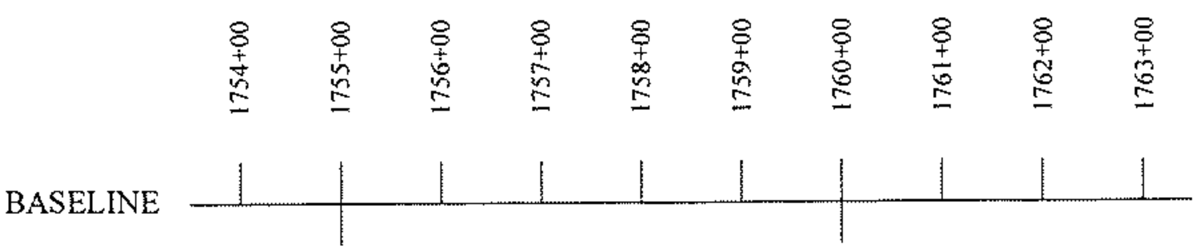
The BASELINE is the basic reference point used for all horizontal measurements.

Follow this BASELINE and you will notice regularly spaced marks. Every fifth (5^{th}) mark goes through the baseline and there are four other marks equally spaced between these marks that do not go through the baseline. These shorter marks are on the left side of the BASELINE as you look up station (i.e. from station 1755+00 to 1760+00).

These marks indicate STATIONS along the baseline that are based on a reference point which may, or may not, be on this particular project. For this reason, it is not uncommon to see a project begin with a number that is quite high, not zero as you might expect.

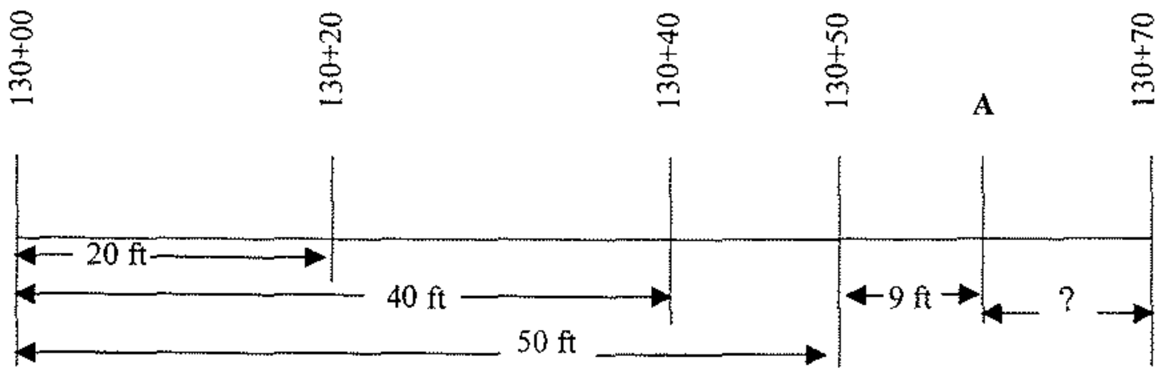
Numbers such as 1755 and 1760 are directly above the lines that cross through the baseline and indicate a distance of 500 feet between each of these.

Between these stations are stations one hundred (100) feet apart and depicted as follows:



1. How many stations are there between 1755+00 and 1761+00? ______________

Any point between stations is written as station number (+) feet, such as 1755+80.



2. What is the station number for Point A?________________.

A station number is read as follows:

130+02: Station one thirty plus zero two (meaning 2 feet AHEAD of station one thirty).

130+00: Station one thirty plus zero, zero (meaning exactly at station one thirty).

NOTE: The word NAUGHT is generally used instead of zero, or "0" Thus, the above stations might be read this way:

130+02: Station 130+ naught, two.
130+00: Station 130 + naught, naught.

When you take the plus (+) sign out of a station number such as 134+50, you have the value of the number in actual feet.

Example: 134+50=13,450
or
134 x (100) + 50 = 13,400 + 50 = 13,450

To calculate the DISTANCE (or points between stations) subtract the lower station from the higher station.

For example, to calculate the distance from sta. 134+50 to sta. 132+80, you would delete the (+) sign and subtract in this way:

$$\begin{array}{r} 13450 \\ \underline{-13280} \\ 170 \end{array}$$

OR, you may want to figure it this way:

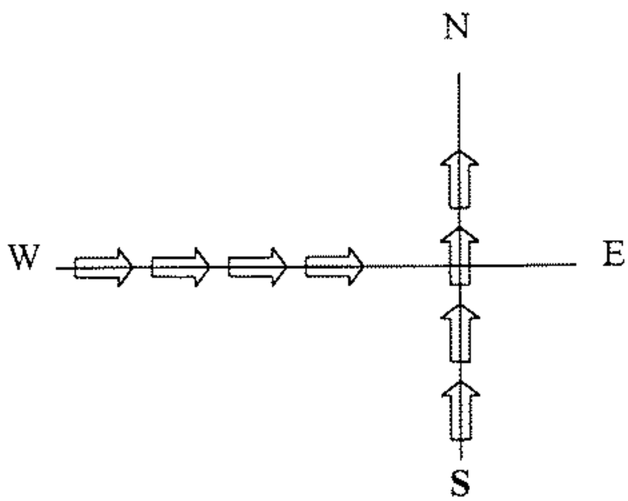
from sta. 132+80 to sta. 133+00 is 20 ft from sta. 133+00 to sta. 134+00 is 100 ft

from sta. 134+00 to sta. 134+50 is 50 ft

Therefore, we have a total of 170 ft

3. What is the distance from Point A to station 130+80? ____________________

Observe which way the station numbers increase. Looking again at the Plan Sheet, find the compass arrow. Notice that the station numbers normally increase from WEST to EAST. On highways that are oriented to the north or south, station numbers normally increase from SOUTH to NORTH.



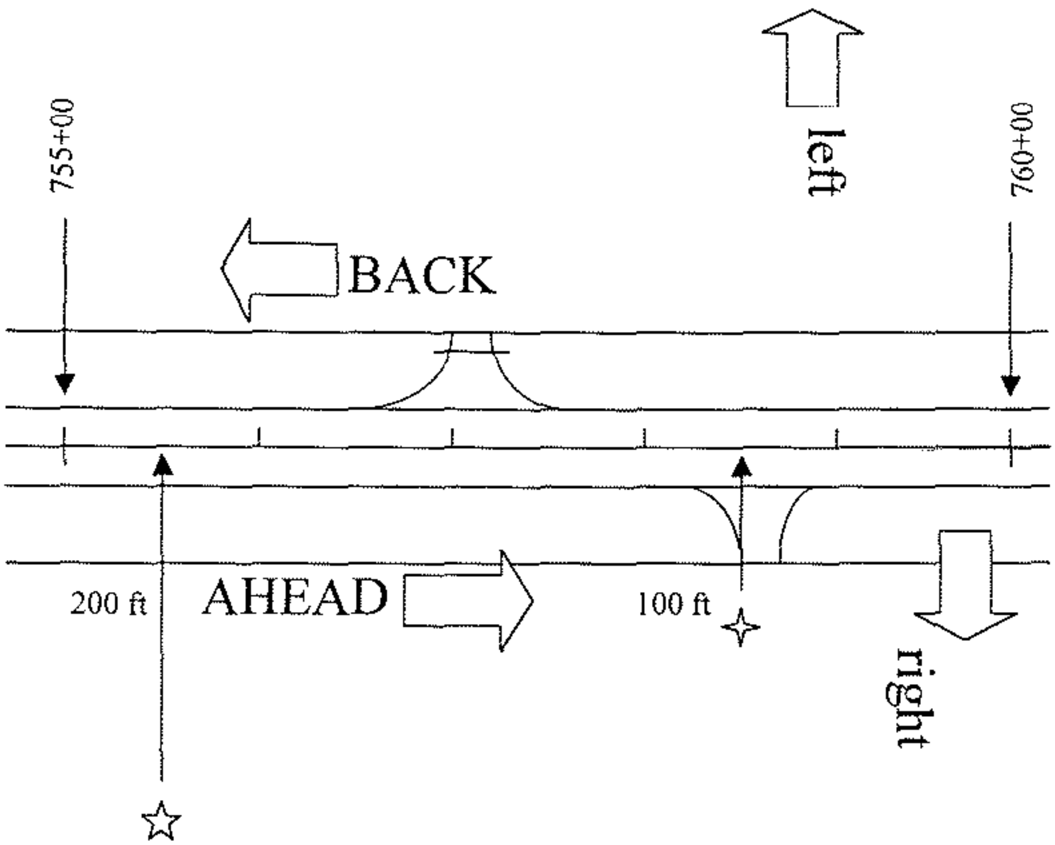
Remember: WEST to EAST and SOUTH to NORTH.

Wooden stakes with the station numbers written on them are driven into the ground early in the construction process to orient construction personnel. These stakes will be moved later to the side of the roadway as construction progresses in order to maintain points for reference. The distance from the baseline will also be written on these stakes.

Any point pertaining to a project may be located on an actual spot on the ground or on tbe plans by station and the distance left or right of the baseline.

The word AHEAD is used to denote the direction in which the project is going. This is indicated by increasing station numbers; it is not found on the plans.

The word BACK is used to denote the opposite direction and is indicated by decreasing station numbers; it is not found on the plans.



LEFT or **RIGHT** relates to facing **AHEAD** on a project.

Locate point ☆ on the plan. You will find it 200 ft to the right of the baseline at station 755+50.

The "highway address" is: Station 755+50, 200 ft RT. of the baseline.

4. From this plan, give the "highway address" (location) of point ✧

__________________________.

5. Is this point AHEAD or BACK of sta. 761 + 42________________________.

CURVES

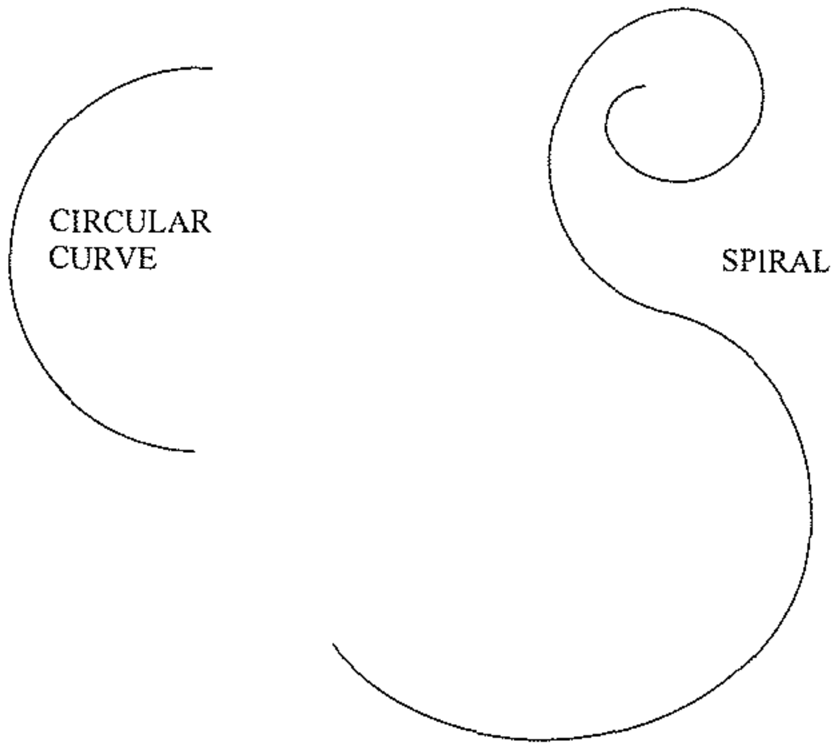
A CURVE is defined as any section of roadway in which the points along the baseline do not fall on a straight line or tangent.

On a horizontal curve, the roadway bends to the right or left.

On a vertical curve, the road bends up or down.

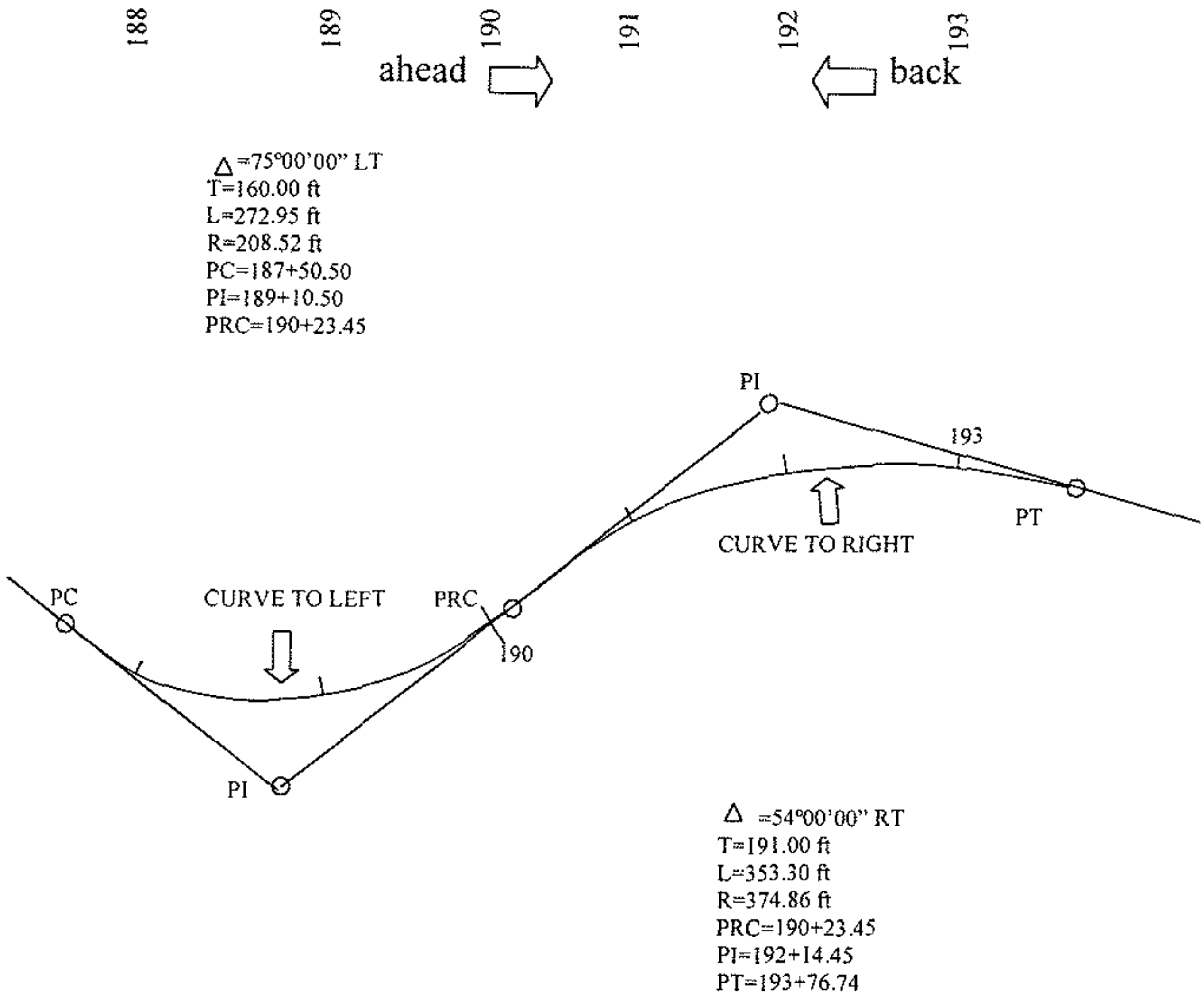
There are two kinds of horizontal curves:

CIRCULAR & SPIRAL CURVES



A circular curve would make a complete circle if it kept going around. A spiral curve would keep getting smaller and smaller if it kept going around. In order to approximate the path a vehicle makes when entering or leaving a circular horizontal curve, a spiral transition curve will be provided for horizontal curves with a radius less than or equal to 2865 feet, except for interchange ramps and loops.

A spiral is simply a transition from a tangent section (with an infinite radius) to a curve having a defined radius. Spirals are needed because all vehicles follow a transition path when entering or leaving a horizontal curve because the changes in steering and centrifugal force cannot be accomplished instantly. On sharp curves (without spirals) at high speeds where this transition path is significantly longer, the driver tends to encroach on the adjoining traffic lanes and/or reduce speed, signifying a reduction in driver comfort. Spirals make it easier for the driver to maintain control of the vehicle while negotiating these curves at a uniform speed. Volume 2 of the Road Design Manual contains figures and an explanation of Spiral Curves and Transition (Spiral) Curves in metric.



This drawing depicts two horizontal curves. The Curve to the Left starts at the Point of Curve, PC station 187+50.50 and goes to the Point of Reverse Curve, PRC station 190+23.45. The Curve to the Right starts at this PRC and goes to the Point of Tangent, PT at 193+76.74 where a tangent begins.

Direct your attention to the curve to left. Directly above it, or to the inside of tbe curve, you will note a series of numbers and symbols which together make up the CURVE DATA.

Now for an explanation of each symbol:

The POINT OF CURVATURE (PC). This is where the baseline leaves the tangent and begins to form a curve.

The intersection of the tangents is the POINT OF INTERSECTION (PI). This is much like a corner on a city street system. It is obvious that such corners are impractical on high-speed highways; therefore, we construct curves.

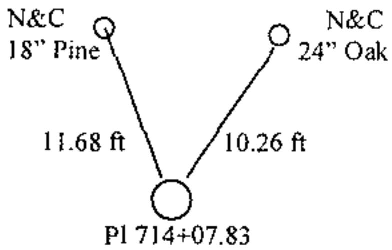
Whether a highway is curving LEFT or RIGHT depends on which side of the baseline the PI is located. If the baseline is located on the right side of the PI, the CURVE is to the RIGHT. If the baseline is to the left of the PI, the CURVE is to the LEFT.

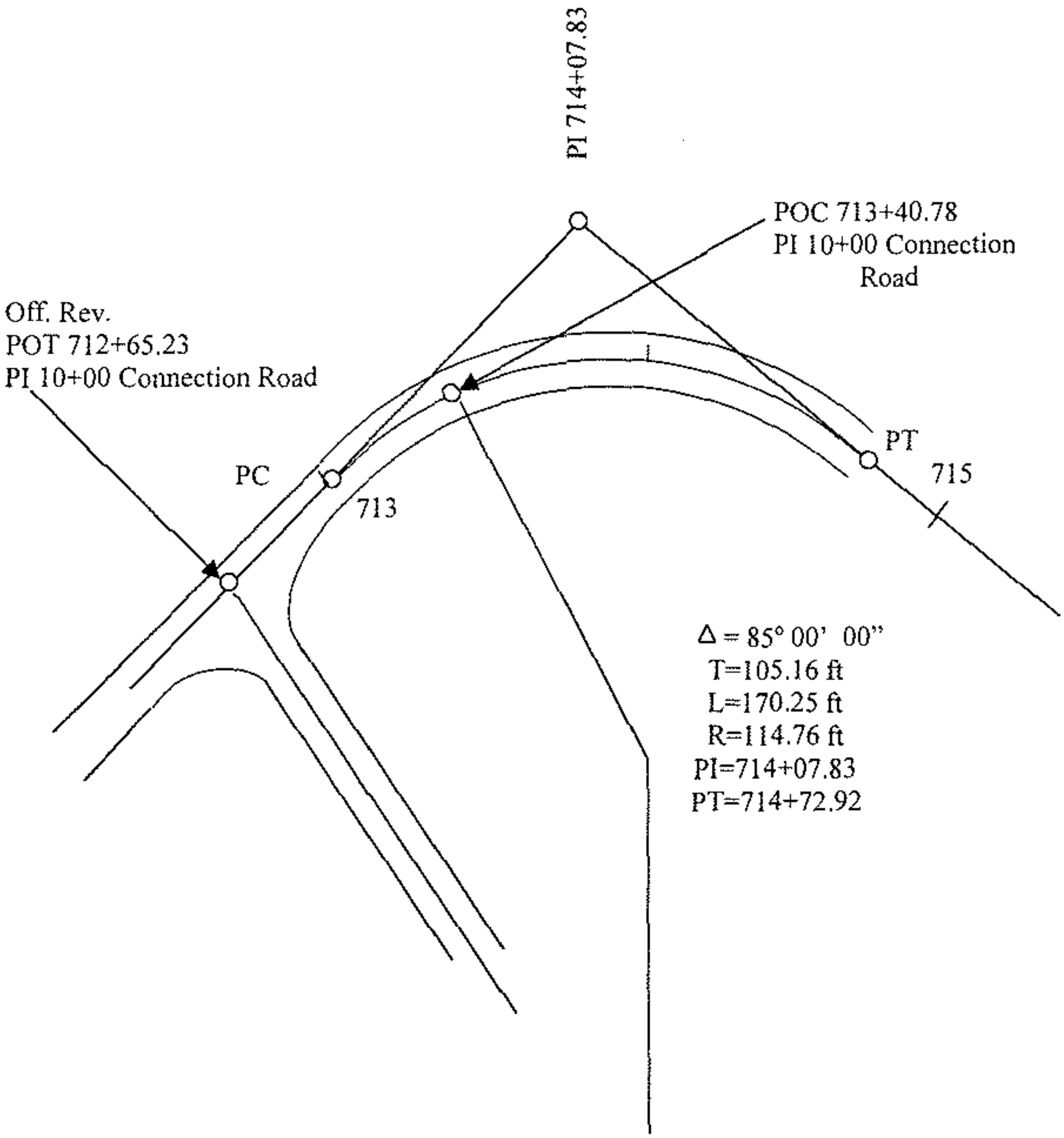
The baseline of the road is controlled by the terrain features around it. The highway curves around such terrain features as hills and lakes and it stretches out in straight lines (tangents) through the level valleys. Such a series of straight lines and curves is called the HORIZONTAL ALIGNMENT. This alignment can be recognized by looking at the Plan View of the highway.

On the CURVE DATA, for the curve to the right, is a designation PT which means POINT OF TANGENT. This is the station where the curve ends and the tangent (straight line) begins.

In addition to designations PRC, PC, PI & PT, you will often find the designation POC. This refers to a POINT ON THE CURVE. This point can be any point on the curve where some information is necessary. Usually it is a point where two baselines intersect, therefore, serving as a reference to the tie-in point for connecting roads.

The designation POT (POINT ON THE TANGENT) will frequently be found. It too has no relative position in regards to anything other than itself, but serves to pinpoint some special information.

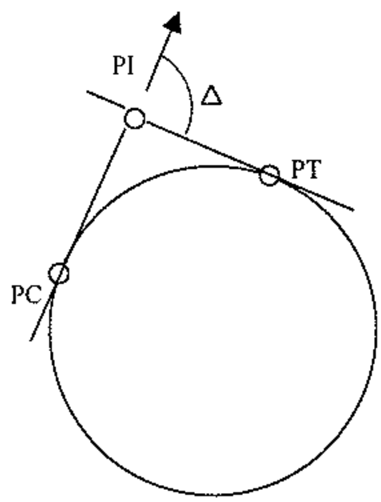

N&C
18" Pine
N&C
24" Oak
11.68 ft
10.26 ft
PI 714+07.83


PI 714+07.83
POC 713+40.78
PI 10+00 Connection
Road
Off. Rev.
POT 712+65.23
PI 10+00 Connection Road
PC
713
PT
715
Δ = 85° 00' 00"
T=105.16 ft
L=170.25 ft
R=114.76 ft
PI=714+07.83
PT=714+72.92

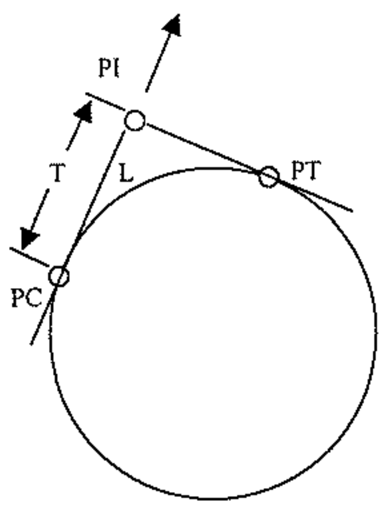
Check the notations on this plan and note that the original baseline for the connection at sta. 713+50.78 was a POC (Point on the Curve); however, subsequent revisions placed the actual connection to a POT (Point on the Tangent) at sta. 712+65.23.

In the upper left hand corner of the plan you will find a diagram of survey data used to relocate particular points along the roadway in the event marking stakes are moved. This particular reference pinpoints the Point of Intersection (PI) at sta. 714+07.83. An explanation of survey data will be covered later in this guide.

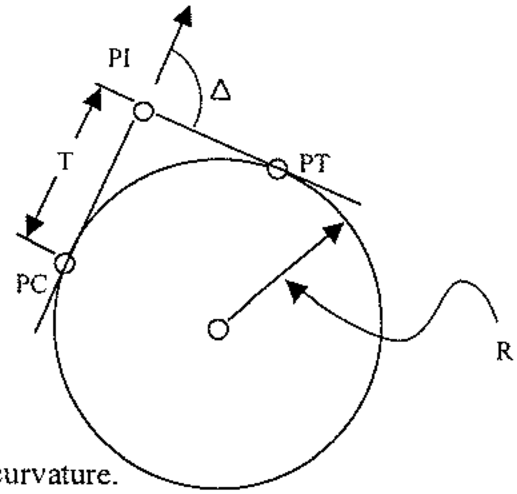
6. Using this plan, (a) locate and give the station number of the PC ____________, and (b) indicate which way the curve bends________.



Δ This symbol is called delta, meaning delta angle, and refers to the angle between the original tangent direction and the new tangent direction.



T is the distance along the tangent from P.C. to P.I. or from P.I. to P.T.
L is the length along the curve from P.C. to P.T. and is computed by formula.



R refers to the radius of curvature.

Elements of the Curve Data with which you should be familiar are:

Δ
T
L
R

Study the drawing for the meaning of these symbols.

Given some of the curve data you can compute other dimensions such as:

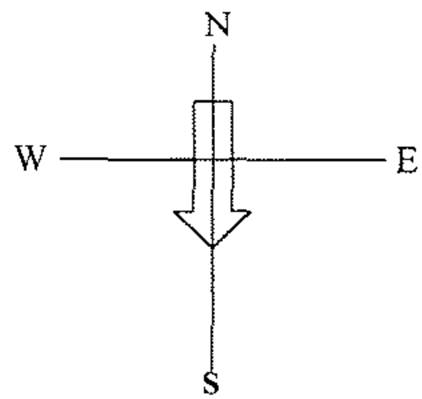
$L = 2\ R(\ /360^\circ)$ where is 3.14

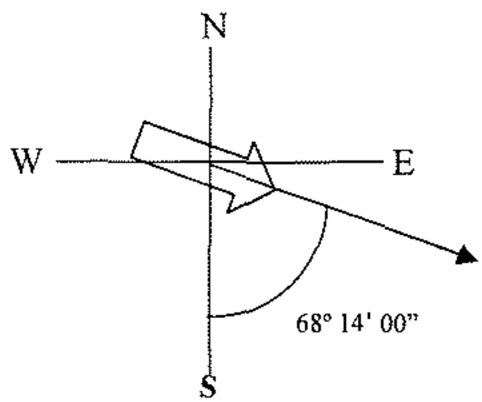
$T = R \tan(\ /2)$

PI = PC + T or PRC + T

PT = PC + L

Now that we have determined what the symbols represent, let's find out how to use them. On any set of plans you will see figures arranged in this manner: S68° 14' 00"E. This is known as a bearing (or direction) and is read as: South sixty-eight degrees, fourteen minutes, naught seconds east. To explain this we will look at a few diagrams.





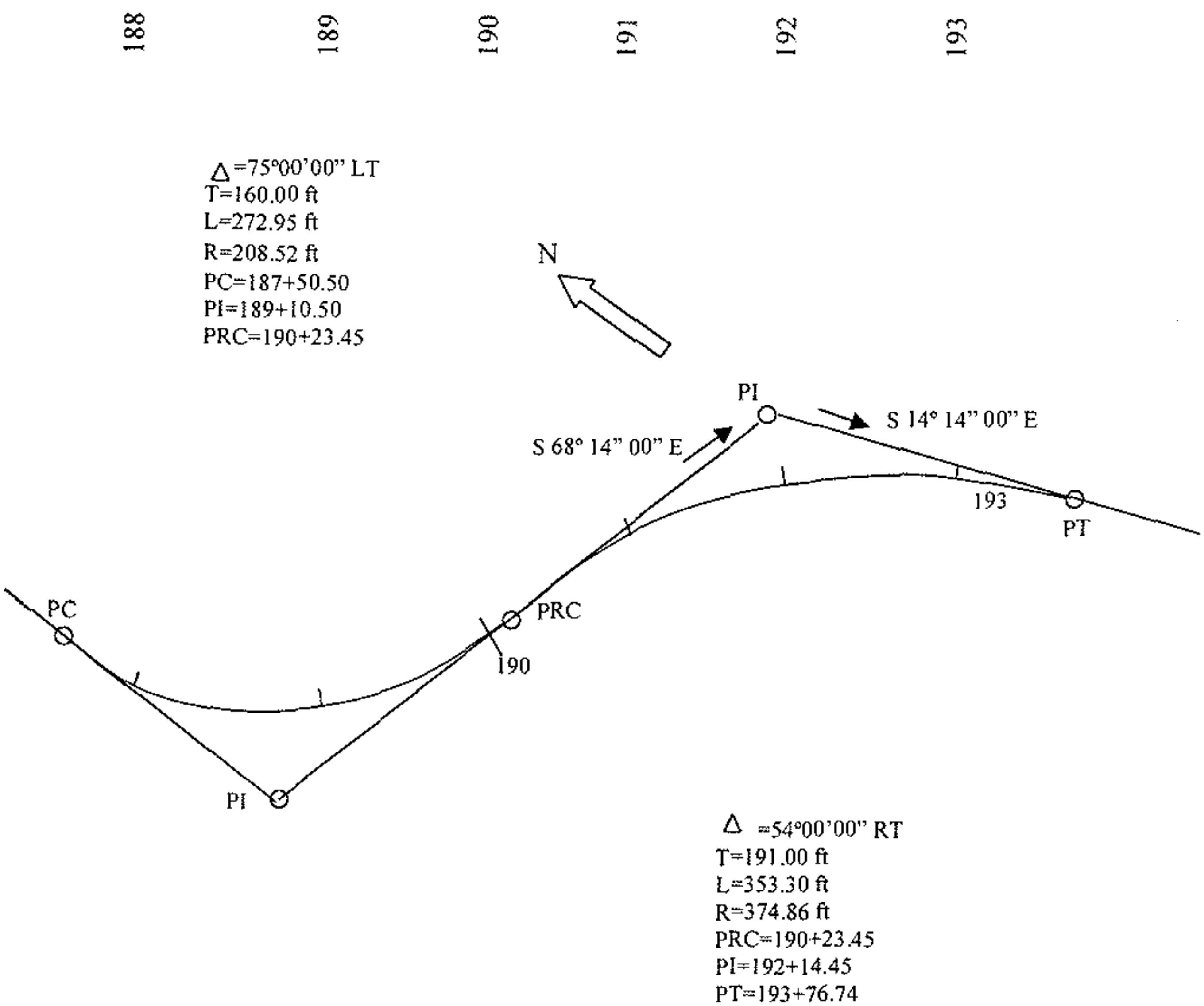
NOTE: Always use the first letter (N or S) as zero, starting point, and the second letter as the direction towards which you turn.

7. Looking straight down on the top diagram, the arrow is facing due

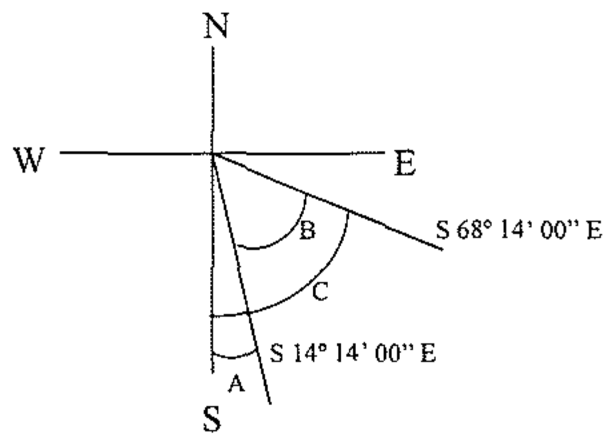
   ______________________________.

Therefore, if a person is facing South and turns toward the East in the direction of the second arrow, he would be facing South and turn toward the East 68° 14' 00" and would then be facing S68° 14' 00"E.

All bearings used in highway work use NORTH or SOUTH as a STARTING POINT and proceed either east or west. The angle cannot be greater than 90°.

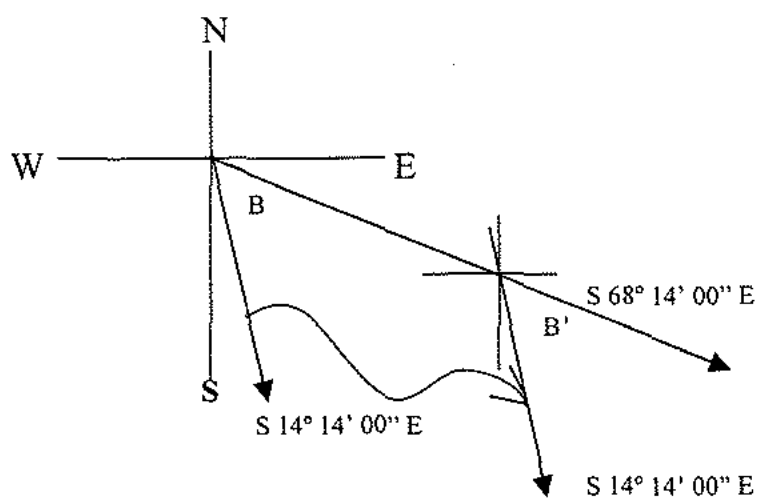


Check this drawing and note that the bearing of the tangent as it enters the curve (back tangent) is S 68° 14' 00" E. On the tangent between the PI and the PT (ahead tangent) a bearing of S 14° 14' 00" E is given.



If we plot both of these bearings in the same manner, we find that angle A, formed between SOUTH and bearing S 14° 14' 00" E, is smaller than angle C, formed between SOUTH and bearing S 68° 14' 00" E.

Therefore, bearing S 14° 14' 00 E (Angle A) is closer to SOUTH than bearing S 68° 14' 00 E (Angle C). How much closer (Angle B) is what we have to calculate in order to figure the delta angle. So, subtract 14° 14' 00 from 68° 14' 00". The difference is 54° 00' 00", the delta angle.

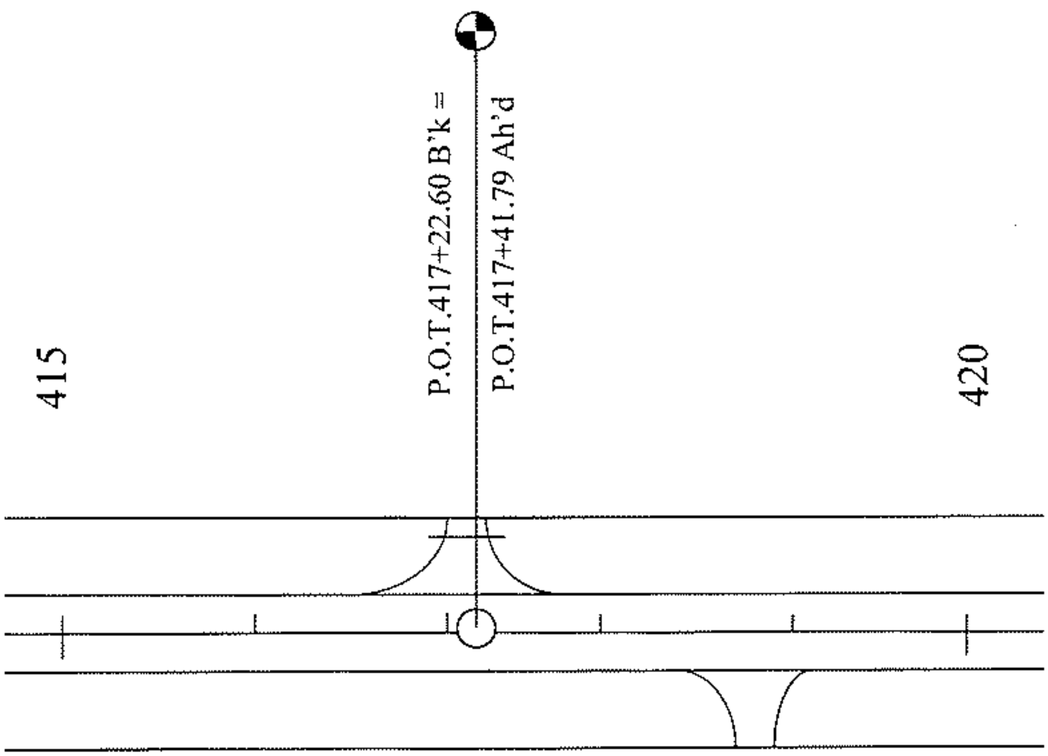


If we re-arrange our diagram by moving bearing S 14° 14' 00 E, tangents are formed and intersect.

We know from geometry that angle B and angle B' are identical. Therefore, angle B is the same as the delta angle. This is also called the angle of deflection. This is the angle that you would have to turn in order to leave a bearing of 68° 14' 00" E and begin a bearing of S 14° 14' 00" E.

8. In this case, the delta angle, or angle of ______________is_________ degrees.

<u>**EQUALITY**</u>



In the center of this drawing you will note a vertical line topped by a black and white checkered circle. This is called an **EQUALITY.**

This particular point along the baseline has TWO station numbers. The one that is used depends on the direction in which you're going. There are numerous reasons for establishing an **EQUALITY** and they will be covered later. Right now all we're concerned with is how to compute measurements across equalities.

As an example: To determine the distance along the baseline from sta. 415+00 to sta. 420+00, start at one end and measure up to the equality using the value on the same side of the line as your starting point:

from sta. 415+00 to sta. 417+22.60 = 222.60 ft.

Now start with the value on the other side of the line and measure to your destination:
from Sta. 417+41.79 to sta. 420+00 = <u>258.21 ft</u>
for a total of 480.81 ft

So the total distance from station 415+00 to sta. 420+00 is not 500 ft as you might expect at first glance. In other words, you have a negative equality, and the length of that equality is minus 19.19 feet. Between 415+00 and 420+00 is 500 – 19.19 = 480.81 ft.

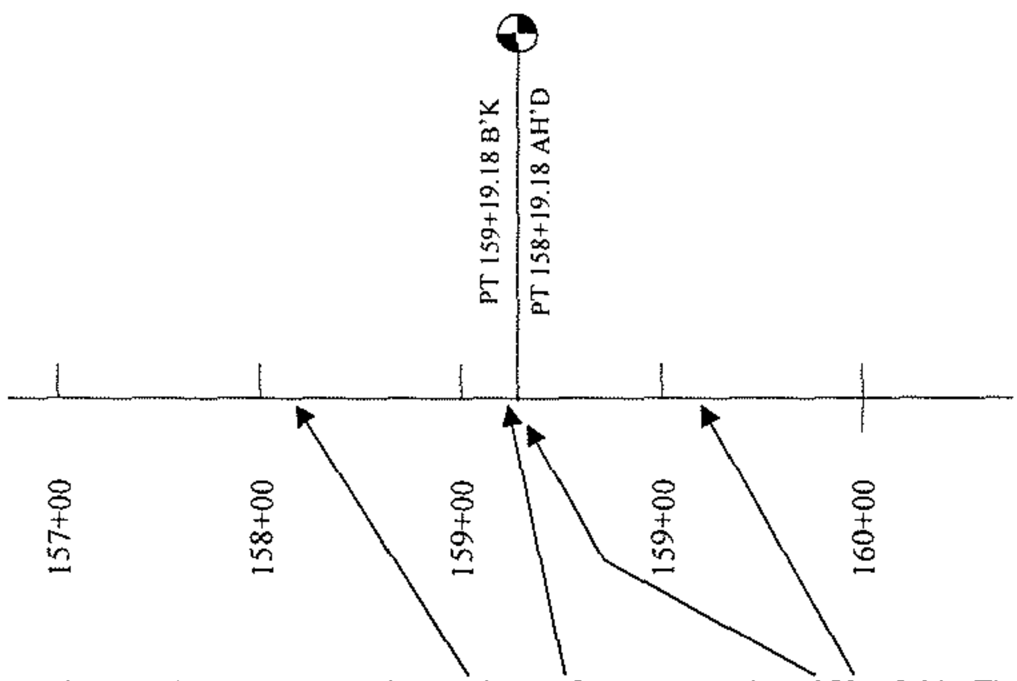
Take another look at the equality. Notice that one side of the equality says POT 417+22.60 B'K (BACK) and the other, 417+41.79 A'HD (AHEAD). Always subtract your AHEAD station from your BACK station. This is true even if your AHEAD station is larger. For example:

For this example the results are negative (a negative equality):

	417+22.60 B'K
subtract	417+41.79 AH'D
	-19.19 feet

If your AHEAD station is smaller than your BACK station, simply subtract and you will arrive at a plus figure. You now have a PLUS EQUALITY, and an important thing to remember in cases like this is that you will have more than one station with identical numbers. That is why we use the words BACK (BK) and AHEAD (AHD).

Let's see how it works.



Notice that there are two stations 158+19.18 and two stations 159+19.18. That is why we have a sta. 159+19.18 B'K and sta. 158+19.18 AH'D.

Using the procedure we learned earlier, measure the distance from sta. 157+00 to sta. 160+00. The distance from station 157+00 to 159+19.18 B'K (back) is 219.18 feet. The distance from station 158+19.18 AH'D (ahead) to 160+00 to is 180.82 feet. Adding 219.18 and 180.82 produces a total of 400 feet. This is the actual distance from station 157+00 to 160+00, not 300 feet as you may expect. This is due to the equality which is because an even 100 feet was added to the baseline length. Often the baseline length is not increased or decreased an even number of feet, however the principle is the same as described here. Pay particular attention when measuring distances involving plus equalities.

9. Determine the distance from station 157+50 to station 158+19.18 B'K in feet.

____

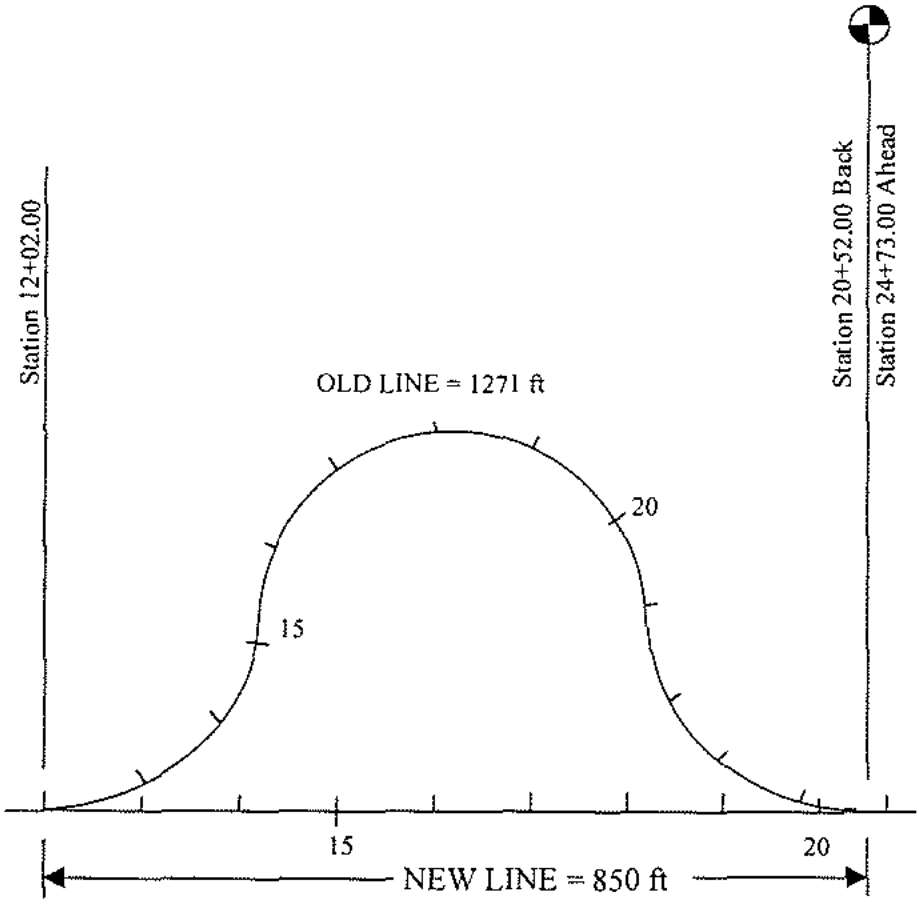
10. Determine the distance from station 159+19.18 B'K to station 158+19.18 AH'D in feet.

____________________.

We mentioned earlier that there are many reasons for using EQUALITIES. Perhaps the following illustration will help explain one of them:

After the baselines are laid out by the survey party, portions of the alignment sometimes have to be changed. This requires an increasing or a decreasing of distances between certain stations. Where the new line converges with the old line, the station numbers will not agree. This is due to the differences in the distances of the old and new line. To re-survey the entire route to conform to the new length would be a tremendous task, and would require revision of many records, so equalities are created. This requires no changes in the stationing of the undisturbed portions of the highway.

For example: Let's take an alignment where the PC is sta. 12+02.00 and which runs 1271.00 feet to the PT at sta. 24+73.00. It is decided to straighten the highway by projecting a tangent between these two points. The length of this new tangent is 850.00 feet. Therefore, the station at the point of tie-in of the new line and the old line will become 20+52.00. This point then is designated as Sta. 24+73.00 AH'D and Sta. 20+52.00 B'K. Notice that by retaining the old station 24+73.00, we can continue along the baseline without changing station numbers beyond the point of tie-in. What we have actually done is taken 421.00 feet out of the baseline.



The old line was	1271.00 feet
The new line is	850.00 feet
The difference is	421.00 feet

The PC is sta. 12+02.00. Drop the (+) and we get a distance of 1202.00 feet. By adding the length of the old line, which is 1271.00 feet, you end up with 2473.00. Divide by 100, slip your (+) back in and you get sta. 24+73.00.

Now, by subtracting the AH'D STATION from the B'K, STATION as previously covered, you'll find the length of the equality is minus 421.00 feet.

So far we have examined only the baseline. Let's check out a few other features found on a Plan Sheet. On some plans you will note the words "proposed easement" with the following symbol:

[80'
+ 50]

This easement break point describes a point 80 feet off the base line. The 80 feet is measured perpendicular to the base line at the nearest station plus 50 feet. These break points are read the same as Right of Way break points.

In the upper left hand corner of each Plan Sheet you will find information as to the ownership of power and telephone poles which may have to be moved during the course of construction. On the Title Sheet are found the appropriate symbols for power and telephone poles. The Plan Sheets graphically illustrate other features such as Construction Limits, Right of Way lines, R/W Break Points, Property Lines, Property Owners, and Parcel Numbers.

PROFILES

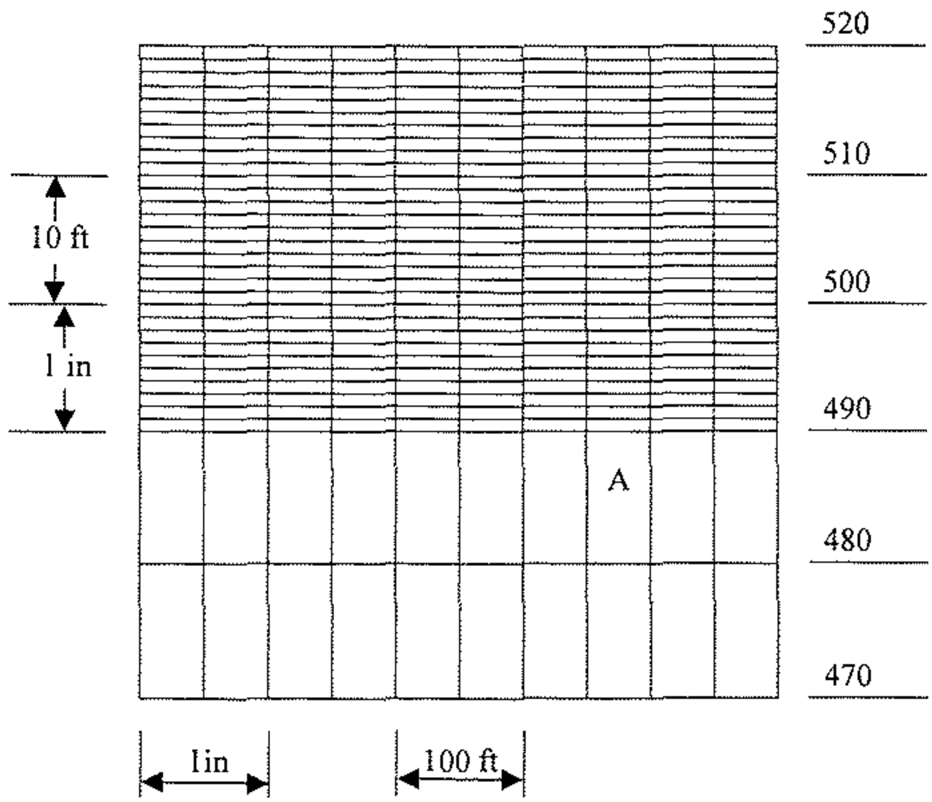
So far in our study of plan reading, we have been concerned only with the PLAN view. From a Plan view, it can be determined whether the road is curving to the right or to the left, or going straight. This is referred to as the horizontal alignment.

Just as roads curve left and right in their horizontal alignment, they sometimes curve up and down. This is known as the vertical alignment.

To study vertical curves we must look at the PROFILE. Remember that we said that we had to look at the highway from one side or the other in order to get a PROFILE (side) view. The scale drawn in the lower right hand corner of the plan sheet is called a Horizontal Scale and indicates the ratio of the horizontal distances on the plan sheet compared to the actual horizontal dimensions on the ground. Normally full size plans are scaled at 1 inch equaling 100 feet. On the Title Sheet, the scale is much smaller, such as 1 inch equals 2000 feet. The smaller scale is necessary to depict the entire project on one sheet.

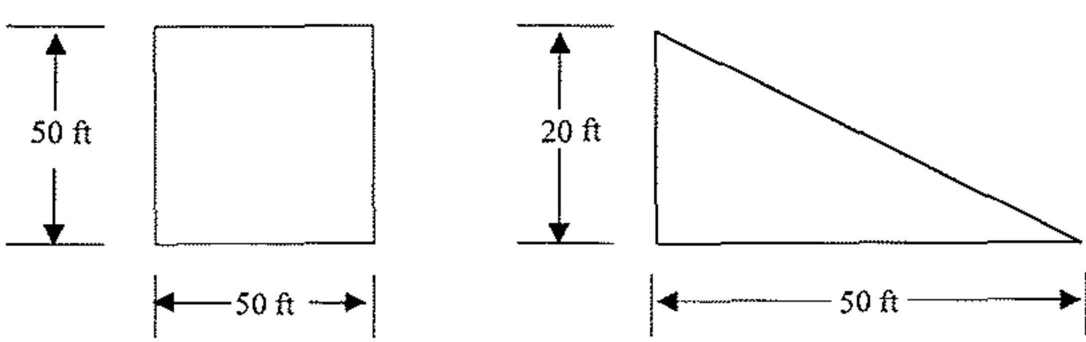
There are times when you will be using reduced size (usually half-size) plans in the field. It is important that you realize that the scale will also be half-size.

The horizontal scale is the same for both the Plan and the Profile sheets. In addition, the Profile Sheet has a numerically graduated vertical scale along the left and right margins to measure elevation. This scale is usually 1 inch equals 10 feet; however, this is not always so. A look at the Profile Sheet will tell you just what the scale is for that particular profile.

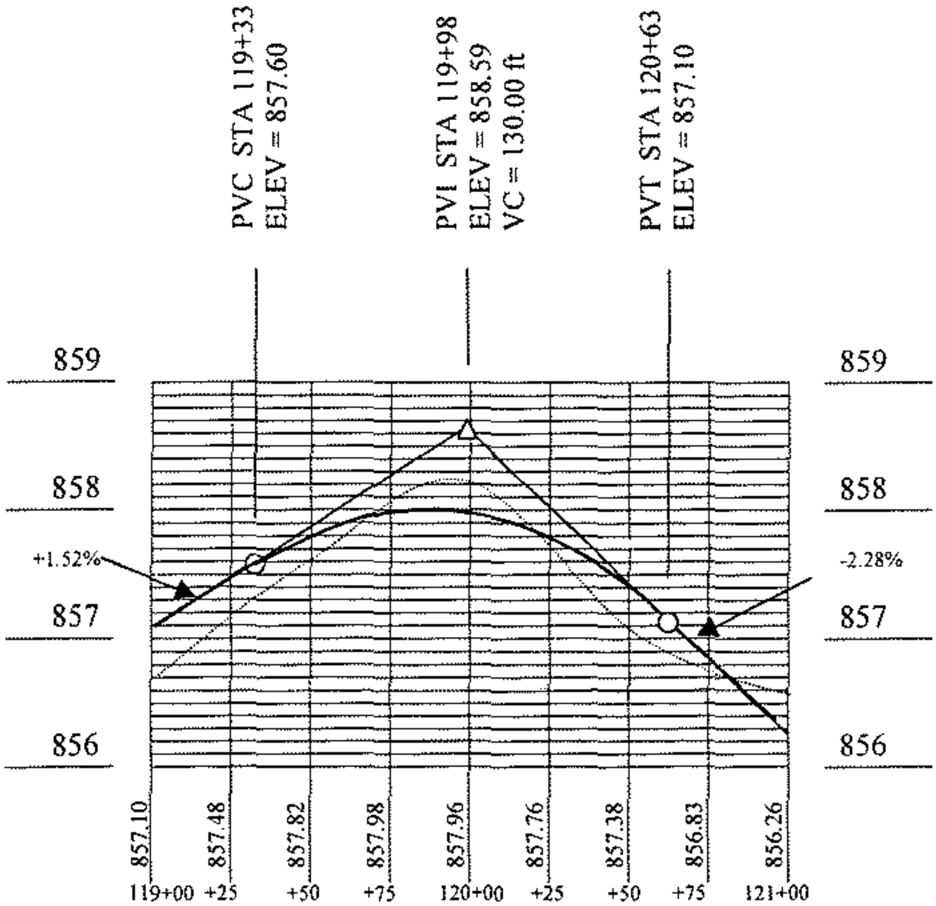


Study this drawing and determine the horizontal and vertical dimensions of block "A".

If you came up with a 50 ft horizontal distance and a 10 ft vertical distance you're correct. Notice that the height exceeds the width considerably. This exaggeration is necessary in order to amplify the grade to a point where it is discernible, thus facilitating an easier view of the profile. To emphasize this exaggeration, shade in an area equal to each of the following areas on the previous drawing.



By now you should understand the exaggeration of dimension (measurement) found on the vertical (up and down) part of the Profile. Because of bumps and curves along the grade, which may be extremely small and hard to see, it is necessary to enlarge these by "blowing them up" so they can be readily seen.



Profile Drawing

In the right and left hand margins of this Profile Sheet locate the numbers 859, 858, 857 and 856. This is the vertical scale and it indicates the elevation of the existing and proposed grade as determined by some reference point, usually sea level.

Below the profile are figures across the sheet indicating station numbers such as 119+00 and 121+00. Every station on the profile corresponds to that same station on the plan sheets. Just above each of these numbers are vertically written numbers; these are the elevations of the road at the respective stations. Across the sheet are stations and elevations for the profile, such as 120+00, elev. 857.96. This means that the POINT OF FINISHED GRADE at the baseline is 857.96 feet above some reference point. This elevation refers only to the baseline. Follow the line straight up from 120+00 to intersect the heavy line on the profile and follow a line directly over to the right vertical scale to determine the 857.96 ft elevation.

The heavy line represents the baseline (planned elevation) of the road upon completion of the project. The thin dashed line below or above the baseline (proposed grade) represents the existing grade. Where this line is above the proposed grade, a CUT is necessary; where this line is below the proposed grade, a FILL is required. When both the existing and proposed elevations are the same it is known as a GRADE POINT.

On the profile you will see the figures –2.28% and +1.52%. These refer to THE PERCENT OF GRADE. Grades that are going downhill are designated negative (-) grades. Grades going uphill are designated positive (+) grades.

The figure –2.28% indicates that the grade falls 2.28 ft vertically for each 100 ft of horizontal plane. This method of calculation is true for all straight grades whether uphill or downhill. From station 119+33 (PVC) (point of vertical curve) to 120+63 (PVT) (point of vertical tangent) is a vertical curve. The tangents to and from this curve intersect at station 119+98 (PVI) (point of vertical intersection). Elevations at 25 ft intervals are listed for the curve at the bottom of the profile. Check your vertical scale and you will find that at Sta. 119+98, the PI is at an elevation of 858.59 ft; at Sta. 121+00 the tangent elevation is 856.26 ft; a drop of 2.33 feet. This is a drop of 2.33 ft in 102 feet which is 2.28%.

The elevation of the baseline profile is determined by multiplying the PERCENT OF GRADE by the distance in feet from the last known elevation (written along the bottom of the profile) and subtracting or adding the result obtained from the previous elevation.

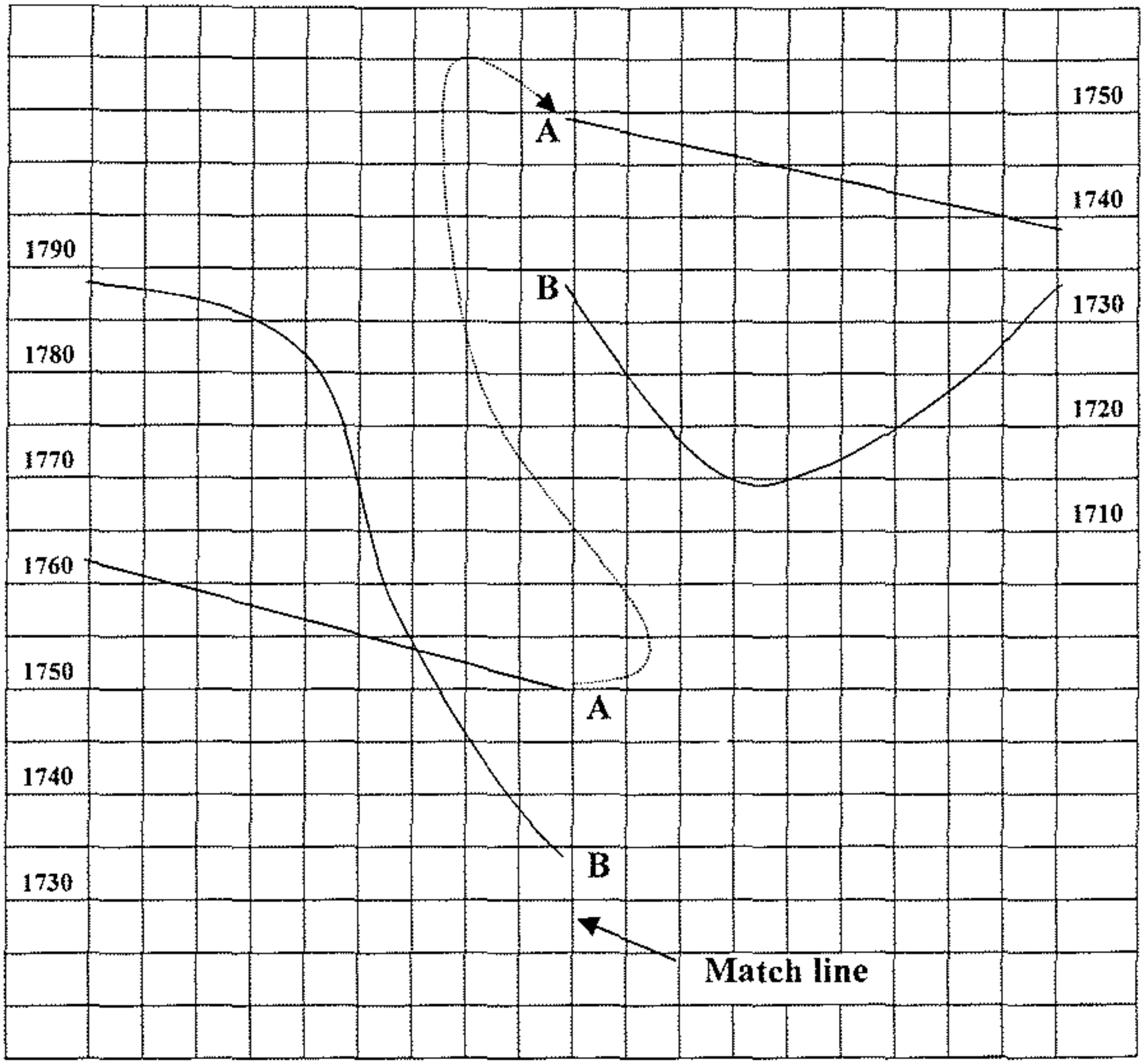
To compute the elevation at station 120+80:

> The elevation is 856.83 feet at Sta. 120+75.
>
> From Sta. 120+75 to Sta. 120+80 is 5 feet.
>
> The grade is – 2.28%.

Converting – 2.28% to decimals produces – .0228. Remember that for every 100 feet of distance, you'll drop (minus) 2.28 feet. Multiply 5 feet by .0228 and you'll get 0.11 feet. Subtract this figure from the last known elevation of 856.83 ft at Sta. 20+75, and you have the elevation at Sta. 120+80 of 856.72 feet.

There are several items to remember in order to prevent making an error in computing elevations.

- When calculating the distance, do not overlook an EQUALITY. This could create quite an error.
- Make sure that with minus (-) grades (going down), you subtract the vertical drop when on the downhill side of the previously known elevation.
- Likewise, remember that plus (+) grades are going up and therefore you must add the vertical rise when on the uphill side of the known elevation.

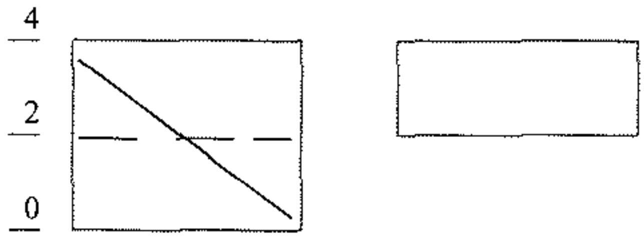


This partial profile illustrates a break in both the existing grade line and the proposed grade line. Notice that the vertical scales differ from side to side. The reason for this break is that the profile is too steep to illustrate it on our profile sheet. Therefore, we must raise the lower portion to fit within our limits. But to do this we must still have a scale by which to determine the elevation, thus we raise the lower scale also.

If we lowered the right hand profile lines, A & B would match the left-hand profile. The match line merely represents a linear reference point for realignment of the two profiles.

The following should help understand this break and the reason for it.

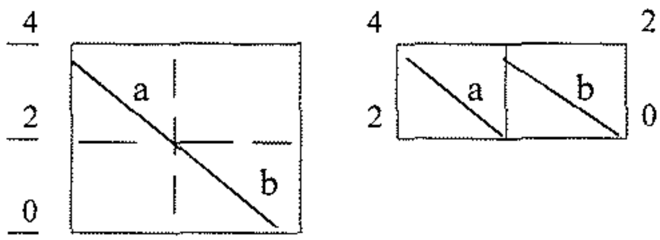
Given the profile on the left below:



and given only the space shown to the right above to represent the profile.

The numbers represent elevations.

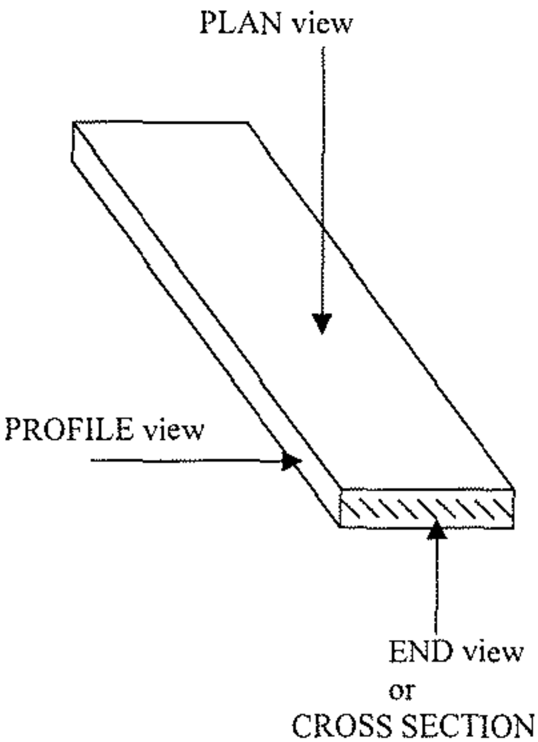
Suppose we had a profile that was extremely steep that necessitated the use of a large area to represent it as is the case with the left side in this drawing. If we had only the space on the right to represent this profile, the first thing to do is to find out how much of the line will fit onto the smaller space or sheet.



The numbers represent elevations.

By dividing the larger sheet we find that the line is contained in two of the blocks: a and b. The other two are blank. So we place b in the blank space alongside of a. Now we have the entire profile on one sheet, but note that the left scale is from 4 ft to 2 ft and the right scale is from 2 ft to 0 ft.

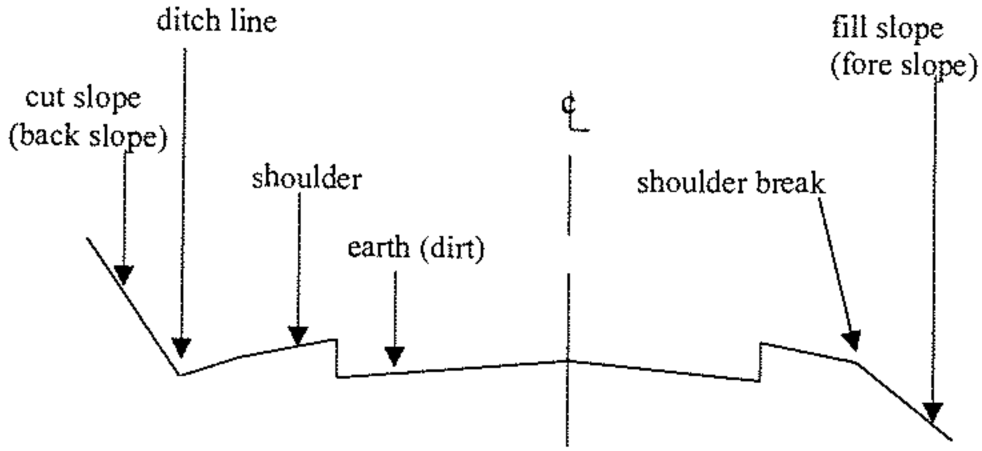
So far we have been looking at the project from above, known as the PLAN view. We have also been looking at the project from the side which gave us a PROFILE view. Now lets look at highway construction from what is known as the END view or CROSS SECTION,



Here you see the Plan view, Profile view and the END view or CROSS SECTION.

We will now go over some of the highway nomenclature.

CROSS SECTIONS



This drawing labels areas that are of interest in road design and construction.

We will cover plotted cross sections later in this material to determine and measure the number of cubic feet of cut or fill required to attain a desired grade.

The trench (empty space) between the shoulders on the drawing is where the PAVEMENT will be placed.

You will recall in our study of the Title Sheet that the Index of Sheets listed Typical Sections and Summary Sheets. Let's take a good look at a Typical Section now.

TYPICAL SECTIONS

Sheet Number 2 is assigned to the main Typical Section Sheet. General notes are to be shown on this sheet, if feasible, e.g. Secondary projects or other projects that do not require multiple typical sections.

Sheet Nos. 2A, 2B, etc., are assigned to other Typical Section Sheets, Detail Sheets, Summary Sheets and the Hydrologic Data Sheet, where applicable.

TYPICAL SECTIONS include the dimensions and details for each typical section of roadway.

There are often several drawings on the TYPICAL SECTION sheets. As an example, the TYPICAL SECTION sheet may have a title such as:

TYPICAL SECTIONS

I-95 N.B.L.

The TYPICAL SECTION may include a detail with numbers in circles and a legend such as:

Asphalt Concrete Surface Type SM-12.5A @ 165 lb. per sq. yd.

Asphalt Concrete Intermediate Course Type IM-19.0A @ 220 lb. per sq. yd.

10 inches Asphalt Concrete Base Course Type BM-37.5

3 inches Open Graded Drainage Layer

8 inches Subbase Material, Cement Stab. Aggr. Base Matl. Type I
No. 21A 4% Cement by Weight

Underdrain Std. UD-4

8 inches Aggregate Base Matl. Type I No. 21B

Item 1 denotes Asphalt Concrete Surface Course Type SM-12.5A @ 165 lb. per sq. yd.

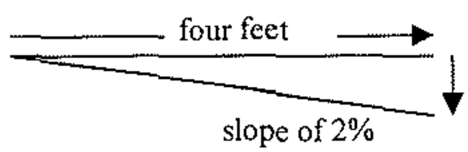
This means that the contractor is to place an asphalt surface course type SM-12.5A at the rate of 165 lb. per sq. yd. of pavement area.

Item 7 denotes 8 inches Aggregate Base Matl. Type I No. 21B

This specifies 8 inches Aggregate Base Material, Type I, Size 21B for the subbase. If there are asterisks such as * or **, these indicate that additional information is given on the sheet regarding the material.

In pavement designations, B refers to base course; I refer to intermediate course; S refers to a surface course. Further information concerning the make-up of these courses is contained in the VDOT Road and Bridge Specifications which govern the construction of highways in Virginia.

References on a profile are to "POINT OF FINISHED GRADE" or "PROFILE GRADE LINE". From these elevations you can determine proposed elevations at locations left or right by looking at the cross slope. Examining a Typical Section sheet, you will find pavement cross slope such as 2% → This indicates a slope of 2% (2 feet per 100 feet).



If you were four feet horizontally from the POINT OF FINISHED GRADE at the BASELINE, where the elevation was 10 ft, the elevation of where you are now would be 4 ft times 2% = 0.08 ft lower than the 10 ft elevation.

Therefore, if you were four feet horizontally from the POINT OF FINISHED GRADE at the BASELINE where the elevation was 10 ft, the elevation of where you are now would be 9.92 ft.

DETERMINING SUBGRADE ELEVATION

In order to establish the elevation of the subgrade (top of earthwork) we will have to subtract the total thickness of the pavement, base and select material from the elevation of the POINT OF FINISHED GRADE.

Material	Thickness
SM-12.5A @ 165 lb. per sq. yd.	1.50 inches
IM-19.0A @ 220 lb. per sq. yd.	2.00 inches
10 inches BM-37.5	10 inches
3 inches Drainage Layer	3 inches
8 inches 21A	8 inches
8 inches 21B	8 inches
TOTAL	32.50 inches = 2.71 ft

Subtracting this 2.71 feet from a 857.96 foot Finished Grade elevation produces 855.25 feet. This is the elevation of the subgrade (top of earthwork)

NOTE: The thickness, for the asphalt concrete courses applied at the rates specified for SM-12.5A and IM-19.0A are approximate.

From the example profile shown in the section on PROFILES answer the following:

11.

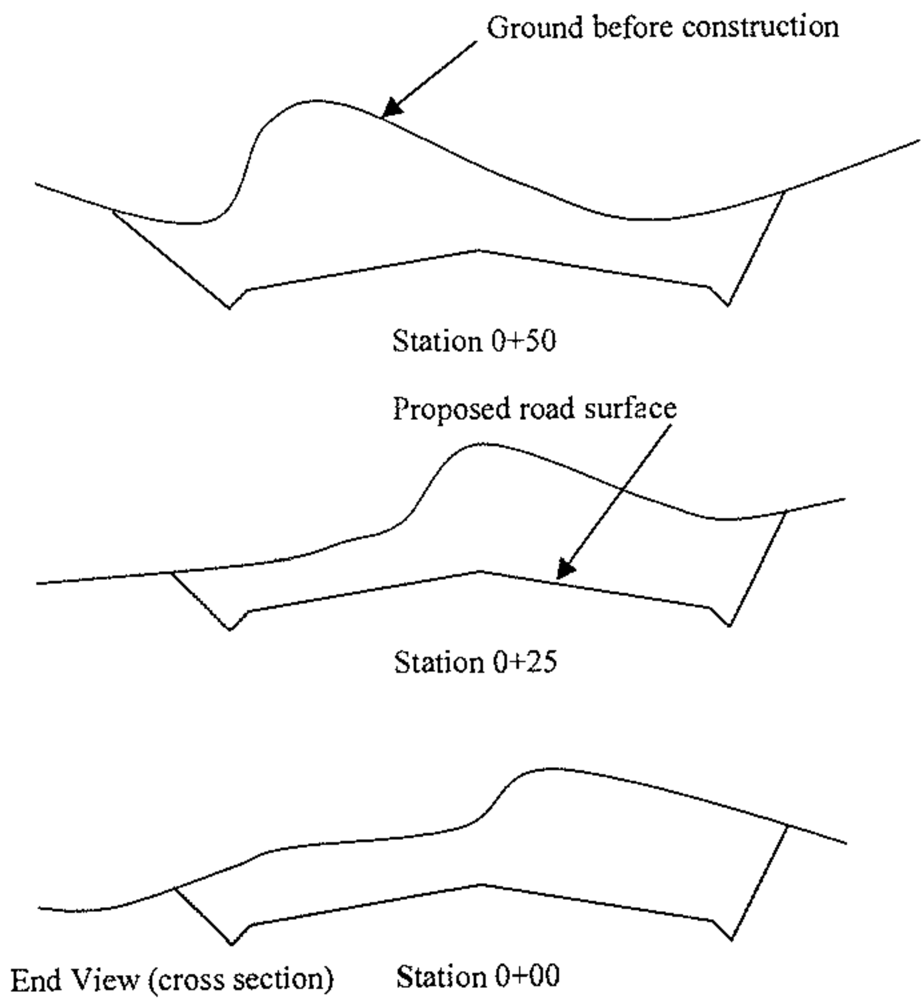
(a) At sta. 120+85, what is the elevation of the baseline_____________.

(b) What is the elevation of the Point of Grade at sta. 120+90?___________________.

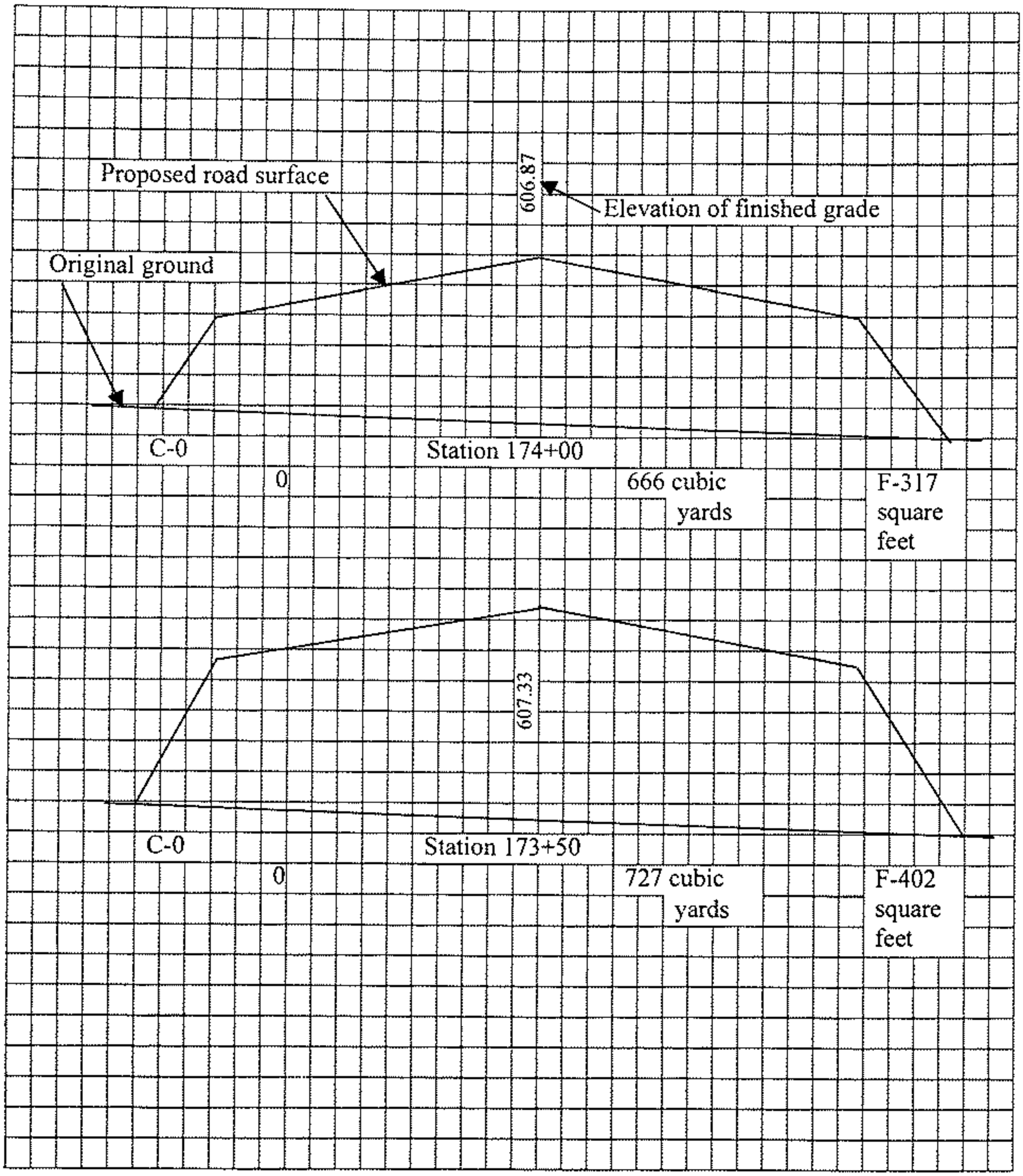
(c) Using the courses listed, what is the subgrade elevation at the baseline at sta. 120+25?________________.

CROSS SECTIONS

Imagine the road under construction to be like a loaf of bread. Looking at the "heel" of the loaf will give you an end view. Remove the heel and you will get a cross section of the loaf of bread at this point. Imagine each sliee of the loaf as occupying 25 feet; one side of the slice will be an even station such as 100+00 and the other side will be 100+25. As you remove the slices one at a time you get a cross section view of the highway at 25 foot intervals.



This sketch is similar to slices of earth at 25 foot intervals, along a proposed roadbed. These are called cross sections. Cross sections are lined with grid lines so that the road pattern may be drawn according to the typical section dimensions. These cross sections are necessary in order to determine and measure the number of cubic feet of cut or fill within the limits of the proposed roadway as indicated between the existing ground and the typical section. The following drawings will help understand the use of cross sections:

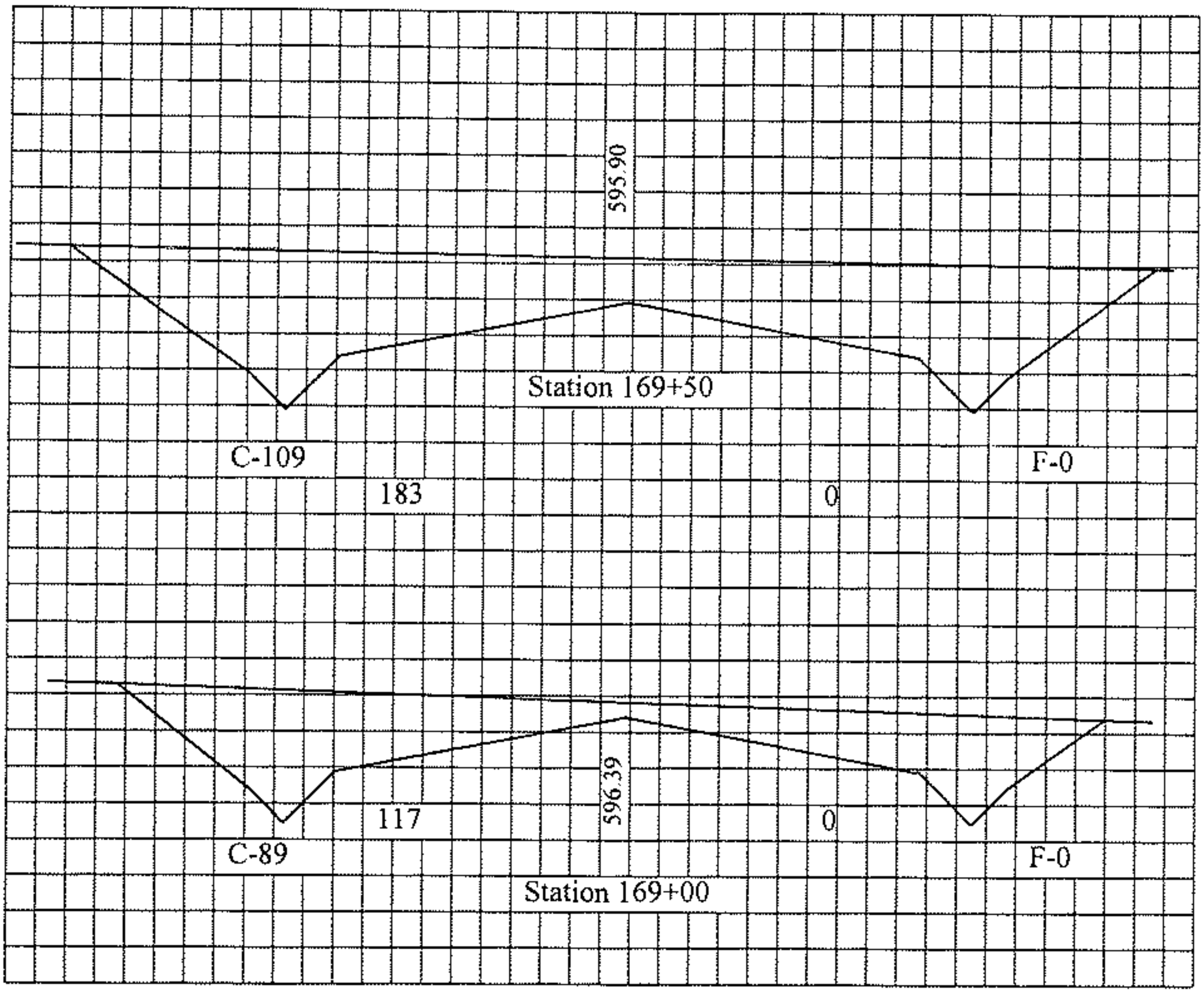


The previous drawing is of two cross sections taken at stations 50 feet apart. The lower section is taken at sta. 173+50.00. The Point of Finished Grade is at an elevation of 607.33 feet. The elevation of the existing ground is represented by the line that the typical section is resting on. These sections represent FILL sections along the project.

The cross section at sta. 174+00.00 shows four numbers:

C - 0 (Cut) F - 317 (Fill)
0 666

C - 0 means that there is no CUT here. F - 317 means that there is a 317 square foot area of FILL at this station. 666 represents the number of cubic yards of material that is needed for the fill between station 173+50.00 and station 174+00.00.



The sections on the drawing above represent CUT sections of the project. Compare these sections with the ones for the FILL and you will notice that they are similar except for the location of the original ground line.

12. Answer the following questions from the previous cross section drawings:

(a) THE POINT OF FINISHED GRADE has an elevation of ______________________ at sta. 169+00.00.

(b) What is the cut area at sta. 169+00.00?________________

(c) What is the fill area at sta. 174+00.00?________________

(d) How many cubic yards of material are there between Sta. 169+00.00 and Sta. 169+50.00?

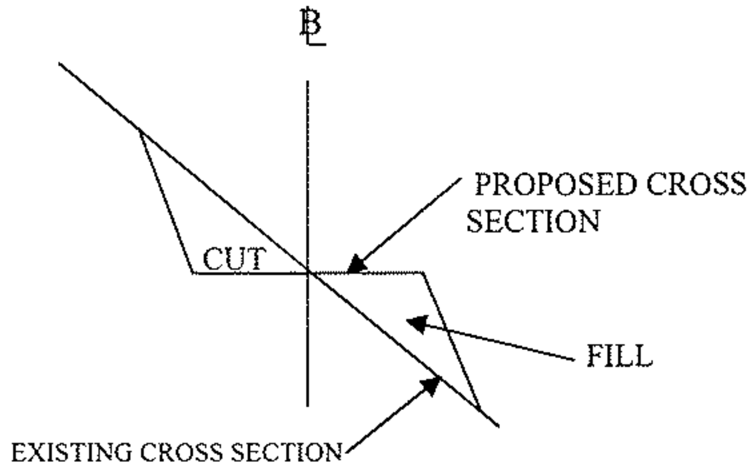
We will look at how to figure the amount of cut or fill required. AREA is measured in square feet. The cut area of sta. 169+00.00 is 89 square feet and the cut area of Sta. 169+50.00 is 109 square feet. Find the average area of the two by adding the two and dividing by two.

Therefore, $\frac{89 + 109}{2} = \frac{198}{2} = 99 \text{ ft}^2$ (average)

Now we will find the volume of the area between the two stations. The cross section has an average of 99 square feet and there is 50 feet between stations. Therefore, 99 multiplied by 50 = 4950 cubic feet to be removed from between these stations. If the distance between the stations or sections is 20 feet then this distance should be multiplied times the average square feet of end area (99).

Plans sometimes have a GRADING SUMMARY which is a breakdown, by location, of excavation required to establish the grade line. This is accomplished by removing high points (CUT) and building up low areas (FILL). In a large number of cases the Grading Summary is supplemented by a Grading Diagram which is schematically illustrated to denote this movement of earth from one point to another. Grading diagrams are not always illustrated in the same manner. However, basically they serve the same purpose.

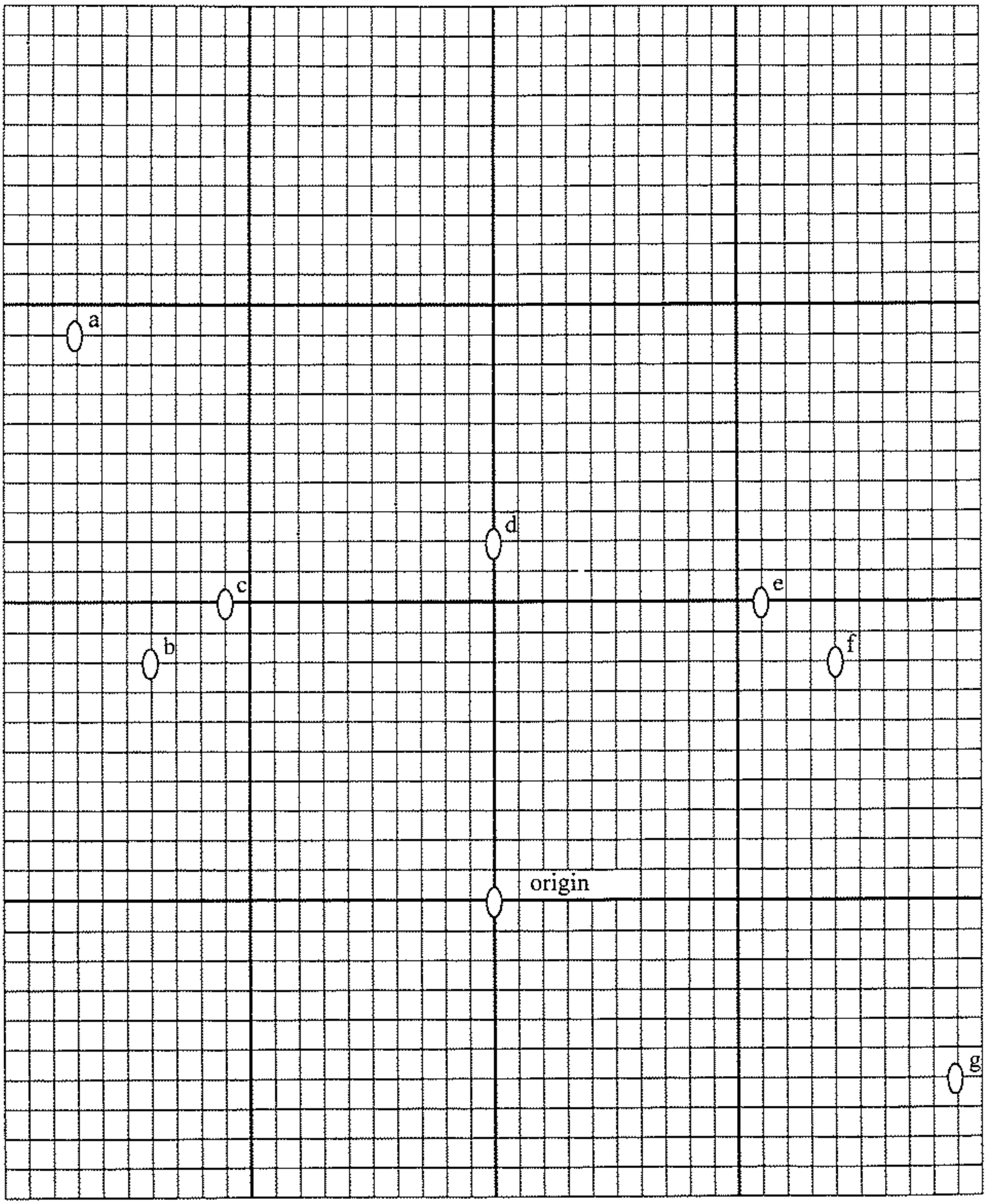
Not all plans include a grading diagram. In such cases a more comprehensive grading summary is outlined. For an example, explanation and guidelines concerning grading diagrams, grading summary and earthwork quantities see Instructional and Informational Memorandum 138 entitled "Earthwork Quantities" and section 2G-2 of the Road Design Manual.



END VIEW OF ROADWAY SECTION

This drawing depicts how cut material is used for fill areas to provide as near an earth balance as practical. Sections of road are not always similar to this drawing. Often many feet of road will be in a cut section followed by many feet in a fill section. Often the fill required is compacted to a greater density than the cut material exist. This (shrinkage) necessitates a larger volume of cut material to fill an area than the volume of fill required.

This drawing is an example of how points are plotted on a cross section:



On this drawing, are several points labeled a, b, etc. Each of these points can be described as a distance or elevation <u>vertically</u> above or below <u>or</u> a distance <u>horizontally</u> right or left from the origin. These distances can be feet (or Elevation) above (or below) the origin and feet (Distance) right (or left) of the origin. If each large block in the drawing is 10 feet X 10 feet, complete the following chart. Points below the origin are described with a minus, those above are positive. Points right of the origin are described with an R, points left with an L. The locations of a couple of points are provided as examples.

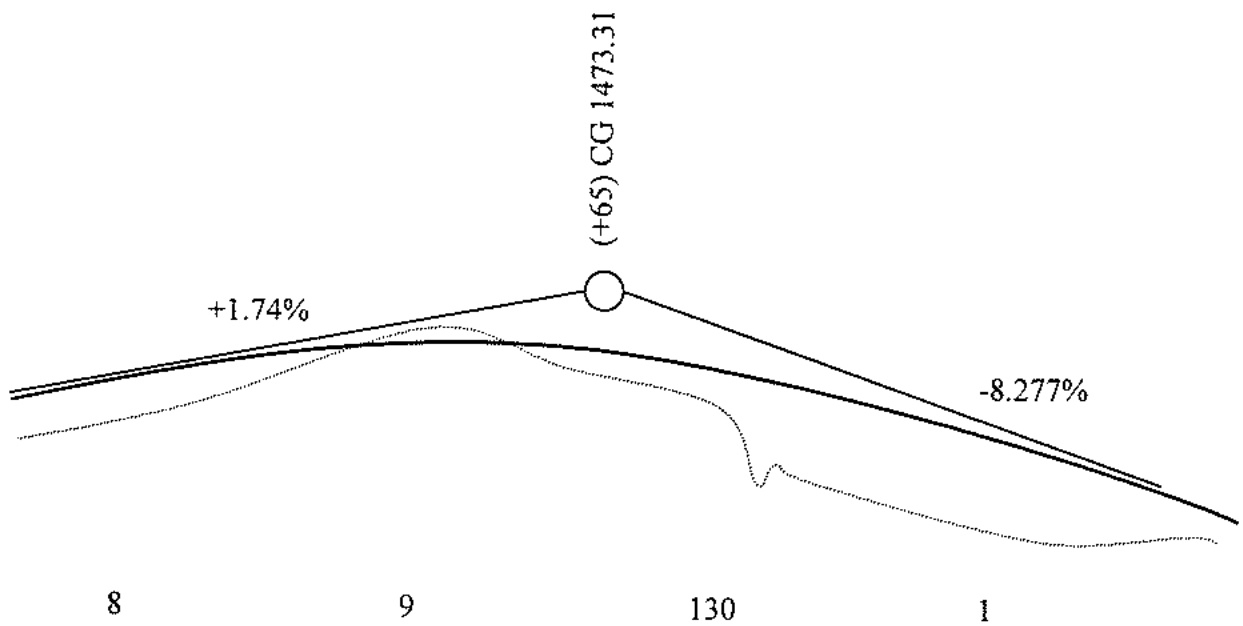
13. Determine the missing data.

Point no.	ELEV.	DIST.	Point no.	ELEV.	DIST.
a			e		
b			f		
c	10 ft	11 ft L	g	-6 ft	19 ft R
d					

A drawing of this cross section would have a line connecting the points a to b to c to d to e to f to g.

From the table that you completed, you should now realize that the vertical lines of the graph represent distances to the left and right of a specific point. Distances are measured horizontally from the vertical line that goes through the origin. In highway work this vertical line represents the baseline and all distances are measured to left and right of this baseline.

The horizontal line that passes through the origin represents a specific elevation. Elevations are measured vertically from this horizontal line that goes through the origin. In highway work this horizontal line represents a specific elevation and all elevations are measured above and below it, in feet.



This drawing is a profile of existing and planned grades between stations 128+00 and 131+00 By matching this with a grading diagram you can see another view of what is happening. One point to remember is that the planned profile is at the baseline of the roadway. High or low spots to either side of baseline are expected and the grading diagram takes this into consideration.

On many construction projects, there will be a set of computer "print-outs" instead of drawn cross sections. Once understood, these printouts can be a great time saving convenience. The "print-outs" are often in the form where points are defined as an elevation and distance from a specific reference point or origin. The following drawing is an example of a how points are plotted on a cross section.

ANSWERS TO QUESTIONS

1. 6
2. 130+59
3. 21 feet
4. 758+50, 100 feet RT.
5. BACK
6. a) 713+02.67
   b) to the right
7. south
8. deflection is 54° 00' 00"
9. 69.18 feet
10. 0 feet
11. a) 856.60
    b) 856.49
    c) 855.05
12. a) 596.39
    b) 89 square feet
    c) 317 square feet
    d) 183 cubic yards
13.

	elev.	dist.
a)	19 ft	17 ft L
b)	8 ft	14 ft L
d)	12 ft	0 ft L
e)	10 ft	11ft R
f)	8 ft	14 ft R