TENNESSEE
DEPARTMENT OF
TRANSPORTATION

HIGHWAY
CONTRACT
PLANS READING

TDOT

Rev 08/09

Developed by the Tennessee Department of Transportation

Table of Contents

Developed for construction inspection and right-of-way personnel but appropriate for the training of design, planning technicians, and Graduate Transportation Associates (GTA's)

INTRODUCTION

Upon completion of this course you should be able to read, interpret, and relate to a standard set of highway contract plans. You should be able to identify and interpret symbols used in a standard set of highway contract plans. You should be able to interpret a set of highway contract plans in non-technical terms to laymen (property owners and others). Prior to detailed descriptions of the contract plans, some terms will be defined.

A contract is the written agreement between the Department of Transportation of the state of Tennessee and the contractor setting forth the obligations of the parties thereunder, including but not limited to, performance of the work which, within itself, includes the furnishing of labor, equipment, and materials and the basis of payment. The contract includes the notice to contractors, proposal, all conditions and terms of the contract form, contract bond, specifications, supplemental specifications, revisions and additions, special provisions and addenda, general and detailed plans, the work order, construction changes and supplemental agreements that are required to complete the construction of the project in an acceptable manner including authorized extensions thereof; all of which constitute one instrument.

Plans are the approved plan, profile, and cross-section sheets along with standard roadway and structure drawings, working drawings and supplemental drawings, or exact reproductions thereof, which show the location, character, dimensions, and details of the construction to be performed under the contract. Each set of plans makes up a project. A project is the specific improvement, together with all appurtenances, to be constructed under the contract.

The definition of a contract includes many parts of which the plans are just one portion. The Specifications, any Supplemental Specifications, the Plans, Special provisions and all other documents which are part of the Contract, are intended to be complementary and to describe and provide for a complete work. Requirements in one of these are as binding as if occurring in all of them. In case of discrepancy, Supplemental Specifications will govern over Specifications, Plans will govern over both, and Special Provisions will govern over both Plans and Specifications. In interpreting Plans, calculated dimensions will govern over scaled dimensions; Contract Plans, typical cross-sections, and approved working drawings will govern over standard sheets.

CHAPTER ONE

This chapter will discuss and explain in detail the elements that make up the roadway including horizontal and vertical alignments, the relationship of superelevation to horizontal alignments, and how all three combine to produce cross-sections.

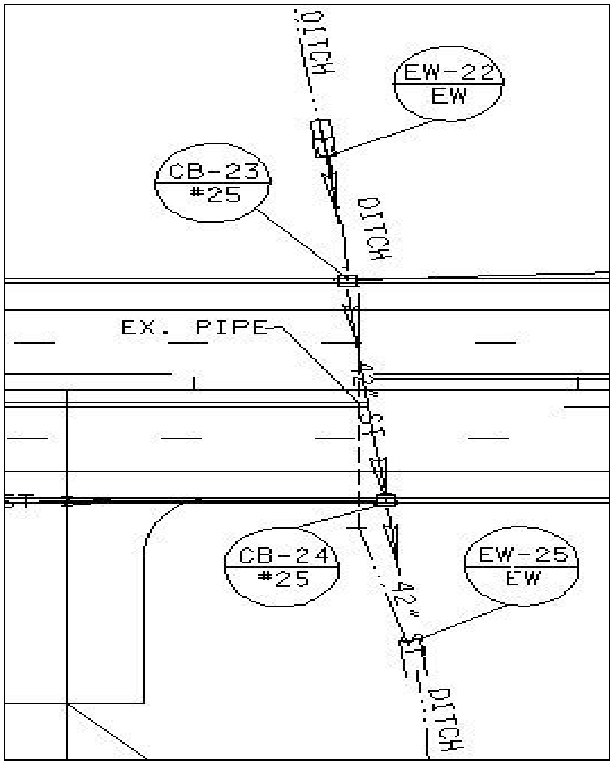
VIEWS

Most objects have different appearances when viewed from different angles. A top view usually is quite different from a side view. Highway plans are shown in three different views: plan, elevation and cross-section. Upon completion of this class, you should be able to recognize each view and understand what each view represents.

Plan View

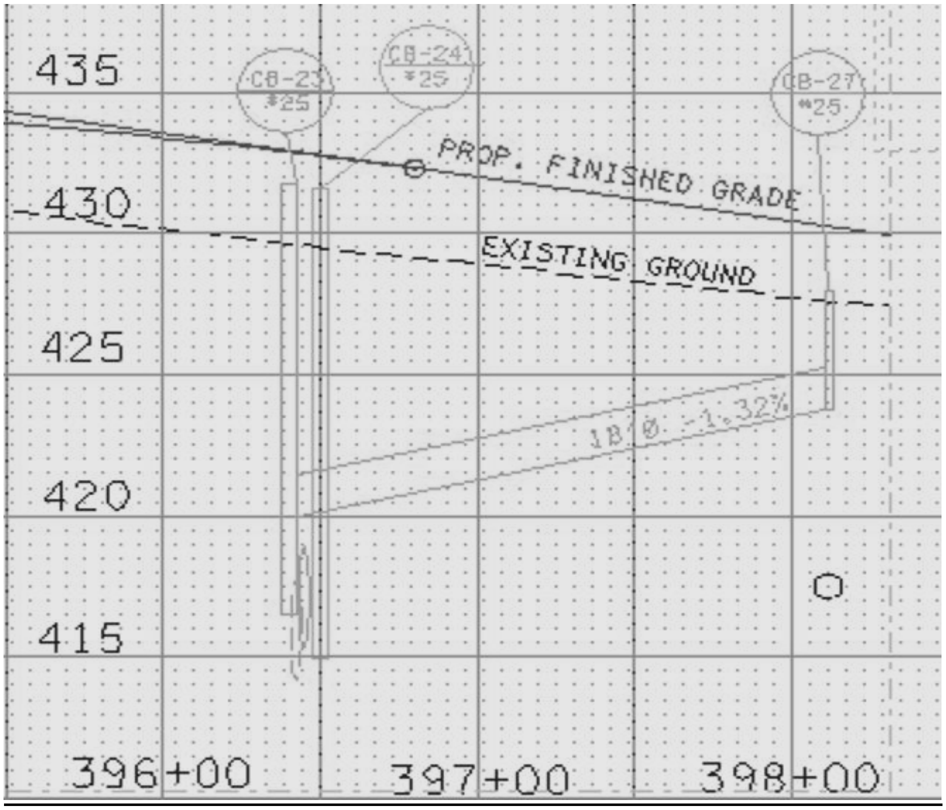
A view from the top is a plan view. The view will look like it is taken from directly above an object as if looking down on it from an airplane. The following is a shot taken from aerial surveys. All plan view sheets will show a north arrow.

The following three examples for each view are from a 5 lane curb and gutter section. A stream is running through an existing pipe under the existing two lane road. Since the road is being widened, the pipe must also be widened or removed and replaced. For this project, the existing pipe had to be removed, and a new pipe added. The stream flows into endwall (EW-22). The endwall connects to CB-23. CB-23 is connected to CB-24 by the new 42" storm sewer pipe which runs under the road. CB-24 connects to EW-25 and flows in the existing system.



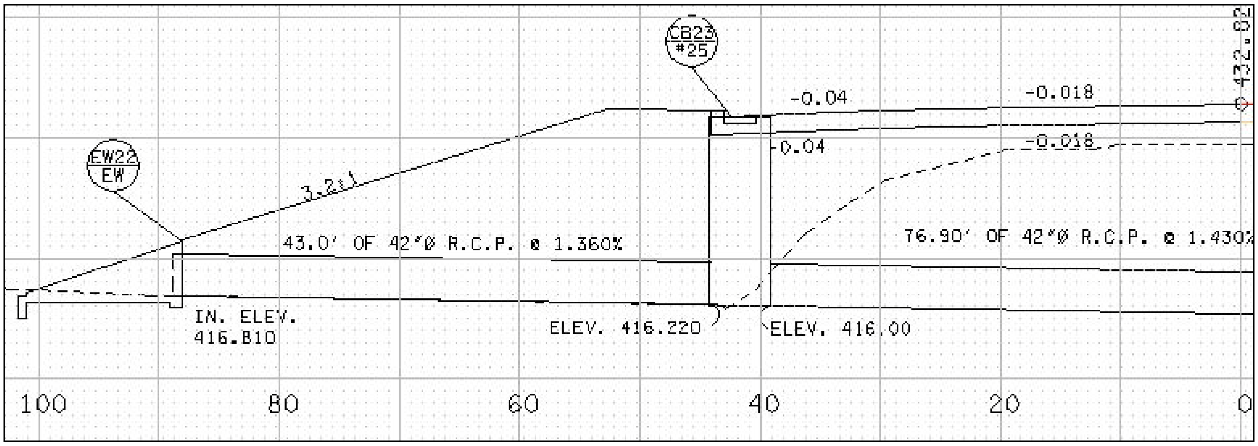
Profile View

A view from the front or side is a profile view. A profile view shows the elevation of an object. The profile below shows the existing ground line, proposed finish grade, existing utilities, catch basin I.D.'s (number and type), catch basin depths, and pipes connecting the catch basins.



Cross-section View

A cross-section view shows the inside of an object as if the object had been cut open. For example, if you cut the road from curb to curb at the middle of the proposed 42” pipe, the result would be the culvert cross-section shown below. For readability, only the left side of the road is shown in the cross-section which omits CB-24 from the cross section. The culvert begins with water going into EW-22 at the invert elevation of416.810. EW-22 Is connected to CB-23 with 44’ of 42” R.C.P. at a slope of -1.36%. CB-23 and CB-24 are connected with 76.90’ of 42” reinforced concrete pipe. The number 432.82 is the finished grade elevation at the horizontal centerline of the road. The pipe is located in a tangent section but is at a skew which is why the cross slope is -0.018 at this section is not at normal crown (-0.02 F/F) and why the side slope is at a 3.1:1 instead of a 3:1. Skewed cross sections will be discussed in further detail later.



LAND SURVEY DATA

Much of the information shown on the plan sheets is based on surveys made in the field by the Field Survey Section. To help better understand the plans, some of the concepts and terms used in land surveying will be discussed.

Surveying within the Dept. of Transportation can be described as the act of recording and documenting physical features at or near the earth’s surface, measuring and locating lines, angles, and elevations and transferring the data shown on a set of plans to the proposed work area in such a fashion as to define the work to be performed

Leveling

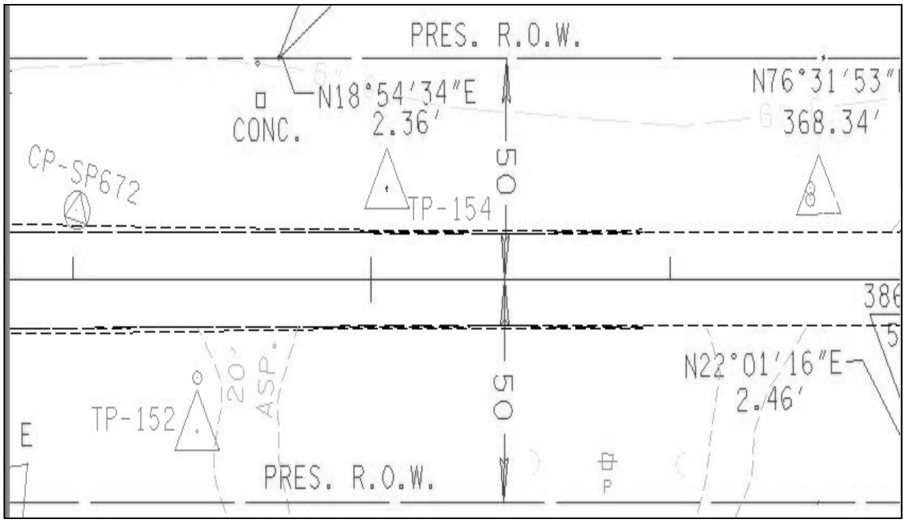
Leveling may be defined as the process of determining the elevations (vertical differences) of various points. An elevation may be defined as the vertical distance above a reference plane (datum). Mean sea level is the datum most commonly used in leveling. TVA and NGS (National Geodetic Survey) have established networks of monuments called benchmarks which are referenced to mean sea level. Benchmarks (BM) are markers, such as posts, stakes or concrete monuments which represent points of known elevation. There are many permanent benchmarks throughout Tennessee. Benchmark notes are shown along the bottoms of profile views.

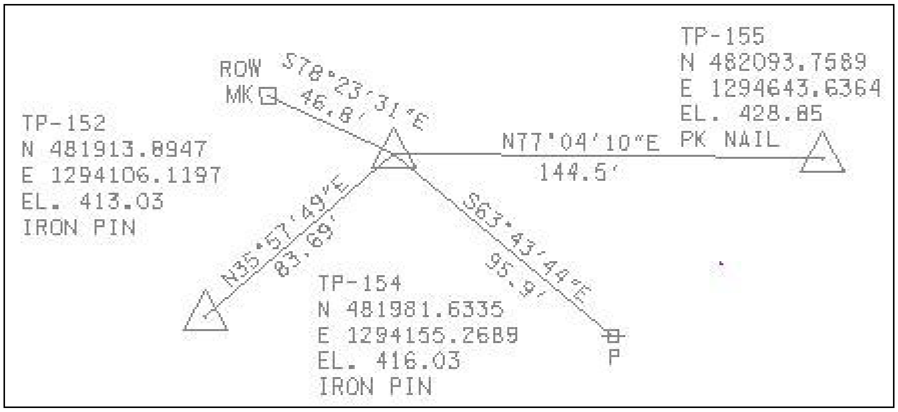
In the past these benchmarks were used to establish benchmarks along our projects for elevation purposes. Now the survey Global Positioning System (GPS) crew establishes GPS monuments along the project for horizontal and vertical controls. The monuments are set using static GPS equipment and techniques and are accurate within 2 mm. The GPS monuments are 3.25” domed aluminum monuments mounted on 0.75” diameter rebar which is 30” in length.

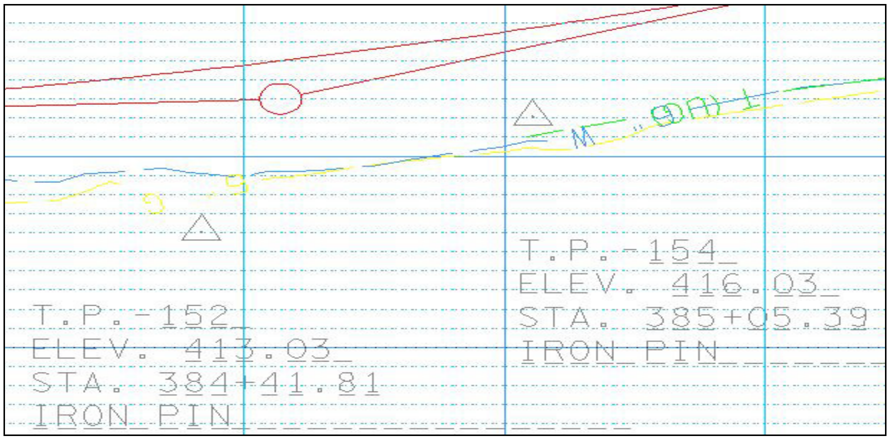
Control Points

Control points (CP) may be added which originate or terminate on a BM or may be looped back to it. Control points are shown on the plan view along with survey information and may be GPS or Traverse Points (TP). On sheet 4, locate CP-S7 on the plans at approximate station 32+50 where the existing bridge is located. At the lower right corner of the sheet, the table lists the Northern and Eastern Coordinate, Elevation, Station, Offset, and Description. On sheet 4C, CP-S7 is shown on the profile where it is physically located according to station and elevation. The description for the point is also shown with the numerical information of the station and elevation, coordinates, and the type of material used for the point.

In the following figures, several traverse points are used in conjunction with a concrete R.O.W. marker and nail. The first figure is a plan view of the markers as they are in the field. The second figure is also on the plan sheet but has the details of the coordinates and elevations. The third figure is the profile view which shows the traverse points in the elevation view.







Survey Stakes

Survey stakes allow the survey party to communicate pertinent information to other divisions (Construction, Right of Way, Geotechnical, etc.). The pertinent information is written on the stake with lumber crayons (keel), felt-tip markers, or other devices. This information could include station identification, line & grade, drill hole number, and so on. The information on the stake should be written neatly and legibly. Any abbreviations should conform to our list of standard abbreviations which are contained in the TDOT standard roadway drawing RD-A-1.

The most common survey stake used by TDOT is a wooden stake measuring 1”x2”x18”. TDOT also uses a 2”x2” wooden “hub” driven flush for marking important survey points, reference points, etc. The department also uses a 36” tall wooden stake for “witness” or “guard” stake.

The TDOT survey office sets ¾” diameter x 30” length rebar with a 3.25” diameter domed aluminum cap with the point number imprinted on the cap. These are set for control points on each project and are driven flush with the ground. They have bright orange carsonite witness posts which are 5’ tall.

Collecting Information

In plane surveying, distances are generally measured as horizontal (level) distances as opposed to slope distances. All distances on our plans are shown as horizontal distances. Our modern total stations (combination of a theodolite and an electronic distance measuring device (EDM)) use a built in EDM which provides horizontal and slope distances. The theodolite portion of the total station measures angles in degrees divided by minutes and seconds and has a precision of 3 seconds.

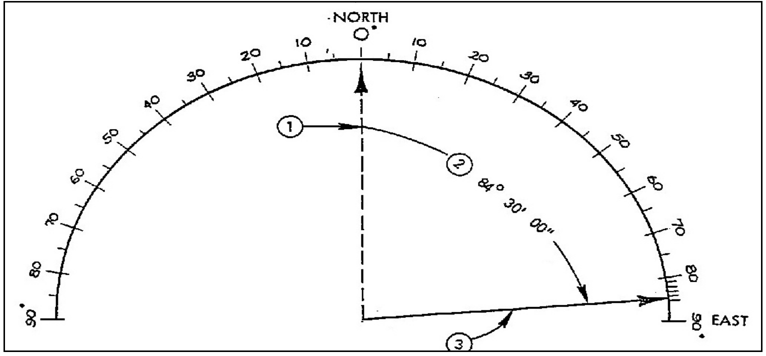
GPS equipment can also be used to measure distances and determine three dimensional positions of topographic elements on the earth’s surface. This procedure is known as rapid static or RTK. When we set our control monuments, the procedure is known as static. The main difference between the two procedures is the length of time the point is occupied with the precision increasing as the time increases.

Another method of gathering information in the field is to do an aerial survey. A special camera mounted on a helicopter or airplane is used to photograph a wide corridor which can be processed at our Aerial Survey division to provide topography and a digital terrain model. This information is augmented with field survey information to produce a workable field survey.

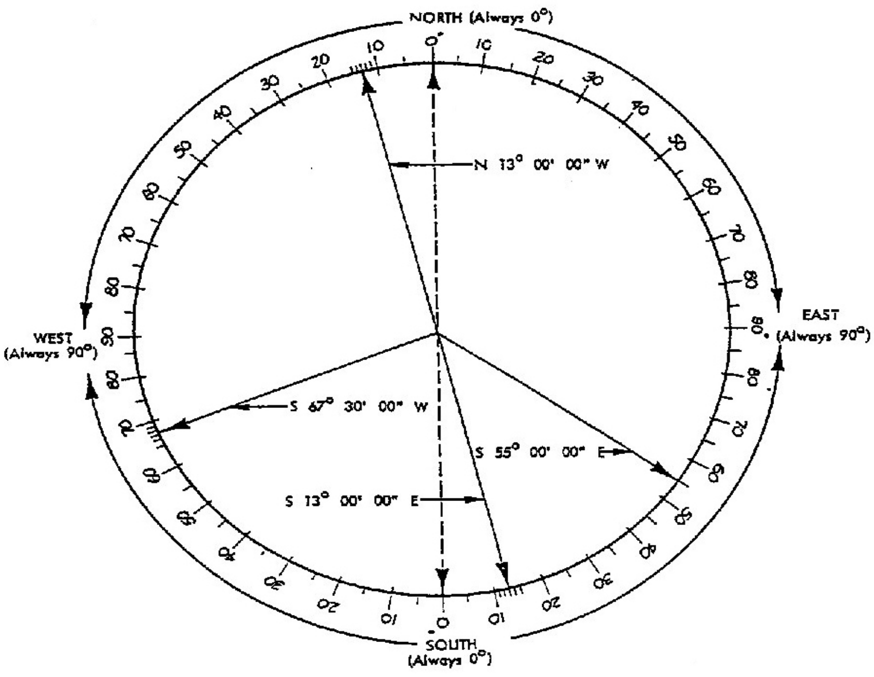
Bearings

The direction of a surveyed line is described by a bearing. Bearings are described in terms of degrees (°), minutes (') and seconds (") in relation to north or south. Bearings are taken for all straight (tangent) sections of the road. Bearings are also shown for all property lines as calculated off the centerline of the road.

To find the bearing for N 84° 30' 00" E, face North and then turn an angle of 84° 30' 00" to the East. The solid line shown as “3” is the direction of the surveyed line.



The same process holds true for other bearings:

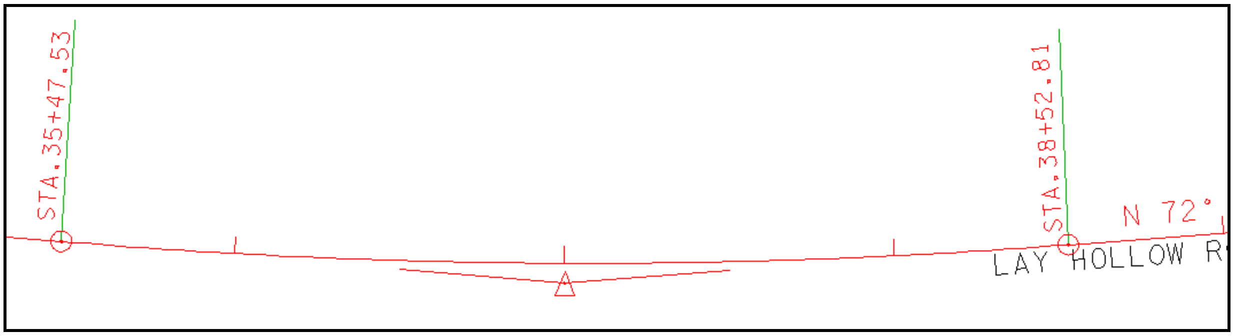


MEASURING DISTANCES

Stations

A station 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. For a station of 39+00.00 or 39 stations that means 3900 feet. Throughout this manual, stations will be shown with the plus. However, on plan sheets, the plus is not shown for the stations shown along the alignment. The plus is included on curve data, offsets etc. Station numbers get larger as you go from West to East or South to North or increasing log mile. Cross roads shall be stationed left to right looking forward along the mainline centerline. There are no negative stations. Stations are shown on all plan sheets, profiles, and cross-section sheets.

The centerline of a proposed road is shown on the plan sheets. At every even 100' station interval, there is a short tick that only extends to the left of the centerline. A long tick which extends to the left and right of the centerline is located every 500'. Look at sheet 4. Find Station 35+00.00 which is close to the end of the proposed bridge. The full tick is shown for Sta. 35+00.00 and Sta. 40+00.00 with four small ticks in between at the 100' intervals.



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.

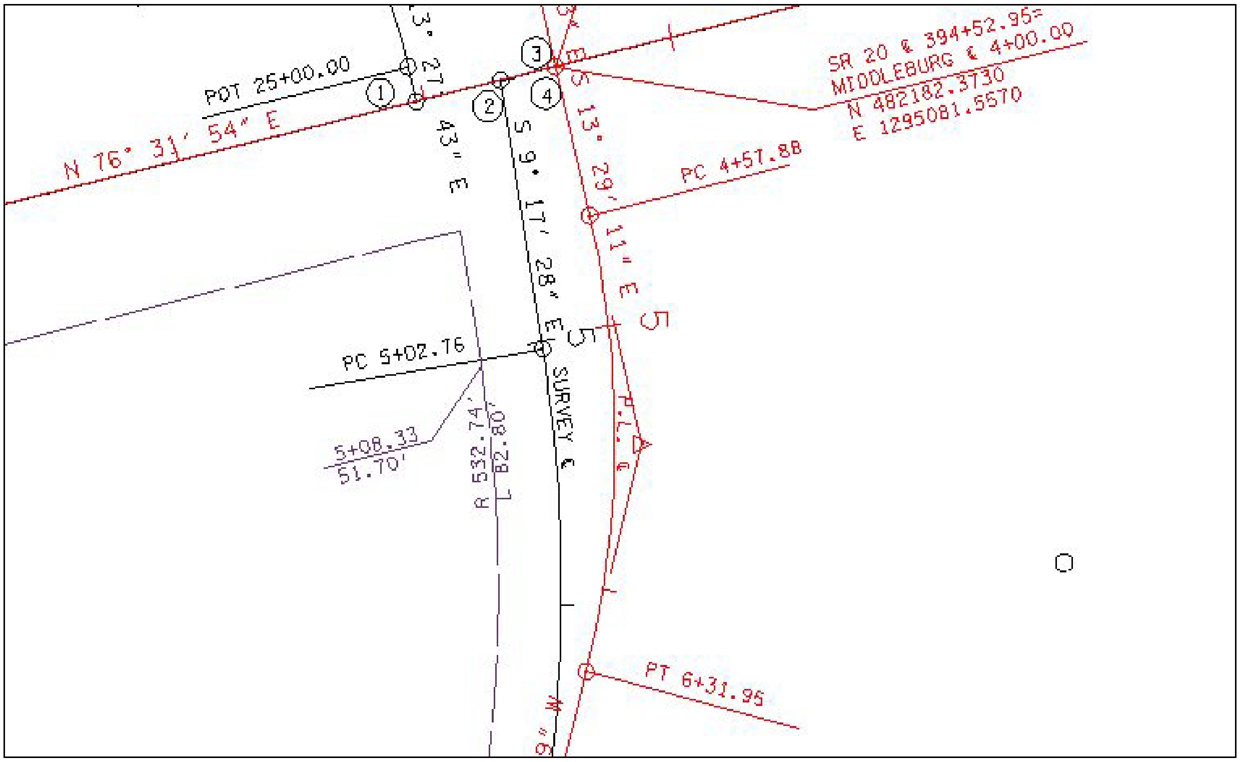
EXAMPLE: Distance between STA. 35+47.53 and STA. 38+52.81

Ignore the plus sign,	3852.81
Subtract smaller station.	-3547.53
Answer	305.28

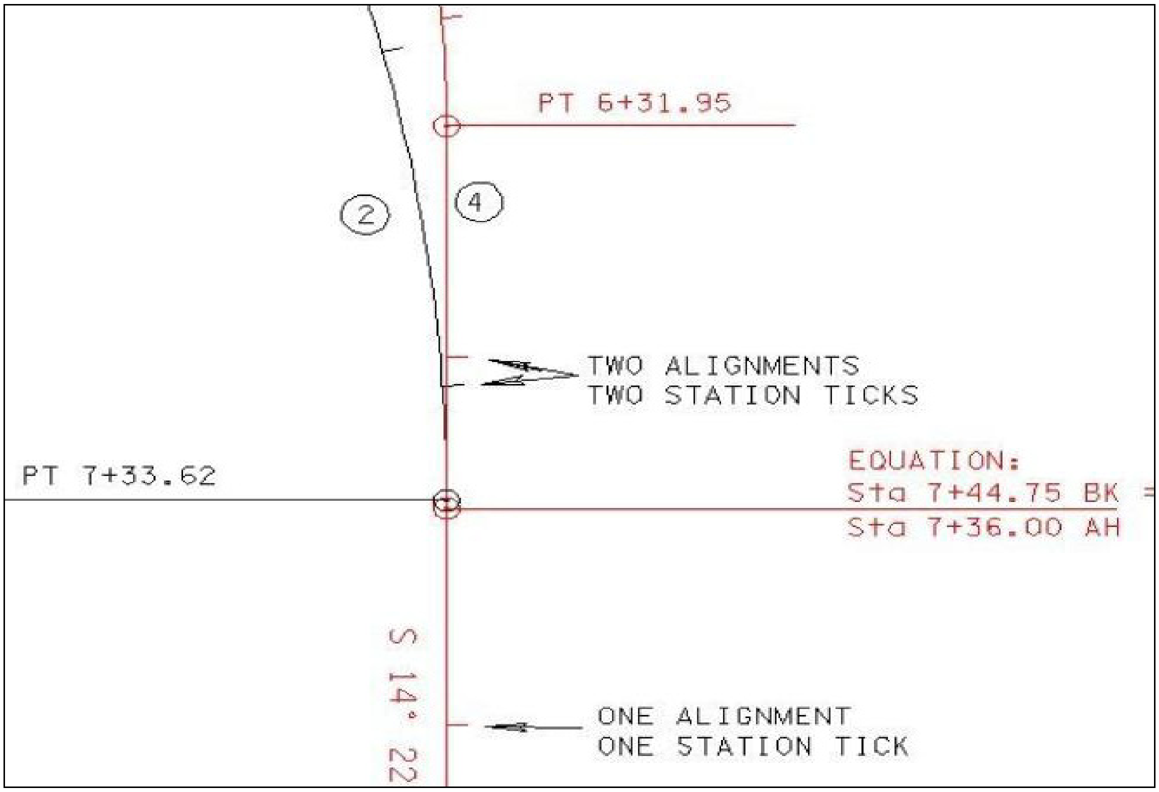
Station Equations

Station equations are not used on most jobs that have been recently surveyed because the computer software used to create coordinate geometry elements, GEOPAK, does not work well with equations. However, station equations will still be found in older jobs. Station equations are needed when only a portion of a road's centerline is being moved. We add a station equation so that there are not two stations for the same point in the area where the two centerlines meet. If an equation is used, any elements that is described by a station and offset from the centerline would not have to be edited because it would match the existing station and offset.

In the figure below, the existing centerlines of cross roads 1 and 2 do not align. As an improvement, each are moved and become 3 and 4 respectively. Middleburg Road (existing 2, proposed 4) has noticeably different alignment changes. One break in the R.O.W. line shows a station of 5+08.33 with an off set of 51.70'. This is calculated based on the new centerline for Middleburg. If the offset and station was measured from the existing, the Sta. would 5+05.68 with an offset of 25.04'. The difference between the two readings is 2.65 in stations and 26.66 from the centerline.



Once the proposed Middleburg Road centerline ties into the existing centerline, a station equation is needed so that there are not two sets of distances and offsets shown in reference to both centerlines. This would create confusion because a contractor or land surveyor wouldn't know which set of offsets and bearings were correct. So, a station equation is added. The two centerlines meet at Sta. 7+44.75 on the proposed Middleburg Road centerline and at Sta. 7+36.00 on the existing Middleburg Road centerline. The difference between these stations is 8.75'. The station equation reads "Sta. 7+44.75 BK (Back) = Sta. 7+36.00 AH (Ahead)" meaning the proposed road centerline will change from 7+44.75 to 7+36.00 from this point forward. Using the equation allows us to use one set of ticks, stations, and offsets for the remainder of the centerline.



ROADWAY ELEMENTS

This following section will describe in detail the elements that make up the roadway including horizontal and vertical alignments, the relationship of superelevation to horizontal alignments, and how all three combine to produce cross-sections.

Horizontal Alignment

The horizontal alignment of the proposed road is found on plan sheets such as present, R.O.W. details, proposed, erosion control, property maps, traffic control, etc. Many components make up the horizontal alignments including reference points, curves, and tangent sections.

Points

Points on curves (P.O.C.'s) and points on tangents (P.O.T.'s) are reference points to help assure that the roadway is constructed exactly where it is supposed to be according to coordinate location. The locations of each P.O.C. and P.O.T. often are identified by additional reference points. The first and last point on the alignment shown on will have a station and northern and eastern coordinates shown for the points. On sheet 4, the P.O.T. for Indian Creek Road centerline is at Sta. 26+20.40,
N 327385.2620, and E 1419244.7460.

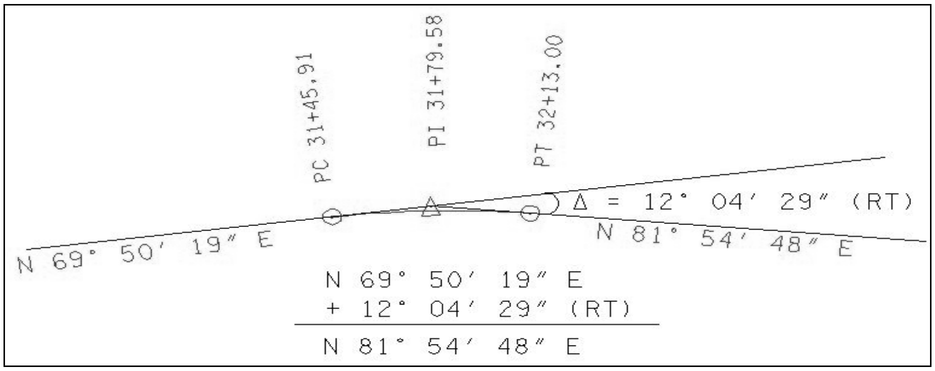
Tangents

Generally, a horizontal alignment consists of straight segments connected by curves. Tangent sections are the straight segments of the road where the bearings do not change. Tangent sections can be extremely short or long according to the radii of curves between each tangent section. Curves are needed for easy transitions into a change of direction on an alignment. It would be hard to build a road that consisted of only straight line with changes in direction that are too abrupt for the safety of the driver.

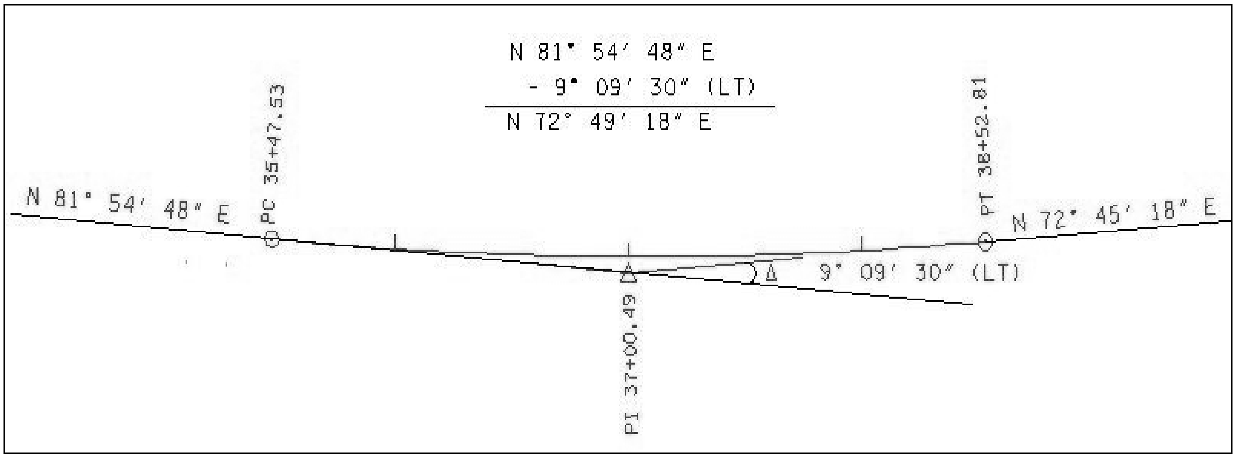
Bearings

A direction on a tangent section is called a bearing. When the road changes direction, the surveyor drives a stake in the ground at the Point of Intersection, P.I. At the P.I., the surveyor turns the transit in the direction of change and measures the angle of the change. The angle the tangent line turns to the left or right once the P.I. is reached is called the delta angle Δ. The bearing for the tangent ahead can be calculated if the back bearing and delta angle are known.

Look at sheet 4 in the plans. For Lay Hollow Road, the beginning bearing is N 69° 50' 19" E. At the P.I., the direction changes to the right so the delta angle should be added to the first bearing.

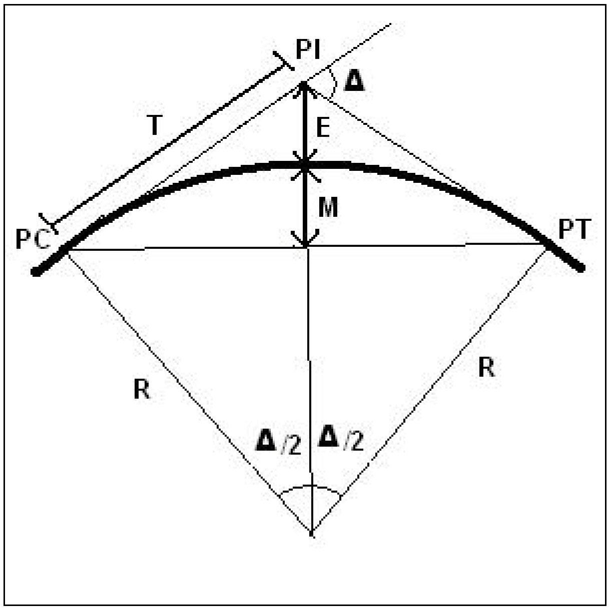


If the angle turned to the left, the delta angle would be subtracted. Look at the second curve on sheet 4. Using the delta angle given in the curve data, calculate the bearing after the P.I.



Curves

A curve is made up of several components. The point where the curve begins is referred to as the Point of Curvature (P.C.). The point where the curve ends is referred to as the Point of Tangency (P.T.). Each is easily identified on the horizontal alignment represented by a circle and text identifying the station where each occurs. The curve length is the distance measured along the curve from P.C. to P.T. The tangent length (T) represents equal distances from P.C. to P.I. and from P.I. to P.T. The radius (R) of the curve represents the distance from the P.I. to the edge of the circle. The radius (R) is always perpendicular to the P.C. and P.T. If a line representing the length of the radius is drawn perpendicular from the P.C and P.T. points, the two lines would intersect as shown below. The angle between these two lines would be the intersection angle or delta angle. M is the middle ordinate and measures the distance from the midpoint of a straight line between the P.C. and P.T. and the midpoint of curve.



Calculations for the tangent of a curve is

$$T = R\tan\left(\frac{\Delta}{2}\right)$$

The smallest distance between the P.I. and the vertex of the curve is the external distance, E. This distance can be easily calculated by using the property of right triangles with *T* and *R*.

$$E = R\left(\frac{1}{\cos\left(\frac{\Delta}{2}\right)} - 1\right)$$

Similarly, the middle ordinate *M* can be found.

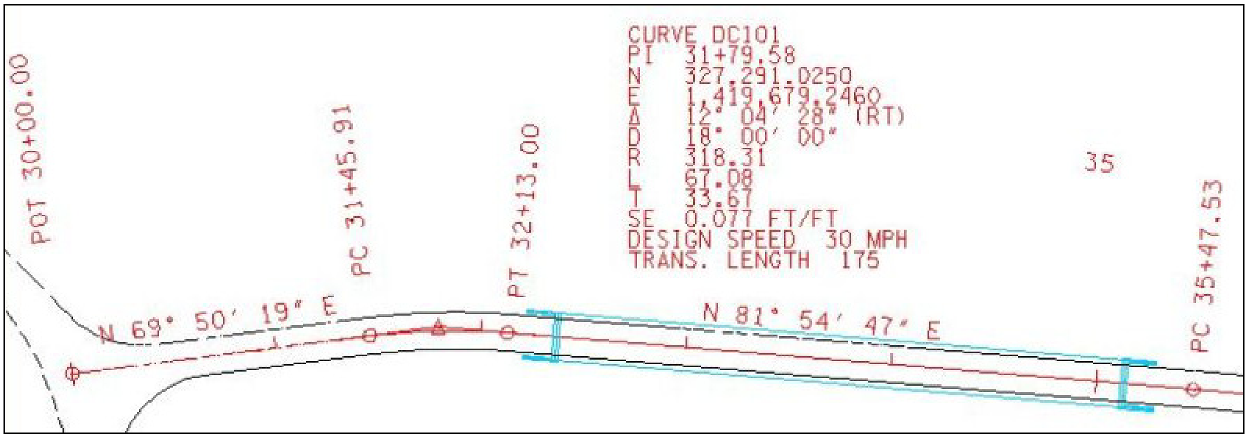
$$M = R\left(1 - \cos\left(\frac{\Delta}{2}\right)\right)$$

Curve length, L, can be determined using the formula for semicircle length.

$$L = \frac{R\Delta\pi}{180}$$

On sheet 4, the beginning point for Lay Hollow Road is at the intersection of Indian Creek Road and Lay Hollow Road at Sta. 30+00.00. The end point for the Lay Hollow Road alignment is at Sta. 40+00.00. The Northern and Eastern coordinates are given for each point.

The horizontal alignment for Lay Hollow Road has two curves; thus, there will be two P.I.'s. For the first curve, the P.I. is at Sta. 31+79.58. The station and coordinate readout for the P.I. is shown in the curve data. On the plans, the P.I. is represented by a triangle. The beginning of the first curve is at the P.C. Sta. 31+45.91. The curve ends at P.T. Sta. 32+13.00.



Using the curve data shown, check the length. First, the delta angle Δ needs to be changed to decimal format.

$$12 + \frac{04}{60} + \frac{28}{60*60} = 12.07444$$

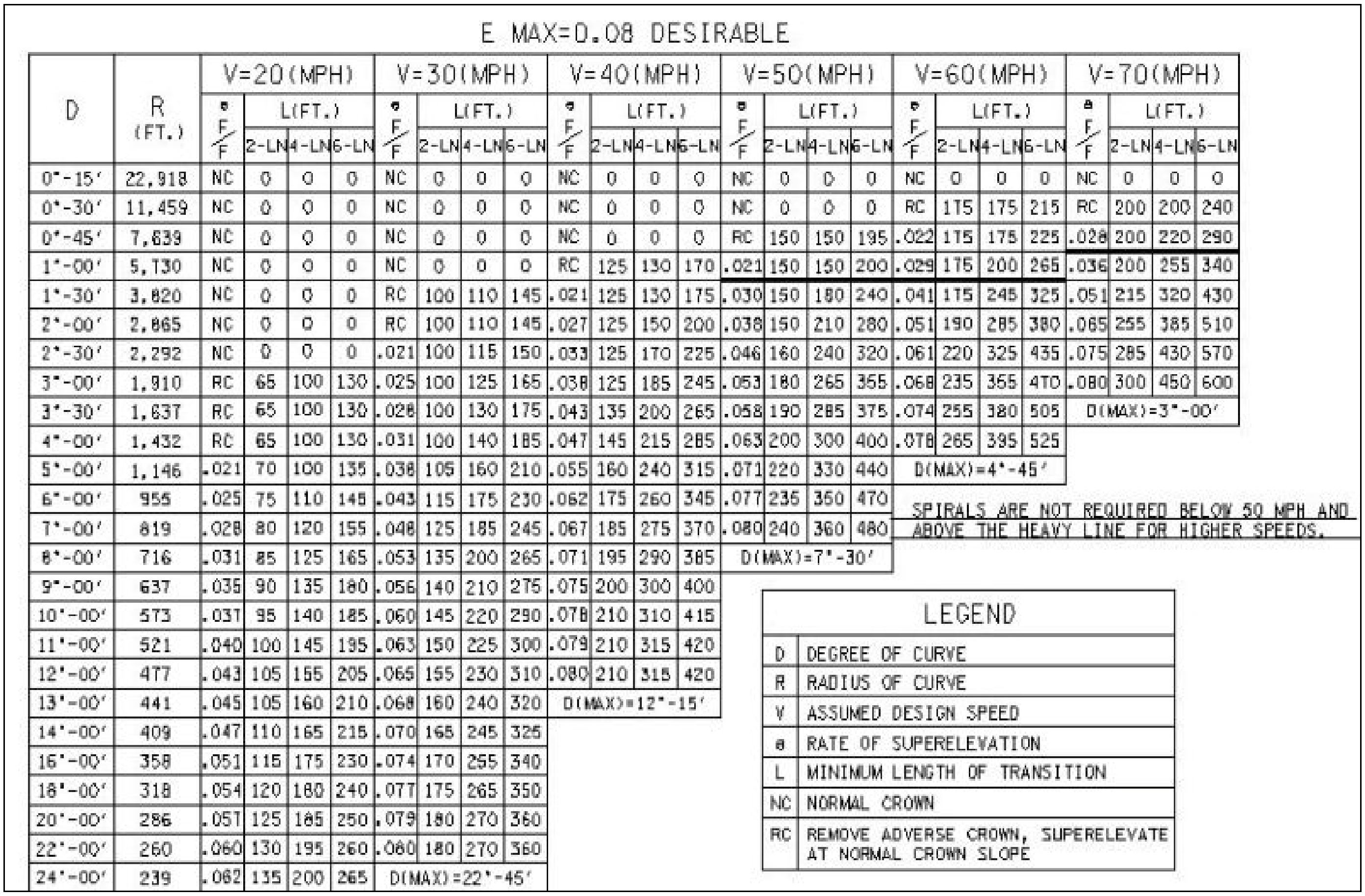
The Length was given as $L = \frac{R\Delta\pi}{180}$

$$L = \frac{318.31 * 12.07444 * 3.1416}{180} = 67.08$$ which matches the curve data.

On a high speed road, the curves need to be as flat as possible with larger radii and longer transition lengths going into and coming out of the curve. For low design speeds, the curves are usually sharper. There is an inverse relationship between the degree of curvature and radius. As the degree of curvature increases, the radius gets smaller producing a sharper curve. The degree of curvature is expressed as

$$D= \frac{5730}{R}$$

Degree of Curvature and its relationship with radii, speeds, and superelevation can be found in Roadway Standard Drawings for superelevation: RD01-SE-2 (Urban Superelevation Rates) and RD01-SE-3 (Rural Superelevation Rates). The sample project is in a rural area so we will use Roadway Standard Drawing RD01-SE-3. From the table, the Degree of Curve for various speeds can be found. Notice that as speeds get higher, the available options for D and R are reduced. For example, at a speed of 30 M.P.H., the maximum degree is 22^{o} 45’00” with a radius of 239. There are twenty-five options for 30 M.P.H. At a higher speed of 70 M.P.H., the maximum degree decreases to 3^{o} 00’00” with a larger radius of 1,637.0 but there are only nine options. This is because of the higher speeds requiring only the larger, flatter radii.



E MAX=0.08 DESIRABLE

D	R (FT.)	V=20(MPH)				V=30(MPH)				V=40(MPH)				V=50(MPH)				V=60(MPH)				V=70(MPH)			
		e F/F	L(FT.)			e F/F	L(FT.)			e F/F	L(FT.)			e F/F	L(FT.)			e F/F	L(FT.)			e F/F	L(FT.)		
			2-LN	4-LN	6-LN		2-LN	4-LN	6-LN		2-LN	4-LN	6-LN		2-LN	4-LN	6-LN		2-LN	4-LN	6-LN		2-LN	4-LN	6-LN
0°-15′	22,918	NC	0	0	0	NC	0	0	0	NC	0	0	0	NC	0	0	0	NC	0	0	0	NC	0	0	0
0°-30′	11,459	NC	0	0	0	NC	0	0	0	NC	0	0	0	NC	0	0	0	RC	175	175	215	RC	200	200	240
0°-45′	7,639	NC	0	0	0	NC	0	0	0	NC	0	0	0	RC	150	150	195	.022	175	175	225	.028	200	220	290
1°-00′	5,730	NC	0	0	0	NC	0	0	0	RC	125	130	170	.021	150	150	200	.029	175	200	265	.036	200	255	340
1°-30′	3,820	NC	0	0	0	RC	100	110	145	.021	125	130	175	.030	150	180	240	.041	175	245	325	.051	215	320	430
2°-00′	2,865	NC	0	0	0	RC	100	110	145	.027	125	150	200	.038	150	210	280	.051	190	285	380	.065	255	385	510
2°-30′	2,292	NC	0	0	0	.021	100	115	150	.033	125	170	225	.046	160	240	320	.061	220	325	435	.075	285	430	570
3°-00′	1,910	RC	65	100	130	.025	100	125	165	.038	125	185	245	.053	180	265	355	.068	235	355	4TO	.080	300	450	600
3°-30′	1,637	RC	65	100	130	.028	100	130	175	.043	135	200	265	.058	190	285	375	.074	255	380	505	D(MAX)=3°-00′			
4°-00′	1,432	RC	65	100	130	.031	100	140	185	.047	145	215	285	.063	200	300	400	.078	265	395	525				
5°-00′	1,146	.021	70	100	135	.038	105	160	210	.055	160	240	315	.071	220	330	440	D(MAX)=4°-45′							
6°-00′	955	.025	75	110	145	.043	115	175	230	.062	175	260	345	.077	235	350	470								
7°-00′	819	.028	80	120	155	.048	125	185	245	.067	185	275	370	.080	240	360	480								
8°-00′	716	.031	85	125	165	.053	135	200	265	.071	195	290	385	D(MAX)=7°-30′											
9°-00′	637	.035	90	135	180	.056	140	210	275	.075	200	300	400												
10°-00′	573	.037	95	140	185	.060	145	220	290	.078	210	310	415												
11°-00′	521	.040	100	145	195	.063	150	225	300	.079	210	315	420												
12°-00′	477	.043	105	155	205	.065	155	230	310	.080	210	315	420												
13°-00′	441	.045	105	160	210	.068	160	240	320	D(MAX)=12°-15′															
14°-00′	409	.047	110	165	215	.070	165	245	325																
16°-00′	358	.051	115	175	230	.074	170	255	340																
18°-00′	318	.054	120	180	240	.077	175	265	350																
20°-00′	286	.057	125	185	250	.079	180	270	360																
22°-00′	260	.060	130	195	260	.080	180	270	360																
24°-00′	239	.062	135	200	265	D(MAX)=22°-45′																			

SPIRALS ARE NOT REQUIRED BELOW 50 MPH AND ABOVE THE HEAVY LINE FOR HIGHER SPEEDS.

LEGEND

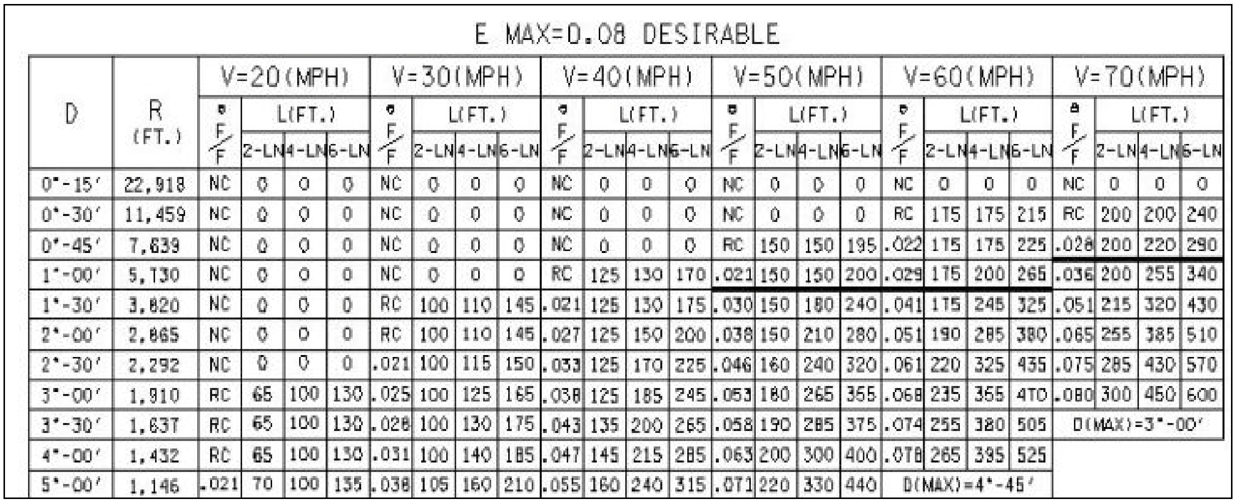
D	DEGREE OF CURVE
R	RADIUS OF CURVE
V	ASSUMED DESIGN SPEED
e	RATE OF SUPERELEVATION
L	MINIMUM LENGTH OF TRANSITION
NC	NORMAL CROWN
RC	REMOVE ADVERSE CROWN, SUPERELEVATE AT NORMAL CROWN SLOPE

Superelevation

Superelevation (banking) is the rotation of the pavement on the approach to and through a horizontal curve. Superelevation is intended to assist the driver by counteracting the lateral acceleration produced by tracking the curve. If a roadway is superelevated, one of the outside edges of the roadway is higher than one of the inside edges at the centerline where rotation occurs. The roadway surface slopes down from the outside edge to the inside edge instead of sloping from the centerline out.

Although the curves on vertical and horizontal alignments are independent of each other, the relationship to superelevation is plotted on the profile so that the contractor can see what is going on in both perspectives. Look at Sheet 4C to see the superelevation at the bottom of the profile. The cross slopes for the left and right sides of the road are shown at each fifty foot interval.

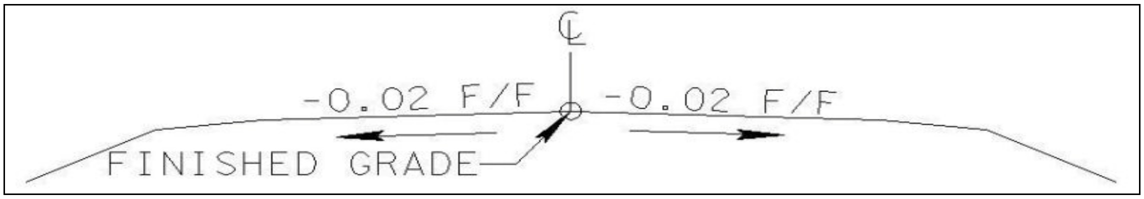
The superelevation rate increases as curves get sharper. Superelevation is abbreviated with an "e" in the table and has units of foot per foot (F/F). From the superelevation table below, notice that the largest super rates are at the bottom of each speed column.



E MAX=0.08 DESIRABLE

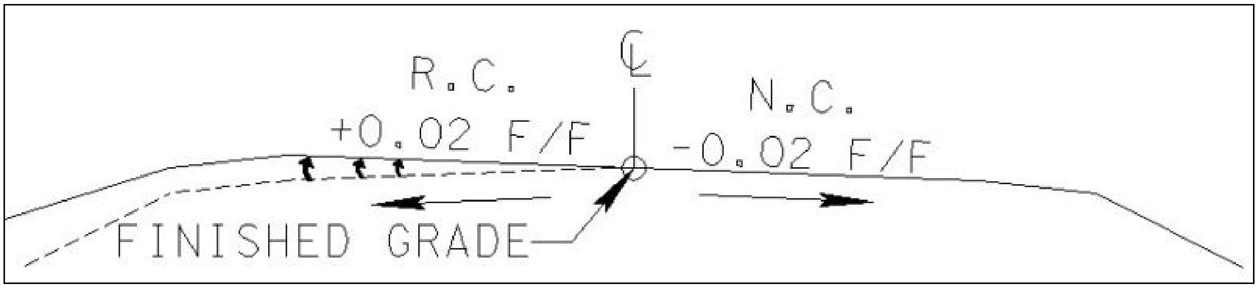
D	R (FT.)	V=20(MPH)				V=30(MPH)				V=40(MPH)				V=50(MPH)				V=60(MPH)				V=70(MPH)			
		e F/F	L(FT.)			e F/F	L(FT.)			e F/F	L(FT.)			e F/F	L(FT.)			e F/F	L(FT.)			e F/F	L(FT.)		
			2-LN	4-LN	6-LN		2-LN	4-LN	6-LN		2-LN	4-LN	6-LN		2-LN	4-LN	6-LN		2-LN	4-LN	6-LN		2-LN	4-LN	6-LN
0°-15′	22,918	NC	0	0	0	NC	0	0	0	NC	0	0	0	NC	0	0	0	NC	0	0	0	NC	0	0	0
0°-30′	11,459	NC	0	0	0	NC	0	0	0	NC	0	0	0	NC	0	0	0	RC	175	175	215	RC	200	200	240
0°-45′	7,639	NC	0	0	0	NC	0	0	0	NC	0	0	0	RC	150	150	195	.022	175	175	225	.028	200	220	290
1°-00′	5,730	NC	0	0	0	NC	0	0	0	RC	125	130	170	.021	150	150	200	.029	175	200	265	.036	200	255	340
1°-30′	3,820	NC	0	0	0	RC	100	110	145	.021	125	130	175	.030	150	180	240	.041	175	245	325	.051	215	320	430
2°-00′	2,865	NC	0	0	0	RC	100	110	145	.027	125	150	200	.038	150	210	280	.051	190	285	380	.065	255	385	510
2°-30′	2,292	NC	0	0	0	.021	100	115	150	.033	125	170	225	.046	160	240	320	.061	220	325	435	.075	285	430	570
3°-00′	1,910	RC	65	100	130	.025	100	125	165	.038	125	185	245	.053	180	265	355	.068	235	355	470	.080	300	450	600
3°-30′	1,637	RC	65	100	130	.028	100	130	175	.043	135	200	265	.058	190	285	375	.074	255	380	505	D(MAX)=3°-00′			
4°-00′	1,432	RC	65	100	130	.031	100	140	185	.047	145	215	285	.063	200	300	400	.078	265	395	525				
5°-00′	1,146	.021	70	100	135	.038	105	160	210	.055	160	240	315	.071	220	330	440	D(MAX)=4°-45′							

When a segment of road is in a tangent section or a curve that is so flat that superelevation is not needed, the road is said to be at Normal Crown (denoted as NC in the table). The slopes are both -0.02 F/F and fall on each side of centerline as shown below:



The largest radius shown is 22,918' which reads normal crown for all speeds and lanes.

Other curves require enough superelevation to make the road on one side of the centerline have same cross slope direction as the other side of the road which has normal crown. In other words, one side of the road is superelevated to a rate of +0.02 F/F while the other side remains at normal crown at a rate of -0.02 F/F. This amount of superelevation is referred to as Reverse (or Remove) Crown It is labeled R.C. in the superelevation tables.



For the sample project, there are two curves. Look at the curve information for the second curve on sheet 4. The degree of curvature is 3^{o} 00’ 00”, speed is 30 M.P.H, and from the typical sections, we know we have a two lane road. Using these parameters, look up the super rate on the table shown on the previous page. It reads 0.025 F/F. This information is also in the curve data. From the plans and the way the curve rotates, we can see that the most banking occurs on the right side of the road. This means that the right side of the road will start rotating before the left because more rotation is required on the right side. This station for rotation will be calculated below. The length it takes for full rotation from normal crown cross slope of -0.02 F/F to the superelevation cross slope of 0.025 F/F is called the transition length, L. For a two lane road, the table shows a transition length of 100’ is needed for the curve to reach full super. The 100’ of transition will be equally divided on each side of the P.C. This is usually the case unless there isn’t enough length for this to occur and the transition lengths have to be adjusted or shifted.

For the next superelevation calculations, refer to superelevation cross-section sheets 100 and 101 which are provided for illustration only and are not part of the contract plans.

P.C. Station – (1/2) Transition Length = Last station for Normal crown.

3547.53 – 50 = 3497.53 Rotation for the right side will start after this station.

P.C. Station + (1/2) Transition Length = Full super station.

3547.53 + 50 = 3597.53

At this point, we know where the rotation starts on the right and the station where full super starts on both sides. To find the station where rotation begins on the left side of the road, the transition rate for the curve must be calculated using the change in cross slope and transition length. The largest change in cross slope should be used to find the transition rate. The most change occurs on the right side of the road which goes from a - 0.02 F/F to + 0.025 F/F. This is a total change of 0.045 F/F.

$$\text{Transition Rate} = \frac{\text{Total Change in Cross Slope (on right)}}{\text{Transition Length}}$$

$$= \frac{0.025 - (-)\ 0.020}{100} = \frac{0.045}{100} = 0.00045$$

For the left side of the road, less length is needed for the transition because the left side goes from -0.02 F/F to -0.02 F/F5 for a change of only 0.005 F/F. The same equation is used but the calculated transition rate is used to calculate the transition length for the left side.

$$\text{Transition Length} = \frac{\text{Total Change in Cross Slope (on left)}}{\text{Transition Rate}}$$

$$\text{Length} = \frac{-\ 0.025 - (-)\ 0.020}{0.00045} = -\frac{0.005}{0.00045} = -\ 11.11$$

Full Super Station – Calculated Transition Length
Rotation for the left side will **start** after this station.
Both travel lanes are sloping in same direction.

$$3597.53 - 11.11 = 3586.42$$

At Sta. 3586.42, both sides of the road rotate together until full super is reached. Rotation for both sides of the road begins when the right side is equal to the left, with the left being -0.02 F/F and the right being +0.02 F/F. To verify this, look at the previous equation from a different thought process. The length of 11.11' was found with the transition rate and a change of 0.005 F/F. This means there only remains 0.005 F/F of cross slope left before full super is reached.

Full super rate – remaining cross slope = rate for right side

$$0.025 - 0.005 = 0.002 \text{ on right side}$$

The transition rate can be used to calculate a cross slope and find the station corresponding with this cross slope. One station that is commonly calculated by a roadway designer is the station where one side reaches 0.00%. This would be an area where ponding might occur and a catch basin could be added within in a curb and gutter section or special attention could be paid to the vertical grade in this section to ensure proper drainage. To find the station where 0.00% is reached on the right side, use the previous calculations.

$$\text{Length} = \frac{-\ 0.025 - 0.00}{0.00045} = \frac{-\ 0.025}{0.00045} = -55.55'$$

Full Super Station – Calculated Transition Length (for 0% cross slope)

3597.53 – 55.55 = 3541.98

Calculations for remainder of curve with P.T. Notice that the functions have reversed; minuses are now pluses and vise versa.

P.T. Station – (1/2) Transition Length = Last Full super station

3852.81 – 50 = 3802.81

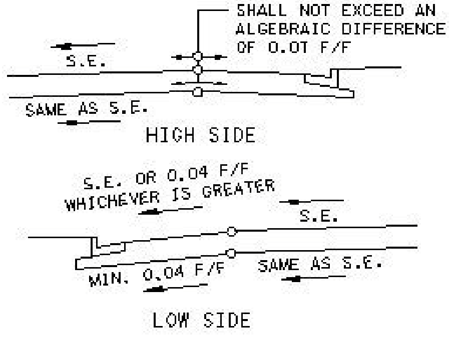
P.T. Station + (1/2) Transition Length =First station for N.C. on right side

3852.81 + 50 = 3902.81

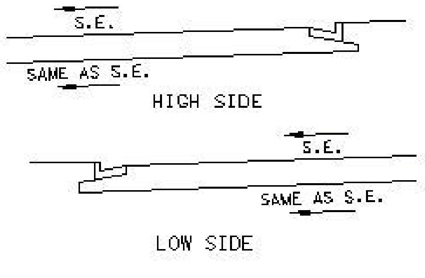
Full Super Station + Calculated Transition Length (for 0% cross slope)

3802.81 + 55.55 = 3858.36

Shoulders are handled a little differently than the traveled way on superelevated sections. Look at the superelevated typical section on Sheet 2B. Notice the note about the shoulders "algebraic difference between the superelevation cross slope and the cross slope of the outside shoulder should not exceed 0.07 F/F." On superelevated sections, if the superelevation cross slope is too steep, the cross slope of the outside shoulder should be flattened to decrease the difference. To find the maximum shoulder cross slope, subtract the superelevation cross slope from 0.07 F/F. For example, if the superelevation cross slope is 0.025 F/F, the maximum shoulder cross slope is 0.07F/F. minus 0.025F/F = 0.045 F/F. One the left below are the details for superelevation on a curb and gutter section for the high and low side of the shoulders. The detail on the right is used when a shoulder is built that may be striped as a traffic lane in the future.



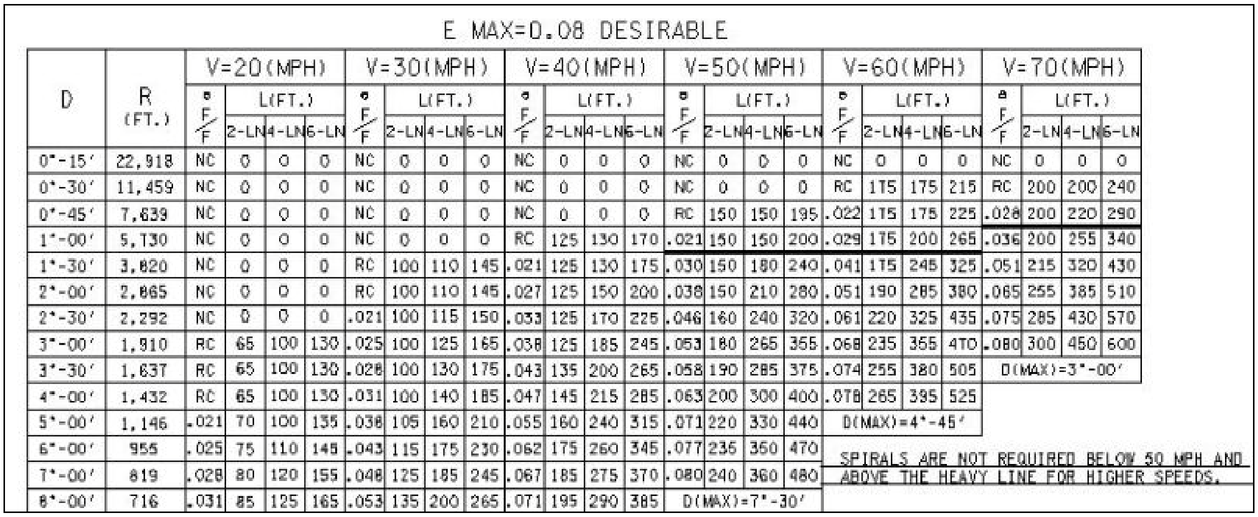
SUPERELEVATION DETAIL FOR SHOULDERS



SUPERELEVATION DETAIL FOR SHOULDERS
(WHERE SHOULDERS MAY BE USED AS A THROUGH TRAFFIC LANE IN THE FUTURE)

Spiral Transitions

For high-speed roads with sharp curves, the plans sometimes show spiral transitions at the beginning and end of circular curves. Spiral transitions permit cars to gradually ease into circular curves without a sharp break from the tangent section. Roadway Standard Drawing RD01-SE-3 shows specific speeds and radii that require spirals. As shown on the drawing, spirals are not required for any speed below 50 M.P.H. For the speeds of 50 M.P.H. or higher, spirals are not required above the heavy lines shown.

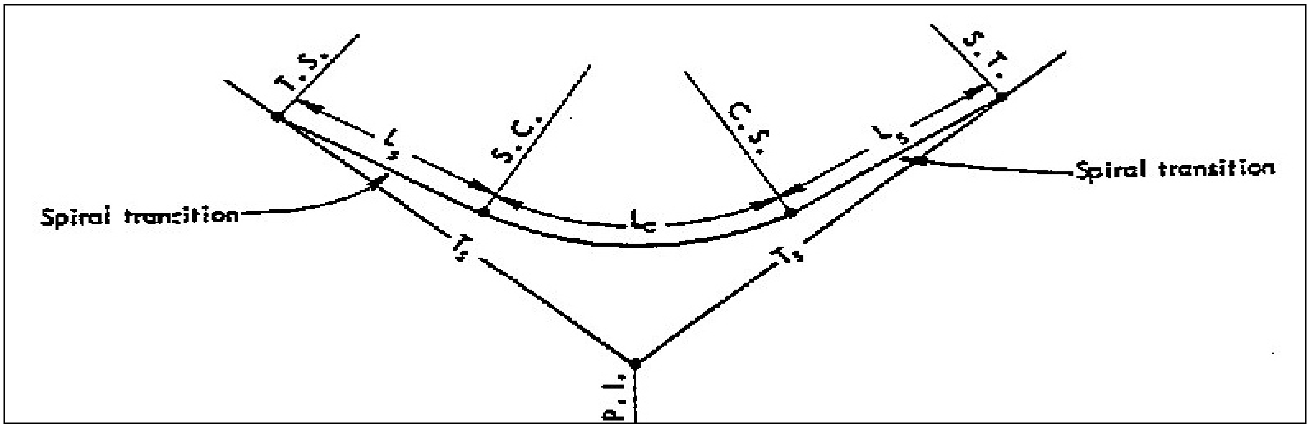


E MAX=0.08 DESIRABLE

D	R (FT.)	V=20(MPH)				V=30(MPH)				V=40(MPH)				V=50(MPH)				V=60(MPH)				V=70(MPH)			
		e F/F	L(FT.)			e F/F	L(FT.)			e F/F	L(FT.)			e F/F	L(FT.)			e F/F	L(FT.)			e F/F	L(FT.)		
			2-LN	4-LN	6-LN		2-LN	4-LN	6-LN		2-LN	4-LN	6-LN		2-LN	4-LN	6-LN		2-LN	4-LN	6-LN		2-LN	4-LN	6-LN
0°-15′	22,918	NC	0	0	0	NC	0	0	0	NC	0	0	0	NC	0	0	0	NC	0	0	0	NC	0	0	0
0°-30′	11,459	NC	0	0	0	NC	0	0	0	NC	0	0	0	NC	0	0	0	RC	175	175	215	RC	200	200	240
0°-45′	7,639	NC	0	0	0	NC	0	0	0	NC	0	0	0	RC	150	150	195	.022	175	175	225	.028	200	220	290
1°-00′	5,730	NC	0	0	0	NC	0	0	0	RC	125	130	170	.021	150	150	200	.029	175	200	265	.036	200	255	340
1°-30′	3,820	NC	0	0	0	RC	100	110	145	.021	125	130	175	.030	150	180	240	.041	175	245	325	.051	215	320	430
2°-00′	2,865	NC	0	0	0	RC	100	110	145	.027	125	150	200	.038	150	210	280	.051	190	285	380	.065	255	385	510
2°-30′	2,292	NC	0	0	0	.021	100	115	150	.033	125	170	225	.046	160	240	320	.061	220	325	435	.075	285	430	570
3°-00′	1,910	RC	65	100	130	.025	100	125	165	.038	125	185	245	.053	180	265	355	.068	235	355	470	.080	300	450	600
3°-30′	1,637	RC	65	100	130	.028	100	130	175	.043	135	200	265	.058	190	285	375	.074	255	380	505	D(MAX)=3°-00′			
4°-00′	1,432	RC	65	100	130	.031	100	140	185	.047	145	215	285	.063	200	300	400	.078	265	395	525				
5°-00′	1,146	.021	70	100	135	.036	105	160	210	.055	160	240	315	.071	220	330	440	D(MAX)=4°-45′							
6°-00′	955	.025	75	110	145	.043	115	175	230	.062	175	260	345	.077	235	360	470								
7°-00′	819	.028	80	120	155	.048	125	185	245	.067	185	275	370	.080	240	360	480								
8°-00′	716	.031	85	125	165	.053	135	200	265	.071	195	290	385	D(MAX)=7°-30′											

SPIRALS ARE NOT REQUIRED BELOW 50 MPH AND ABOVE THE HEAVY LINE FOR HIGHER SPEEDS.

A circular curve with spiral transitions looks something like this



Notice that there is no P.C. or P.T. Instead, the symbols have these meanings:

T.S. -- Tangent to Spiral

S.C. -- Spiral to Curve

C.S. -- Curve to Spiral

S.T. -- Spiral to Tangent

Ls -- Length of Spiral.

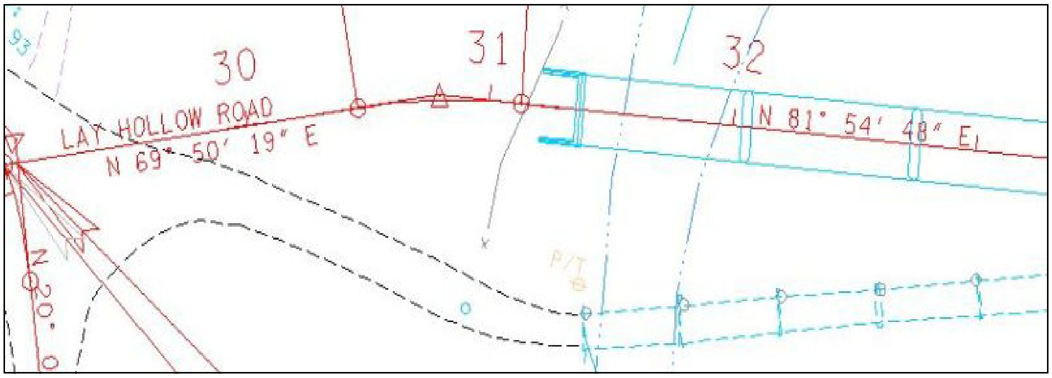
Lc -- Length of Circular Curve

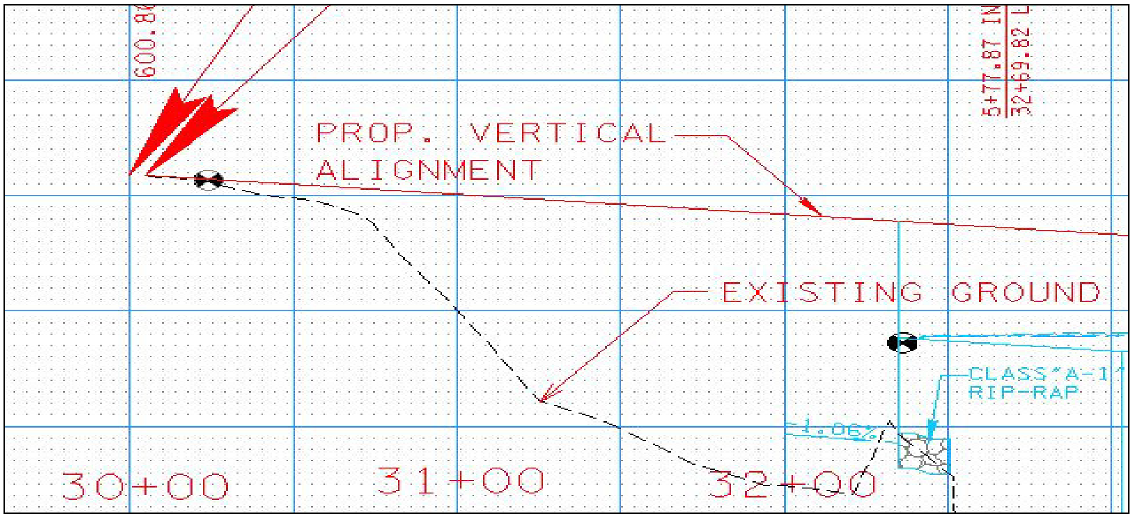
Ts -- Tangent Length (Spiral Curve)

VERTICAL ALIGNMENT

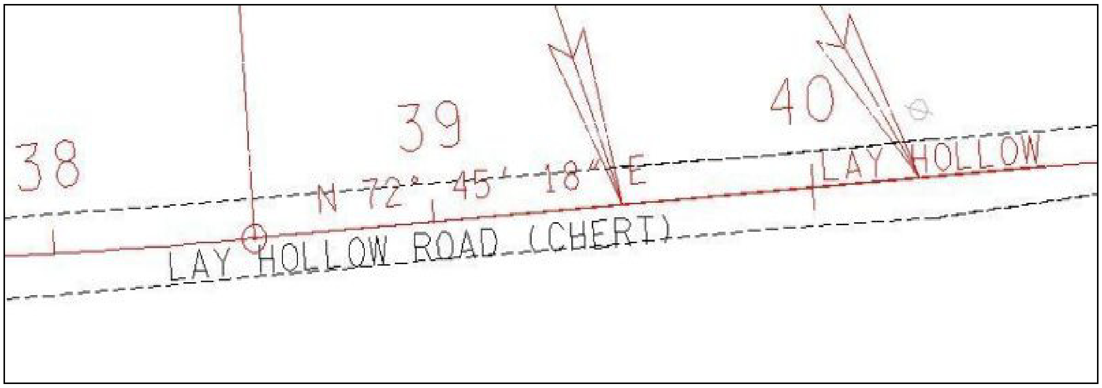
Vertical alignment is the relationship of roadway elevations to a horizontal alignment centerline. Once a horizontal alignment is placed, elevations are taken at every change in grade along the horizontal alignment. Each of these elevations is combined to plot an existing ground profile of the proposed road. The profile is plotted on a grid. The grid consists of stations corresponding to the horizontal alignment and also has elevations for plotting the vertical alignment points. The proposed vertical alignment or finished grade line is a representation of the elevations of the proposed roadway. Elevations of the finished 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 finished grade line elevations.

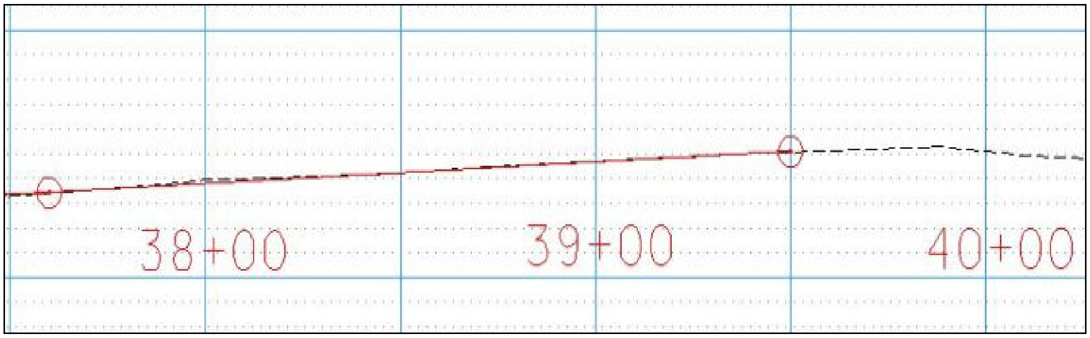
Turn to sheets 4 and 4C in your plans. Look on your plans at the station range as shown below (30+00 thru 32+00). Notice that the proposed horizontal alignment on the present layout has been shifted north of the existing. At Indian Creek, the existing and proposed centerlines are seventy feet apart. Because the proposed centerline is in terrain where no existing road is, the profile is extremely irregular. This is to be expected when a new centerline is laid in an area where no road presently exists.





Now, look on your plans at the station range shown below (38+00 thru 40+00). Notice that the proposed horizontal alignment on the present layout has been shifted back to the existing road between the edges of pavement. Because the proposed centerline is now located where the existing is, the profile is smooth without numerous grade changes. Since we are nearing the end of the project and end of construction, the proposed vertical alignment follows the existing profile for a smooth tie.



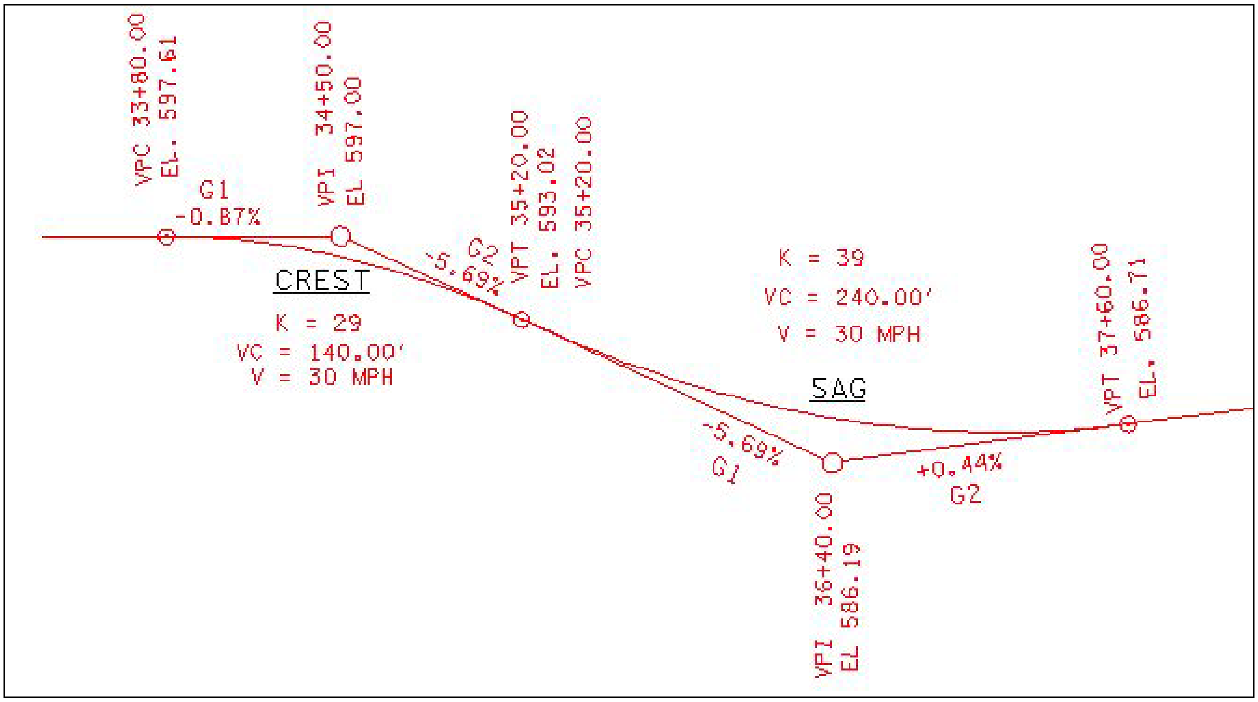


Vertical Curves

Vertical curves are the curved portions on the profile. Vertical curves are either downhill curves called sags or uphill curves called crest. There is NO relationship between a horizontal curve on the plan view and a vertical curve as shown on the profile view. A road may have a horizontal curve where there is a vertical curve, or it may not and vice versa.

Look at sheet 4C. Notice that there are similarities in the naming convention of vertical and horizontal curves. There is a point of curvature, point of intersection and point of tangency for vertical curves just like horizontal curves but the terminology for the vertical curves adds a "V" to the initials each. A vertical alignment may also have tangent sections between the curves. These tangent sections are grades and are shown as G_1 and G_2 below. Grade One (G_1) is the grade coming into the curve and Grade Two (G_2) is the grade coming out of the curve. For the curves on this project, there is no tangent section between crest curve (curve 1) and sag curve (curve 2). The

V.P.T. station of curve 1 is the same station as the V.P.C. of curve 2. The vertical points are also labeled with an elevation



There are several parameters used when designing a vertical curve. The maximum and minimum grades, stopping sight distance, and passing sight distance are all in each roadway standard drawing for each type of road. For this project, the standard is RD01-TS-1, Design Standards for Local Roads and Streets. The values in the T.D.O.T. tables are from the book AASHTO (American Association of State Highway and Transportation Officials) Geometric Design of Highways and Streets. From the table, the maximum grade for the three types of terrain is listed. Another important factor shown in the table is the K value for stopping and passing sight distance. The K value is the desired length of a curve per unit change in grade. The required curve length is determined by G1, G2, and the necessary K value for the curve. The following table is from RD01-TS-1. The entries for Maximum Rural Grades through Minimum K Value for Crest Vertical Curve correspond to vertical curve constraints. The last entry, superelevation is related to the horizontal alignment. Look at the column for 30 M.P.H. which is the design speed for Lay Hollow Road. Notice the maximum rural grades for each type of terrain as well as the K values for crest and sag curves.

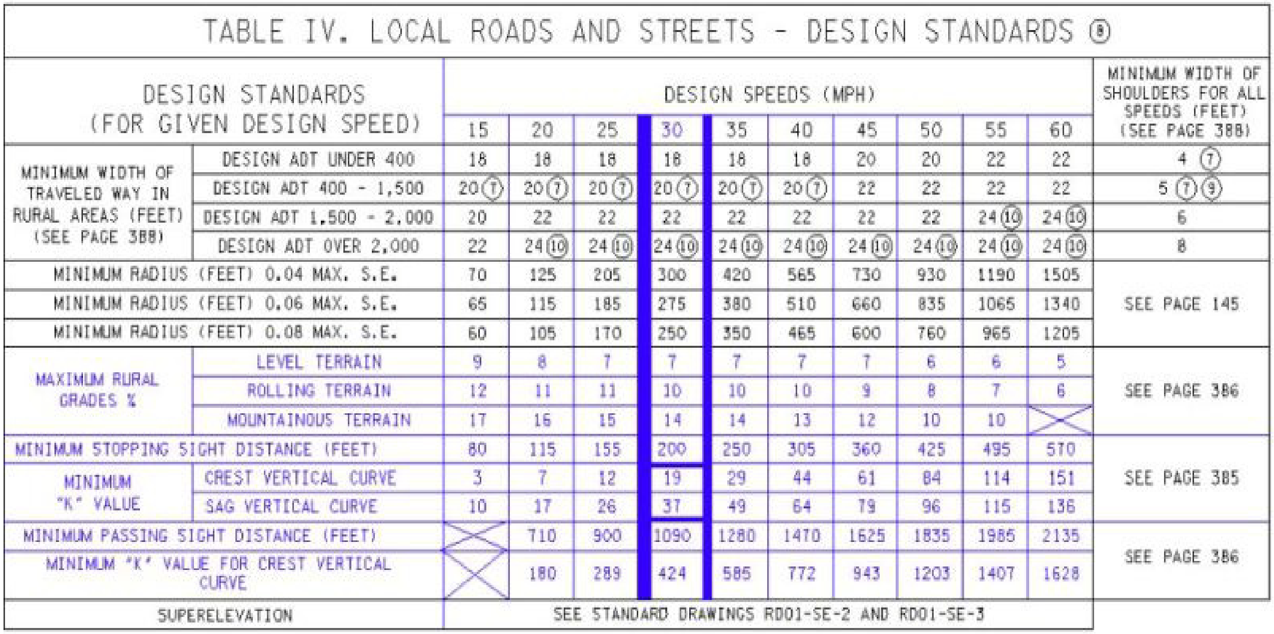


TABLE IV. LOCAL ROADS AND STREETS - DESIGN STANDARDS ⑧

DESIGN STANDARDS (FOR GIVEN DESIGN SPEED)		DESIGN SPEEDS (MPH)										MINIMUM WIDTH OF SHOULDERS FOR ALL SPEEDS (FEET) (SEE PAGE 388)
		15	20	25	30	35	40	45	50	55	60	
MINIMUM WIDTH OF TRAVELED WAY IN RURAL AREAS (FEET) (SEE PAGE 388)	DESIGN ADT UNDER 400	18	18	18	18	18	18	20	20	22	22	4 ⑦
	DESIGN ADT 400 - 1,500	20⑦	20⑦	20⑦	20⑦	20⑦	20⑦	22	22	22	22	5 ⑦⑨
	DESIGN ADT 1,500 - 2,000	20	22	22	22	22	22	22	22	24⑩	24⑩	6
	DESIGN ADT OVER 2,000	22	24⑩	24⑩	24⑩	24⑩	24⑩	24⑩	24⑩	24⑩	24⑩	8
MINIMUM RADIUS (FEET) 0.04 MAX. S.E.		70	125	205	300	420	565	730	930	1190	1505	SEE PAGE 145
MINIMUM RADIUS (FEET) 0.06 MAX. S.E.		65	115	185	275	380	510	660	835	1065	1340	
MINIMUM RADIUS (FEET) 0.08 MAX. S.E.		60	105	170	250	350	465	600	760	965	1205	
MAXIMUM RURAL GRADES %	LEVEL TERRAIN	9	8	7	7	7	7	7	6	6	5	SEE PAGE 386
	ROLLING TERRAIN	12	11	11	10	10	10	9	8	7	6	
	MOUNTAINOUS TERRAIN	17	16	15	14	14	13	12	10	10	╳	
MINIMUM STOPPING SIGHT DISTANCE (FEET)		80	115	155	200	250	305	360	425	495	570	SEE PAGE 385
MINIMUM "K" VALUE	CREST VERTICAL CURVE	3	7	12	19	29	44	61	84	114	151	
	SAG VERTICAL CURVE	10	17	26	37	49	64	79	96	115	136	
MINIMUM PASSING SIGHT DISTANCE (FEET)		╳	710	900	1090	1280	1470	1625	1835	1985	2135	SEE PAGE 386
MINIMUM "K" VALUE FOR CREST VERTICAL CURVE		╳	180	289	424	585	772	943	1203	1407	1628	
SUPERELEVATION		SEE STANDARD DRAWINGS RD01-SE-2 AND RD01-SE-3										

The Minimum K value for stopping sight distance for a crest curve is 19 and 37 for a sag curve. For the crest curve on our project, the grades are added using the GEOPAK software and the K value is read from the table to give a resulting length of curve. Determine the minimum length, L, for the crest curve with G1= -0.87, G2 = -5.69 and K = 19.

L= length of vertical curve
A = algebraic difference in grades, percent
K = length of vertical curve per percent change in A (A.K.A. the design control)

L = abs (K*A); where A=G2 - G1
L= 19 * (-5.69 (-) -0.87) = abs (19 * 4.82) = 91.58 ours is 140, the curve is O.K.

Generally, a designer will round up to the nearest 25' interval. This designer increased the length to 140 which is fine as long as the minimum K is met. It is always OK to have a larger K value than what is needed. Notice that the K value is larger than the required 19 because a larger length than necessary was used.

$$K = \frac{L}{A} = \frac{140}{\text{abs}(-5.69\ (-)\ -0.87)} = \frac{140}{4.82} = 29$$

The K values previously discussed were for stopping sight distance (SSD). SSD is the distance required for a driver to react to a hazard in the road and to stop before hitting the hazard. The SSD is the principal control in the design of the crest curve. The SSD is shown in RD01-TS-1 as 200'.

$$K = \frac{(SSD)^2}{200 * ((h_1)^{0.5} + (h_2)^{0.5})^2}$$ Where:

SSD = stopping sight distance, feet
h_1 = height of eye above road surface in feet (3.5' for passenger cars)
h_2 = height of object/hazard above road surface in feet (2')
K = horizontal distance needed to produce a one percent change in gradient

When h_1 is 3.5' and h_2 is 2', the equation for a crest vertical curve can be reduced to:

$$K = \frac{(SSD)^2}{2158} \rightarrow (SSD)^2 = K * 2158$$

Using the previous equation to solve for SSD as shown in the table with K = 19:

$$(SSD)^2 = 19 * 2158 = 41002$$

SSD =202 rounded to 200 in table.

Sometimes, it is necessary to provide passing sight distance (PSD) for a two lane road. Enough distance needs to be there for the driver to feel comfortable making a passing maneuver. If possible, a few areas of the road need to be striped so that a car can pass another. The equation for PSD is the same for SSD except the height of the object is increased to 3.5' because the object is the oncoming car. Because the passing driver should be able to see a sufficient portion of the top of the oncoming car, the height is increased to 3.5'.

$$K = \frac{(PSD)^2}{200 * ((h_1)^{0.5} + (h_2)^{0.5})^2}$$

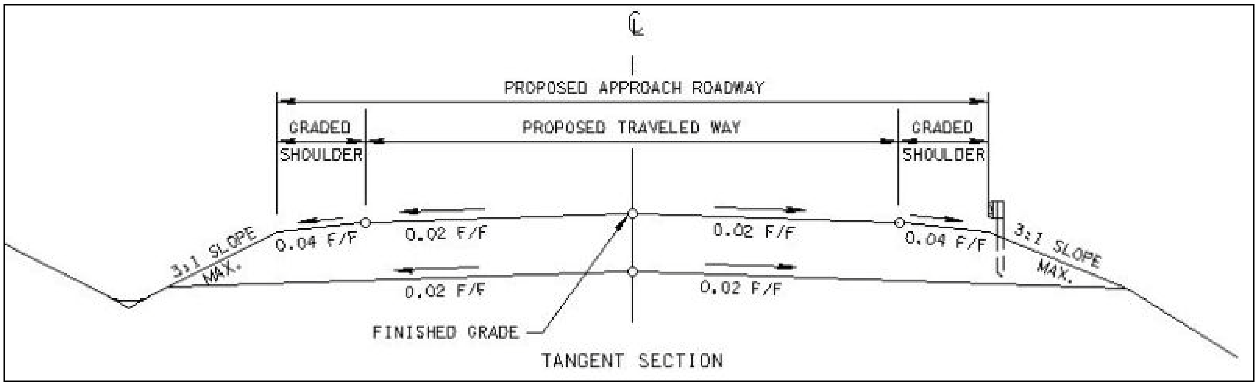
With h_1 and h_2 = 3.5' the bottom of the equation can be reduced 2800. Check PSD from the table with the K value from the table = 424

$$(PSD)^2 = 424 * 2800 = 1187200; PSD = 1089.58 = 1090$$

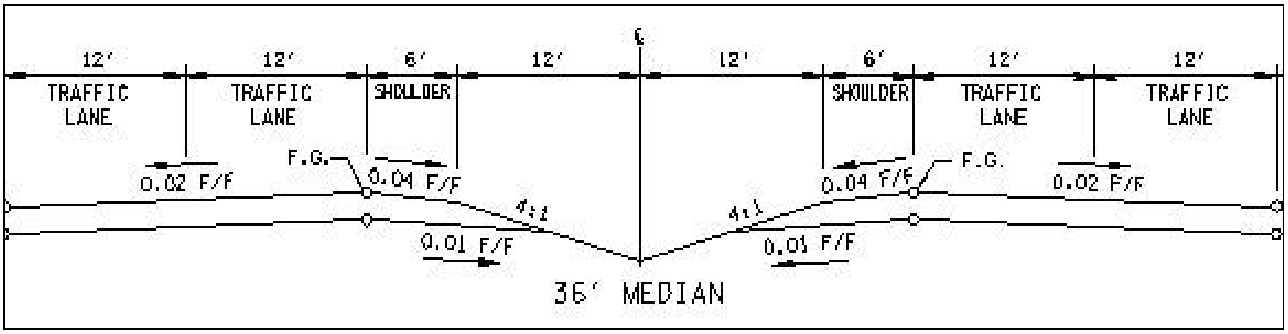
Cross-sections

Cross sections pull the elements of horizontal and vertical design together. On every roadway standard drawing for each type of road, the placement of the horizontal and vertical alignment is shown. Usually, both are at the same place, the centerline of the road. However, on roads that are considered divided highways which have flushed or depressed medians, the vertical alignment or finished grade is at two separate locations.

First, let’s look standard drawing RD01-TS-1 which is used on these plans. The horizontal alignment is represented at the top of the drawing by CL. This type of road has the finished grade at the centerline. The proposed vertical alignment (finished grade) shown in the profile view will be plotted on the cross sections at the centerline and the remainder of the road on each side will be built according to that elevation.



Now, let’s look at standard drawing RD01-TS-6 which has a finished grade at two locations. The horizontal alignment is still in the middle of the road. The proposed vertical alignment (finished grade) view will be plotted on the cross sections at these two locations and the remainder of the road built according to these elevations.



MEASURING GRADES AND SLOPES

The way the ground rises and falls is expressed by either a grade, side slope, or cross slope. The terminology used changes according to what type of view you are in.

Grades

Grades are written as a percent of vertical rise or fall to horizontal distance.

$$\% \text{ Grade} = \frac{\text{Vertical Distance}}{\text{Horizontal Distance}} \text{ X } 100$$

Look on sheet 4C of your plans. The first station for Lay Hollow Road is 30+04.58, elevation 600.86. The down grade of -0.87% continues to where the curve begins at V.P.C. Sta. 33+80.00, elevation 597.61. To calculate the grade of -0.87% for this section, use the formula shown below. To find the vertical distance, subtract the elevation at the beginning from the elevation at the end point. To find the horizontal distance, subtract the station at the beginning from the station at the end.

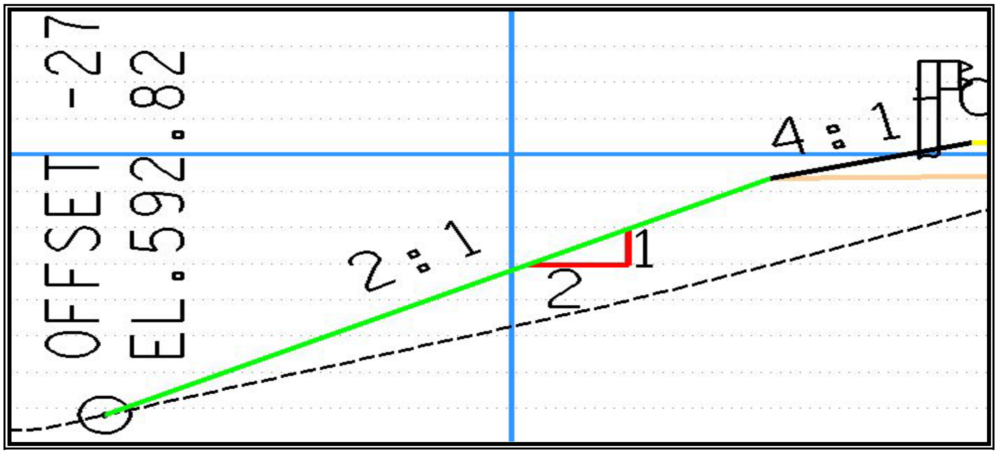
$$\% \text{ Grade} = \frac{\text{Vertical Distance}}{\text{Horizontal Distance}} \text{ X } 100 = \frac{(597.61 - 600.86)}{(3380.00 - 3004.58)} \text{ X } 100 = \frac{- 3.25}{375.42} \text{ X } 100 = -0.87\%$$

Grades are positive when going uphill and negative when going downhill as read from left to right on the plans. Negative grades will have a minus sign like the one shown in the example above. A minimum grade of (±) 0.4% is standard for drainage; however, the grade may be level (0.00%) on side roads intersecting the mainline at the intersection. The maximum grade for each type of road is located on the roadway standard drawing for that type of road.

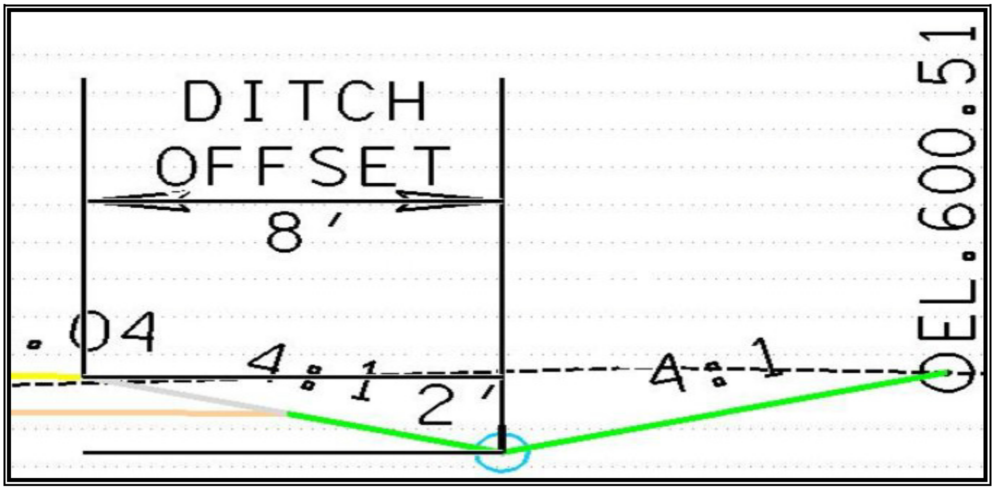
Side Slopes

The roadside slope gives a measure of steepness. It is measured as a ratio between the changes in horizontal distance compared to the distance for a one foot vertical drop. The side slopes are either fill (embankment) or cut (excavation) slopes. A roadside slope consists of the slope for the subgrade, foreslope for a fill, and a foreslope and backslope for a cut. When slope ratios are given, the horizontal distance is always given first, and the vertical distance is listed second, expressed as the number one because of the one foot drop. The first number is larger for flat slopes (6:1) and smaller for steep slopes (2:1).

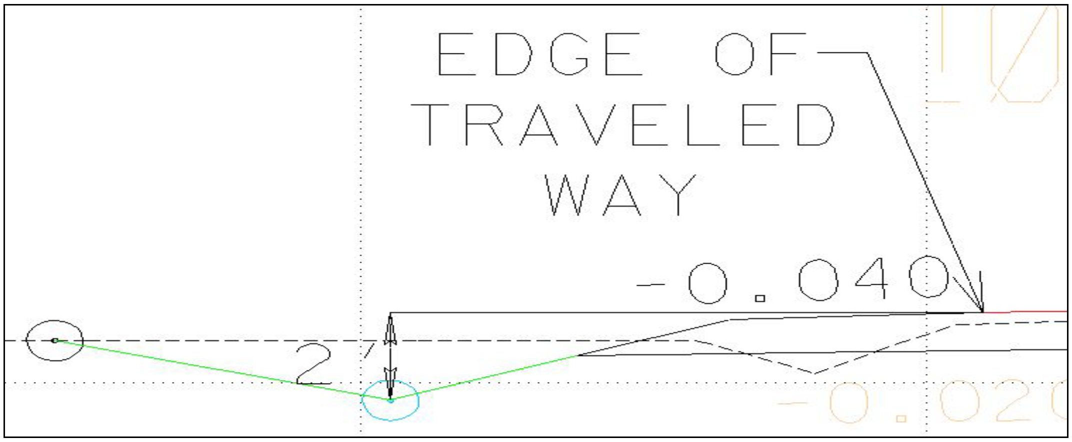
Turn to sheet 10 in your plans and locate the cross-section at Sta. 30+50.00. To the left of the centerline, the subgrade slope is 4:1 and the foreslope is 2:1 for the fill slope.



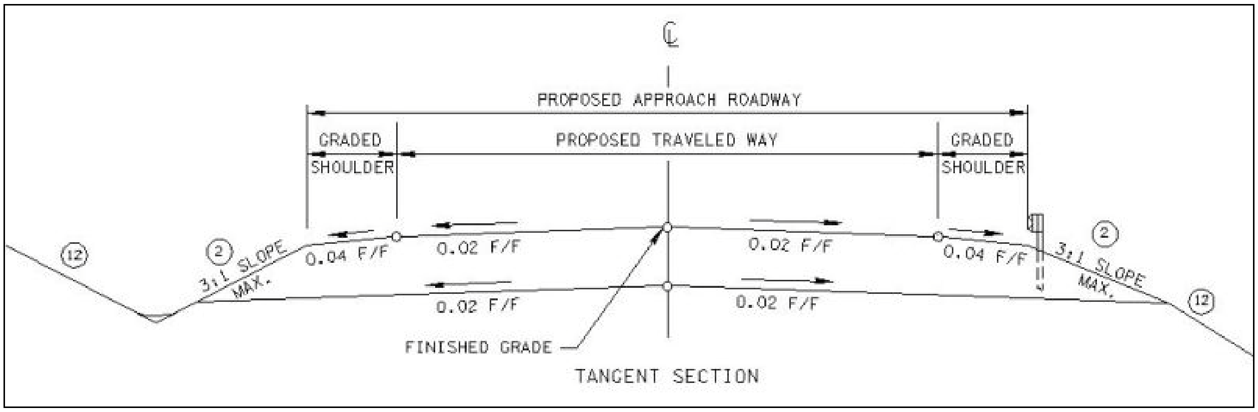
The right side of the road has a cut section with a 4:1 to subgrade and a 4:1 foreslope and backslope for the ditch. In a cut section, the foreslope of the ditch is the same as the subgrade slope.



Whether or not the slope becomes a cut or a fill depends on whether or not the existing ground is reached after a specified vertical drop from the edge of traveled way. If the requirement for a ditch in the standard drawing is a 2.5' deep ditch, then a ditch will be placed if the foreslope reaches existing ground before a 2.5' vertical drop is reached. The drop is measured from the edge of traveled way which is usually the edge of pavement. If the foreslope has not reached the existing ground by this depth, the slope will continue until existing ground is met and will be a fill section. For RD01-TS-1, the required ditch depth is 2'. If the existing ground is met before a required two foot vertical drop from the edge of traveled way, a cut section will be placed as shown below. The depth for the ditch changes for other standards.



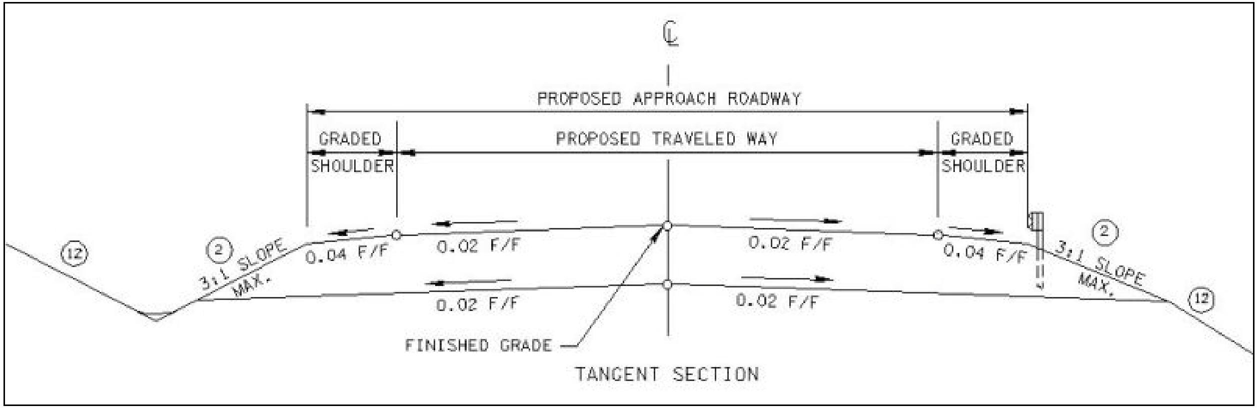
The side slopes used for the subgrade and cut or fill slopes depend on what type of road is being used. For the subgrade, a side slope is specified on the standard drawing for both cut and fill. The road on this project is based on standard drawing RD01-TS-1, Design Standards for Local Roads and Streets. As shown below, the side slope is shown as 3:1 for the subgrade in the standard.



However, notice that there is a footnote for the subgrade. The foot note associated with the subgrade is as follows:

2) 4:1 SLOPE FOR 40 MILES PER HOUR OR GREATER WITH A DESIGN ADT OF

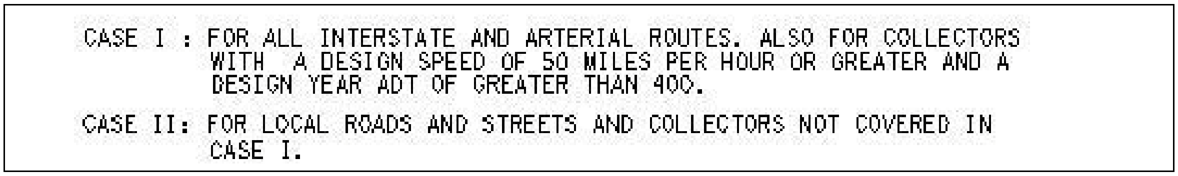
1,000 OR GREATER OR ANY LOCATION GUARDAIL IS USED.



Also, notice from the figure, the foreslope in the cut remains a 3:1 because the foreslope takes on the same side slope as the subgrade in a cut section. For the fill section shown on the right, there is a footnote for the foreslope. The same footnote is shown for the backslope on the cut section. To determine what should be used for remainder of the slope on a fill or the backslope on the cut, refer to footnote 12 which refers you to another drawing:

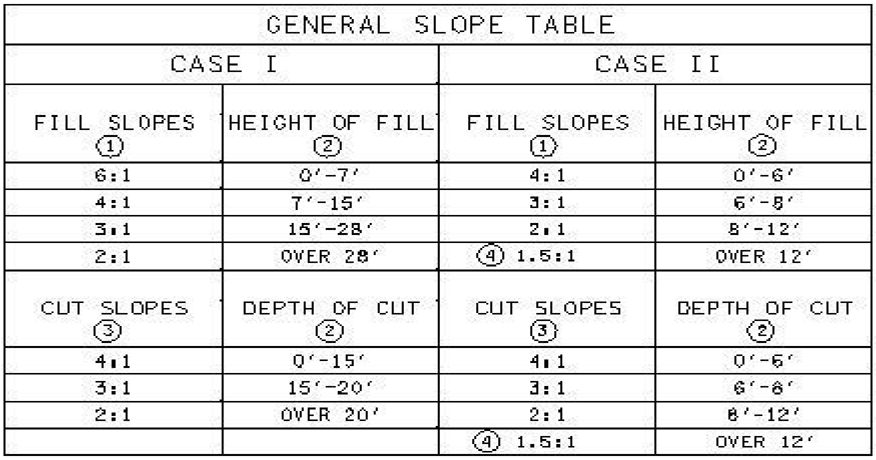
12) SEE STANDARD DRAWINGS RD01-S-11 (CASE II) AND RD01-S-11B FOR DESIRABLE SLOPE AND NOTE REGARDING GEOLOGICAL RECOMMENDATIONS.

As stated in footnote 12, the side slopes for the foreslope on the fill and backslope on the cut are found from tables in Standard Drawing RD01-S-11, Design and Construction Details for Roadside Slope Development. The note also says that for this standard, a Case Two table should be used. Lay Hollow Road falls into the Case Two category because it is not an interstate or arterial route or a collector with a design speed of 50 M.P.H. and a design year ADT greater than 400 which are all attributes of Case One.



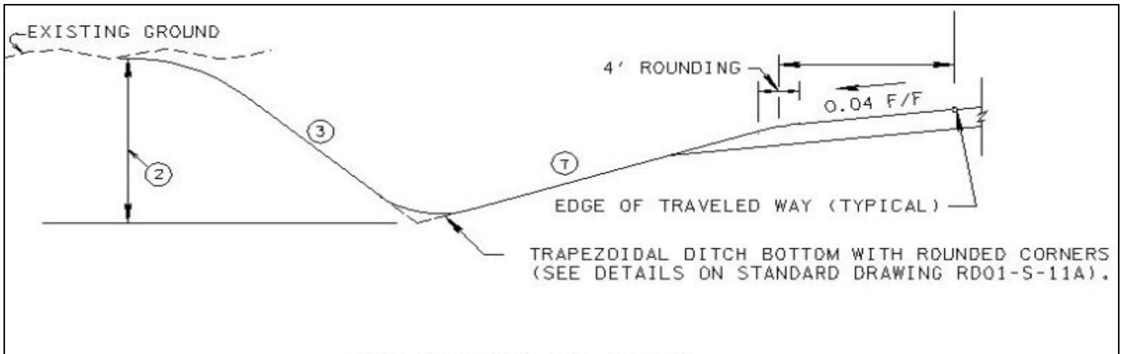
CASE I : FOR ALL INTERSTATE AND ARTERIAL ROUTES. ALSO FOR COLLECTORS WITH A DESIGN SPEED OF 50 MILES PER HOUR OR GREATER AND A DESIGN YEAR ADT OF GREATER THAN 400.

CASE II: FOR LOCAL ROADS AND STREETS AND COLLECTORS NOT COVERED IN CASE I.



GENERAL SLOPE TABLE			
CASE I		CASE II	
FILL SLOPES ①	HEIGHT OF FILL ②	FILL SLOPES ①	HEIGHT OF FILL ②
6:1	0'-7'	4:1	0'-6'
4:1	7'-15'	3:1	6'-8'
3:1	15'-28'	2:1	8'-12'
2:1	OVER 28'	④ 1.5:1	OVER 12'
CUT SLOPES ③	DEPTH OF CUT ②	CUT SLOPES ③	DEPTH OF CUT ②
4:1	0'-15'	4:1	0'-6'
3:1	15'-20'	3:1	6'-8'
2:1	OVER 20'	2:1	8'-12'
		④ 1.5:1	OVER 12'

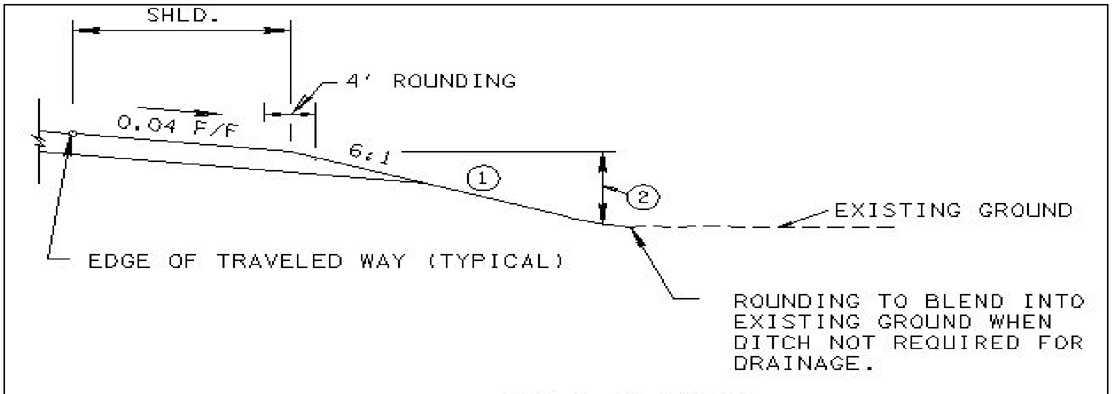
From the General Slope Table, the slopes will be placed according to the heights shown. For example, if a ditch is placed as shown below, the foreslope (7) will be determined by the RD01-TS-1 drawing. If the height of cut (2) is 9', the backslope will be a 3:1as stated in the General Slope Table.



CUT SLOPES IN EARTH

7) SEE APPROPRIATE RD01-SERIES DRAWING FOR FORESLOPE.

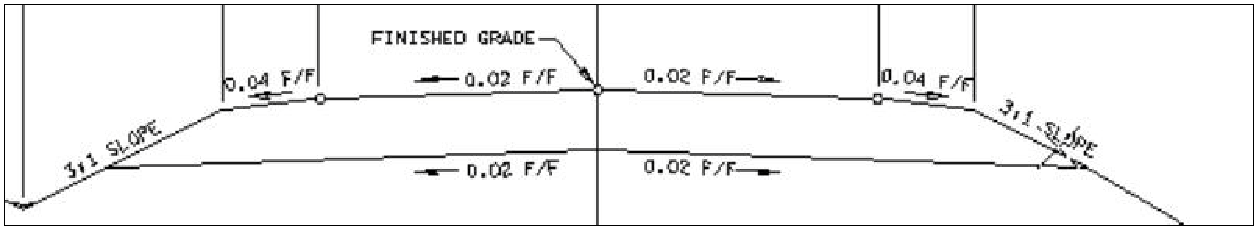
From the table, a fill height of 5' will result in a foreslope of 4:1.



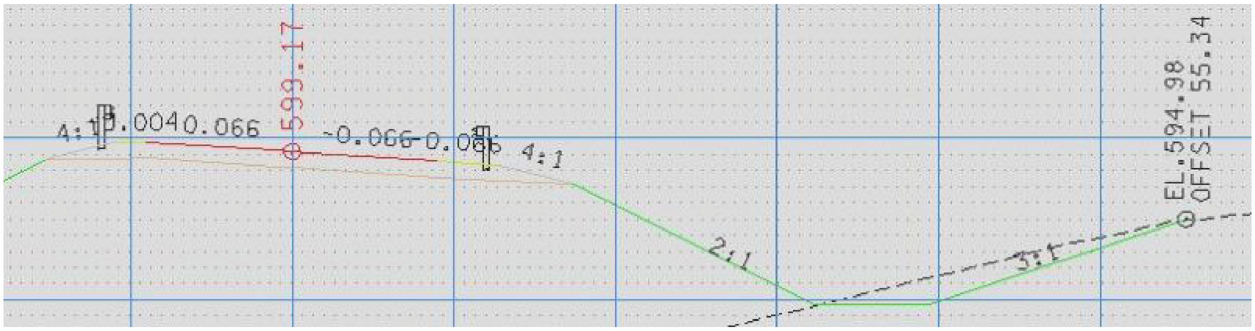
FILL SLOPES

Cross Slopes

Cross slopes of highway surfaces are shown as a foot per foot of slope. Cross slopes allow water to drain to the shoulders of the road instead of ponding on the travel lanes. If the cross-section is a normal crown as shown below, the highest elevation points occurs in the middle of the road and the slopes drain away from the centerline of the road.



If the road is superelevated, the water will drain to one side of the road. Look at cross-section sheet 11, Sta. 32+00.00. The full super of 0.066 has been reached at this section. The left side of the road will drain to the right side and continue on into the trapezoidal ditch.



For the superelevated section, the change in elevation is calculated as a drop 0.066 feet vertically for each foot horizontally away from the centerline on the right side and an increase on the left. The finished grade elevation is at 599.17. The travel lane (shown in red) is 9’ wide. So, the elevation at the edge pavement is

599.17 – (9’ X .066) = 598.576 for the right edge of pavement
599.17 + (9’ X .066) = 599.764 for the left edge of pavement

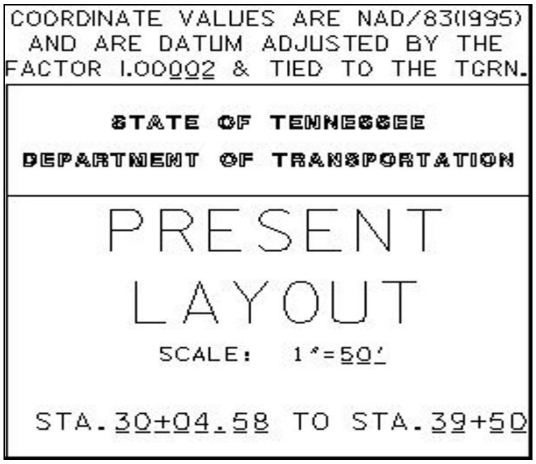
CHAPTER TWO

This chapter will explain the terminology and basic information procedures used on sheets that make up a set of contract plans as well as how to read and interpret the sheets.

SHEET IDENTIFICATION

Sheet Title Blocks

The sheet title block below appears in the lower right corner of most types of sheets. The cell block states the sheet name corresponding to the sheet name listed in the index. Sometimes the block shows additional information such as the scale and station range. If there are any coordinate values on a sheet for the P.I.'s of curves and/or the values for the beginning and endpoints of the alignments, the notation about the coordinate values must be used as part of the sheet. The datum adjustment factor is given by the Field Survey Section.



COORDINATE VALUES ARE NAD/83(1995)
AND ARE DATUM ADJUSTED BY THE
FACTOR 1.00002 & TIED TO THE TGRN.

STATE OF TENNESSEE
DEPARTMENT OF TRANSPORTATION

PRESENT
LAYOUT
SCALE: 1"=50'

STA. 30+04.58 TO STA. 39+50

A few types of sheets don't have a block like the one above. Title sheets and cross-section sheets don't have a block because each is easily identified. The title sheet is the first sheet in each set of plans. Cross-section sheets are easily identified by the grids and content. Bridge plans do not have blocks like the one above but the sheet names still appear in their lower right corners.

Sheet Identification Blocks

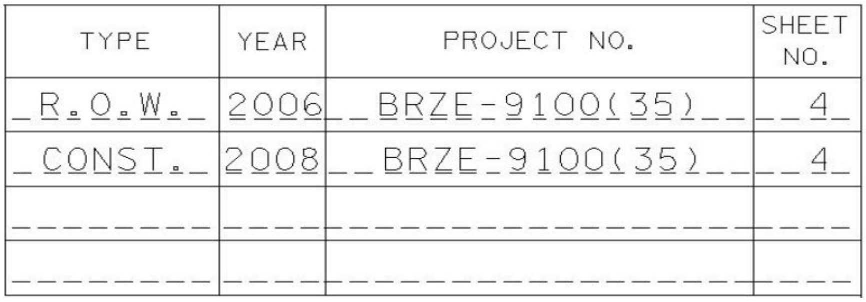
Sheet identification blocks are located on all sheets. They contain information describing the sheet by phase, year, project number, and sheet number. Sheet numbers and project numbers appear in the upper right corners of all sheets except standard drawings. Look on Construction sheet 2B in the sample set of plans. Notice that the

R.O.W. sheet number for the same sheet is 2. The numbers are sometimes different because numerous second sheets (General Notes, Estimated Quantities, and Tabulated Quantities etc.) are not part of the plans turned in at the R.O.W. phase. The R.O.W. numbers are not changed at the construction phase to match the construction phase sheets.

Three different blocks are used to show sheet numbers and project numbers. The following block is used for the **title sheet**.

TENN.	YEAR	SHEET NO.
	2008	1
FED. AID PROJ. NO.	______BRZE-9100(35)______	
STATE PROJ. NO.	______91945-3493-94______	

The block below is used for most **plan sheets** with the exception of the title sheet and bridge sheets. The first line is used for the R.O.W. submittal and the second line is for the construction submittal.



TYPE	YEAR	PROJECT NO.	SHEET NO.
_R.O.W._	2006	__BRZE-9100(35)__	__4_
CONST.	2008	__BRZE-9100(35)__	__4_
________	____	___________________	____
________	____	___________________	____

The block below appears on **bridge plans**. Only one line is shown for each entry because bridge drawings and sheets are not turned in for the R.O.W. phase. The bridge sheets are submitted for construction.

Project No.	Year	Sheet No.

Project Numbers

Project numbers identify what type of project is being built. Two kinds of project numbers are used: federal-aid project numbers and state project numbers. On the title sheet, both numbers are shown (see above). Where both numbers are used, the state project number appears only on the title sheet, while the federal-aid project number appears on all sheets that show project numbers.

Federal-aid project numbers (sometimes called project reference numbers) are shown if federal funding is used for the projects. Each federal-aid project number is a combination of letters and numbers different from every other project number. All Interstate Highway projects have federal-aid project numbers that begin with or include the letter **"I"**. In the project number, **IM-65-2(33)98**, **IM** is for interstate maintenance, **65** indicates the route number, **2** indicates the section number, **33** indicates the job sequence (33rd project in section 2), **98** indicates the mile-post number at the beginning of the project (measured south to north and west to east).

The National Highway System (NHS) are major roads consisting of the Interstate System, a large percentage of urban and rural principal arterials, the Strategic Defense Highway Network (STRAHNET), and strategic highway connectors. Project numbers with NHS funding will include the letters "NH" such as **NH-15(83)**. Another common source of funding is the Surface Transportation Program (STP) which consists of roads not functionally classified as a local or minor collector. Project numbers with STP funding will include the letters "STP" such as **STP-20(29)**.

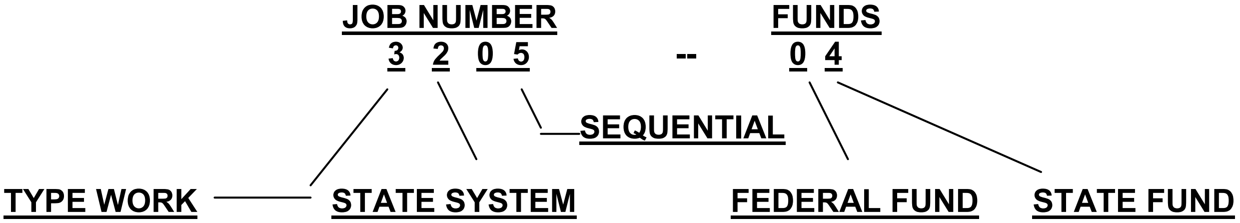
Other common letter prefixes for federal-aid project numbers are as follows:
APD - Appalachia Development Highway System Projects
BR and BRZ - Bridge Replacement projects (on-system and off-system routes, respectively)
CMAQ – Congestion Mitigation Air Quality
FH / PL - Forest Highway / Public Lands Projects.
HPP – High Priority Projects
HSIP –Highway Safety Improvement Program

State project numbers are 11-digit numbers made up of elements. For example: 22011-3205-04
22 indicates the county (alphabetical listing)
011 indicates the control section
3205 indicates the type of work, the state system, and the job sequence number
04 indicates the federal funds participation and the state funds participation.

In your sample construction plans, the right-of-way project number (91945-2493-94) shown for the beginning and end of project is different than the construction number (91945-3493-94) shown for the beginning and end of project. Funding is the reason for the different numbers. Projects are funded in three phases: preliminary, R.O.W., and construction. The number changes for each phase.

The diagram below may help you better understand the naming convention.

JOB AND FUND NO. REFERENCE



JOB NUMBER **FUNDS**

3 2 0 5 -- 0 4

SEQUENTIAL

TYPE WORK

1- PE for Survey, Design, & Location
2- R.O.W. & Utilities
3- Construction
4- Routine Maintenance
7- Planning and Research
8- Resurfacing
9- Outdoor Advertising, Mass Transit, & Waterways and Rail

STATE SYSTEM

1- Interstate
2- State of Tennessee
4- Local County
5- Local City
6- No System
7- New Urban System

FEDERAL FUND

0- None
1- Primary
4- Interstate
5- Urban
6- Appalachia
7- H.P.R.
8- Forest
9- Bridges & Survey

STATE FUND

4- General

Standard drawings have no project number. Standard drawings are used as references in creating plans so the same ones are used over and over and are not project specific. If a standard drawing has to be printed with plans because the drawing is new or has been developed specifically for the project, a drawing number will be located in the lower right corner. There will not be a sheet number. Standard Drawings are divided into these categories: Roadway Design Standards, Drainage - Culverts and Endwall, Drainage-Catch Basins and Manholes, Roadway and Pavement Appurtenances , Safety Appurtenances and Fence, Traffic Control Appurtenances , and Erosion Control and Landscaping.

Sheet Numbers

Three types of numbers are used to identify plan sheets: sheet numbers, standard drawing numbers, and bridge drawing numbers.

Sheet numbers are located in the sheet identification blocks in the upper right corners of sheets. All sheets except standard drawings are numbered sequentially with sheet numbers from the title sheet to the final sheet. To maintain consistency on plans and allow all agencies and contractors to easily find a certain sheet, a sheet naming convention is used. The title sheet is always sheet number 1. Sheet 1A will always be the Index and Standard Drawings for a construction set and is not included in a R.O.W. set of plans. If there is a bridge on the project, sheet number 2 will be designated for the bridge quantities. There are several sheets in the two series (2A, 2B, 2C etc). The two series sheets will always include general notes, typical sections, quantities, and details. The sheet 3 series will always be sheets used to define the property map and R.O.W. acquisition table, notes and utility owners. The sample plans are small enough to have all of the R.O.W. information on one sheet without the addition of sheet 3A. Sheet 4 will always be the first present layout sheet. The proposed layout and profile sheet will match the present layout sheet number that shares the same station range followed by a letter (4A, 4B, etc.). One of the few times that the numbering would be different would be on a resurfacing job where many of the sheets are eliminated from the plans. Throughout this class, the construction sheet number will be the sheet that is being referenced.

Bridge layout sheets and bridge detail sheets have both sheet numbers and drawing numbers. These drawing numbers appear in the lower right corners of bridge layout and detail sheets. When reading bridge plans in this course, you will find that all references are made to drawing numbers and not sheet numbers. Drawing numbers also appear on standard drawings in the same location. Standard drawing numbers always begin with a letter, and standard drawings appear in the plans in alphabetical order. Standard roadway drawings are shown first, followed by standard bridge drawings.

SCALES OF DRAWINGS

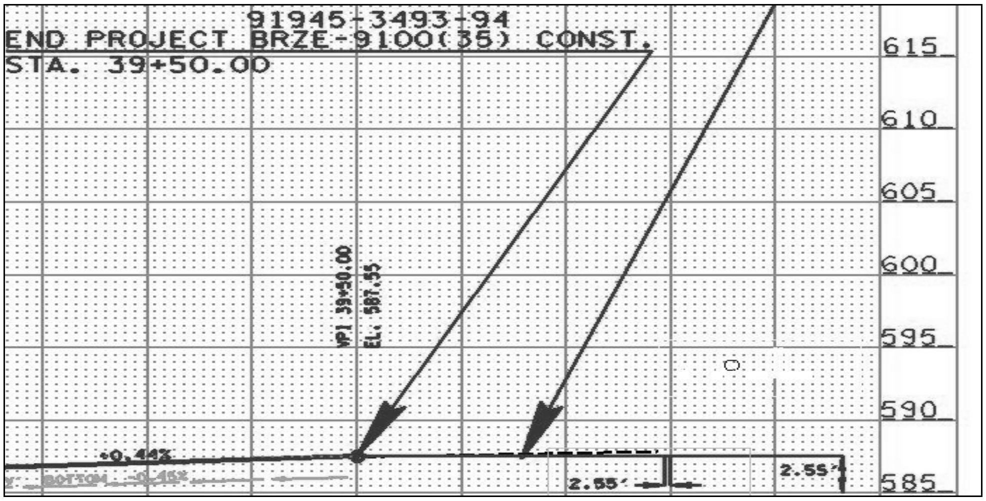
Plan Sheets

Most plans sheets are drawn according to scale. This means that graphics placed on plans are drawn an exact length to represent an exact distance on the ground or a dimension of real objects. Each sheet will list the scale factor in the sheet title cell.

The sample plans for this text are a reduced size set of the original plans sheets. Original final construction plans sheets are drawn on 34" x 22" mylars. Your sample plans are called “1/2 size plans” because the originals have been reduced by one-half on 11" x 17" paper. The fact that the plans are reduced will change the how to use the scale. For example, turn to sheet 4 in your sample plans. It shows this note: SCALE 1”=50’. This note means that every inch on the plan view represents fifty feet on the ground **IF** the sheets were full size. For example, the station ticks are 100’ apart. If the distance between the ticks is measured on a half size set, the distance will measure one inch. Since the set is half size and the scale for the sheet is 1’=50’, the distance would double and 1”=100’.

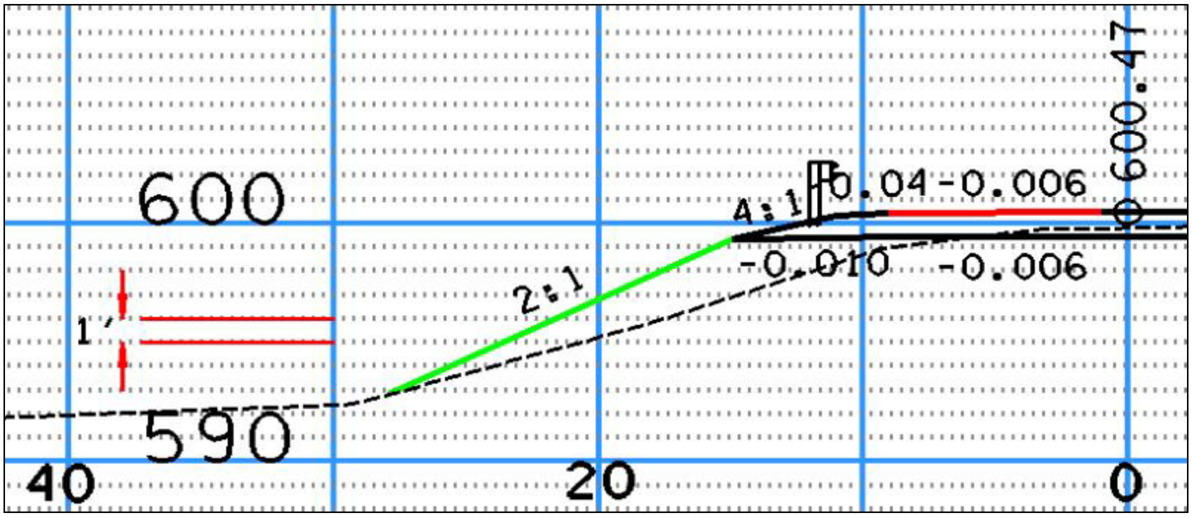
Profile Sheets

Two scales are used for each profile view. Typically, the scales are 1"=50' horizontally and 1"=5' vertically. There are heavy grid lines every fifty feet horizontally and every five feet vertically. The light grid lines represent one-half (0.5) foot increments vertically and five foot increments for the horizontal. The vertical scales are exaggerated ten times (10 X) to better represent small differences of elevation. The drawings on the profile view look out of proportion because of the exaggeration. On sheet 4C, look at the arrow for the end of construction at Sta. 39+50.00. Notice that the elevation for the V.P.I. at that station is 587.55; 2.55 feet above the elevation line for 585. Below, a distance of 2.55’ has been marked vertically and horizontally so that you can see the difference in the vertical exaggeration.



Cross-section Sheets

Cross-section sheets are drawn on a scale of 1”=10’. Turn to sheet 11 in your plans to view a cross-section sheet. Notice the heavy grid lines are an inch apart, both vertically and horizontally. Also, light grid lines represent one foot elevation increments. The grid lines are numbered every twenty feet horizontally and every ten feet vertically. Since this is a half size set of plans, 1”=20’.



TYPES OF HIGHWAY PLAN SHEETS

There are several types of plan sheets. Most plans consist of plan sheets which include present layout, proposed layout, drainage, and traffic control sheets. There are profile sheets for the mainline, side roads and private drives. Cross sections for the mainline, side road, and culvert sections are also included. Some sheets referred to as “second sheets” have information pertaining to standard drawings, notes, quantities, and details.

The project used for this class is small and the alignment can be placed on one layout sheet. The following are the sheets listed in the Index and Standard Drawing sheet for this project:

Sheet 1-Title Sheet
Sheet 1A-Roadway Index and Standard Drawings Index
Sheet 2-Estimated Bridge Quantities and Bridge Index
Sheet 2A-Estimated Roadway Quantities
Sheet 2B-Typical Sections and Pavement Schedule
Sheets 2C-2E-General Notes and Special Notes
Sheet 2F-Tabulated Quantities
Sheet 2G-Special Ditch Details
Sheet 3-Property Map and Acquisition Table
Sheet 4 -Present Layout
Sheet 4A-Right-Of-Way Details
Sheet 4B-Proposed Layout
Sheet 4C- Proposed Profile
Sheet 5-Erosion and Sediment Control Plans
Sheet 5A-Erosion and Sediment Control Plan (Special Notes)
Sheet 6-Existing Contours
Sheet 7-Proposed Contours
Sheet 8-Drainage Map
Sheets 9-9B-Traffic Control Plans
Sheets 10-15-Roadway Cross-Section Sheets
Sheets U1-1 Utilities (Not shown in Plans)

The sheets listed in this index apply only to this project. There will be more plan sheets listed for a larger project. Common sheets that were not included in this plan set are Side Road and Private Drive Profiles, Culvert Sections, Wetland Mitigation Plans, Signing and Pavement Marking and Soils sheets, etc. This project is short with only one private drive and no side roads. The one private drive is located on the profile sheet for the mainline. While reading through these descriptions, refer to the set of plans provided for your use during the class.

Title Sheet (Sheet 1)

The first sheet on a set of highway contract plans is called the title sheet. This sheet contains general information regarding the project.

Each title sheet contains the Tennessee Department of Transportation (T.D.O.T.) heading. Located directly below the heading, the county **(Wayne)** where the project is located is displayed. Beneath the county listing, a written description of the project location is shown giving the limits of the work including the Log Mile at the middle of the surveyed project**(Lay Hollow Road Bridge and Approaches Over Indian Creek @ L.M. 0.05)**. This description is usually written from a beginning point of reference to an ending point of reference. Occasionally, on short projects where improvements are at a spot location, a description is given only for that location.

Below the description of the project location, a general description of the type of project work is shown. The title sheet in your sample plans describes the project as grade, drain and pave. Other descriptions sometimes used for the scope of work on projects are bridge, striping, signing, lighting, etc. Also located under the heading, is the State Highway Number and the Federal Aid Highway System Number, if applicable, for the proposed route improvement **(N/A for this project because it is not on the state highway system).**

In the center of the title sheet is a location map of the general geographical area of the project. The beginning and ending of the project is flagged. A north arrow is shown along with references to larger cities. On projects that are of considerable length, you will find small numbered rectangles shown along the proposed route improvement. The number in each rectangle corresponds with the sheet number in the plans which will depict details for that specific location. The scale for the map is also shown.

The next feature shown on a title sheet beneath the location map is the project length **(0.179 miles).** The project length will be divided into roadway **(0.127 Miles)**, bridge **(0.052 Miles)**, and box bridge length **(0.000 Miles)**. If a project is located in more than one county, the length will be shown separately for each. All lengths are shown to one thousandth of a mile.

The traffic data block contains the traffic data for that particular section of road. The traffic block lists the following information:

ADT (2008)	40
ADT (2028)	50
DHV (2028)	7
D	60-40
T (ADT)	5%
T (DHV)	3%
V	30 M.P.H.

The first line is the current average daily traffic (ADT) on this highway facility. The next line is the projected future average daily traffic which is typically 20 years after the current traffic. The ADT future is the design year traffic. Next is the future design hourly volume. The letter D represents the directional distribution of the design hourly volume. The letter T represents the percent of trucks that will be using the facility. Last is the design speed for the project. The example plans indicate that the roadway will be designed for safe travel at 30 M.P.H.

Another feature located on the title sheet addresses equations and exclusions. Station Equations will be discussed later. If there are exclusions within the project, the station ranges will be shown in a table. An exclusion would be a section of road that is not being worked on that lies within the construction station limits of the job. An example would be a five mile paving job where one mile has already been paved that lies within the construction station limits.

In the upper right hand corner, the title sheet block is shown. A map depicting an outline of the State of Tennessee with all 95 counties is shown in the upper right corner below the sheet title block. The county or counties where the project is located will be highlighted.

In the lower right hand corner of the sheet are the signatures of the Chief Engineer **(Paul D. Degges)** and commissioner of the Tennessee Department of Transportation **(Gerald F. Nicely)**. The Professional Engineering Registration Stamp and signature of the in house Civil Engineering Manager or consultant will be above the Chief Engineer’s signature (not shown on these plans).

In the lower left hand corner, two special notes are shown. The first one addresses the fact that bid proposals may be rejected by the Commissioner if they are unbalanced or too high or too low. The second note states which edition of the Standard Specifications shall govern the project. Also, listed in this area is the T.D.O.T. Roadway Specialist Supervisor Two **(Shane Hester),** Designed by (needed if a consultant designed the project), the Designer **(Aso Hawrami),** and the Checker **(Karolee Phillips).** The Preliminary Engineering number **(91945-1493-94)** which is used to record design time charges, and the PIN (**Project Identification Number 102060.00**) which is a numerical number assigned to each project are also at this location.

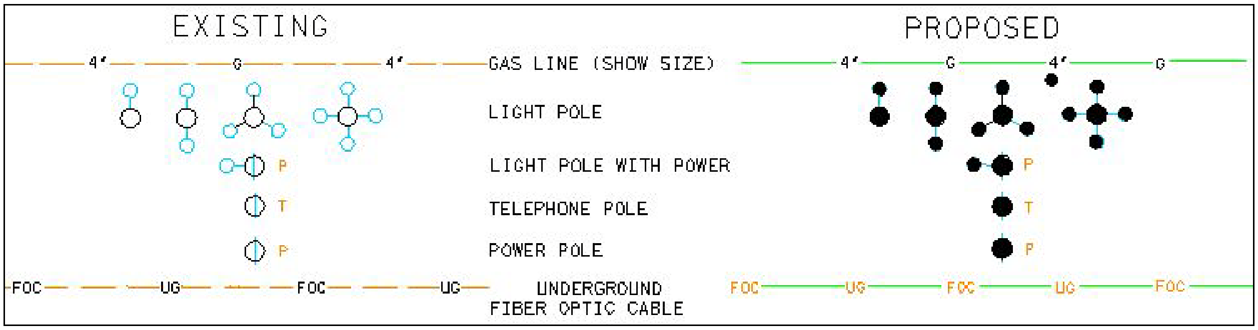
Index and Standard Roadway Drawings Sheet (Sheet 1A)

The index and standard drawing sheet is the second sheet in a set of plans. The index tells which sheets are in a set of plans, their logical order, and sheet number. Using the index can save time.

The Roadway Design Standard Drawings that apply to the project are also on sheet 1A. Standard roadway drawings show details of standard items that can be used on many projects. For example, signs and guardrail are often standard items that are the same on many different highways. Standard roadway drawings are normally not printed with the contract plans. Standard roadway drawings are published in a separate loose leaf binder as well as being provided in pdf format on the internet. The only time standard roadway drawings are printed with the plans is when a drawing has been recently revised or a new drawing has been recently added and has not been officially added to the standard roadway drawings.

There are a few standard drawings that are on most plans: RD-A-1, RD-L1 thru RD-L7. These are the drawings that show abbreviations and legends that are used on all roadway plans. 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. The Standard Legend depicting symbols to be used for existing and proposed objects is shown on Standard Drawings RD-L-1. RD-L-2 is the standard legend for utilities. RD-L-3 and 4 are standards for signalization and lighting. RD-L-5 thru RD-L-7 are for erosion and sediment control. Frequently, it is necessary to abbreviate words on the plan sheets. For uniformity and clear understanding, standard abbreviations have been adopted. Standard Drawing RD-A-1 lists the Standard Abbreviations.

Below are some of the symbols found in RD-L-2. The symbol for each utility is nearly the same for both the existing and the proposed. The only difference is that existing utility symbols are not shaded and have dashed lines; proposed-utility symbols tend to be shaded and have solid lines.



Sheet 2, Estimated Bridge Quantities, will be discussed in Chapter 7.

<u>Estimated Roadway Quantity Sheet (Sheet 2A)</u>

The estimated quantities for roadway and bridge items are tabulated separately. If a project is located in more than one county, the estimated quantities will be tabulated separately by each county.

The estimated roadway quantity block shows the total quantities of all items included in this particular contract. This sheet contains foot notes that better explain how or where the quantity is going to be used .These quantities are used by the T.D.O.T. Estimating and Bid Analysis office to prepare the Engineer's Estimate and are used by the contractors to prepare their bids to construct the project.

For each bid item of construction, the following information is shown in the estimated quantity block:

1) The item number - This number identifies a particular item of construction as referenced from the Specifications and Special Provisions.
2) The description - This identifies the item to be used, usually a short phrase.
3) The quantity - This number shows the estimated amount of each item.
4) The unit - This tells how the item is to be measured in the field for payment to the contractor.

It is important to remember that each of the quantities is an **estimate** of items to be used in constructing the project. The contractor will be paid only for the actual quantities used in the construction of the project.

Typical Section Sheet (Sheet 2B)

A cross-section of a highway is the view you would have if you cut a line perpendicularly across the road. A typical section sheet shows typical cross-sections of the road to be built. The width of travel lanes and shoulders, subgrade depth, side slopes, and roadside ditches are shown. The typical section sheets will also show a typical section for private drives, field entrances, and business entrances.

Look at the Pavement Schedule Block at the bottom of sheet 2B. This block identifies the materials to be used and gives material specifications, application rates, thicknesses, and pay item numbers for each layer. The layer is numbered in the block and used in the typical section drawings for identification and placement. This information is used for the paving process on a project.

For some projects, the proposed road is very simple, straight, and level and may only need the tangent typical section with no superelevated section. Also, if the road has curves that are very large and flat, there may not be any superelevation. If the road is transitioning from one type of road to another (example 5 lane curb and gutter to 4 lane divided highway) both typical and superelevated sections must be shown for each section of road.

For this project, there are two sections shown: tangent and superelevated. There are two station range entries for the superelevated section which implies there are two curves on the job that are superelevated. To find the rate of the curves refer to the curve data information on the present layout sheets or to the superelevation rates shown on the profiles. A typical is not drawn for each curve even though the superelevation rate is different for each.

Remember, this is a **typical** section meaning the majority of the road uses the parameters shown. Every cross-section is not exactly like the one shown. The road may transition from a proposed 11' foot lane to an existing 9' lane. A typical for each of these would not be shown but the lane transitions would be labeled and shown in the proposed layout sheets. Side slopes may vary. The cross-sections should be referred to for any changes in side slopes. If there are special or independent ditches, details of these ditches would be shown on this sheet if there is enough room or on another sheet added to the sheet two series of the plans.

General Notes and Special Notes Sheet (Sheet 2C-2E)

A general notes sheet is included in each set of contract plans. It summarizes the scope of work and describes construction procedures that apply to the whole project. These general notes are grouped according to subject matter to make it easier to find a particular note. Special notes are notes that may be provided by other T.D.O.T. sections such as Environmental or Construction. These notes may limit the times of year that construction can be done due to the terrain or traffic.

Tabulated Quantities Sheet (Sheet 2F)

Tabulated quantities are tables that may show the specific location, type, and amount of roadway items such as pipes, guardrail, drainage structures, etc. Tables or blocks are also shown for grading and box culverts. These sheets contain no drawings, only tabulations of materials and work estimates. Tabulated quantities are shown broken down according to location then brought forward and listed on the Estimated Roadway Quantities block.

For example, on the Tabulated Quantities sheet, 2F, there are actually four separate entries for item number 705-02.02, Single Type 2 guardrail. The total for the four entries is 212.5 LF. On the Estimated Quantities sheet, 2A, the total for the single guardrail is entered once with a quantity of 213 (rounded up from the Tabulated Quantity sheet).

Detail Sheet (Sheet 2G)

Detail sheets show plans for nonstandard items, items particular to the project or to a specific location on that project. For example, on Sheet 2G, the details for three special ditches are shown. The station ranges, side slope parameters, and bottom width for each ditch is shown. Other common detail sheets are retaining wall details.

Property Map and Acquisition Table Sheet (Sheet 3)

One of the main purposes of property maps is to show how tracts of land are affected by right-of-way acquisition. A property map is similar to a present layout sheets but usually on a larger scale. The property owners and associated tract number are shown along with the existing and proposed right-of-way (R.O.W.) lines, proposed centerline and major drainage features. Both existing and proposed R.O.W. lines are labeled so that the difference between the two is easily noted. On sheet 3, the existing R.O.W. is dashed and parallel to the existing centerline of the road. The proposed road will be moved north; thus, pushing out slope lines and requiring more R.O.W. to be purchased.

A R.O.W. acquisition table is shown which lists each property owner, county records for the tract, total acreage of the tract, amount of area to be acquired and remaining as well as any easements that might be needed. If there is a line through a tract owners name and associated number, this means no R.O.W. or easements will be purchased from this tract owner. The owner may be an individual, group, business or government agency. Usually, a wife is listed as “et ux.” If several people own the property, there may be only one name listed and the others referred to as “et al." Easements are agreements with landowners allowing the State to use specific land for specific purposes. A slope or construction easement is sometimes needed to build the slope or to have room outside the slope for the construction of the slope. This usually occurs on urban jobs where the R.O.W. is a set dimension, such as 100’; 50’ on each side of the centerline. For any slopes that fall outside the 50’, slope easements will need to be bought to build the slope to existing ground. Usually, an additional 15’ is needed outside the slope lines to be able to construct the slopes. Tract owners are paid for slope and construction easements but re-gain the area after completion of the project. A drainage easement may be needed to maintain an endwall or other drainage feature that is located outside the proposed R.O.W. These easements are needed so that the state can always maintain the structure. These are permanent easements, and the owner does not get the area back.

If possible, the R.O.W. notes and utility owners are listed on this sheet. If the sheet becomes too cluttered with the additions, a sheet 3A can be added. The R.O.W. notes summarize provisions on access control and the removal of improvements from the R.O.W. Also, the R.O.W. notes usually identify the owners of utilities to be relocated.

Look at Tract One owned by Dian J. Nix. Notice her tract is on each side of Lay Hollow road. She has 27.878 acres on the left side of Lay Hollow Road and 2.392 acres on the right side for a total of 30.270 acres. From the R.O.W. Acquisition table, the area that will be required on the left side of the road is 0.327 acres and 0.191 acres on the right. The area remaining after acquisition is shown.

Occasionally, R.O.W. acquisition results in cutting off all access to the tract. In other words, access to the remainder of a tract is lost. Where this occurs, the remainder of the tract is labeled "Loss of Access". None of the tracts on this project had a loss of access.

Tracts sometimes are divided like Tract One is on this project. This usually occurs when a new road is being built that cuts through the middle of a land owners property. If the tract on each side of the road has the same tax map number, parcel number, and book and page number from the deed document, the tract will share the same number. For this project if any of these variables had differed, the tracts would have two different numbers.

Present Layout Sheet (Sheet 4)

Present layout sheets show plan views of the existing area where the proposed road will be built. Topography, such as rivers, trees, buildings, and fences, is clearly shown. Existing overhead and underground utilities and survey control points are shown. The tract owner and number associated with the tract are also shown. If a R.O.W. Detail sheet is included in the plans, the present layout sheet will not show the existing and proposed bearings/distances and station/offsets associated with all breaks in a R.O.W., just the lines will be shown. The property lines and associated text will also not be shown if a R.O.W. detail sheet is used. The present layout sheet will show some proposed features to relate the effect that the construction will have on the existing topography. The proposed features shown on the present layout include proposed centerlines and associated curve data, proposed right of way to be acquired, proposed driveways, proposed construction limits (slope lines), and proposed structures.

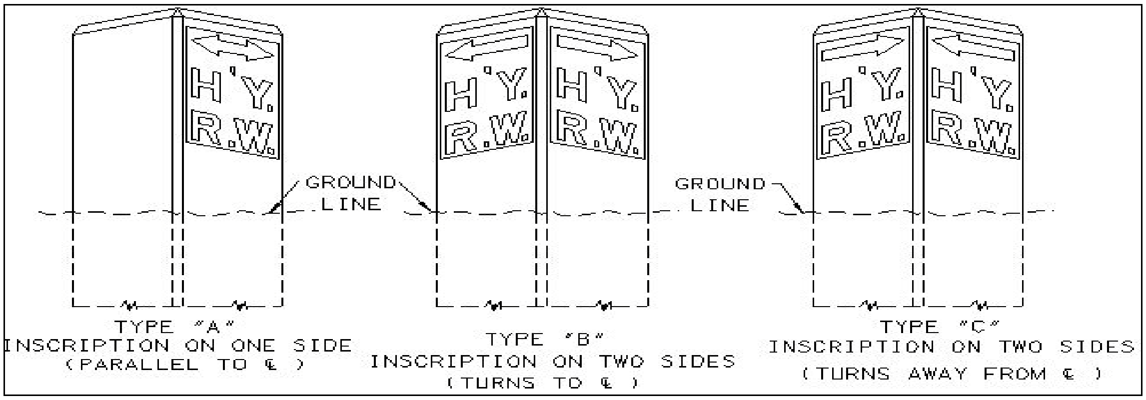
Property lines are located between property owners. A property line is labeled "PL" and has bearings and distances. A tract boundary will consists of property lines and may even have existing or proposed R.O.W. as a boundary as shown in the plans on Sheet 4A. Some physical features such as creek centerlines or fences may serve as a property line. Control of access or access control are sometimes labeled "control of access" or "C.A." This means that vehicles outside the lines may not legally cross the lines to enter the highway. Quite commonly, on projects for freeways the proposed R.O.W. line, the control-of-access line and the fence line will coincide. Normally, the control-of-access line and the fence line are one foot apart, but this normal one-foot offset is never shown on the plans.

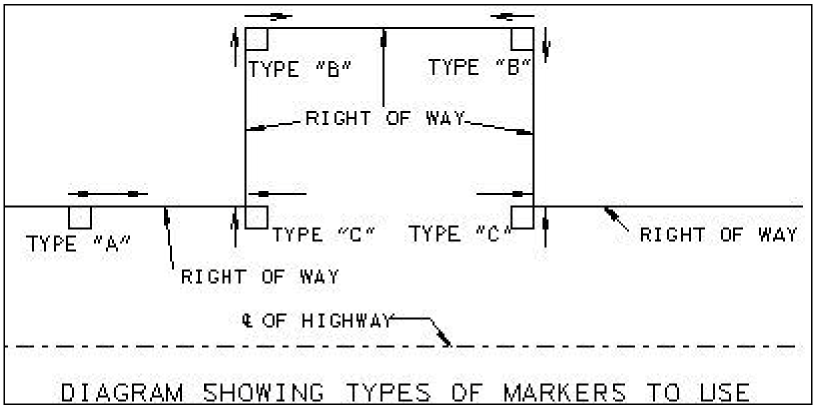
R.O.W. Detail Layout Sheet (Sheet 4A)

R.O.W. is the public-owned land that roadways are built on. R.O.W. details include existing survey control points, proposed driveways, proposed centerline and centerline text, and existing and proposed R.O.W. data including the tract owner and number and property lines. The sheet also shows existing and proposed R.O.W. lines, existing and proposed bearings/distances and station/offsets. Present R.O.W. is land that was acquired in the past, while proposed R.O.W. is land acquired for this project. If needed for readability, a table can be used to represent the existing and proposed bearings/distances and station/offsets. This sheet does not have to be in the plans and is added at the designer's discretion. For this project, the sheet was added.

Proposed R.O.W. lines are labeled and shown as solid, heavy lines on both sides of the proposed highway. Present R.O.W. lines are lighter and dashed. On Sheet 4A, the total existing R.O.W. width for Lay Hollow Road is 30'. For the proposed R.O.W., the width varies. R.O.W. is acquired as needed in a rural section instead of acquired as a set width.

At each change in direction on the proposed R.O.W., there are R.O.W. markers. R.O.W. markers are concrete monuments used to define the locations of R.O.W. lines in the field. The markers are shown in the plans as small solid squares located just inside the R.O.W. lines at the breaks. Each marker is labeled "A", "B", or "C". These letters represent different types of right-of-way markers. Each type is detailed on Standard Drawing No. S-RP-2 shown below.





Proposed Layout Sheet (Sheet 4B)

Proposed layout sheets show the proposed improvements for the road. The sheet will include the proposed centerline, edges of pavement, guardrail, proposed structures, proposed drainage, etc. The only existing features that are shown on the proposed layout sheets are drainage features such as rivers or streams and possibly an existing culvert that is going to be lengthened. The existing drainage features are shown because there will be new pipes, bridges or drainage structures in conjunction with these waterways. Existing topographic features such as houses, trees, utilities, and property lines are not shown.

On small projects without a lot of topography, proposed layout sheets sometimes show two views of construction details. The top half shows a plan view. The bottom half shows an elevation view.

Proposed Profile Sheet (Sheet 4C)

The proposed profile sheet shows the existing and proposed vertical grade and earthwork balances. All existing underground and overhead utilities are shown as well as survey control data. The existing and proposed structure and associated hydraulic data are shown. The superelevation rates are also shown so that the contractor can see how the vertical and horizontal alignments relate.

Erosion Prevention and Sediment Control Plan and Notes Sheets (Sheets 5 and 5A)

The erosion and sediment control plans show the necessary erosion control measures that should be taken during each phase of construction. The Environmental Division may provide special notes to add to the project.

Existing and Proposed Contour Sheets (Sheets 6 and 7)

Existing contour sheets show the proposed centerline, existing edges of pavement, and drainage. The proposed contour sheets also show the proposed centerline and drainage, but show the proposed edges of pavement and proposed slope lines. The Storm Water Permits Section of the Environmental Division requests these sheets.

Drainage Map (Sheet 8)

The Drainage map will show as much hydraulic information as possible for the project site. The proposed centerline and structures will be shown. If there are sub-divided areas that are draining to pipe culverts or structures, these areas will be shown along with the hydraulic data for the area. The hydraulic data will show the design discharge and other design parameters used to design the structure. For this project, the entire 42.5 square miles is draining to Indian Creek to the proposed structure and the fifty year discharge is 5080 CFS.

Traffic Control Notes and Plans Sheets (Sheets 9, 9A and 9B)

Each project contains a traffic control plan which depicts how the contractor should maintain existing traffic which will be affected by the construction of the project. This plan also itemizes the traffic control devices which will be required to maintain this traffic.

There are several standard traffic control notes such as #4 which prohibits the contractor from parking vehicles or construction equipment within thirty feet of the edge of pavement. There are also special traffic control notes that usually apply to high volume or interstate projects that limits the time of construction. A note may specifically state that no work is to be done on I-40 on UT or Titan football game days in the areas close to the games, on holiday weekends, or on during morning or evening rush hours. There could also be notes about night time work.

The sequence of construction should be noted on the sheet. The sequence spells out what the contractor builds and in what order; whereas, the proposed plan sheets shows the end results after all is constructed. The traffic control appurtenances needed for each phase is shown including the types of signs and the spacing between each sign. A table listing the types and quantities of signs are also shown.

Roadway Cross-Section Sheets (Sheets 10-15)

Roadway cross-section sheets show cross-section views at frequent points along the proposed roadway including the beginning and last station of the project and on whole numbered 100’ and 50 ‘ station increments. Roadway cross-section sheets provide a picture of what the roadway will look like. The proposed road surface and subgrade are shown on the sheet along with the existing ground line. The construction limits are shown for each range. If the project has retaining walls, guardrail, or bridges, each would be projected onto the sections. If there is a box bridge or cross drain, there would have to be a culvert cross-section sheet.

On Sheet 11 for station 32+00.00, the construction limit on the right side of the centerline is at elevation 594.98 at an offset of 55.34. This construction limit is the point where the proposed slope line ties into the existing ground and no more work is required. This cross-section is in a cut area because the proposed 3:1 back slope is below the existing ground line. At the same cross-section, notice the left side of the road is in a fill section. The construction limit/slope tie for the left is at elevation 586.77 at an offset of -39.06 (negative sign signifies left side of road). If you looked on sheet 4 at Sta. 32+00.00, you would see a dashed line (represents fill section) on the left side of the road that is offset 39.06’. On the right, you would find a solid line (represents cut section) that is offset 55.34. When cross-sections are drawn the construction lines are projected into a design file. The cross-section sheets will also have the amount of cut and fill per section as well as the name of the road. This sheet also shows the bridge typical and guardrail that is shown in the Proposed Layout sheet.

Bridge Plans will be discussed in the section “Using Bridge Plans”

CHAPTER THREE

PLANS DEVELOPMENT WORKFLOW

In the previous chapters, the contract plans and its components have been discussed in great detail. 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 as previously discussed. The contract plans show how the project is to be built, and an estimate of the amount of work to be done. The contract plans are the final result; however, prior to completing the contract plans and after submittal of the plans, there are several processes conducted by other T.D.O.T. agencies that must occur.

Project Planning Division

Long before contract plans are prepared, the Project Planning Division gathers information on the types and amounts of traffic for the road. Estimates are made on what the future traffic will be in twenty years. These facts are shown in the traffic block on the title sheet. Turning movements for the mainline and side roads or ramps are also furnished. Crash analysis data is also prepared for the road at a certain trouble spots or at an intersection if requested. This information helps to plan the right type of roads to accommodate future traffic needs and which roadway standard should be used. The data can be used to determine if a signal or other traffic feature may be warranted at an intersection. Sometimes, the project Planning Division will hold a public meeting or hearing prior to any work actually being done on the project to receive feedback from the public about the possible change. All of the information is combined into a document called a Transportation Planning Report (TPR) and sent to the Roadway Design Division.

Field Survey Section

When the decision has been made to build a new highway or widen an existing one, 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, elevations, topography features, utilities, drainage areas and many other features that will be important to designing the road. All of the information is compiled in a MicroStation survey file by the Field Survey Section and sent to the Roadway Design Division.

Roadway Design Division

In the Roadway Design Division, plans similar to the example set of plans used in this course are produced. The plans are produced in stages of preliminary, R.O.W., and construction. The Design Division sends preliminary plans to the Hydraulics Division for grade approval for the proposed vertical alignment. The Hydraulics Division approves the proposed vertical alignment or requests changes. Sometimes, more vertical clearance may be requested over a waterway or railroad or a vertical curve shifted. If there are waterways under boxes or slab bridges that have flows less than 500 C.F.S. of water, the Hydraulics Division will inform the Design Division the required size of the structure. The Design Division takes the information and applies it to the project to determine how wide the structure should be. If the flow is over 500 CFS, the Structures Division designs the bridge.

The plans are also sent to the Geotechnical Engineering Section so that the soil at the site can be tested to see how stable the soil is. This determines if certain steep side slopes cannot or should not be used. Any field findings on side slopes made by the Geotechnical Engineering Section will supersede the side slopes shown in the roadway standard drawings. The Geotechnical Engineering Section also takes rock samples and determines if there is any material within the rock such as pyrite that could be harmful to the environment and may require special handling or off-site disposal.

Plans are also sent to the Environmental Division to check impacts on all natural waterways and historical areas and that the areas are preserved and protected as much as possible. The Environmental Division will advise the Design Division on the best way to construct any new streams or waterways by planting new trees and making the proposed waterways resemble the existing waterways as much as possible.

Upon completion of R.O.W. plans, the R.O.W. Division appraises and acquires the land needed to construct the project and also relocates families, businesses, if necessary. The Utilities Office is also part of the R.O.W. Division. The Utilities office coordinates with local utilities and railroads to relocate any utilities that might be affected.

Construction Division

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. The Construction Division is responsible for preparing proposals from these plans. The Construction Divisions let the plans to contract and write the contract documents which will be discussed next.

CONTRACT BOOKS

Standard Specifications

The book of Tennessee 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, supplemental specifications are written and included separately with each project. The supplemental specifications supersede the standard specifications and are used on each project until they can be included in a new publication of the book of standard specifications.

Special Provisions

Frequently some unusual problems or conditions are found when designing a project, and special instructions are needed. For this situation, special provisions are written that apply only to a particular project. Special provisions supersede both the standard specifications and the supplemental specifications if there happen to be any discrepancies. The next highest level of authority would be the contract plans, supplemental specifications, and last, the standard specifications.

CHAPTER FOUR

PREPARATION FOR CONSTRUCTION

Before roadway construction begins, some other work must be done first to prepare the site for construction of the roadway. Utilities may have to be relocated, obstructions may have to be removed, and the area may need to be cleared of trees and brush.

Utility Adjustments

Certain public utilities such as power lines, telephone lines, water lines, sewer lines, and gas lines must be removed from the proposed project right-of-way. Our concern is where these utilities are and how to remove them. Sometimes, the utilities are part of the contract and the utility work is done prior to the roadway work.

Utility sheets are the main source of information on utility adjustments. They show plan views and some profile views of existing and proposed utilities. Unlike present and proposed layout sheets, utility 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 sheets are submitted separately from the roadway plans.

Removal of Building and Other Obstructions

Buildings and obstructions must be removed from the project right-of-way before construction begins. Obstructions include utilities, buildings, fences, existing roads, underground storage tanks, drainage structures, trees and brush. Most requirements for removing obstructions are set forth in the Standard Specifications. However, special information and instructions for removing obstructions for a specific project appear as notes on the general notes sheet. For example, a general note can be added that states “the contractor is responsible for scarifying and obliterating existing roads with the right-of-way that are to be abandoned.”

The R.O.W. notes on the first property map usually summarize the arrangements for removing buildings and other structures. Turn to sheet 3 in your sample plans. Read note number one that refers to removal of buildings. The removal of certain buildings may also be shown in a tabulated box and in the estimated roadway quantity block.

Clearing and Grubbing

Clearing and grubbing is the process of removing trees, brush and other obstructing vegetation and debris within the limits of the right-of-way. Building removal is not included in the category of clearing and grubbing.

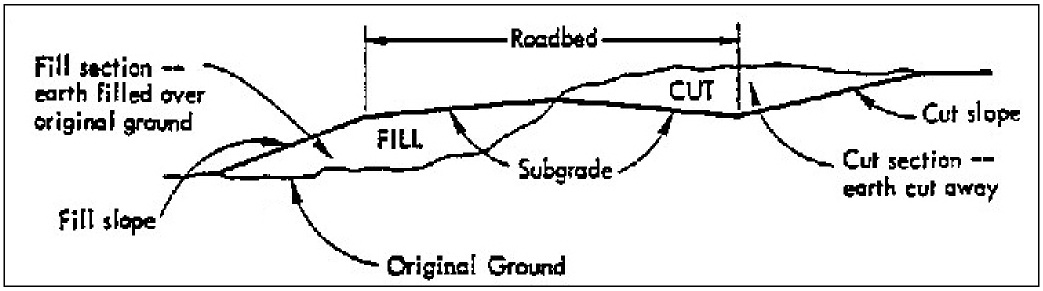
The contractor will clear and grub all vegetation not designated by the engineer to remain for ornamental purposes. Since the amount of work to be done in clearing and grubbing varies from one project to the next, clearing and grubbing is usually a special pay item in each construction contract. Turn to sheet 2A in your sample plans. The first pay item listed is 201-01 "Clearing and Grubbing". It will be paid as one lump sum.

Since present layout sheets show existing topography, many of the items to be cleared and grubbed are shown on those sheets; however, if there is a lot of clearing and grubbing on a large project, a phase can be added to the plans for clearing and grubbing.

CHAPTER FIVE

GRADING

The most important part of grading operations is constructing the roadbed. The roadbed is constructed by excavating through cut sections and building embankments through fill sections. Grading is required on projects where the road is being widened or where a new road is being built. For resurfacing projects, grading is not required.



Turn to the typical sections sheet on 2B in your sample plans. The typical sections show the shape of the subgrade and the total width of the subgrade. The contractor must prepare the subgrade and compact the material prior to placing the base and asphalt layers.

EARTHWORK

On many projects, several types of earthwork are encountered or needed. The type of earthwork usually depends on its location or its purpose. Basic information on earthwork types and estimated quantities of each type is shown on quantities sheets and roadway cross-section sheets.

Quantities Sheets

Quantities sheets show estimates of each type of earthwork to be done. For example, turn to Sheet 2A. The types of earthwork listed in the upper left corner include Road and Drainage Excavation (unclassified), Borrow Excavation (unclassified), and Furnishing and Spreading Topsoil. Road and Drainage Excavation is typically the bulk of the earthwork on a project. The quantity comes from making ordinary cuts inside the right-of-way and above the subgrade to shape the roadway. It is called "unclassified" because it includes excavation of all types of materials: sand, rock, muck, shale, etc. Furnishing and spreading topsoil is one of the last earthwork activities. This is done after the major cuts and fills are completed prior to seeding or sodding.

Earthwork Types

There are several types of earthwork encountered during the excavation process. Sand, gravel, clay, dirt or rock can be encountered. Some earthwork is unsuitable which means that it cannot be used as fill material for embankment on the project. Suitable materials removed from excavation areas can be used in the construction of embankments, intersecting road approaches, or in other places as directed.

Only excavation quantities are pay items. Embankment quantities are not pay items. This does not mean that there will be no embankment. Instead, it means that the cost of embankment work is absorbed in the contractor's bid for excavation work. Embankment work is paid for indirectly.

Roadway Cross-section Sheets

Roadway cross-section sheets show earthwork types and quantities in considerable detail. For example, turn to sheet 10. Notice on the right side of the sheet, quantities for cut and fill are given in square feet. For Sta. 30+50.00, there are twenty-nine square feet of cut and twenty-five square feet of fill for this cross section.

SOILS DATA

The contractor and the construction inspector must be aware of the kinds of soils that will be encountered during grading operations. Some are suitable for embankment construction, others are not. Some soils may be too dry requiring water for proper compaction in the embankment. Other soils may too easily begin to flow when water is added and rock may need to be added for the embankment.

Many soils problems can be encountered during grading. The Geotechnical Engineering Section attempts to minimize these problems by taking soils samples before construction begins. Soils data affect roadway design and are included in the contract plans to assist the contractor and the construction inspector in identifying soils problems.

The soils data is shown on several types of sheets. The Geotechnical Engineering Section sometimes provides layout sheets that show the actual locations of soil borings depicted by a numbered circle. Cross-sections at these locations are also supplied. Sample cross-sections 202-204 are given to show cross sections supplied by the Geotechnical Engineering Section for a job that has pyritic material located in DeKalb County. These are typical sections for certain locations and these details must be added to the roadway cross sections for a specific station range. The following is from the Geotechnical report that was supplied to the Roadway Design Division:

Station 35+25 to 50+50
This interval involves alternating cut and fill sections with cut depths of up to 98 feet and fill heights of up to 25 feet. Rock will be encountered from Sta. 37+50.00 to Sta. 50+50.00. It is recommended that this rock cut be placed on a .25:1 slope. A minimum rock fall catchment width of 45 feet will be required for this cut slope. Little soil overburden is expected overlying the bedded rock. No soil slope or bench is recommended with the exception of left Station 45+00.00 to left Sta. 46+00.00. For this station interval, a 20'-wide bench is recommended at an elevation of 880 with the upper soil material laid back on a 2:1 slope. Refer to cross section Sta. 45+50.00.

From the report and the sample cross section, the Roadway Design Division can add the areas for rock, catchment areas, and bench areas to the roadway cross sections to get an estimate of how much rock there is to be removed and how much of it is pyrite. The pyrite has to be taken off site and capsulated so a good estimate must be made to know the size of the area necessary to accommodate the encapsulation. This area will have to be purchased by T.D.O.T. and have continuous monitoring.

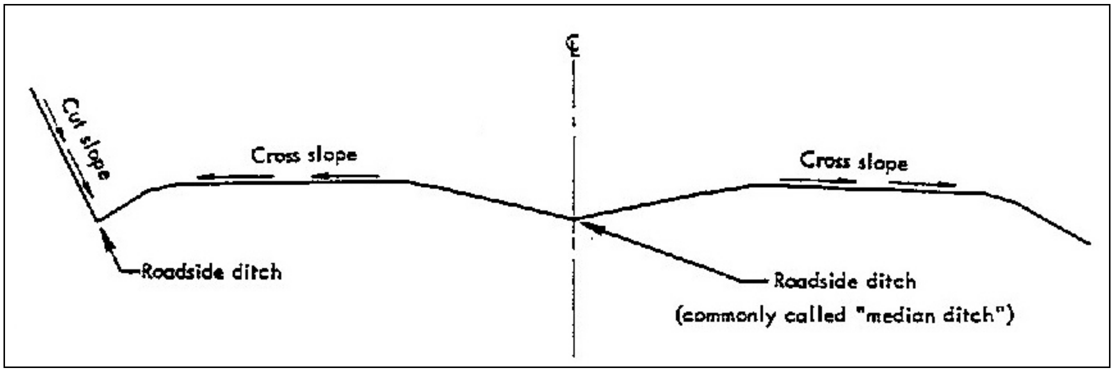
CHAPTER SIX

DRAINAGE

A major concern in highway construction is water drainage. Water must be kept from standing on or washing over the road. The side slopes must also be protected from erosion. To handle these drainage problems, the natural flow of water in the area is studied, and a system of pipes, ditches, culverts, slopes, etc. is developed. Many of these are shown on proposed layout sheets, typical section sheets, culvert cross-section sheets, and roadway cross-section sheets.

Ditches

Ditches are formed along roadways in cut sections and in the median strip of divided roadways as shown below:



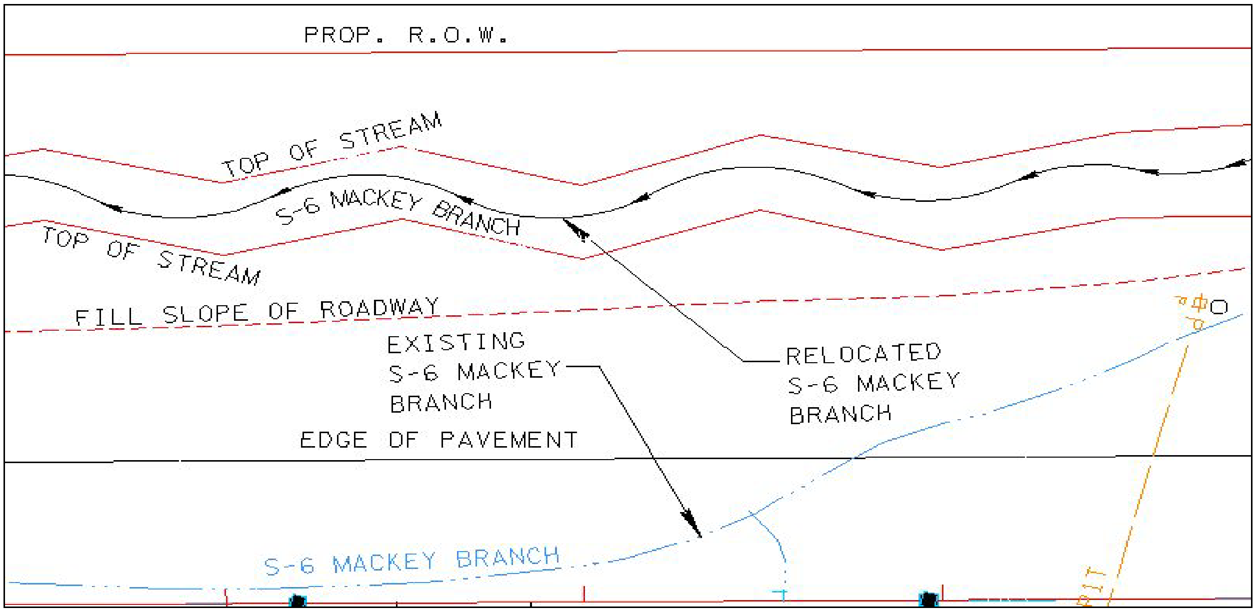
Ditches are referred to as roadside ditches, special ditches or independent special ditches. The ditches collect water from cut slopes and cross slopes. Roadside ditches often are sodded, paved with concrete or lined with rip-rap to prevent erosion. To find these and other general ditch requirements, refer to STD-RD-11 and 11A which are provided in your sample plans.

A normal roadside ditch is part of the roadway meaning it is a continuation of the roadway. A regular roadside ditch has a "V" shaped bottom and meets the general depth requirement according to those specified on the roadway standard drawing. It is not labeled in the layouts or cross-sections and isn't shown on the profile.

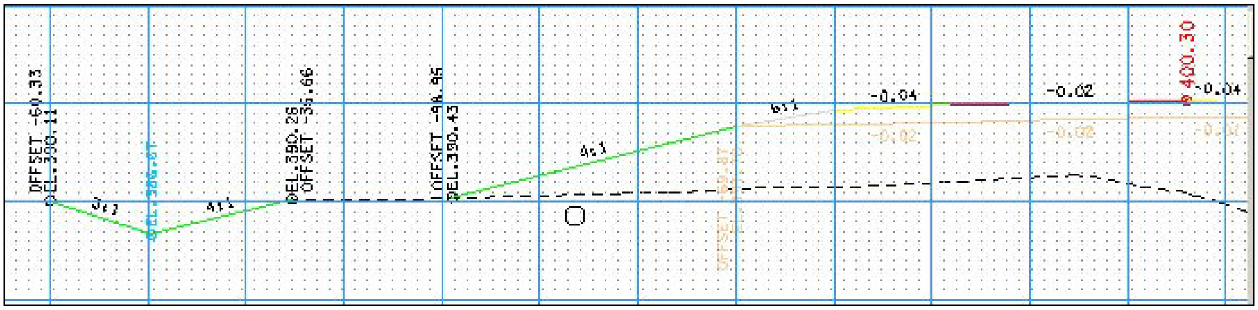
A special ditch is constructed to meet drainage requirements not covered in the roadway standard drawing for the road. Requirements such as a deeper depth, trapezoidal bottom, and/or grade changes in the ditch would have to be accomplished by using a special ditch. Special ditches are labeled and described on proposed layout sheets, profile sheets, and detail sheets. Sheet 2G in your sample plans shows the details for all special ditches on this project. The two V-bottom ditches are special ditches because the depth varies and is not kept at a constant two foot as shown in the standard. Look at the proposed 10' flat bottom ditch for the right side of the road from

Sta. 36+50.00 to Sta. 39+00.00. Now, turn to sheet 4B in your plans and look at the same station range. The ditch is labeled 10’ T. Look at sheet 4C. The trapezoidal ditch is labeled on the profile at the beginning and end. The slope is also shown. If there had been changes in the slope, the V.P.I.’s of the ditch would have been shown as well as the elevations for these points. Turn to sheet 14 to see the trapezoidal ditch on the cross-sections.

An independent special ditch is generally one that does not connect to the roadway. In the figure below, Stream 6 (S-6) Mackey Branch must be relocated. The proposed centerline of the road has shifted north and the existing branch is between the proposed centerline and edge of pavement. The proposed re-located stream will shift north outside of the roadway slopes. Notice the area between the top of stream for the proposed stream and the fill slope of the roadway. This is a bench.

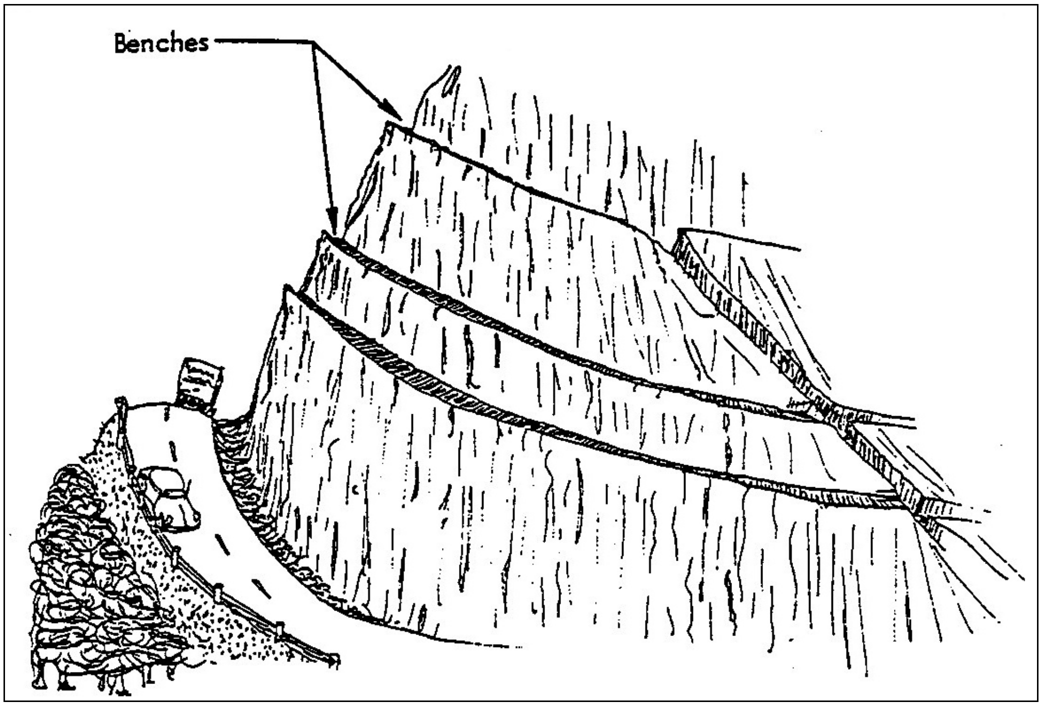


The cross-section below shows the left side of the road where the proposed stream is located. Notice the bench between the stream and the 4:1 slope of the roadway where the two do not connect. Benches will be discussed next.



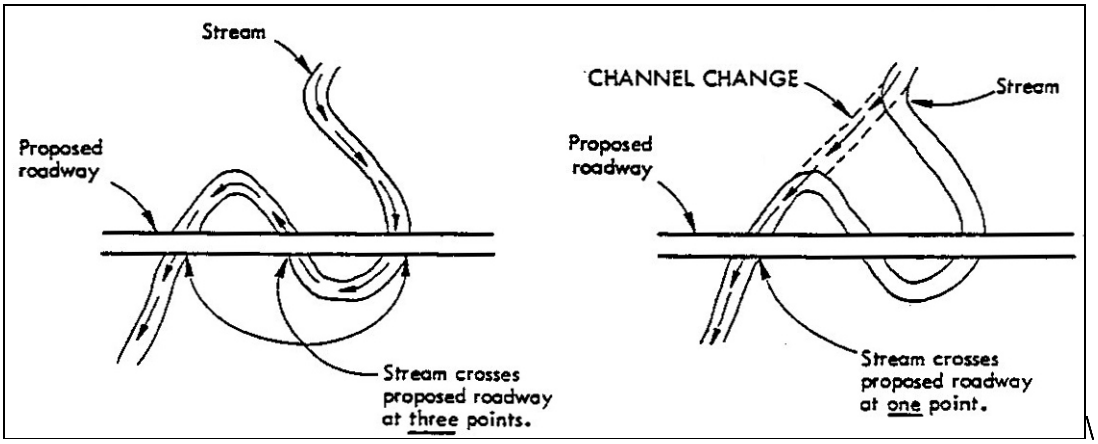
Benches

A common kind of special ditch that is a strip of land at a constant height is a bench. The bench shown on the previous page is in a slightly sloping area between the proposed road and proposed ditch. Another place that benches are used is in mountainous regions. Benches are made as cuts into the side of a cut slope or rock or earth so that each step is a ditch bed. The practice of benching often produces several benches instead of one, and prevents drainage, falling rocks and earth from reaching the roadway. The figure below shows benches:



Channel Changes

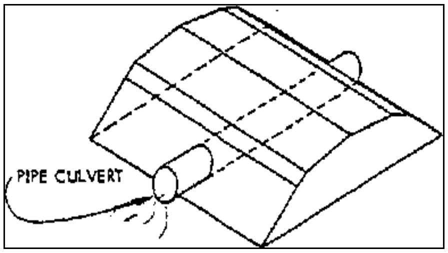
Channels are sometimes re-aligned to straighten the stream and eliminate the need for several structures within a given area. The channel change below is necessary because the stream crosses the road three times which would require three small structures or one large one. In this case, it is less expensive to construct a channel change than to construct several bridges.



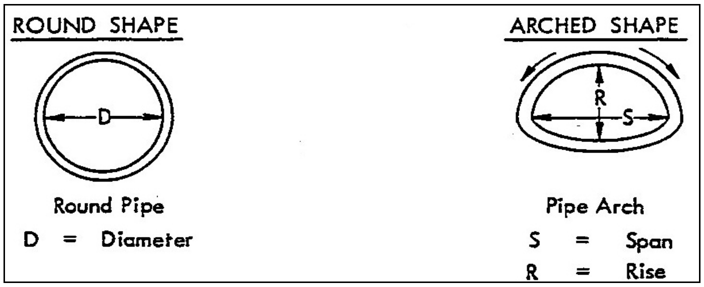
PIPE CULVERTS

A culvert is any structure which is not a bridge and which provides an opening under the roadway. A culvert conveys stream flow through a roadway embankment or past some other type of obstruction. 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.), reinforced concrete pipe (R.C.P.), or plastic (HDPE).

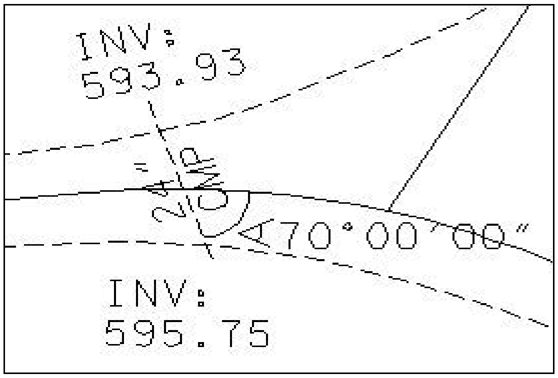
Examine the figure below which represents a pipe under a section of road:



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



Sometimes, pipes are skewed to follow the natural flow of water as it would be under the road. Look on sheet 4. On Indian Creek Road, find the 24" C.M.P. pipe at approximate Sta. 25+50.00. This culvert does not cross the centerline at a 90 degree angle. The crossing angle, or skew angle, is 70° 00' 00" to the right of the centerline. The skew of a culvert is measured in degrees to the right or the left of the centerline. The skew is never more than 90° 00' 00". The skew angle is measured from centerline ahead to the nearest end of the culvert.



Culvert Tabulations

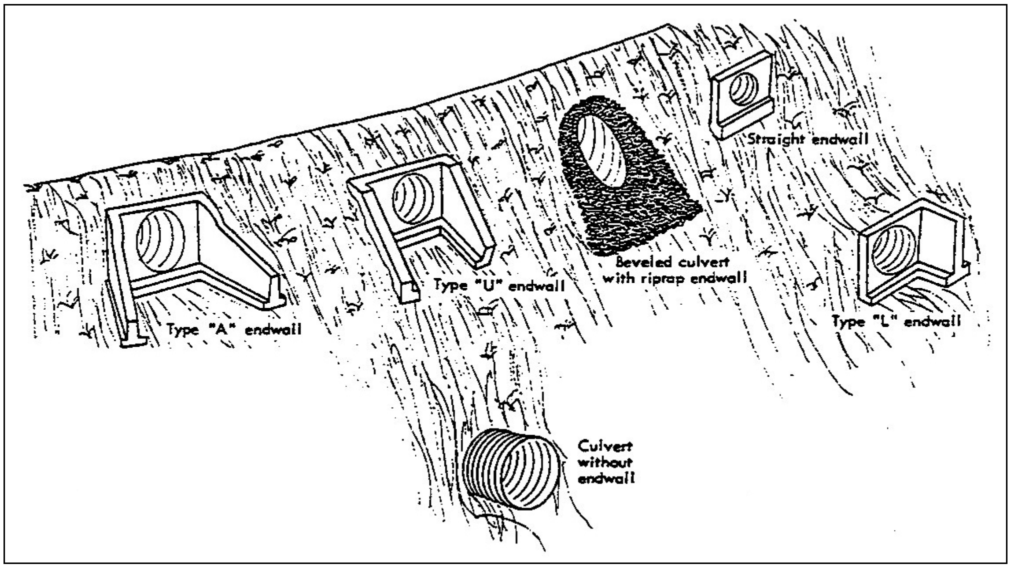
The proposed culverts are shown on the plan views of proposed layout, profile, and culvert cross-section sheets. The quantities are shown on the estimated and tabulated quantities sheets. The quantities are broken down into three parts: length of pipe, culvert bedding, and end treatment. A pipe is paid for by linear foot of required pipe.

Pipe Culvert Bedding

For a pipe to withstand the weight of traffic and not collapse there must be sufficient bedding material under the pipe. The bedding material must be compacted prior to laying the pipe. The bedding material is specially selected granular material, Class B. Although standard drawing D-PB-1 has a table for the amounts (cubic yards per linear foot) of class B bedding for several culvert shapes and sizes, Class B bedding is paid for with the cost of the linear foot of pipe.

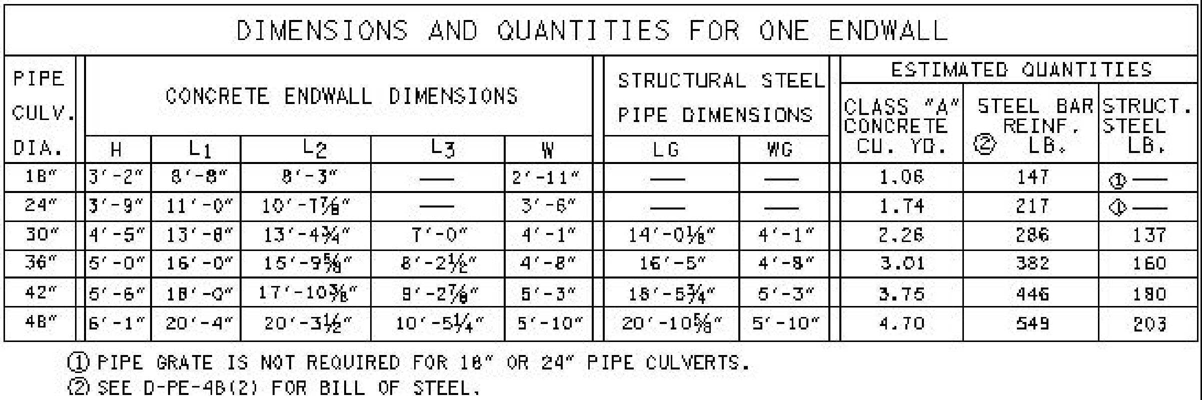
End Treatments

Endwalls are used on the end of pipes for several reasons. An endwall will shorten the culvert length because the pipe does not have to project until it hits natural ground. Endwalls help maintain the fill material and help prevent erosion of surrounding embankments. An endwall can also provide structural protection to the inlet and outlets of the pipe. Special end treatments can increase or restrict the flow of water.



Standard drawings provide details of endwalls for straight, “L” shaped, “U” shaped, type “A’, and type “B” endwalls. There are numerous drawings for each type based on pipe sizes and side slopes. The estimated quantities for the endwalls are shown on each drawing. Each endwall has class “A” concrete and steel bar reinforcing. However, structural steel is not needed on all endwalls, only those that need pipe grates.

The following table is from Roadway Standard Drawing D-PE-4B(1), Concrete Endwall Type "U" With Steel Pipe Grate(for 18" thru 48" pipes) (4:1 slope). Notice that no structural steel is noted for the 18” and 24” diameter pipes and a note about each not needing a pipe grate is below the table. Also, notice that the entire table gives quantities for one endwall not two. Although most pipes have endwalls on both ends, not all do. A pipe may begin or end in a catch basin or other type of structure or an existing pipe may be extended onto one side of the road only.



DIMENSIONS AND QUANTITIES FOR ONE ENDWALL

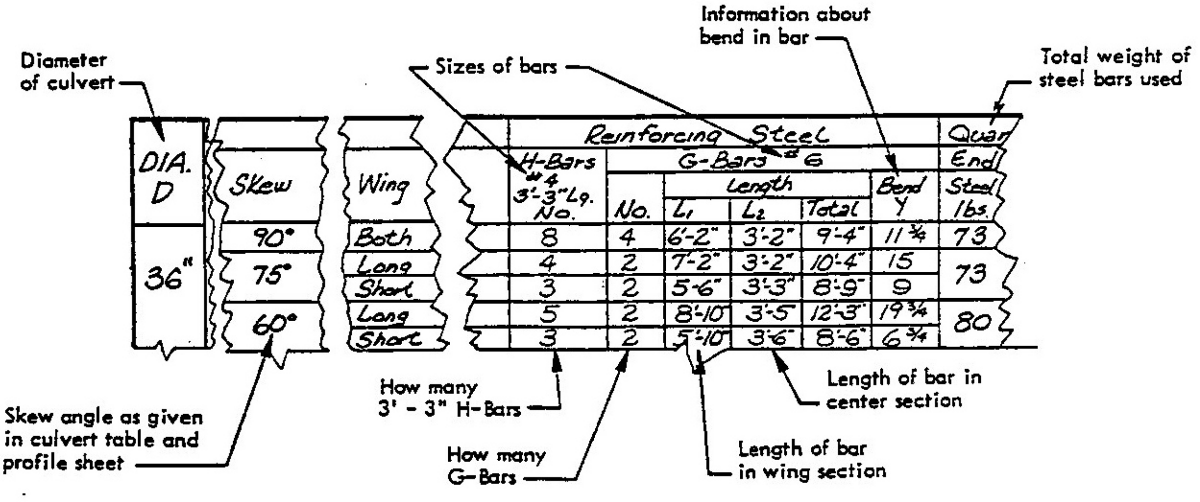
PIPE CULV. DIA.	CONCRETE ENDWALL DIMENSIONS					STRUCTURAL STEEL PIPE DIMENSIONS		ESTIMATED QUANTITIES		
	H	L1	L2	L3	W	LG	WG	CLASS "A" CONCRETE CU. YD.	STEEL BAR REINF. ② LB.	STRUCT. STEEL LB.
18"	3'-2"	8'-8"	8'-3"	—	2'-11"	—	—	1.06	147	① —
24"	3'-9"	11'-0"	10'-7⅞"	—	3'-6"	—	—	1.74	217	① —
30"	4'-5"	13'-8"	13'-4¾"	7'-0"	4'-1"	14'-0⅛"	4'-1"	2.26	286	137
36"	5'-0"	16'-0"	15'-9⅝"	8'-2½"	4'-8"	16'-5"	4'-8"	3.01	382	160
42"	5'-6"	18'-0"	17'-10⅜"	9'-2⅞"	5'-3"	18'-5¾"	5'-3"	3.75	446	180
48"	6'-1"	20'-4"	20'-3½"	10'-5¼"	5'-10"	20'-10⅝"	5'-10"	4.70	549	203

① PIPE GRATE IS NOT REQUIRED FOR 18" OR 24" PIPE CULVERTS.

② SEE D-PE-4B(2) FOR BILL OF STEEL.

Reinforcing Bars

Any concrete structure can be made stronger by systematically placing reinforcing steel bars throughout the structure before pouring the concrete. Highway concrete structures are almost always reinforced concrete. Standard Drawing No. D-PE-1, Type “A” Endwall (for 36" thru 78" pipes) (2:1 slope), shows several parameters associated with reinforcing steel data as shown below:



DIA. D	Skew	Wing	Reinforcing Steel						Quan
			H-Bars #4 3'-3" Lg.	G-Bars #6					End Steel
			No.	No.	Length L1	L2	Total	Bend Y	lbs.
36"	90°	Both	8	4	6'-2"	3'-2"	9'-4"	11¾	73
	75°	Long	4	2	7'-2"	3'-2"	10'-4"	15	73
		Short	3	2	5'-6"	3'-3"	8'-9"	9	
	60°	Long	5	2	8'-10"	3'-5"	12'-3"	19¾	80
		Short	3	2	5'-10"	3'-6"	8'-6"	6¾	

Bar Sizes

Bar sizes are shown as #4, #7, #2, etc. In the previous table, the number of H #4 bars is shown. Bars with larger diameters have larger numbers. Bars with smaller diameters have smaller numbers. The number of a bar is a measure of its diameter. The diameter in inches is equal to the bar number divided by 8".

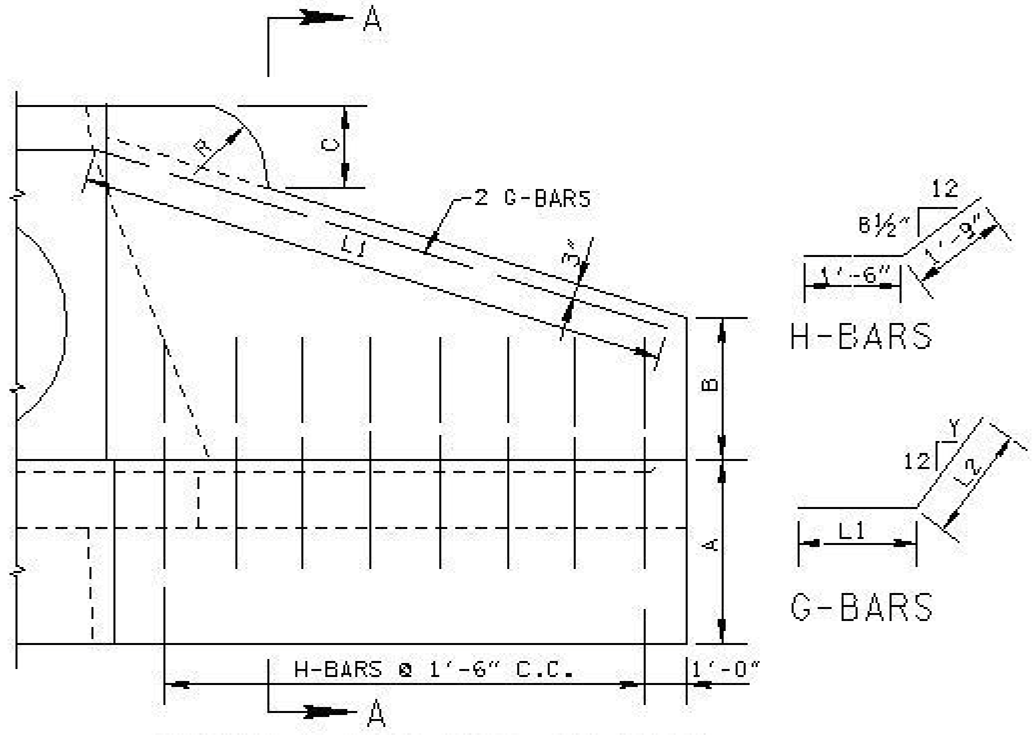
Bar Number (#) divided by Bar Diameter = 8"

For example, a #4 bar would have a diameter of 4/8" or 1/2".

A #8 bar would have a diameter of 8/8" or 1".

Bar Bending

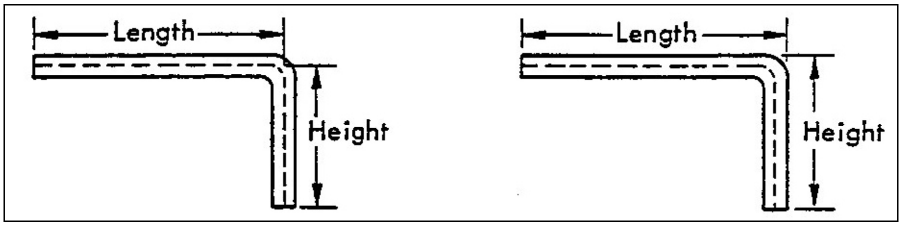
A sketch of an "A" type endwall with bars is shown below. The table shows the length of the H-bars (3'-3" long) and how many of them are used. The table also shows the length of the G-bars based on L1 and L2 for each bar. The lengths for L1 and L2 are also shown in the standard. The amount each bar should be bent is also shown in the drawing. Bars are usually shown as broken lines, but are actually continuous.



FRONT ELEVATION OF WING

Bar Dimensions

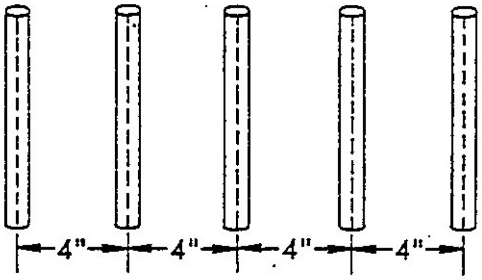
Bar dimensions (other than diameters) may be measured from center to center or from outside to outside. The plans will indicate how bar dimensions are measured.



CENTER CUT **OUT TO OUT**

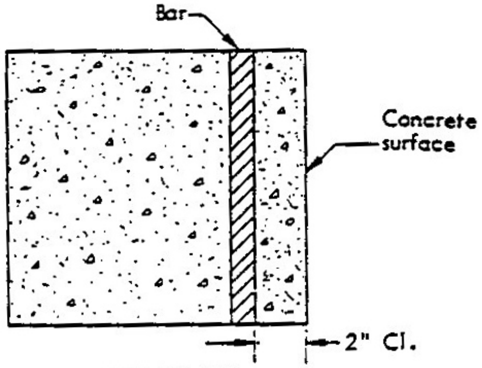
Bar Spacing and Clearance

Bar spacings are distances between bars. Bar spacings are measured center to center.



SPACING

Bar clearances are distances between concrete surfaces and the nearest edges of the bars as shown below. Where bar clearances are required, the abbreviation "Cl." appears on the plans. If "Cl." does not appear, the distances between concrete surfaces and bars are measured to the centers of the bars.



CLEARANCE

Bar Supports

Reinforcing bars in concrete structures must be supported in place before the concrete is poured. T.D.O.T. requires the use of specific kinds of bar supports for certain concrete slabs. These bar supports are detailed in Standard Drawing No. STD-9-1, Standard Reinforcing Bar Support Details for Concrete Slabs, which is included in your sample plans.

Three standard bar supports are shown in the center of the sheet: heavy beam bolster, beam bolster, and special upper beam bolter. Note the differences on spacing. The two drawings on the left side of the sheet show typical uses of the bar supports. The bar supports, used in conjunction with tie wires, hold the reinforcing bars in place while the concrete is poured. Note the location of the 16 gauge tie-wires used in both drawings.

CATCH BASINS

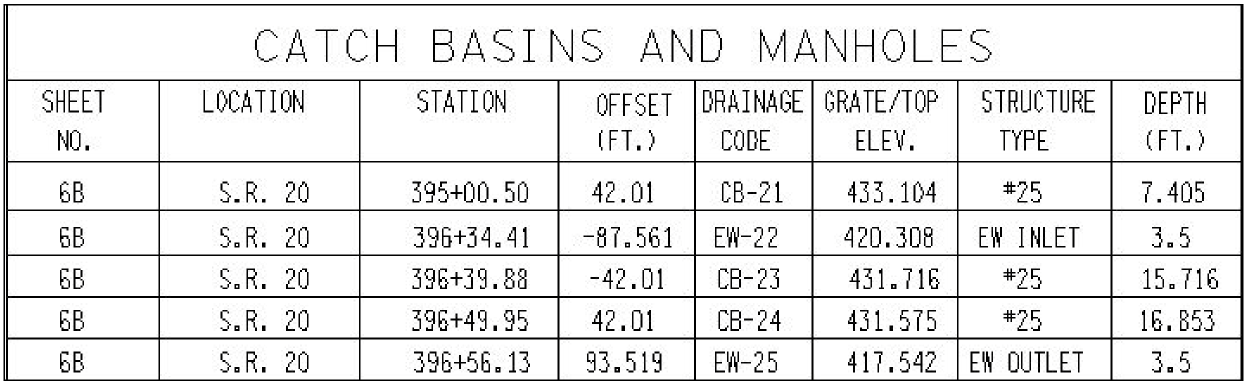
Catch basins primary use is to collect pavement runoff and act as a junction for a storm drain system. Drainage flows into catch basins and is collected by underground pipes until an outlet is met.

Catch basins come in various sizes, depths, and types. Catch basins may be square, rectangular, circular, concrete, or precast. The type used depends on the location of the catch basin and the sizes of the pipes coming in and going out of the catch basin. Some catch basins are used in sags or as median or field drains. Several types are set apart based on their use with a 4” or 6” mountable or nonmountable curb. For example, type 12 catch basins can be used in conjunction with a 6” non-mountable curb. Below are examples of three types of type 12 catch basins used with nonmountable curbs.

D-CB-12RA	PRECAST 48" CIRCULAR NO.12 CATCH BASIN (FOR USE WITH 6" NONMOUNTABLE CURB)
D-CB-12RB	PRECAST 60" AND 72" CIRCULAR NO.12 CATCH BASIN (FOR USE WITH 6" NONMOUNTABLE CURB)
D-CB-12RC	PRECAST 84" THRU 120" CIRCULAR NO.12 CATCH BASIN (FOR USE WITH 6" NONMOUNTABLE CURB)

Of these three, the one used depends on the sizes of the pipes connected to the catch basin. D-CB-12RA can be used in conjunction with 18” or 24” pipes. D-CB-12RB can be used with 18” thru 48” pipes (with increments of 6” between). D-CB-12RC can be used with 18” thru 78” pipes (with increments of 6” between). The size of pipe can be used to narrow down which drawing to use for larger pipes 54” and up. However, notice that all of these drawings can be used in conjunction with 18” or 24” pipes. So, the next determining factor is the depth of the catch basin. The maximum depth is 20’ for D-CB-12RA and 40’ for the other two types. Therefore, if a type 12 catch basin 18’ deep with 18” pipes connected to it was needed, all three would be options. The smaller, less costly of the three would be chosen.

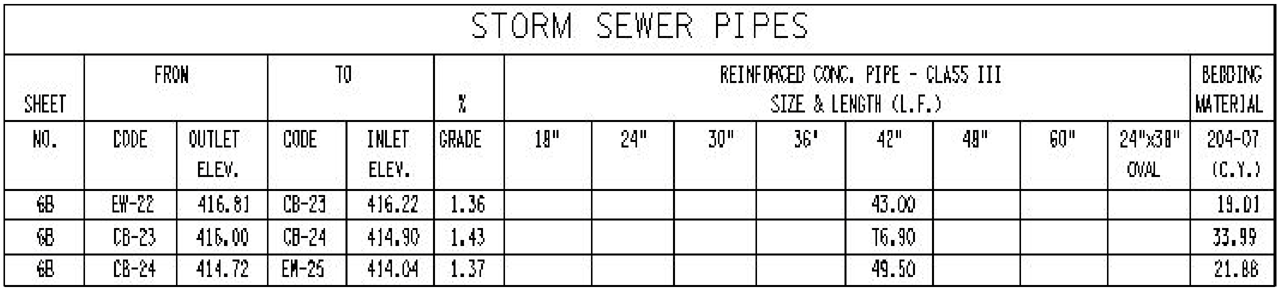
Catch basins are shown on proposed layout sheets and profile sheets as shown in chapter one. There are also sheets in the two series sheets for the catch basins which give more detail about the locations, elevation and depth as shown below:



CATCH BASINS AND MANHOLES

SHEET NO.	LOCATION	STATION	OFFSET (FT.)	DRAINAGE CODE	GRATE/TOP ELEV.	STRUCTURE TYPE	DEPTH (FT.)
6B	S.R. 20	395+00.50	42.01	CB-21	433.104	#25	7.405
6B	S.R. 20	396+34.41	-87.561	EW-22	420.308	EW INLET	3.5
6B	S.R. 20	396+39.88	-42.01	CB-23	431.716	#25	15.716
6B	S.R. 20	396+49.95	42.01	CB-24	431.575	#25	16.853
6B	S.R. 20	396+56.13	93.519	EW-25	417.542	EW OUTLET	3.5

The connection or link between the catch basins is shown below in the storm sewer pipes tables. CB- 23 is connected to CB-24 by 76.9' of 42" R.C.P. on a grade of 1.43%. There is a mandatory drop across the structure for the pipes coming in and going out. For CB-24, the pipe comes in at an elevation of 414.90 but the pipe going out of the catch basin to EW-35 is at an elevation of 414.72 for a drop of 0.18'.

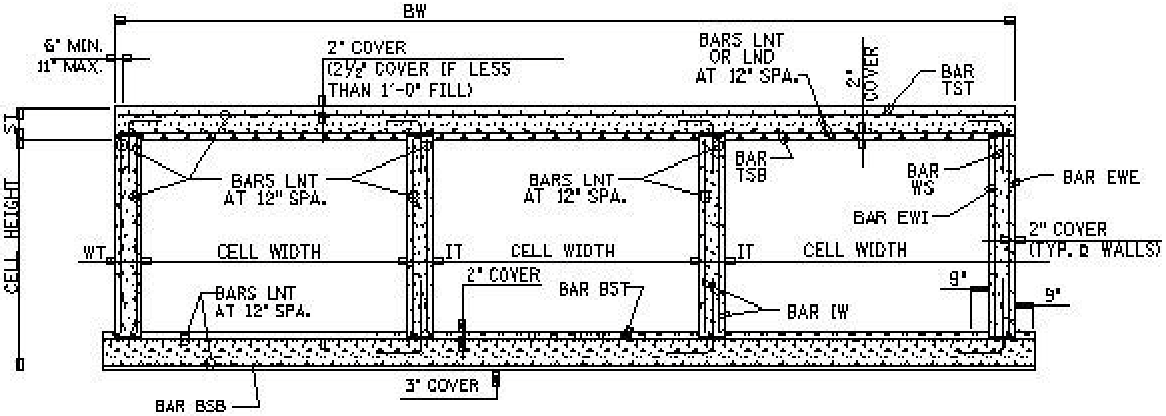


STORM SEWER PIPES

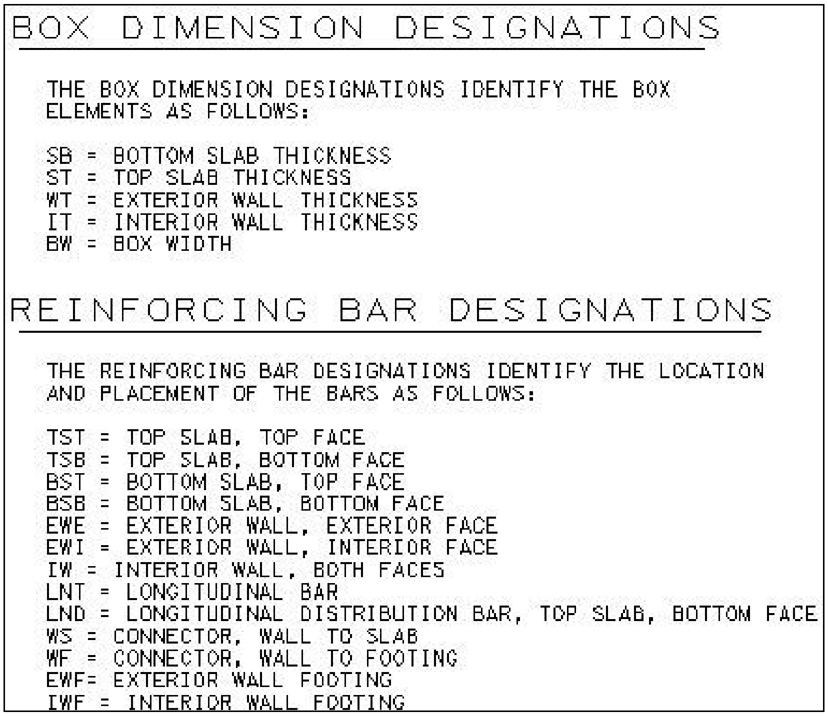
SHEET	FROM		TO		%	REINFORCED CONC. PIPE - CLASS III SIZE & LENGTH (L.F.)								BEDDING MATERIAL
NO.	CODE	OUTLET ELEV.	CODE	INLET ELEV.	GRADE	18"	24"	30"	36'	42"	48"	60"	24"x38" OVAL	204-07 (C.Y.)
6B	EW-22	416.81	CB-23	416.22	1.36					43.00				19.01
6B	CB-23	416.00	CB-24	414.90	1.43					76.90				33.99
6B	CB-24	414.72	EW-25	414.04	1.37					49.50				21.88

SLAB AND BOX BRIDGES

When pipe solutions are not applicable, another type of culvert section must be used. Slab or box bridges are used in place of pipes where larger openings are needed to allow flow under the road. Slab bridges are open at the bottom meaning a footing is not found across the bottom. The rock in the stream bed can serve as the bottom of the culvert. If there is a foundation at the bottom of the structure, the structure is a box bridge. There are numerous standard drawings for each listed according to the number of barrels, width of barrel, and height of barrel. These three dimensions are used to describe the structure. A 3 @ 18 X 8 box or slab means there are three barrels or openings, the cell width of the barrel is eighteen feet, and the cell height of the barrel is eight feet. An example of a box bridge and a legend for the abbreviations is shown below. The box is drawn along the roadway as if standing in the stream facing the box.



TYPICAL SECTION FOR BOX BRIDGE



BOX DIMENSION DESIGNATIONS

THE BOX DIMENSION DESIGNATIONS IDENTIFY THE BOX ELEMENTS AS FOLLOWS:

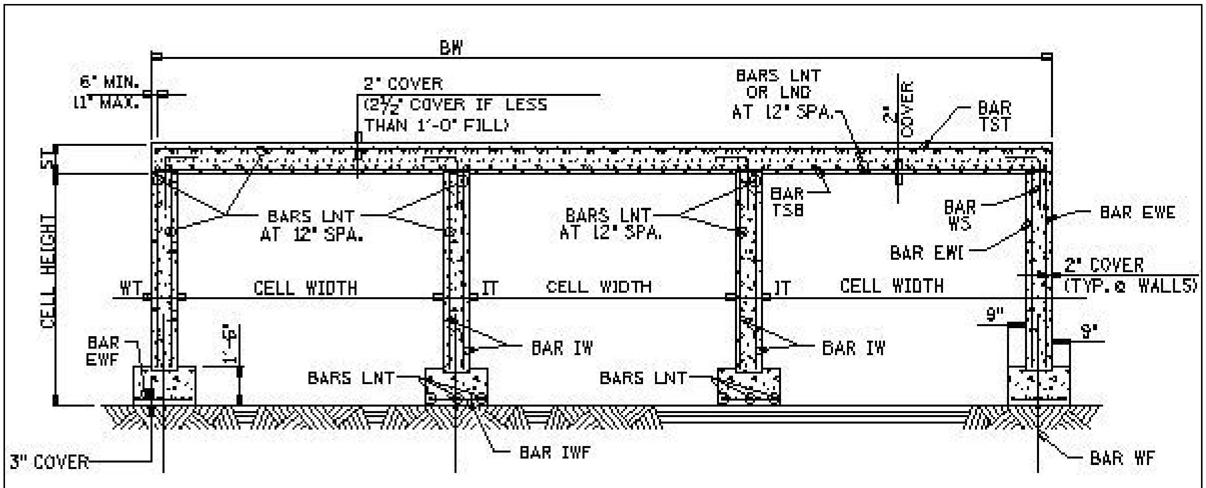
SB = BOTTOM SLAB THICKNESS
ST = TOP SLAB THICKNESS
WT = EXTERIOR WALL THICKNESS
IT = INTERIOR WALL THICKNESS
BW = BOX WIDTH

REINFORCING BAR DESIGNATIONS

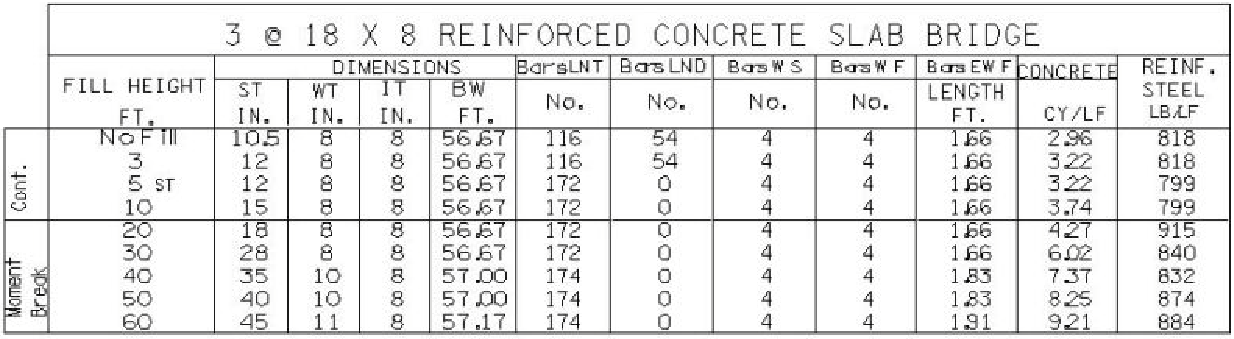
THE REINFORCING BAR DESIGNATIONS IDENTIFY THE LOCATION AND PLACEMENT OF THE BARS AS FOLLOWS:

TST = TOP SLAB, TOP FACE
TSB = TOP SLAB, BOTTOM FACE
BST = BOTTOM SLAB, TOP FACE
BSB = BOTTOM SLAB, BOTTOM FACE
EWE = EXTERIOR WALL, EXTERIOR FACE
EWI = EXTERIOR WALL, INTERIOR FACE
IW = INTERIOR WALL, BOTH FACES
LNT = LONGITUDINAL BAR
LND = LONGITUDINAL DISTRIBUTION BAR, TOP SLAB, BOTTOM FACE
WS = CONNECTOR, WALL TO SLAB
WF = CONNECTOR, WALL TO FOOTING
EWF= EXTERIOR WALL FOOTING
IWF = INTERIOR WALL FOOTING

Box and slab bridge drawings have tables listed which have the dimensions for the abbreviations and the associated quantities. Each row is divided according to the height of fill above the culvert. The fill above a box or slab is measured from the bottom of the top slab (ST) to the finished grade. A box or slab culvert that is being used as the riding surface will have no fill. Below is an example of a slab bridge and the table that goes with the diagram:



TYPICAL SECTION FOR SLAB BRIDGE



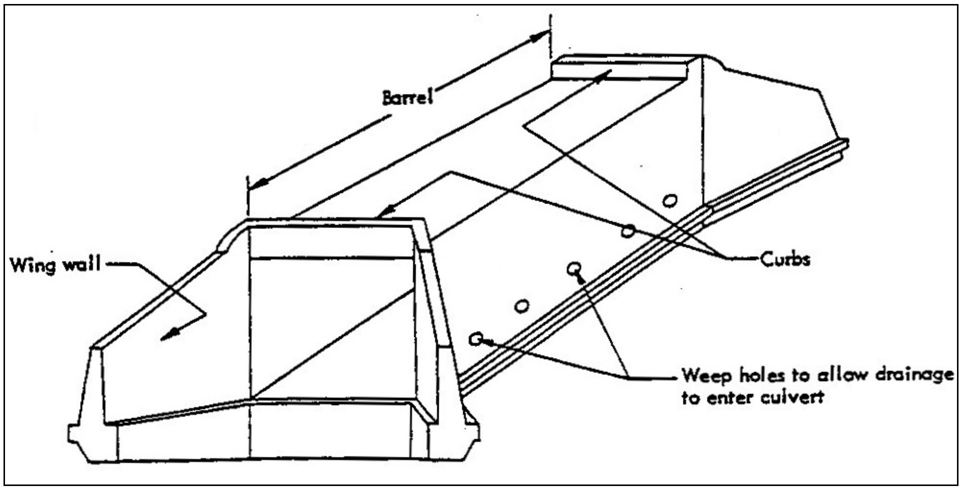
3 @ 18 X 8 REINFORCED CONCRETE SLAB BRIDGE

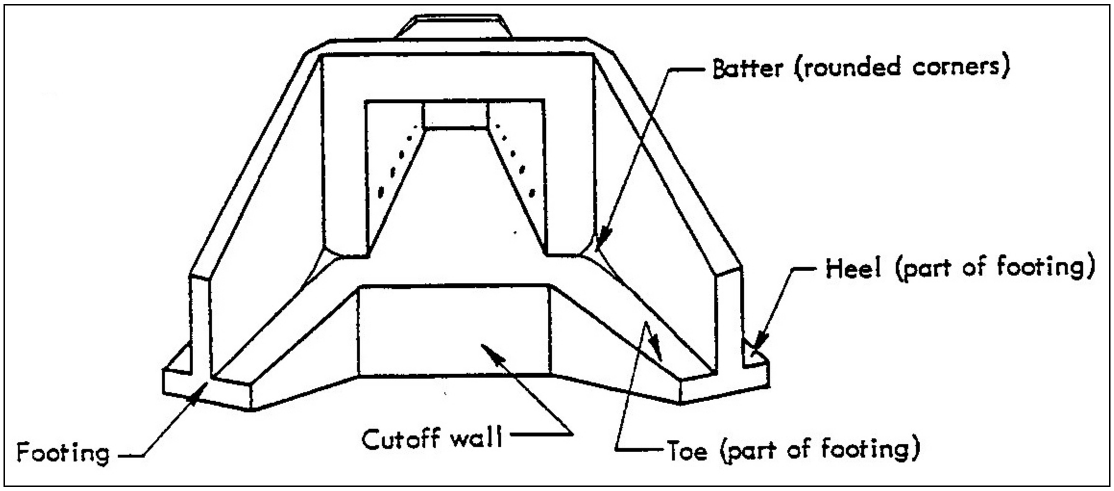
	FILL HEIGHT FT.	DIMENSIONS				BarsLNT	Bars LND	Bars W S	Bars W F	Bars EW F	CONCRETE	REINF. STEEL LB/LF
		ST IN.	WT IN.	IT IN.	BW FT.	No.	No.	No.	No.	LENGTH FT.	CY/LF	
Cont.	No Fill	10.5	8	8	56.67	116	54	4	4	1.66	2.96	818
	3	12	8	8	56.67	116	54	4	4	1.66	3.22	818
	5 ST	12	8	8	56.67	172	0	4	4	1.66	3.22	799
	10	15	8	8	56.67	172	0	4	4	1.66	3.74	799
Moment Break	20	18	8	8	56.67	172	0	4	4	1.66	4.27	915
	30	28	8	8	56.67	172	0	4	4	1.66	6.02	840
	40	35	10	8	57.00	174	0	4	4	1.83	7.37	832
	50	40	10	8	57.00	174	0	4	4	1.83	8.25	874
	60	45	11	8	57.17	174	0	4	4	1.91	9.21	884

Once a slab or box is drawn in the culvert section, the width of the box across the road can be determined. If the width of the slab bridge across the road is 50' and has a fill height of 5', the dimensions from the table would be 12" for the top slab, 8" for both the exterior and interior wall thickness, and a base width of 56.67' along the road. For the concrete and reinforced steel calculations, the quantities would be read from the table and multiplied by 50'. The results would be

Concrete (CY) = 50 ft. X 3.22 CY/LF = 161 CY
Reinforced Steel (LB) = 50 ft. X 799 LB/LF = 39,950 LB

Another important part of a box or slab bridge is the wingwalls as shown below:



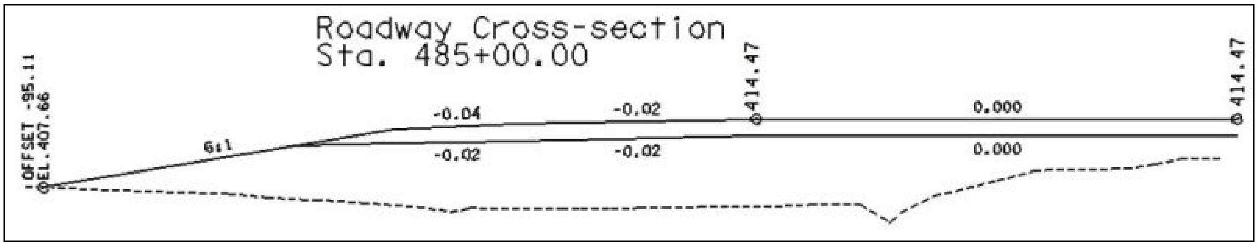


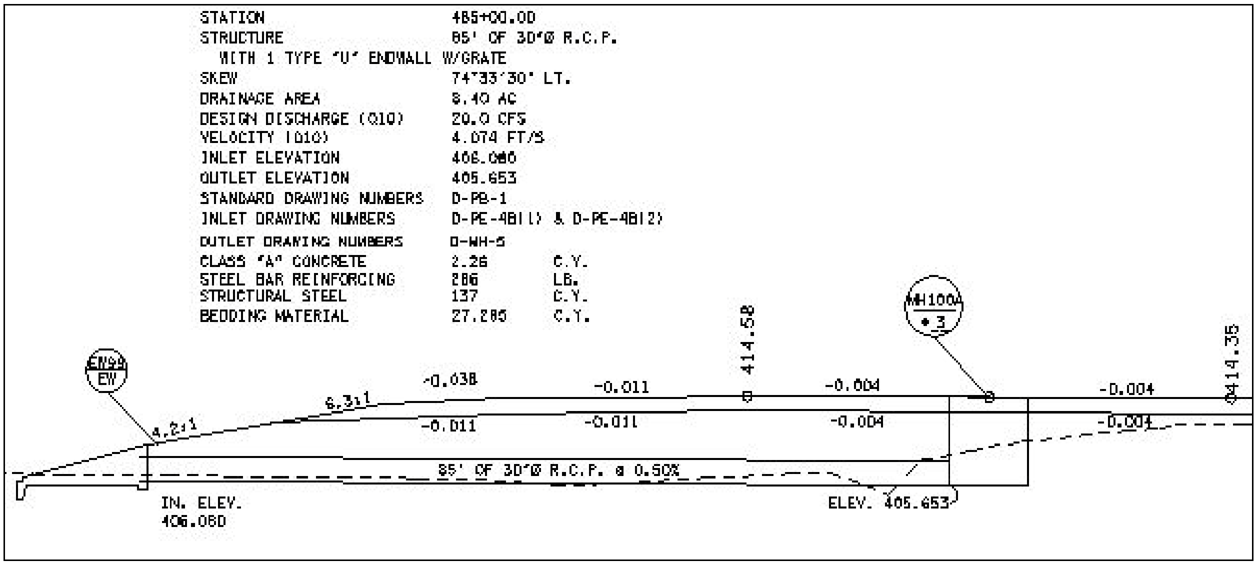
Wingwalls serve the same purpose as endwalls. The quantities for wingwalls are also in the standard tables based on side slope of the road and height of the box.

Culvert Cross-section Sheets

Cross-section views of culverts are shown on culvert cross-section sheets. Culvert cross-section sheets are placed before roadway cross-section sheets in a contract plan set. Culvert cross-section sheets look much like roadway cross-section sheets, but there are several differences. Culvert cross-sections show views of the roadway sliced along the centerline of the culvert; whereas, roadway cross-sections show views of the roadway sliced at right angles to the centerline of construction. If the culvert is skewed and intersects the centerline at station where a roadway cross section is cut, the cross sections appear differently. The skew changes the lengths of the travel lanes and shoulders as well as the cross slopes and side slopes. A side slope may be 3:1 on the roadway cross section but when a culvert cross section at a skew is cut that crosses the same stations, the side slope may become 3.2:1. The culvert sections will have the drawings used, the quantities, and the drainage information for the structure.

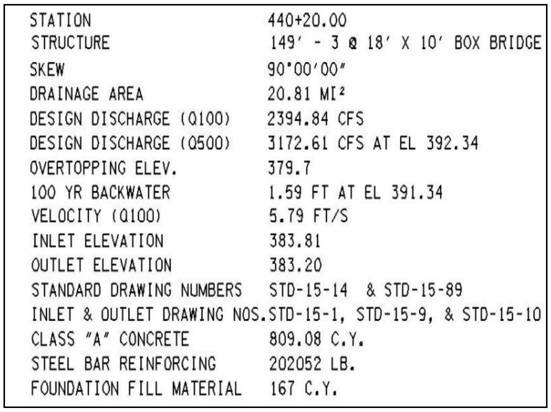
An example of a pipe at a skew and the roadway cross section for the same station are shown below. (The grid lines were turned off prior to making these captions for readability). Both cross-sections are cut at Sta. 485+00.00. The roadway section is a 4-lane divided highway; however, this particular section has a cross over to turn onto a side street so the median is not shown on this cross-section. The section with a -0.02 F/F cross slope is two travel lanes and the -0.04 F/F is the shoulder. Notice how these cross slopes change when the section is cut at a skew for the pipe. Also, notice that none of the culvert features are shown on the roadway cross-section.



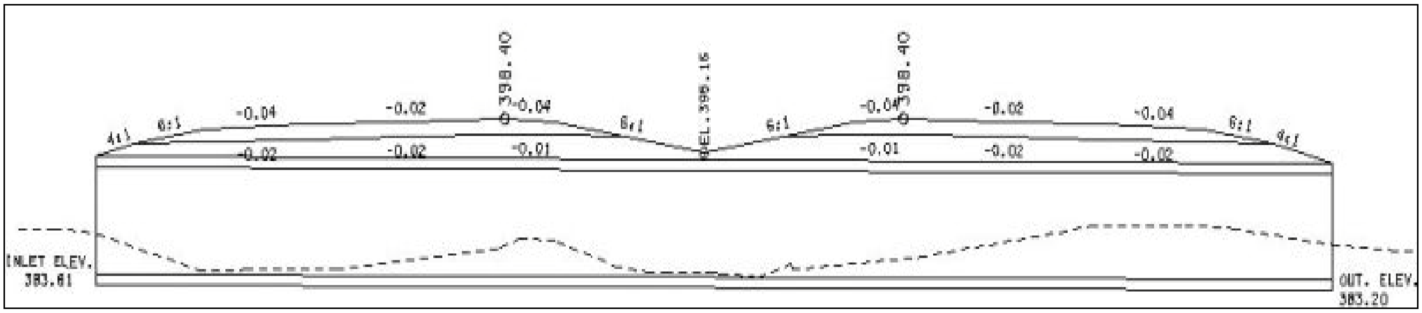


STATION	485+00.00	
STRUCTURE	85' OF 30"Ø R.C.P.	
WITH 1 TYPE "U" ENDWALL W/GRATE		
SKEW	74°33'30" LT.	
DRAINAGE AREA	8.40 AC	
DESIGN DISCHARGE (Q10)	20.0 CFS	
VELOCITY (Q10)	4.074 FT/S	
INLET ELEVATION	406.080	
OUTLET ELEVATION	405.653	
STANDARD DRAWING NUMBERS	D-PB-1	
INLET DRAWING NUMBERS	D-PE-4B(1) & D-PE-4B(2)	
OUTLET DRAWING NUMBERS	D-WH-5	
CLASS "A" CONCRETE	2.26	C.Y.
STEEL BAR REINFORCING	286	LB.
STRUCTURAL STEEL	137	C.Y.
BEDDING MATERIAL	27.285	C.Y.

If the flow for a structure is under 500 C.F.S. and a pipe is not applicable, the Hydraulic Section of the Structures Division will supply the Design Division with the type of box or slab to use. Below is the culvert section for a box bridge. The Hydraulics Section gave grade approval for a 3 @ 18' X 10' box located at Sta. 440+20.00 on a 90° 00' 00" skew. To determine the length, the box is drawn based on the inlet and outlet elevations. The line drawn between these two elevations serves as the top of the bottom slab. The remainder of the box is drawn based on this line. Once the top of the top slab meets with the side slopes, the side slopes and top of the box are intersected. This intersection point is measured from the centerline and determines the width of the box for each side of the road. For this box, the length of the structure is 149’ which may or may not be divided equally on each side of the road. The same design process is used when pipe culverts are designed. Notice the hydraulic data, standard drawings, and quantities are all part of the text associated with the box.



STATION	440+20.00
STRUCTURE	149′ - 3 @ 18′ X 10′ BOX BRIDGE
SKEW	90°00′00″
DRAINAGE AREA	20.81 MI²
DESIGN DISCHARGE (Q100)	2394.84 CFS
DESIGN DISCHARGE (Q500)	3172.61 CFS AT EL 392.34
OVERTOPPING ELEV.	379.7
100 YR BACKWATER	1.59 FT AT EL 391.34
VELOCITY (Q100)	5.79 FT/S
INLET ELEVATION	383.81
OUTLET ELEVATION	383.20
STANDARD DRAWING NUMBERS	STD-15-14 & STD-15-89
INLET & OUTLET DRAWING NOS.	STD-15-1, STD-15-9, & STD-15-10
CLASS "A" CONCRETE	809.08 C.Y.
STEEL BAR REINFORCING	202052 LB.
FOUNDATION FILL MATERIAL	167 C.Y.



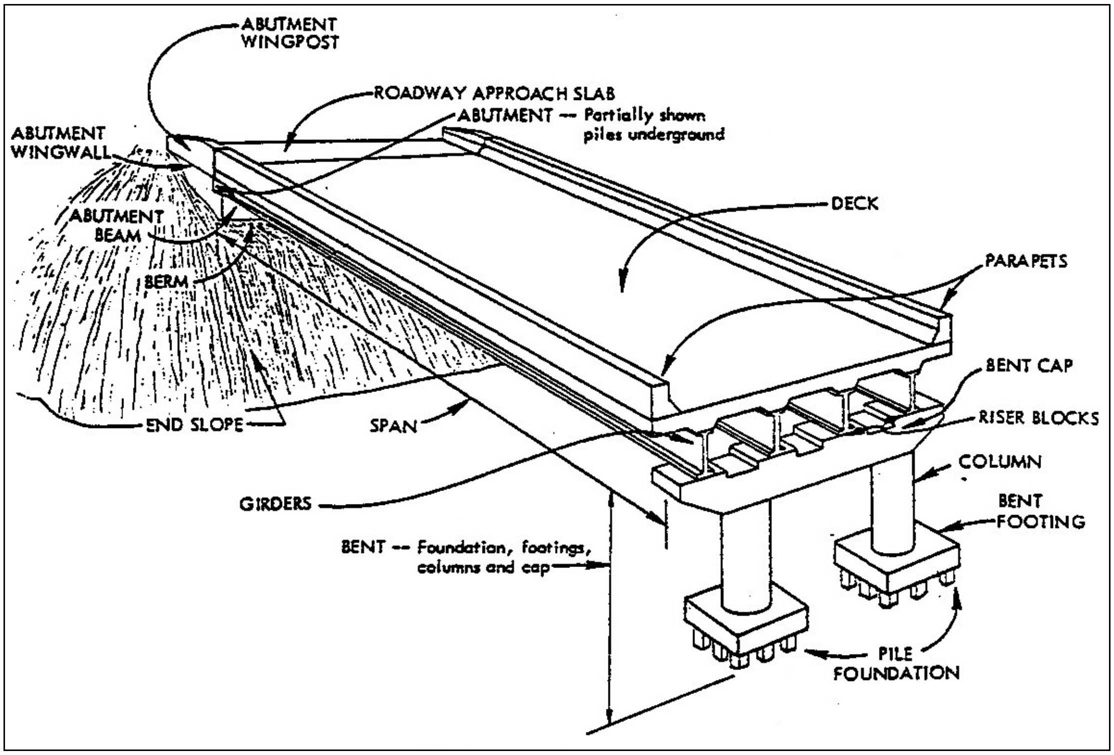
CHAPTER SEVEN

BRIDGES

A bridge is a traffic carrying structure, including supports, which is constructed over an obstruction in the roadway. The obstruction may be a creek, river, railroad or even another roadway.

TERMINOLOGY

Learning basic bridge terminology is an important first step in understanding bridge plans. Several bridge terms are defined below. After reading each definition, locate the part on the sketch below:



Starting "underneath" the bridge, the bridge parts are as follows:

Abutments are the bridge supports located at bridge ends. The major parts of an abutment are the foundation, the bent cap which rests over the foundation and the backwall. The foundation may be rock, or it may be Piles. The backwall holds the fill behind the abutment. Notice that a berm earth fill surrounds the abutment.

Bents are bridge supports between the bridge ends. Bents include everything under the bearing devices. Each bent is made up of a foundation, a footing, two columns, and a cap. If the supporting structure is particularly massive or if it is located in a waterway, it is often called a Pier rather than a bent.

Piles are the parts of bents and abutments which are driven or drilled into the ground to support the rest of the bent or abutment.

Bent Footing is a reinforced concrete slab which supports the columns.

Columns are the vertical members of the bent which support the cap.

Cap is the horizontal support member of a bent or an abutment. The cap supports the bearing devices which support the girders.

Girders are the longitudinal members resting on the bearing devices. Girders support the deck.

Deck is the reinforced concrete slab placed over the girders. The deck supports traffic using the bridge. It is the "roadway" of the bridge.

Parapets are placed on the outer edges of the deck. They help control drainage and prevent vehicles from going off the bridge.

Span is the distance from the center of bearing of one bent or abutment to the center of bearing of the next bent or - abutment.

Superstructure consists of all bridge members above the bearing devices.

Substructure consists of all bridge members below the bearing devices.

Bearing Devices rest on the substructure and support the superstructure. They are not considered a part of the superstructure or the substructure.

Roadway Approach Slab is the reinforced slab which provides a transition from the roadway to the bridge.

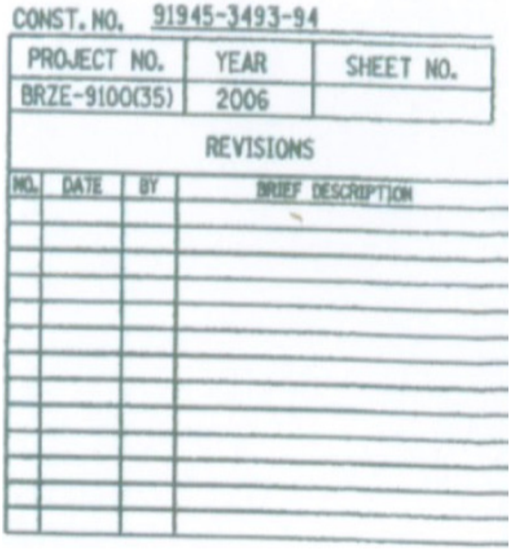
BRIDGE PLANS

Types of Bridge Plans

The previously discussed sheets in the contract plans were prepared by Roadway Design. The specific details of a bridge are provided by the Structures Division; therefore, bridge plan sheets are added to the plans after Roadway has submitted them for letting. Bridge plans are drawn on a larger scale and show details of the structure including Piers, abutments, etc. The main sheets in bridge plans are Estimated Bridge Quantity Sheet, Bridge Layout Sheets, Bridge Detail Sheets, and Standard Bridge Drawings.

There are several items that are common to every sheet in the bridge drawings. Below are some of these items:

- In the upper right-hand corner, you will note the construction number, the project number, the year of letting, and a revision block. There have been no revisions on this bridge, so the revision block is blank.



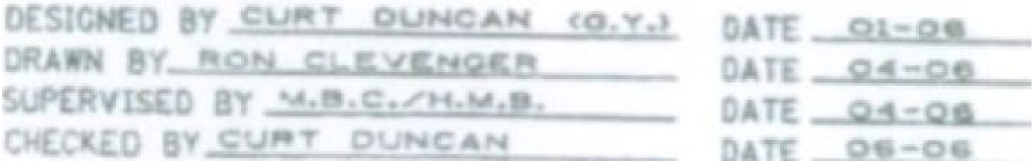
CONST. NO. 91945-3493-94

PROJECT NO.	YEAR	SHEET NO.
BRZE-9100(35)	2006	

REVISIONS

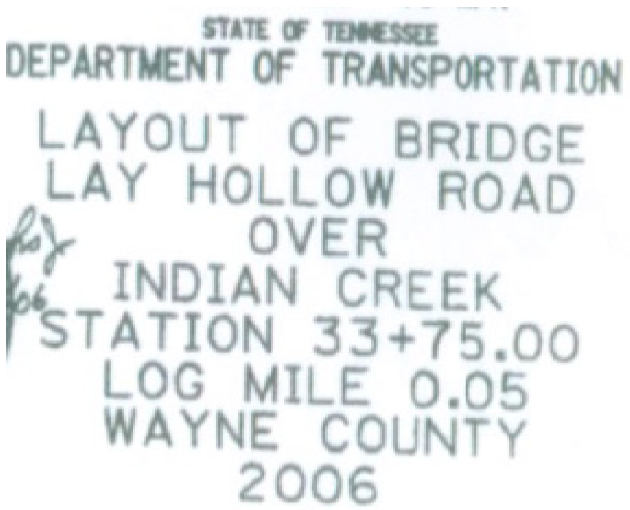
NO.	DATE	BY	BRIEF DESCRIPTION

- In the lower left-hand corner, you will note four lines identifying the designer, drafter, supervisor, and plans checker.



DESIGNED BY CURT DUNCAN (G.Y.) DATE 01-06
DRAWN BY RON CLEVENGER DATE 04-06
SUPERVISED BY M.B.C./H.M.B. DATE 04-06
CHECKED BY CURT DUNCAN DATE 06-06

- In the lower right-hand corner, you will note the title of the sheet, the crossing ("Lay Hollow Road over Indian Creek"), the station number, the log mile, the county, and the year of letting. The title will change for each sheet, but the remaining information will appear on every sheet.



STATE OF TENNESSEE
DEPARTMENT OF TRANSPORTATION
LAYOUT OF BRIDGE
LAY HOLLOW ROAD
OVER
INDIAN CREEK
STATION 33+75.00
LOG MILE 0.05
WAYNE COUNTY
2006

<u>Layout of Bridge (Sheet M-484-112)</u>

The two main features of the layout sheet are the elevation and plan views of the bridge. The elevation view shows the span arrangement with station and elevation given at each substructure (abutments and piers). The approximate existing ground line has been reproduced from the roadway plans. Because this bridge is a hydraulic crossing, you will also note datum, five-year backwater, and 100-year discharge elevations. This information is supplied by the Hydraulics section and is used to size the bridge span openings and vertical clearance. If this had been a grade crossing, the elevation view would show the cross-section of the road under and the point of minimum vertical clearance. For new bridge construction, the minimum vertical clearance is set at 16'-6" for a highway crossing and 23'-0" for a railroad crossing. When a bridge designer asks a roadway designer for a grade change, it is generally to meet the MVC requirement. There is also a horizontal clearance requirement, typically 30'-0" from the edge of traveled lane to face of pier for a highway crossing, 25'-0" for a railroad crossing. (The horizontal clearance may be reduced if guardrails or crashwalls are provided.) Note also that the beginning and end of bridge are dictated by the topography for this hydraulic crossing. A grade crossing would probably have 2:1 side slopes which would set the total bridge length. Riprap is placed around the abutments for slope protection. The riprap is actually a roadway item and the quantity is printed just outside the bottom border.

The plan view also shows the span arrangement with stations given at each substructure. The bearing of the centerline of survey, the cross-section of the roadway, and the north arrow are copied from the roadway plans. This view also has the stream location at datum, contour lines, and dashed lines showing the location of the existing bridge. This particular bridge has no deck or end-of-bridge drains, which would appear in the plan view if present. A grade crossing would have shown the point of minimum vertical clear and stations for the upper and lower roads at the point of intersection.

Note the finished grade sketch and the transition sketch which were copied from the roadway plans. For a grade crossing, there would be a second grade sketch for the lower road, but for this bridge, there is a block of hydraulic data (look just below the revision block). Another feature of hydraulic crossings is the note covering excavation of the stream channel.

Last, there is a list of drawings and standard drawings. The list of drawings shows the titles of all the sheets in this set of bridge plans. If any revisions are made after turn-in, the date of the revision will appear next to the drawing number of any sheets that were revised. The list of standard drawings shows all standard drawings pertaining to the construction of this particular bridge. The standard drawings will all have last revision dates so that readers of the plans know which standard drawing to refer to. If a standard drawing has been revised but not yet distributed, it will be marked with an asterisk and printed with the bridge plans.

General Notes and Estimated Bridge Quantities (Sheet 2 & M-484-112)

Sheet 2, Estimated Bridge Quantities, shows the quantities for the bridge. The Standard drawings are also listed on this sheet.

Sheet M-487-112 is the “General Notes and Estimated Quantities” for this bridge. As the name implies, the two main features of this sheet are notes and quantities. The notes are selected from the complete list of notes based on whether they apply to this particular bridge. For example, some notes may apply only to bridges with steel girders. Since this bridge uses pre-stressed concrete girders, those notes would not be used. The notes cover such topics as specifications used, material specifications for concrete, reinforcing steel, and riprap, value engineering, the type of bridge rail to be used, foundation preparation, and the like.

The estimated quantities cover items used in the construction of the bridge. A table shows the item numbers, descriptions, units of measurement, the total quantity for each item, and the quantities broken into superstructure and individual substructures. Below the estimated quantities block are additional numbered notes which cover specific items. There is also an applied texture finish sketch showing how the bridge is to be painted.

Foundation Data (Sheet M-484-113)

Another detail sheet for the bridge is the Foundation Data sheet. The foundations of a bridge must be compact, so it is necessary to obtain information about the earth under the proposed bridge. This information is given in a foundation data sheet or "sounding sketch". This sheet is one of the first sheets created. It is sent to the Soils and Geology section with plan and elevation views, a grade sketch, and a table showing stations, offset distances, and global coordinates for points that are desired to be drilled. Soils and Geology uses the sheet to locate drilling locations. Once they have obtained subsurface data, they add the boring log, a legend describing the boring log, and ground and rock elevations at points drilled. This data is then returned to Structures along with a Foundation Data Report. This sheet and the FDR are used in determining the type of foundation to be used, usually a pile foundation or a spread footing on rock, and excavation quantities.

On sheet M-487-113, the bridge is shown at the top on the right side of this drawing. There are 6 different boring locations as depicted in the drawing by a number and circle. Below the bridge, is the elevation view of the borings. To the right of the borings is a legend with the types of soil or rock that is encountered. For boring number 3, gravel is encountered from the top of the boring to approximately 562. Then, soft clayey sand is encountered down to approximately 548. The remainder of the boring is limestone.

Superstructure (Sheet M-484-114)

Sheet M-487-114 is “Superstructure.” This sheet, along with the following sheet, “Superstructure Details,” covers the construction of the superstructure. M-487-114 shows a typical cross-section of the bridge, a half-plan of main reinforcement (the negative moment steel in the top of the slab), a slab construction joint detail, a dead load correction curve, a bearing detail (labeled “Detail X”), a few notes, and estimaged quantities for the reinforcing steel and concrete in the superstructure. M-487-115 shows a framing plan, a slab plan showing transverse reinforcing (top and bottom) and the bottom longitudinal steel, and a support diaphragm detail. The framing plan in this set of plans shows girders, endwalls, and support diaphragms (at the piers). This particular bridge does not have intermediate diaphragms, but they would be shown in the framing plan if required.

Screed (Sheet M-484-116)

Sheet M-487-116 is “Screed.” Normally, a straight bridge would not require a screed plan, since the geometry (and therefore the deck elevations) would be relatively straightforward. But as we noted on the layout sheet, this bridge is within a superelevation transition, so we must supply stations and elevations which will aid the contractor in setting his screed machine. Stations and elevations are given at the tenth points of each span along each edge of slab, over each exterior girder line, and at the finished grade line (in this case, the finished grade line happens to be over the interior girder).

Pre-stressed I-Beam Details (Sheet M-484-117)

Sheet M-487-117 is “Pre-stressed I-Beam Details.” (TDOT uses three types of pre-stressed beams: the I-beam, the bulb-tee beam, and the box beam.) On this sheet, there are two elevation views. One view details the pre-stressing strands while the other details the stirrup spacing. Also, there are two cross-sections (Section “A”-“A”) showing the stirrup arrangement and a third cross-section (Section “B” – “B”) showing the pre-stressing strand arrangement and debonding requirements. Below this cross-section is the pre-stressed beam design data. Here, you will find the live load distribution factors for both moment and shear, the composite dead loads for both the bridge components and the future wearing surface, and the composite slab design strength. On the right-hand side of the sheet are the notes. These notes cover the concrete compressive strength, the type of beam to be used, the standard drawing for that beam, and the pre-stressing strand parameters. Also, on the right-hand side of the sheet is the bill of steel per beam block with the bar designation, size, number required and length of each rebar. Below this is the estimated quantities per beam block. Here, you will find how many beams are required, the per-beam weight of the pre-stressing strands in pounds, the per-beam amount of Class “A” Concrete needed in cubic yards, and the per-beam weight of reinforcing steel in pounds.

Abutment (Sheets M-484-118 thru 121)

The next 4 sheets (M-487-118 thru 121) are abutment sheets. Abutments are the bridge supports located at bridge ends. The superstructure is supported on elastomeric bearing pads which are located on the abutment beam. The abutment beam is either supported on rock or piles as mentioned earlier. Behind the superstructure and above the abutment beam is the endwall. The endwall retains the backfill placed behind the abutment. On each side of the roadway, the abutment bends back to form the wingbeams. On top of the wingbeams are the wingwalls which further help retain the backfill and upon which the parapet is placed. The wing lengths are set by the superstructure depth and the slope in front of the abutment. In the plan view on sheet M-487-118, you will see a “V”-groove detail. (The purpose of the v-groove is to force a crack to form between the endwall and wingwall.) In the elevation view, you will find the beam seat elevations. These are based on the vertical alignment, superstructure depth and cross-slope. On the right-hand side at the top is the riser block slope detail. These are provided to ensure that the beams conform to the vertical alignment and have proper bearing on the elastomeric pads. Below the riser block detail are the notes pertaining to the abutment. Finally, the estimated quantities block is provided. Here, you will find concrete and steel (both epoxy and non-epoxy bars) quantities for each abutment. Sheet M-487-119 is the abutment details sheet. Here you will find the layout and spacing of the reinforcement, the elevations of the wings and the P.C.O. (pile cut-off) elevations, the dimensional aspects of the abutment and the cross-sections of both the abutment beam/endwall and the wingbeam/wingwall. Sheets M-487-120 and 121 are the details for abutment 2, which are very similar to abutment 1.

Pier (Sheets M-484-122 thru 125)

Sheets M-487-122 thru 125 are the pier sheets. The first 3 sheets are for piers 1 thru 3 with the 4th sheet depicting pier details common to all 3 piers. This particular type of pier is called a hammerhead pier because of its resemblance to a hammer. On the first pier sheet, you will note plan, elevation and end elevation views. As with the abutment, in the plan view, we see the elastomeric bearing pads on which the beams are placed. The elevation view shows specific details for the elevations, dimensions and rebar placement for the cap, column, and footing. Note the piles which are embedded one foot into the footing. This is one of the two most common foundations, the other being a spread footing on rock. The end elevation depicts the same details as the elevation view but in the transverse direction. A few notes pertaining to the construction of the pier are provided in the top center of the page. As with the abutments, there is a riser block slope detail which ensures that the beam conforms to the roadway grade and has proper bearing on the elastomeric pad. Last, there is an estimated quantities block with concrete and reinforcing steel amounts. The fourth sheet in the pier set includes details such as cap, column, and footing dimensions, rebar placement, and pile pattern.

Final Foundation Data (Sheets M-484-126)

Sheet M-487-126 is the “Final Foundation Data” sheet. It shows the pile pattern for each substructure. The piles are numbered and tabulated. The table has blanks for the pile cut-off elevations, the pile tip elevations, and the in-place pile length. Below the table is a note to the contractor and construction office: “The blanks on this sheet are to be filled in by the construction office and/or field engineer giving as-built conditions. After completion, it is to be sent to the Division of Structures to become part of the final bridge documents.” In practice, this sheet is rarely filled out and returned to Structures Division. It is very useful information, however, and we hope that those of you returning to TDOT’s Field Offices will always make an effort to complete and return the final foundation data sheet.

Bill of Steel (Sheets M-484-127 thru 128)

The final two sheets of our full set of plans, M-487-127 and 128, are “Bill of Steel” sheets. All steel required for the superstructure and each individual substructure are tabulated on these sheets. The tables depict the bar designation, location, size, number required, bending dimensions, and total length. All bars used on the bridge are sketched at the bottom of the page with the A, B, C, and D dimensions specified.

Additional Sheets

To cover the most commonly-used bridge drawings, we have included additional sheets with a few brief comments on each:

M-391-92 is the layout for a highway grade crossing and M-487-91 is the layout for a bridge over a railroad.

On the superstructure sheet we looked at earlier, I-beams supported the girders. M-487-74 shows a bulb-tee superstructure. M-490-109 shows the superstructure for a box-beam widening (the dashed lines indicate the existing structure). M-439-43 shows a welded plate girder superstructure.

M-487-77 shows a pre-stressed bulb-tee beam, and M-490-114 a pre-stressed box beam. Sheets M-439-46 through 50 show details for a welded plate girder. M-439-46 shows the girder elevation, the dead load correction curve, and stud details. M-439-47 is the framing plan, M-439-48 shows cross-frame and stiffener details, M-439-49 is the bolted field splice, and M-439-50 shows bearing device details.

The main set of plans showed a stub abutment (a pile-supported abutment). Sheets M-439-51 through 53 show a closed abutment (the foundation is a spread footing on rock).

We saw a hammerhead pier in the main set of plans. Other common substructures are dual hammerhead (M-391-109), multiple hammerhead (M-492-76), two-post bent (M-478-72), three-post bent (M-482-40), four-post bent (M-492-108), five-post bent (M-492-72), pile bent (M-468-91), wall or shaft pier (M-386-27).

The final drawing, M-369-14, shows a completed final foundation data sheet.

APPENDIX

Glossary

Abutments: The bridge supports located at bridge ends. The major parts of an abutment are the foundation, the bent cap which rests over the foundation and the backwall. The foundation may be rock, or it may be Piles. The backwall holds the fill behind the abutment. Notice that a berm earth fill surrounds the abutment.

Access Control: Specifies locations where vehicles can enter or leave a roadway. When there is no access control, intersecting roads or driveways may connect to the mainline at any point. Typically local roads have no access control. With partial control of access there is a minimum spacing of access locations. With full control of access, connections are only allowed at major crossroads. Full or partial control of access help reduce traffic conflicts.

Arterial Highway: Functional classification of highways that serve major traffic movements or major traffic corridors. While they may provide access to abutting land, their primary function is to serve traffic moving through the area.

Average Daily Traffic Volume: The average number of vehicles that travel on a given road during the day. As defined by traffic engineers, it is the total traffic volume during a given time period in whole days (24-hour periods), greater than one day and less than one year, divided by the number of days in that time period.

Bearing: The direction of a survey line. Bearings are described in terms of degrees, minutes and seconds in relation to north or south. They may not have an angular component exceeding 90º.

Bearing Devices: These devices rest on the substructure and support the superstructure. They are not considered a part of the superstructure or the substructure.

Bench Terraces: Horizontal shelves placed at intervals on a steep slope which reduce erosion by preventing large concentrations of runoff from forming on the slope.

Bents: Bridge supports between the bridge ends. Bents include everything under the bearing devices. Each bent is made up of a foundation, a footing, two columns, and a cap. If the supporting structure is particularly massive or if it is located in a waterway, it is often called a Pier rather than a bent.

Bent Footing: A reinforced concrete slab which supports the columns.

Berm: A ledge at the bottom of a bank or cutting to catch dirt that may roll down the slope, or to strengthen the bank.

Cap: The horizontal support member of a bent or an abutment. The cap supports the bearing devices which support the girders.

Capacity: The maximum number of vehicles that can reasonably be expected to pass over a lane or a roadway during a given time period under prevailing roadway and traffic conditions. Typically, the maximum expressway capacity for automobiles is 2,000 vehicles per lane per hour.

Catch Basin: Curbside opening that collects rainwater from streets and serves as an entry point to the storm drain system.

Categorical Exclusion: It is prepared for projects that fit specific regulatory requirements. When approved by the U.S. Environmental Protection Agency and the U.S.Department of Transportation it rules that a transportation project or group of projects does not individually or cumulatively have a significant environmental effect on the natural or human environment.

Channel: A long narrow depression associated with a waterway which is shaped by the concentrated flow of a stream and conveys the ordinary flows.

Clearing and Grubbing: A process under which land is prepared for grading by the removal of trees, herbaceous vegetation, roots, large rocks and any other objectionable materials.

Collector: Functional classification of roadways that link local roads to arterial highways.

Columns: The vertical members of the bent which support the cap.

Compound Horizontal Curve: The compound curve consists of two simple curves joined together and curving in the same direction.

Construction Staging: The practice of dividing a construction site into sections so that clearing and grubbing can be done one section at a time. This serves to limit the area exposed to increased erosion risks at any given time.

Contract: The written agreement between the Department of Transportation of the state of Tennessee and the contractor setting forth the obligations of the parties there under, including but not limited to, performance of the work which, within itself, includes the furnishing of labor, equipment, and materials and the basis of payment.

Controlled Access: Partial access restriction that gives preference to through traffic. Also provides for connections to selected public routes and to certain other adjacent locations where vehicles can enter or leave a roadway safely without interfering with through traffic.

Corridor: Land between two termini within which traffic, transit, land use, topography, environment, and other characteristics are evaluated for transportation purposes. Also, it is the general width in which alternative alignments can be located.

Crest Vertical Curve: A vertical curve that is at the crest or top of a hill.

Cross Drain: A pipe that crosses underneath the road and is used to move water from one side of the road to the other side to prevent accumulation of runoff without the need of a culvert or bridge.

Cross-Section View: A view that shows the inside of an object as if the object had been cut open

Cross Slope: The rate of change of roadway elevation with respect to distance perpendicular to the direction of travel and is expressed in foot per foot of slope.

Culvert: A sewer or drain pipe crossing under a road or embankment.

Curb: A rim, especially of joined stones or concrete, along a street or roadway, forming an edge for a sidewalk.

Deck: The reinforced concrete slab placed over the girders. The deck supports traffic using the bridge. It is the "roadway" of the bridge.

Design Criteria: Established state and national standards and procedures that guide the establishment of roadway layouts, alignments, geometry, and dimensions for specified types of roadways in certain defined conditions. The principal design criteria for roadways are traffic volume, design speed, the physical characteristics of vehicles, the classification of vehicles, and the percentage of various vehicle classification types that use the roadway.

Ditch Lining: Materials such as vegetation, machined riprap or geotextiles which protect a waterway from erosion during high flows.

Drainage Easement: The right, obtained from the owner of property adjoining a roadway or other development site, to use a portion of that property to place and maintain part of a proposed drainage facility.

Environmental Assessment: It is prepared for larger scale projects that do not meet the requirements for CE or those for which the significance of the environmental impact is not clearly established. Should environmental analysis and interagency review during the EA process find a project to have no significant impacts on the quality of the environment, a Finding Of No Significant Impact (FONSI) is issued. If it is found that the project will have significant impacts, an EIS must be prepared.

Environmental Impact Statement: It is prepared for projects that will cause a significant adverse effect on the environment.

Environmental Overview: A beginning or summary assessment of environmental features in a study area, usually performed during systems planning or preliminary environmental activities. From this preliminary information, the environmental impacts of the study alternatives will be determined. This overview may sometimes be referred to as Environmental Screening.

Environmental Protection Agency: The federal agency with primary or oversight responsibility for implementing the federal environmental statutes, including the CWA, Clean Air Act, Safe Drinking Water Act and Resource Conservation and Recovery Act. Tennessee is included within EPA Region IV, headquartered in Atlanta.

Erosion Prevention and Sediment Control Plan: A phased set of site plan sheets and construction notes which illustrate and explain the erosion prevention and sediment control measures to be used on a roadway project. These plan sheets are an integral part of the overall Stormwater Pollution Prevention Plan for a project.

Erosion Prevention: Applying planned control measures in order to prevent or slow the increased erosion which can result from man-made changes to the landscape.

Federal-Aid Highways: Those highways eligible for assistance under Title 23 of the United States Code, which does not include those functionally classified as local or rural minor collectors.

Federal Aid Project: An activity, study, survey, project, or other work related to transportation authorized in advance by the Federal Highway Administration, Federal Transit Administration, or other federal agency, and which is paid for either partially or fully by public funds.

Federal Highway Administration: The FHWA deals with highway transportation in its broadest scope, administrating all federal transportation programs, including FLHP.

Finish Grading: Construction activity which establishes the final elevation of the site after excavating or filling in conformance to the grading plan (c.f. – Rough Grading).

Functional Roadway Classification: The organization of roadways into a hierarchy based on the character of service provided. Typical classifications include arterial, collector, and local roadways.

Geographic Information System: Computerized data management system with tools designed to gather, store, retrieve, analyze, transform, and manipulate large amounts of geographic and demographic information to produce color-coded maps, three-dimensional virtual models, tables, and lists.

Girders: The longitudinal members resting on the bearing devices. Girders support the deck.

Grade: The change in vertical rise or fall to horizontal distance. Grade is expressed in percent and found in profiles.

Gutter: The edge of a street (below the curb) designed to drain water runoff from streets, driveways, parking lots, etc. into catch basins.

High-Occupancy Vehicle: Any vehicle carrying two or more passengers. The term usually refers to private vehicles.

Horizontal Alignment: The location in plan view of a linear structure such as a roadway, drainage structure or natural stream.

Horizontal Curve: The curves in a road that connect straight lines (tangents) to change the alignment or direction of the road.

Impacts: Positive or negative effects upon the natural or human environment resulting from transportation projects.

Independent Special Ditch: A ditch that is not part of the roadway typical and does not connect to the roadway.

Level of Service: A quality measure describing operational conditions within a traffic stream generally in terms of speed and travel time, freedom to maneuver, traffic interruptions, and comfort and convenience. Levels range from LOS A, the best, where a driver is unimpeded by other vehicles, to LOS F where flow is unstable and vehicle delay is high.

Limited Access Highway: A highway that has access to it restricted to designated points such as interchanges.

Local Road: A functional classification of roads that mainly provide access to the properties that adjoin them.

Metropolitan Planning Organization: A planning group designated for each urban area with a population of 50,000 or more. Members include both private citizens and local government officials. An MPO addresses Federal aid planning mandates by producing local area transportation plans or transportation improvement programs on an annual or biannual basis, or by employing other strategies that make existing systems more efficient. Knoxville's MPO is called the Knoxville Regional Transportation Planning Organization or TPO.

Mitigation Measures: Specific design commitments made during the environmental evaluation and study process that serve to moderate or lessen impacts deriving from the proposed action. These measures may include planning and development commitments, environmental measures, right-of-way improvements, and agreements with resource or other agencies to effect construction or post construction action.

National Environmental Policy Act: The United States Congress enacted the National Environmental Policy Act of 1969 (NEPA) to establish a national policy to protect the environment. The act is codified in Title 42 of the United States Code, Sections 4321 through 4347 (abbreviated as 42 USC 4321-4347). On January 1, 1970, NEPA was signed into law by President Richard Nixon.

Parapets: These are placed on the outer edges of the deck. They help control drainage and prevent vehicles from going off the bridge.

Phasing of an EPSC Plan: Dividing an EPSC Plan into different parts so that the structural BMPs specified for each part will address the changing erosion prevention and sediment control needs of a project as it progresses.

Piles: The parts of bents and abutments which are driven or drilled into the ground to support the rest of the bent or abutment.

Plan View: A view from directly above an object.

Plans: The approved plan, profile, and cross-section sheets along with standard roadway and structure drawings, working drawings and supplemental drawings, or exact reproductions thereof, which show the location, character, dimensions, and details of the construction to be performed under the contract.

Plan Revisions: Changes to the contract plans predicated by the discovery of unanticipated circumstances as the work on the project progresses. This is addressed in the Subsection 104.02 of the Standard Specifications.

Point of Curvature: The point where the back tangent ends and the curve begins.

Point of Intersection: The point where the back and forward tangents intersect.

Point of Tangency: The point where the curve ends and the forward tangent begins.

Profile View: The view of the roadway from the front or side which shows the elevation of objects.

Programming: A general term to refer to a series of activities carried out by planners, including data assessment, appraisal of identified planning needs, and consideration of available or anticipated fiscal resources to result in the drawing up, scheduling, and planning of a list of identified transportation improvements for a given period of time.

Public Hearing: A NEPA required meeting designed to afford the public the latest project information and the opportunity to express support of or opposition to a transportation project in an forum at which a verbatim record (transcript) of the proceedings is kept.

Public Meeting: An announced meeting conducted by transportation officials designed to facilitate participation in the decision-making process and to assist the public in gaining an informed view of a proposed project at any level of the transportation project development process. Also, such a gathering may be referred to as a public information meeting.

Reverse Horizontal Curve: A reverse curve consists of two simple curves joined together but curving in opposite directions.

Right of Way (ROW): A strip of property that includes the roadway plus the parkway (area between the road and private property). The ROW does not extend onto private property. It begins where one property ends and goes all the way across the road to where another property begins.

Right of Way (ROW) Acquisition: The process of acquiring private property needed for city projects, including drainage improvements, roadway improvements, parks, etc.

Riprap: Crushed rock, usually manufactured to a specific gradation and used to prevent erosion on slopes or in stream channels.

Roadside ditch: A ditch that is part a continuation of the roadway sideslope. It is “V” shaped and meets general requirements according to those specified on a roadway standard drawing.

Roadway Approach Slab: The reinforced slab which provides a transition from the roadway to the bridge.

Rough Grading: Construction activity in which existing land grades are brought into approximate conformity with the grading plan by means of excavation, filling and compaction (c.f. – Finish Grading).

Runoff: Water from rainfall or snow melt which is not absorbed into the ground; but rather flows across the surface of the land and is collected into streams, lakes or other surface depressions.

Run-on: Overland stormwater flows, in either sheet or shallow concentrated form, which would flow onto a construction site from upstream areas.

Sag Vertical Curve: A vertical curve that is at the bottom of a hill.

Sedimentation: The gravity-induced settling of soil or other particles which have been transported by water or wind.

Side Drain: A drainage structure, usually a culvert, which conveys water flowing in a roadway side ditch underneath driveways or other obstructions to flow.

Side Slope: Side slope gives a measure of steepness and is measured as a ration between the changes in horizontal distance compared to the distance in one foot of vertical drop. It is expressed as a ratio of the horizontal distance to the one foot of drop of vertical distance (ex. 4:1).

Side-Tapered Inlet: An improved inlet which increases the capacity of a culvert by providing an enlarged flow area at the entrance and then tapering down to the culvert cross-section.

Simple Horizontal Curve: The simple curve is an arc of a circle where ther radius determines the sharpness or flatness of the curve.

Span: The distance from the center of bearing of one bent or abutment to the center of bearing of the next bent or - abutment.

Special Ditch: A ditch constructed to meet drainage requirements not covered in the roadway standard drawing for the road. It will have grades independent of the roadway profile grade.

Spiral Horizontal Curve: The spiral curve has a varying radius and provides transition from the tangent to a simple curve or between simple curves in a compound curve.

Stair Step Grading: A grading practice in which a steep slope is formed into a series of horizontal shelves which alternate with nearly vertical faces in order to reduce erosion by discouraging the formation of concentrated flows.

State-Funded Project: The design or construction of an improvement that is funded entirely with state highway or bridge funds.

Statewide Transportation Plan: Identifies regional transportation goals, issues, and needs and defines the direction for regional planning, programming, and project development over a 20-year period.

Station: A term used for measuring distances and identifying points on the ground along a surveyed line.

Stormwater Pollution Prevention Plan: A site specific written plan, developed in order to ensure as much as possible that stormwater discharges from a construction project site will not pollute the surrounding natural water resources. This plan must identify all potential sources of pollution associated with the project, including sediment. It must also specify the structural and operational practices to be used to prevent pollution and assure that these practices will be carried out.

Study (or Project) Limits: The physical end points of a proposed project or study, usually designated at geographic or municipal boundaries, at interchanges, at roadway segments where cross sections change, or at the beginning or end of numbered state traffic routes.

Superstructure: A superstructure consists of all bridge members above the bearing devices.

Substructure: A substructure consists of all bridge members below the bearing devices.

Superelevation: Roadway banking on a horizontal curve for the purpose of allowing vehicles to maintain the traveled speed.

Transportation Improvement Program: A three-year, prioritized program of transportation projects within a metropolitan or regional planning area proposed for federal funding. It includes all regionally significant projects, planning research activities and emergency relief projects.

United States Department of Transportation: The Federal Agency that establishes the nation’s overall transportation policy. Under its umbrella there are ten administrations whose jurisdictions include highway planning, development and construction; urban mass transit; railroads; aviation; and the safety of waterways, ports, highways, and oil and gas pipelines.

Utility Relocation: A process by which existing utilities and their associated easements are moved or replaced in order to avoid conflict with a proposed roadway construction project.

Vertical Alignment: The elevations or location in profile of a linear structure such as a roadway, drainage structure or natural stream.

Vertical Curve: The curves in a road that connect straight lines (tangents) to change the slope of the road.

Wetlands: Those areas that are inundated or saturated by surface water or ground water at a frequency or duration sufficient to support, and under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions.

Work Orders: The work order is a document that provides the date at which it is expected that the contractor will begin construction and from which date time will be charged to the project. Additionally, the contractor shall not begin work until after receiving the work order.

Acronyms

AADT: Annual Average Daily Traffic
AADTT: Annual Average Daily Truck Traffic
AASHTO: American Association of State and Highway Transportation Officials
ADT: Average Daily Traffic
APD: Appalachia Development Highway System Projects
ARAP: Aquatic Resource Alteration Permit
BM: Bench Marks
BMP: Best Management Practices
C&G: Curb and Gutter
CB: Catch Basin
CE: Categorical Exclusion
CEI: Construction Engineering & Inspection
CGP: Construction General Permit
CP: Control Points
DOA: Department of the Army
DOT: Department of Transportation
EA: Environmental Assessment
ED: Environmental Division
EDM: Electronic Distance Measuring Device
EIS: Environmental Impact Statement
EOP: Edge of Pavement
EOS: Edge of Shoulder
EPA: Environmental Protection Agency
EPSC: Erosion Prevention and Sediment Control
FEMA: Federal Emergency Management Agency
FHPM: Federal-Aid Highway Program Manual
FHWA: Federal Highway Administration.
FEIS: Final Environmental Impact Statement
GIS: Geographic Information System
GPS: Global Positioning System
HOV: High-Occupancy Vehicle
HSIP: Highway Safety Improvement Program
LOS: Level Of Service
MPO: Metropolitan Planning Organization
NEPA: National Environmental Policy Act
NHS: National Highway System
NOC: Notice of Coverage
NWI: National Wetland Inventory
NFIP: National Flood Insurance Program
NPS: National Park Service
PE: Professional Engineer
PC: Point of Curvature
PI: Point of Intersection
PT: Point of Tangency

PPRM: Program, Project, and Resource Management
PS&E: Preliminary Survey & Evaluation or Plan Specification & Estimate
ROW: Right-of-Way
SIA: State Industrial Access Road
SIP: State Implementation Plan
SHPO: State Historic Preservation Office
SEMS: Statewide Environmental Management System
SSWMP: Statewide Storm Water Management Program
SWPPP: Storm Water Pollution Prevention Plan
TIP: Transportation Improvement Project
TVA: Tennessee Valley Authority
TDEC: Tennessee Department of Environment and Conservation.
TDOT: Tennessee Department of Transportation.
TP: Traverse Points
TPR: Transportation Planning Report.
TVA: Tennessee Valley Authority
TWRA: Tennessee Wildlife Resources Agency
USACE: U.S. Army Corps of Engineers.
USCG: U.S. Coast Guard
USFWS: U.S. Fish and Wildlife Services
USGS: U.S. Geological Survey
VPC: Vertical Point of Curvature
VPI: Vertical Point of Intersection
VPT: Vertical Point of Tangency