INTRODUCTORY HIGHWAY ENGINEERING

PART I - BASIC

TEXAS HIGHWAY DEPARTMENT
DISTRICT 12

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BASIC LABORATORY COURSE

SURVEYING I

I. Fundamentals

A. Definitions

1. Surveying

   Making such observations and measurements needed to determine the position of various points on the earth. These measurements may be either linear or angular in nature.

2. Plane Surveying

   Surveying with the basic assumption that the earth's surface is a plane rather than being curved.

3. Route Surveying

   That portion of general plane surveying which deals with the location and construction of routes of transportation and communications.

4. Elevations

   Relative elevation is the difference in elevation between any two points when one is compared with the other; Absolute elevation of a point is its elevation with respect to some particular point of reference, known as the datum. With reference to the surface of the earth, the datum is mean sea level.

5. Measurements

   There are four kinds of measurements:

   (1) Horizontal distances
   (2) Horizontal angles
   (3) Vertical distances
   (4) Vertical angles

The horizontal distance between two points is the distance between the projection of the points on the horizontal plane. The vertical distance in surveying is the distance between tw points in a vertical line.

Example: (See Figure 1) Let A and B be the points on a sloping surface. The horizontal distance between A and B is not A B but its projection A C.

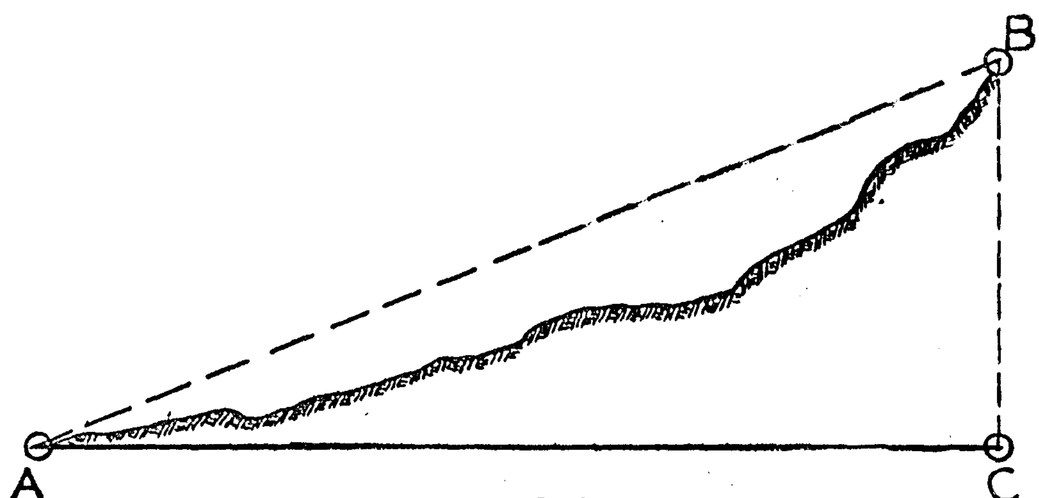


FIG 1

B. Units of Measurement

1. Linear Units

In the United States the unit of length in surveying is the foot. For measurements of less than one foot, decimal parts are used instead of inches and fractions.

2. Angular Units

Angles are measured in degrees, minutes, and seconds. There are 360 degrees in a full circle, 60 minutes in one degree, and 60 seconds in one minute.

3. Units of Area and Volume

The units of area are the square foot, square yard, and the acre. The units of volume are usually the cubic foot and the cubic yard.

C. Principal Surveying Equipment

1. Chains and Tapes

Formerly on surveys of ordinary precision, it was the practice to measure the length of lines with the engineer's chain. The engineer's chain was 100 feet long and was composed of 100 links each one foot long. Distances measured with the engineer's chain were recorded in feet and decimals. Measuring with chains was called "chaining." The term has survived and is now generally used to refer to the operation of measuring lines with tapes.

Tapes are made in many lengths and weights and of a variety of materials. The most common in use by the Texas Highway Department is the heavy steel tape or "chain," the light steel tape, and the cloth-metallic tape.

The heavy steel tape is generally the major device used to make linear measurements. The most commonly used length is 100 feet, but it can be obtained in lengths of 50, 200, 300, and 500 feet. Usually the chain tapes have graduations with numbers every foot, with only the end feet graduated to tenths or hundredths of a foot. Some tapes have an extra graduated foot at one or both ends. Sometimes the ribbon extends about six inches beyond the graduated portion of the tape, and sometimes the ends of the rings mark the zero and last graduation.

The steel tape, being elastic, stretches when a pull is applied. It also expands or contracts as the temperature changes. Generally, it is considered that a 100-foot steel chain is 100 feet long at 68° F. when a 10-lb. pull is applied; however, for precise measurement, each chain must be checked against a standard chain whose length is known.

The ribbon of the metallic tape is of waterproof fabric interwoven with small wires to prevent stretching. It comes in 50 or 100-foot lengths and is graduated into feet, tenths, and half-tenths. It is used primarily in earthwork cross sectioning and other work where a light flexible tape is desirable, and where small errors in length are of no consequence.

2. Engineer's Level and Level Rod

The engineer's level basically consists of a telescope mounted on a bubble tube which is rigidly fastened to a rotating spindle. The bubble in the tube is centered by using the leveling screws. The whole leveling head is fastened to a wooden tripod for use. In the tube of the telescope are cross hairs which will appear on the image viewed through the telescope.

The level rod is used to measure the vertical distance from the horizontal line of sight to a given point. The most common type of level rod we use is the Philadelphia Rod. Even feet are shown in large red numbers. The smaller black figures indicate the even tenths of a foot. The hundredths of a foot are indicated by the small black and white spaces.

3. The Engineer's Transit

The engineer's transit consists of a telescope mounted on a horizontal axis and supported by standards. Attached beneath the telescope is a spirit level tube. Angles of rotation of the telescope in a vertical plane are indicated by a vertical circle which is graduated in degrees and which read by means of an index attached to one of the standards. The standards rest on the upper plate which is equipped with spirit levels and which rotates about the vertical axis on a spindle, called the inner spindle. The lower plate revolves about the vertical axis on the outer spindle. The outer rim of its upper face is a circle graduated in degrees and read by means of an index on the upper circle. The spindles are supported by the leveling head which is screwed to a wooden tripod. The bubbles of the level tubes on the upper plate are centered by means of four leveling screws. A magnetic compass is centered on the upper plate.

D. General Procedures of Field Work

1. Organization of Field Party and Assignment of Work

One of the most important requirements of a good field party is proper organization, both of the field party and the work assignments. Organization of the field party itself will vary according to the work to be done. The number of men in the party will also be a factor in determining the organization. Normally, every party will have its party chief, instrumentman, and notekeeper. Many times, the party chief and instrumentman are one and the same. Other members of the party may be rodmen or chainmen, depending on the nature of the work. The important point is that each member of a field party has a definite part of the operation. Therefore, for him to do his part, he must know the things he is to do. This may sound relatively simple and basic, but many times, field parties have gone out to do some important field work with one or more members of the group who do not have the vaguest idea of what is to be done or what their duties are. A situation such as this can only result in errors, which result in higher costs and time-consuming delays.

Insofar as the assignment of work is concerned, it too must be organized. All work routines must be planned in advance by the party chief. The sequence of performing the work must be considered in order that the maximum efficiency might be gained. To have a group of men standing around on the jobsite waiting to be told what to do is time absolutely wasted. The party chief should review in advance the entire project of work. The sequence of the work should be decided on, and the general operation of the party in performing each sequence should be determined. A good party chief will have his work so organized that each portion of the surveying moves smoothly from one phase to the next.

2. Recording Data

Field notes are the written record of the work done in the field and are written at the time the work was done. They must be as complete and accurate as possible. Unfortunately, this is often not the case. Many surveyors seem to think that their work is well done if the field records, reinforced by their own memories, is sufficiently comprehensive to make the field data of immediate use for whatever purpose the survey may have. On most surveys, it is impossible to predict to what extent the information gathered may become of value in the remote future. Not infrequently, court proceedings involve surveys made long before. Often, it is desirable, particularly in our line of work, to extend, or otherwise make use of surveys made years previously. In such cases, it is quite likely that the old field notes will be the only visible evidence, and their value will depend largely upon the clearness and completeness with which they are recorded.

The notes consist of numerical data, explanatory notes and sketches. Also, the record of every survey should include the date, the weather conditions, names and duties of the surveyor, or party chief and his assistants, and a title indicating the location of the survey and its nature or purpose. All field notes should be recorded at the time the work is done. Notes made later from memory or copied from other notes may be useful, but they are not field notes. The notekeeper should realize that the notes will very likely be used by other persons not familiar with the locality who must rely entirely upon what he has recorded. For this reason, not only should the notebook contain all necessary information, but it should be recorded in such a form which will permit only one interpretation. Accurate and clearly drawn sketches will do more than anything else to convey correct impressions. The use to be made of the notes should guide the notekeeper in deciding what information to include and what information to leave out. To make the notes clear, the recorder should put himself in the place of one who is not on the ground at the time the survey is made.

In recording the data in the notebook, a 4-H pencil, well pointed, should be used. The figures used should be plain. One figure should nevery be written over another. In general, numerical data should not be erased. If a number is in error, a line should be drawn through it, and the corrected value written above. Where decimals are used, the decimal should never be omitted. The numbers should always show with what degree of precision, the measurement was taken. Thus, a rod reading, taken to the nearest 0.01 ft., should be recorded not as 7.4 ft., but as 7.40 ft. Notes should not be made to appear either more accurate nor less accurate than they really are. The pages should be numbered in the upper right hand corner of the right hand leaf only. The number should appear with a circle drawn around it. In this way, an index, a table of contents, may be recorded in the front portion of the book.

3. Safety Hints

One of the prime considerations of any type work should be the safety and well-being of the men involved. This is particularly true in field survey work, which many times is done under hazardous conditions or in a remote area where medical aid is not easily available.

Any situation which involves working under hazardous conditions such as in high places, in traffic, in water, etc., should be completely analyzed in advance. This analysis should consist of spotting the probably danger spots, and determining exactly where the danger lies. Then the work should be planned to eliminate, or reduce to a minimum, personnel exposure to these dangers. In most cases, the work can be so organized and planned that none of the people involved will be exposed to possible hazard. In some cases, complete elimination of hazards is impossible, and some exposure is necessary. The work should be planned to keep this to a minimum, and the personnel involved should be selected on the basis of who is best qualified, physically, mentally, to cope with an emergency, should it arise.

All equipment, tools, etc., involved in the work should be examined daily prior to beginning the day's work to determine if they are in a proper and safe condition. A good party chief will observe the work as it progresses during the day with an eye to eliminating any dangerous or unsafe method or attitude.

II. Chaining

A. General Procedures and Requirements

1. Importance

The basis of all surveying is the linear measurement. No matter how accurately the other phases of work are done, with inaccurate chaining, the survey will be a failure. It is not easy to avoid making errors, and certainly, it is not a simple operation to chain with precision. Chainmen should constantly on the alert for errors in order that a great deal of work may not be lost through inaccurate chaining.

2. Reading a Chain

The equipment required in chaining usually consists of one or more range poles, eleven chaining pins, and a one-hundred foot steel tape with intervals zero to one foot, and 99 to 100 foot, graduated in tenths of feet, and the remainder of the tape or chain graduated in feet. One range pole is placed behind the distance point to indicate its location. The rear chainman with one pin, stations himself at the point of beginning. The head chainman with the zero end of the tape and ten pins advances toward the distant point. When the head chainman has gone nearly one hundred feet, the rear chainman calls "chain" a signal for the head chainman to halt. The rear chainman holds a hundred-foot mark at the point of beginning, and by hand signal or speaking, lines in a chaining pin held by the head chainman with a range pole marking the distant point. During the lining-in process, the rear chainman is in a kneeling position on the line and facing a distant point. The head chainman is in a kneeling position to one side and facing in line so that the rear chainman will have a clear view of the signal marking the distant point. The head chainman with his right hand sets a pin vertically on line and a short distance to the rear of the zero mark. With his left hand, he then pulls the tape taut and making sure that it is straight, brings it in contact with the pin. The rear chainman, when he observes that the hundred foot mark is at the point of beginning calls "stick" or "all right." The head chainman pulls the pin and sticks it in at the zero mark of the tape, with the pin sloping away from the line. He again pulls the tape taut, and notes that the zero point coincides with the pin at its intersection with the ground. The rear chainman then releases the tape, the head chainman moves forward as before and so the process is repeated.

As the rear chainman leaves each intermediate point, he pulls the pin; thus, there is always one pin in the ground and a number of pins held by the rear chainman at any time, indicates the number of hundreds of feet or stations from the point of beginning to the pin in the ground.

At the end of each thousand feet, ten stations, the head chainman has placed his last pin in the ground. He signals for pins, the rear chainman comes forward, with the ten pins he has pulled, both chainmen count them to see that none is lost, and the head chainman records the talley. The head chainman takes the ten pins and the procedure is repeated.

The zero point of a chain and a corresponding ending point at the other end may be:

(1) At the extreme ends of the holding rings.
(2) At the extreme end of the steel ribbon.
(3) On the ribbon, near the ends.

If you are in doubt, compare the end foot with an intermediate foot. The first rule of chaining is that both chainmen must know where the beginning and ending points are located on the chain.

B. Correct Methods of Chaining

1. Measuring Distance less than the Length of the Chain

If the tape, or if the chain, is graduated continuously from 0 to 100, with every foot subdivided into tenths and hundredths, it is obviously simple to make measurements less than the length of the tape. When, however, the end foot is the only one subdivided, it is necessary that both chainmen take part in the actual reading of the tape.

Example: Assume that Points A and B are located 70.65 feet apart, and we have a 100-foot tape without an extension. To measure this distance, the head chainman stretches the tape at Point B and tells the rear chainman at Point A to "hold one," which means to hold a foot mark over Point A. If the rear chainman holds the 70 foot mark, the 0 end of the tape falls short of Point B; obviously, the distance must be 70 feet plus some fraction of the next foot. The rear chainman holds the 71 foot mark and yells "holding 71," the head chainman then reads the distance from the one foot mark on the tape to Point B, and he finds this to be 0.65. The head chainman mentally subtracts one foot from the called 71 and adds the 0.65 to obtain a measured distance of 70.65 feet. For tapes having an extra graduated foot beyond the zero point, it is not necessary to subtract one foot as just described.

2. Laying off Distances less than the Length of Chain

In this case, the procedure is exactly the reverse of that mentioned in Item 1 above.

Example: Let us assume that it is required to lay off a distance of 61.72 feet. The head chainman at the zero end of the chain finds the point in the subdivided end foot that is 0.72 feet from the first foot mark (not from zero). The rear chainman adds 1 to 61 and calls out "holding 62," and this point is held at the beginning point of the distance to be laid off. The head chainman mentally subtracts 1 from 61 and sets the required point opposite the graduation that is 0.72 feet from the one foot mark.

For tapes having an extra graduated foot beyond the zero point, it is not necessary to add one foot to 61.

The chainman at the zero end finds the point in the subdivided extra foot that 0.72 feet from the zero mark. This point is held at the beginning point of the distance to be laid off. The other chainman holds the 61-foot mark and calls out "holding 61" and sets the required point opposite that graduation.

3. Measuring Distances greater than Length of Chain

It is obvious that to measure a distance greater than the length of the chain, chain lengths are laid off repetitiously. In doing this, chainmen must keep four things uppermost in mind:

(1) the chaining must be done in a direct line;

(2) the chain must be stretched tight for each length;

(3) the end of each chain length must be marked in such a way as to be used as the beginning of the next chain length;

(4) accurate count must be kept of the number of chain lengths.

In order to keep on a straight line, a range pole may be set "on line" some distance down the line to be chained. The rear chainman can line in the head chainman by sighting on this pole. If more accurate aligning is desired, the transit may be used. To mark the beginning and end of each chain length, chaining pins may be used. In the event high precision is required, we can set stakes and use a tack or knife mark to indicate the exact point. On ground that is too hard for stakes or pins, nails may be driven. On pavements, points may be marked with a crayon. As you can see, there are several different methods of procedure. Two good chainmen will soon discover which procedure is best suited for the work they will do.

4. <u>Chaining on a Slope</u>

In measuring slopes, there are two ways of getting a <u>horizontal</u> distance which is the distance usually required in surveying:

(1) The distance may be measured along the slope and corrected by calculation.

(2) Holding the tape <u>horizontally</u> every time it is stretched for a measurement. We normally use the second method in our surveying operations.

In chaining with the tape held horizontally, it is easier to chain downhill than to chain uphill. The downhill end of the tape is held high enough off the ground to make the chain horizontal, and the point on the ground is found by using the plumb bob. This process is repeated in a series of steps until the line is chained.

When the slope is so steep that the downhill end cannot be held high enough to keep the chain horizontal, the distance must be measured in sections which are short enough to permit the procedure outlined above. This is called breaking the chain. See Figure 2.

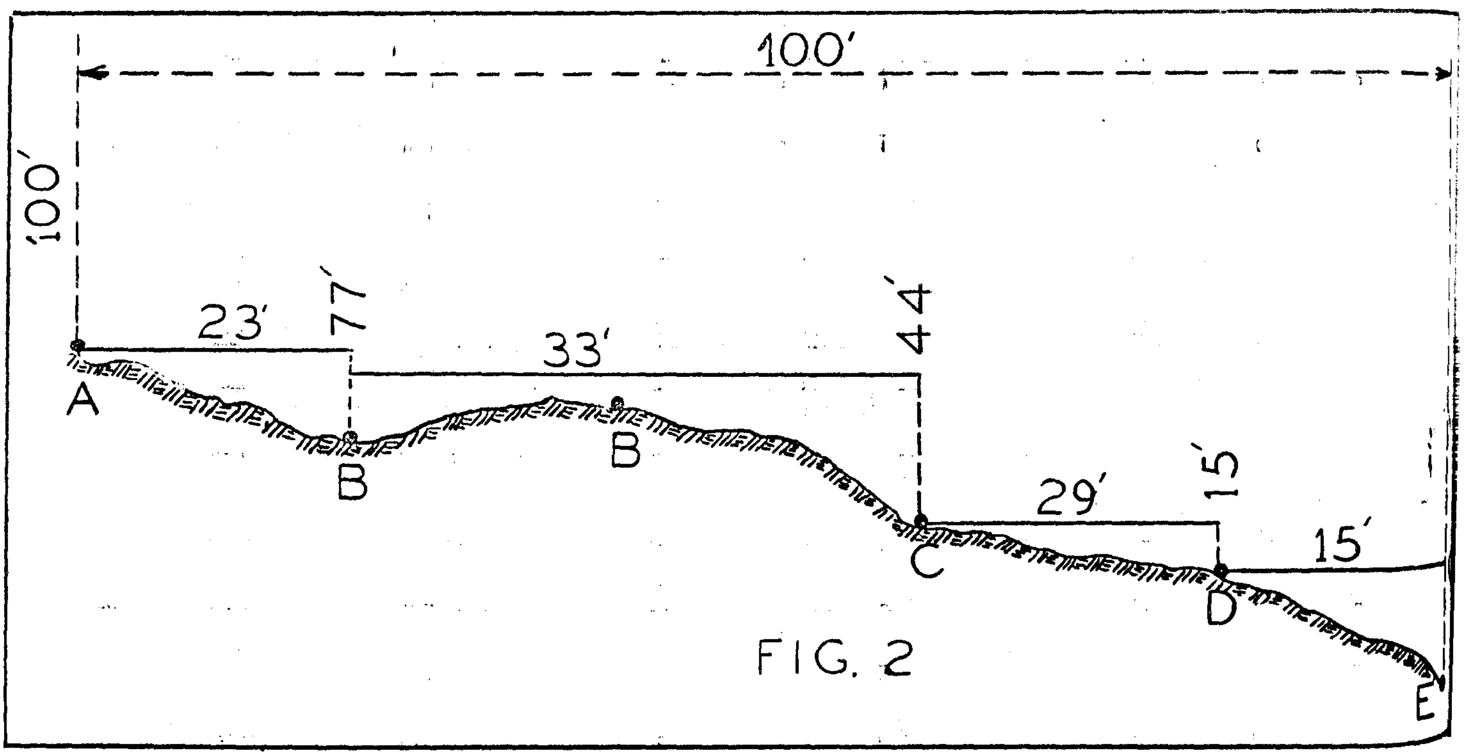


FIG. 2

5. Errors in Chaining

Listed below are some of the common errors that occur in chaining.

a. Tape not correct length

This will produce a cumulative error, since it does not compensate. It may be eliminated by checking it against a standard tape.

b. Chaining not done in direct line

In this case, the head chainman sets the point, sometimes on one side, and sometimes on the other side of the true line. This a cumulative error, but usually, it is the least important of the errors in chaining. This error can be reduced to a negligible quantity by careful aligning while chaining.

c. Tape not horizontal

This error is cumulative normally. With the eye, it is difficult to tell when the tape is horizontal. Inexperienced chainmen have been observed chaining what they thought were horizontal distances on a slope of perhaps ten per cent. This error can be reduced by leveling the tape with a hand level, or by means of a string and string level.

d. Tape not straight

In chaining through grass and brush or when the wind is blowing, it is impossible to have the entire tape in a straight line. This error is cumulative and can be likened to chaining with a tape that is too short. The error can be reduced to a minimum by clearing the line of large obstacles, stretching the tape taut, and by careful checks by the head chainman to see that the tape is straight.

e. Inaccurate Readings

Errors in reading the tape, lining the tape to the points, and in plumbing while taping on a slope are accidental errors. They are not cumulative and tend to vary as the square root of the number of tape lengths. In rough terrain, the error in plumbing is of most importance. Care in the work will tend to eliminate these errors.

f. Variations in Temperature, Tension and Sag

The length of the chain is directly dependent on these three items. However, standard corrections can be applied to eliminate their effect. These corrections are discussed in detail in Item C.

C. Corrections and Adjustments

1. Temperature

If measurements are made at a higher temperature than the 68° standard, the tape is too long. If the measurements are made at a temperature below 68° standard, the tape is too short. For a change in 15° F., a 100-foot steel tape will experience a change in length of about 0.01 foot, which introduces an error of 0.5 foot per mile. An extreme change of 50° would introduce an error of 1.5 feet per mile.

The coefficient of thermal expansion of steel is 0.0000065 per 1° F. If the tape is standard at 68° and measurements are taken at T degrees, the correction (c) to be applied is given by the formula - $C=0.0000065\ l(T-68^{o})$ where l is the measured length.

2. Tension and Sag

Corrections for these two items are not normally made except for very precise measurements such as are involved in triangulation. In the event it is deemed necessary to correct for tension and sag, the need for correction can be eliminated by being compared with a standard tape.

The comparison is made as follows:

a. A flat floor more than 105 feet long is used and both tapes are stretched side by side on the floor to assume the same temperature. The floor may be of any material as long as it is smooth and flat. Temperature is disregarded in this comparison by having both tapes the same temperature.

b. Paper stickers are fastened to the floor at points corresponding to the 0, 25, 50, 75, and 100-foot marks on the standard tape. A starting line is marked at the zero end.

c. The standard tape is then used, under a 10-pound tension, to mark the correct distances on the 25, 50, 75, and 100-foot papers.

d. The tape which is to be compared will then be immediately placed in position and put under standard tension. This is 10 pounds for tapes 100 feet or less in length and 20 pounds for tapes over 100 feet in length. The corrections, if any, at each tape interval will be noted.

e. If the correction can be eliminated by using a tension different from the standard, that tension will be determined. With this information, the tape can be used for exact measurements when it is fully supported.

As baseline measurements must be made under conditions where the tape cannot be fully supported, it is logical to decide, while the comparison is being made, what interval of support will be used in the field and determine what tape tension is required to give correct lengths with those intervals. Twenty feet is suggested and following Step 3 above, the tape can be blocked about 2 inches above the floor at those intervals and checked immediately. About 2 pounds additional tension may be required, depending on the weight of the tape.

III. Leveling

A. Use and Care of Level

1. Care of the Level

Many parts of the level are delicate and are made of soft material, so the first and most important rule is to handle the instrument gently. Never force movable parts or screws. It can be comparatively easy to strip threads or twist off the heads of a screw.

In removing the instrument from its box, always grasp the lower part - <u>not</u> the telescope. Be sure the level itself is securely screwed to the tripod. More than one accident has occurred by an instrumentman simply setting the head on the tripod, turning to do something else temporarily, and having another member of the crew pick up the level and fling it on his shoulder. Always be sure the instrument is screwed to the tripod.

In setting up the instrument for use, the following precautions should be used. Do not let a level stand with the tripod's legs so close together that it can fall over. Never leave it unguarded where it might be knocked over by people, moving vehicles, or animals. In setting up the instrument on pavement or other slick surfaces, try to wedge the shoes of the tripod into cracks or depressions.

In carrying the level, always be sure the spindle is clamped tight so that the telescope will not swing back and forth. Carry the level in front of you when going through restricted places, particularly when there are overhanging limbs.

2. Setting up the Level.

In this procedure the whole point is to get the instrument in such a position that the line of sight through the telescope will revolve in a horizontal plane. The first step is to plant the tripod legs in the ground in such a manner that the upper part or head of the tripod is approximately level. Next, you must adjust the upper part of the instrument by means of leveling screws so that the line of sight will be horizontal in any direction. This adjustment is done by turning the telescope until it is above and in line with two diagonally opposite screws and bringing the bubble approximately to the center of the tube by turning the screws. Then, turn the telescope over the other pair of leveling screws and repeat the process of bringing the bubble to the center. This process is alternated back and forth until the bubble stays in the center of the tube when the telescope is swung in any direction.

In turning the two diagonally opposite screws, the thumbs always move towards or away from each other. Remember, the bubble will move in the direction in which the left thumb is turned. When the thumbs turn towards each other, the bubble will move to the right; away from each other, left.

B. Use of Level Rod

1. Holding the Rod

Since the level rod is used to measure the <u>vertical</u> distance from the horizontal line of sight to a given point, it must be held in a vertical position. This may be accomplished in several ways:

(1) Holding the rod loosely with your fingers and seeking to balance the rod on the point.

(2) Use of a rod level.

(3) By rocking the rod slowly through the vertical position and taking the least reading observed.

2. Reading the Rod

The most common type of level rod we use is the Philadelphia Rod. Figure 3. You will note that the even feet are shown in large red numbers. The smaller black figures indicate the even tenths of a foot. The hundredths of a foot are indicated by the small black and white spaces. You will note that the even foot, tenth, and five hundredth mark is indicated by a point on the black line.

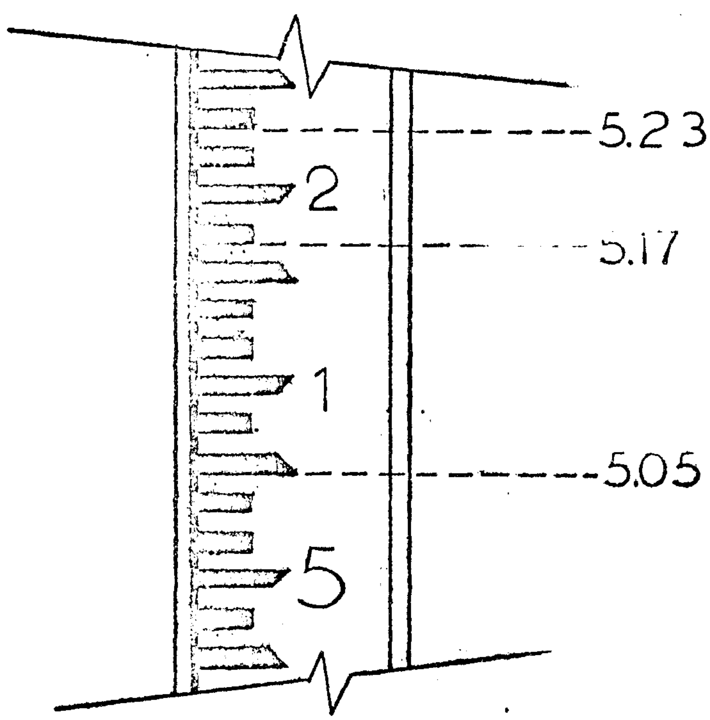


FIG. 3

C. Basic Theory of Differential Levels

1. Definitions

a. Backsight (BS) Sight or reading on any point of known elevations. Always add the backsight to the elevation of the known point to get the Height of Instrument (HI).

b. Foresight (FS) Sight or reading on any point of unknown elevation. Always subtract from HI to get elevation.

c. Height of Instrument (HI) Elevation of instrument. This is arrived at by adding BS to elevation of known point (BM or TP).

2. Explanation of Theory

a. If we hold a level rod on a bench mark and sight through a leveled telescope, the point at which the horizontal cross hair intersects the level rod is the vertical height of the instrument above the bench mark. Thus, if we add the reading on the level rod to the known elevation of the bench mark, we arrive at the actual height of the instrument (HI). The reading on the level rod is called a backsight (BS).

b. Knowing the height of instrument (HI), we can set the rod on a point of unknown elevation and again read the rod. This reading on a point of unknown elevation is called a foresight (FS). This reading is the actual vertical distance from the instrument down to the point. By subtracting this reading (FS) from the instrument height (HI) we arrive at the actual elevation of the point. This point then becomes a bench mark (BM) or as a temporary point, it is called a turning point (TP).

c. The instrument can then be picked up, moved ahead, releveled, and a new backsight taken on the turning point and the process repeated. This "leap frog" procedure may extend as far as needed.

3. Correct Form for Level Notes

Sta.	(+) B.S.	H.I.	(-) F.S.	Elev.	Remarks
BM #Y607	3.76	103.76		100.00	USC&G BM#Y607
TP #1	6.21	105.95	4.02	99.74	
TP #2	4.02	106.06	3.91	102.04	
TP #3	7.11	107.07	6.10	99.96	
BM #Y609			6.29	100.78	USC&G BM#Y609

To check: Sum of BS (+) less sum of FS (-) should equal difference in elevation of beginning BM and ending BM. If you begin at end on the same BM, then the sum of the BS and the sum of the FS should be equal, i.e., (from above)

BS (+)	FS (-)
3.76	4.02
6.21	3.91
4.02	6.10
7.11	6.28
+ 21.10	- 20.32
- 20.32	
+ 0.78	

D. Vertical Control Net

1. General

In our construction work, it is necessary that we control the grades or elevation of the roadway and structures during construction. In order to do this, we need a series of points of known elevation (bench marks) to refer to. Generally, we need these points about every 1,000 feet located near the right of way, but not necessarily in it. In order to determine the elevations of the bench marks, we set every 1,000 feet, it is necessary to run a series of differential levels from established U. S. Government Bench Marks.

2. Method of Bench Mark Leveling

When a line of levels does not form a closed circuit, it may be possible to check the field work by starting from one permanent bench mark and closing on another. When this is not practicable (as is the usual case), a check may be made by rerunning the levels in the opposite directio Example: Assume it is desired to establish a Bench Mark B, starting from Bench Mark A of known elevation. Levels are first run from A to B and the difference, d, in elevation between A and B is determined. Levels are then run from B to A, and a second difference in elevation d' is determine There usually will be a variation between d and d'. If this variation exceeds permissable tolerance, both lines must be rerun until the variation is within tolerable limits. The average value $\frac{1}{2}(d + d')$ is then used to calculate the elevation of B.

In determining the tolerable limit of error mentioned above, between d and d', the formula:

Error = 0.1 $\sqrt{\text{Distance in Miles}}$ will usually give satisfactory limits.

3. Distribution of Errors

In this discussion, two different cases will be taken up:

(1) Levels re-run in opposite directions.

(2) A closed level circuit.

a. Levels rerun in opposite directions

Starting from known Bench Mark A, levels are run to establish the elevations of new Bench Marks B, C, and D. Assume levels were run forward and backward between each pair of successive bench marks as explained in Item III, D, 2, above. Assuming the variation of d and d' between A and B is within tolerance, the average $\frac{1}{2}$ (d+d') is used to calculate the elevation of B. The same adjustment process is used between B and C, etc., througout the whole line of levels.

b. Closed level circuit

Starting from known Bench Mark A, levels are run over a closed circuit, ending on A. Let E represent the error of closure. It is necessary to distribute this error in adjusting the elevations of the new bench marks on the circuit. This error is normally distributed around the circuit in proportion to the distance of the bench mark from the starting point.

Example: If the bench mark is 1/8 the total length from A, then its elevation is adjusted by 1/8 E. If the elevation of A, found from running the levels around the circuit, is higher than its elevation used at the start, i.e., if E is positive, then the correction applied to each bench mark will decrease its elevation. If E is negative, the correction for each bench mark is positive, thus increasing its elevation.

E. Construction Stakes for Vertical Control

1. Construction Hubs

These stakes are usually set by the Field Party prior to beginning construction operations. They are set opposite each station, and on each right of way line. The elevation of the top of each hub should be determined to the nearest hundredth of a foot by running levels between bench marks previously set every 1,000 feet. All vertical distances to each point in the cross section can then be measured from these hubs.

2. Slope Stakes

Slope stakes are stakes set to indicate the toe of slope or the top of a slope. In a normal grading, these points may be scaled directly from the plotted cross section sheets, or in some cases, directly from the Typical Section Sheet. However, in the case of deep fills or cuts, where considerable quantities are involved, this is not sufficient. Since the quantities involved may vary considerably with the slope - it follows then that the slope of cuts or fills must be followed exactly. Since it is humanly impossible to build a slope exactly by eye, it is necessary to set slope stakes.

Example: Starting with the nearest bench mark, differential levels are run to the section of roadway to be staked. The subgrade elevation is subtracted algebraically from H.I. elevation and the difference is the grade rod. A rod reading is then taken to the nearest tenth of a foot on the ground at the center line stake. All rod readings are considered negative. The rod reading and the grade rod are added algebraically and the sum indicates the cut or fill at the point where the reading is taken - minus indicating fill and plus indicating cut.

If the ground is level, the cut or fill to subgrade at the slope stake will be the same and the distance from the center stake to the slope stake is found by multiplying the center cut or fill by the ratio of the side slopes and adding one-half the width of the roadbed.

If the ground is not level, the cut or fill will be different for various points, and the problem is to find the point on each side of the center line whose distance from the center is equal to the cut or fill at that point multiplied by the slope ratio and added to one-half the roadbed. This is a trial and error procedure. For example in Figures 4, 5, and 6, three typical cases are shown.

Figure 4 shows a cut. In this case, the H.I. is always above both the ground and the proposed subgrade and, therefore, when the elevation of the subgrade is subtracted algebraically from H.I., the difference (grade rod) is always positive. In this case, the grade rod = H.I.-Subgrade El.

H. I.	=	543.29	
Subgr. El.	=	-526.70	
Grade Rod	=	16.59	Use 16.6'

The rod reading on the ground at ℄ = -7.3. Therefore, the algebraic sum of rod reading and grade rod = -7.3+16.6 = 9.3 which is the center cut (plus = cut and minus = fill). If the ground were level then the slope stake would be 1.5 (9.3) + 14 or approximately 28' cut from ℄. Assume, however, the rod

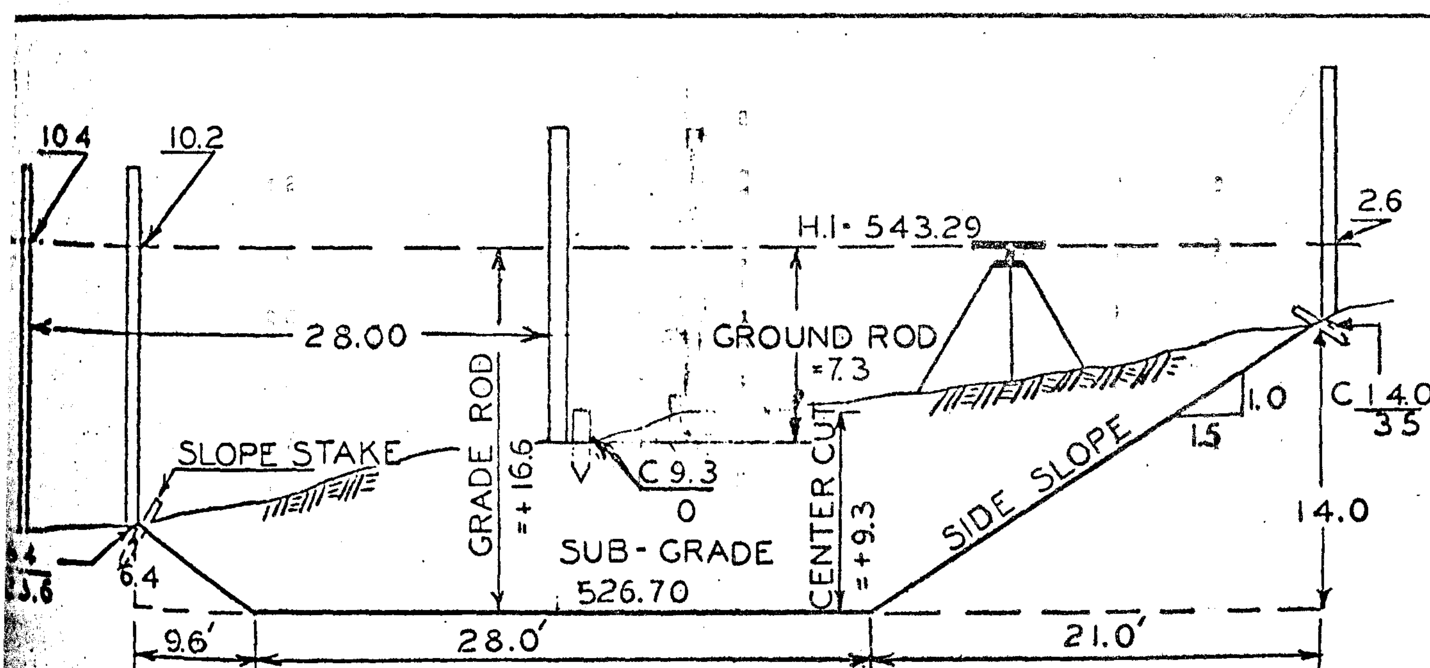


FIG. 4

reading at this point = 10.4 indicating the ground is not level but falling. This reading added algebraically to the grade rod =-10.4+16.6 = +6.2 (cut). Therefore, the slope stake should be 1.5(6.2)+14 or approximately 23.3' out. The rod is then moved to this point which gives reading of 10.2 giving cut of 6.4. The distance = 6.4 (1.5)+14 = 23.6. Moving out the 0.3' we find the rod reading does not change and the slope stake is set.

Figure 5 illustrates a fill of which the finished roadbed is below the H.I. In this case, the grade rod will always be less numerically than the rod readings on the ground. The grade rod in this problem is +3.7; the rod reading at the center stake is -8.5 and their algebraic sum is -4.8, the minus sign indicating a fill. The positions of the slope stakes are found by trial as previously explained.

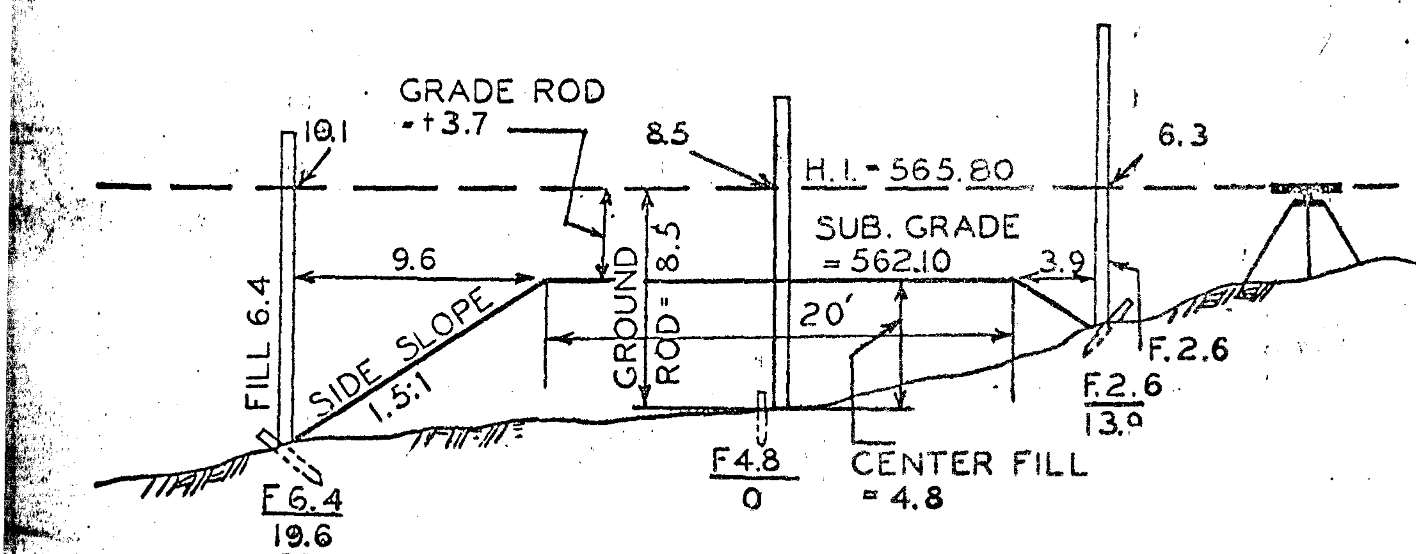


FIG. 5

In Figure 6, the finished roadbed is above the height of the instrument and, therefore, the grade rod has a negative value. Since the rod readings are always considered negative, the fill in this instance is the arithmetical sum of the grade rod and the ground rod. Otherwise, this case is similar to the preceeding ones.

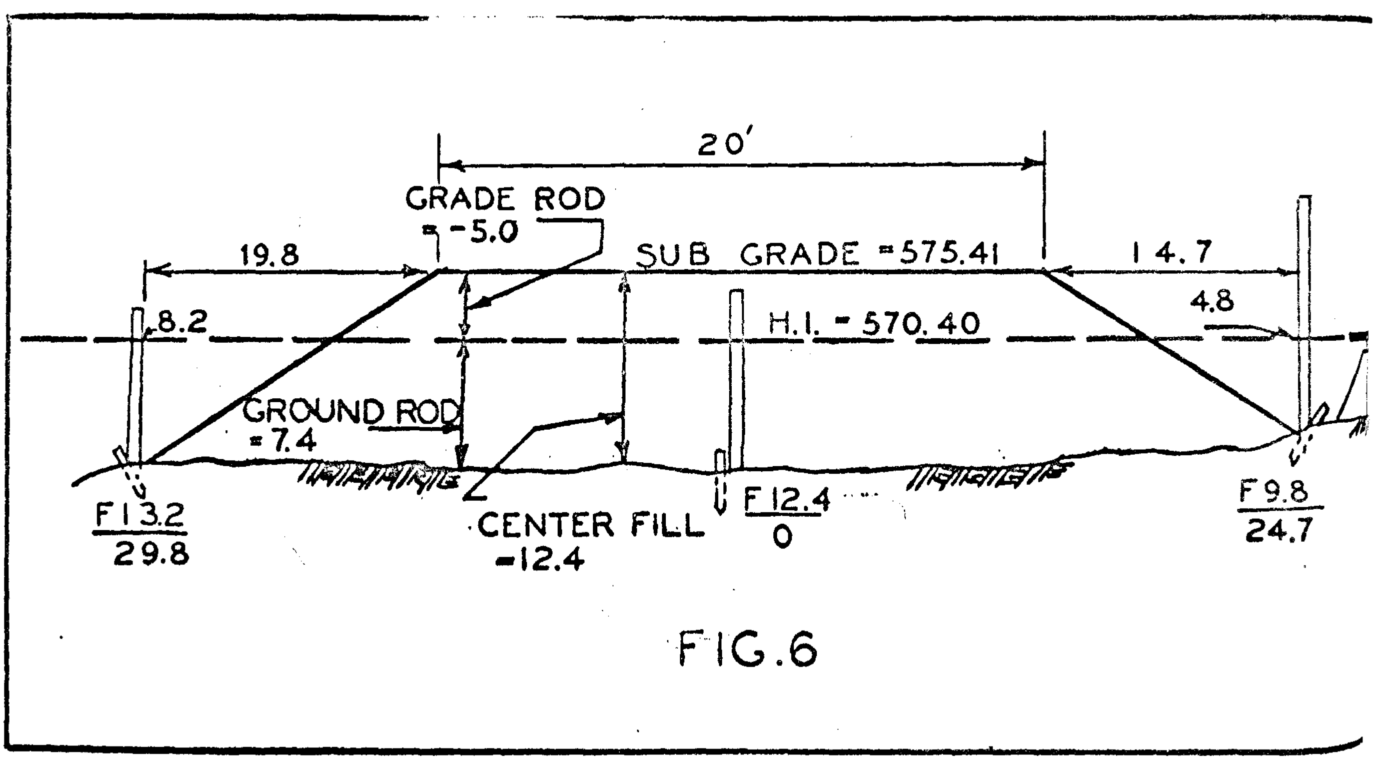


FIG.6

F. Vertical Curves

1. Per Cent Grade

   a. Per cent grade may be calculated by dividing the change in elevation by the horizontal distance over which this change occurs, then converting the answer to per cent.

      2.0' change in 5000'

      2.0 ÷ 5000 = 0.0004 = 0.04%

   b. The grade is positive if the elevations increase as the station numbers increase.

   c. The grade is negative if the elevations decrease as the station numbers increase.

   d. In the case of 100' stations, the actual increase or decrease in elevations in 1 station is equal to the % grade. 0.2' change in 100' station = 0.2% grade.

2. Calculation of Tangent Elevations

   a. A tangent is the straight line between the various breaks or changes in grades.

   b. The point at which these changes or breaks in grade occur are called P.I.'s.

   c. To calculate the elevations along a tangent you must add or subtract from the elevation of the P.I. The amount to be added or subtracted (Change) is calculated by multiplying the grade expressed as a decimal by the horizontal distance from the P.I. to the point on the tangent.

d. Example: P.I. = Sta. 0+00 = 100.00 Elev.
P.I. = Sta. 5+00 = 101.00 Elev.
P.I. = Sta. 10+00 = 96.00 Elev.

Find % grades and tangent elevation of stations listed below.

% grade from Sta. 0+00 to 5+00
Hor. Dist. = 500'
Vert. Change = +1.00
% grade = 1.00 ÷ 500 = 0.002 = + 0.2%

% grade from Sta. 5+00 to 10+00
Hor. Dist. = 500'
Vert. Change = 5.00'
% grade = 5.00 ÷ 500 = 0.01 = -1.00%

Sta.	Tan. Elev.	
0+00 PI	100.00	
1+00	100.20	Elev = 100.00+ (.002 x 100) = 100.20
2+00	100.40	Elev = 100.00+ (.002 x 200) = 100.40
2+34	100.47	Elev = 100.00+ (.002 x 234) = 100.47
3+00	100.60	Elev = 100.00+ (.002 x 300) = 100.60
4+00	100.80	Elev = 100.00+ (.002 x 400) = 100.80
5+00 PI	101.00	Elev = 100.00+ (.002 x 500) = 101.00
6+00	100.00	Elev = 101.00- (.01 x 100) = 100.00
7+00	99.00	Elev = 101.00- (.01 x 200) = 99.00
8+00	98.00	Elev = 101.00- (.01 x 300) = 98.00
8+76	97.24'	Elev = 101.00- (.01 x 376) = 97.24
9+00	97.00	Elev = 101.00- (.01 x 400) = 97.00
10+00 PI	96.00	Elev = 101.00- (.01 x 500) = 96.00

3. Discussion of Vertical Curves

a. A vertical curve connects two different grades.

b. This curve is in the form of a parabola.

c. All distances are measured on a horizontal plane.
All elevations are measured on a vertical plane.

d. The vertical curve is always symmetrical about the PI. Thus, one-half the length lies on either side of the PI.

e. In general, to calculate a vertical curve, first calculate the tangent elevations from P.C. to P.T. Then the vertical offsets from the tangent to the curve are calculated. These offsets may be plus (+) or minus (-) depending on whether the curve is a sag or rise curve.

f. These offsets may be calculated several different ways. We will discuss only one.

4. Calculation of Elevations on a Vertical Curve

a. Symbols used:

e = Offset from PI to Vertical Curve

A = Algebraic difference in grades

L = Length of Curve in Stations

X = Distance in Stations from PC or PT to any point on tangent

d = Offset from tangent to Vertical Curve at any point

b. Formula used:

1. $e = AL/8$

2. $d = e\,(X/\frac{1}{2}L)^2$

5. Sample Problem

a. We will use grades and elevations given in the example on page 36.

Sta 0+00 to 5+00	+ 0.20% grade
Sta 5+00 to 10+00	- 1.00% grade
PI @ Sta 5+00 Elev	= 101.00

b. Calculate an 800' vertical curve.

c. Since the PI is at Station 5+00 and the curve must lie symmetrically about the PI, then the P. C. must be at Station 1+00 and the P.T. must be at Station 9+00.

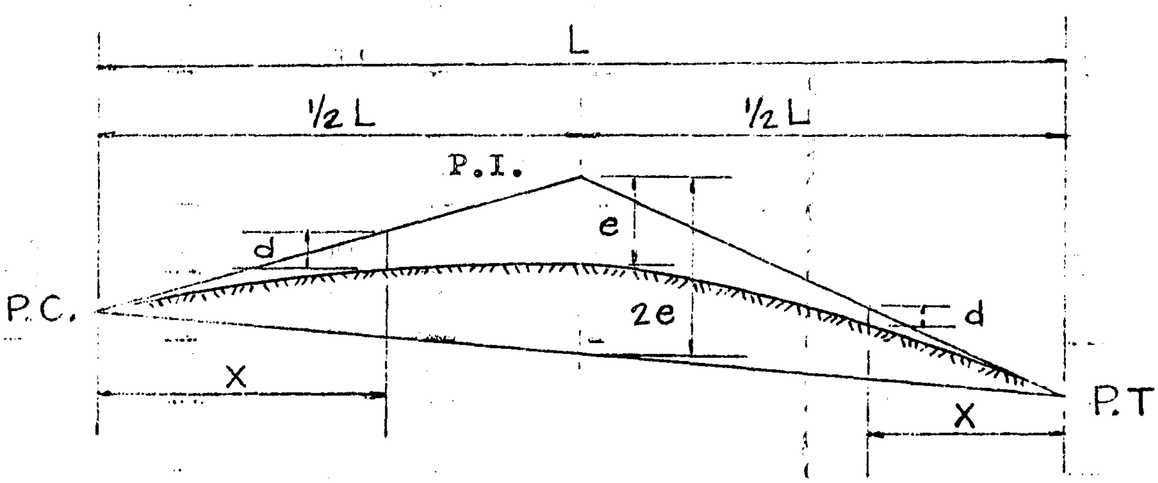
$A = +0.20\% - (-1.00\%) = 1.20$
$L = 8$ Stations
$e = AL/8 = 1.20(8)/8 = 1.20$
$d = e\,(X/\tfrac{1}{2}L)^2$

Sta. 1+00	$d = 0.00$ (P.C.)	
2+00	$d = 1.2\,(\tfrac{1}{4})^2 = 0.075$ use 0.08	
2+34	$d = 1.2\,(1.34/4)^2 = 0.139$ use 0.13	
3+00	$d = 1.2\,(2/4)^2 = 0.30$	
4+00	$d = 1/2\,(3/4)^2 = 0.675$ use 0.68	
5+00	$d = e = 1.20$	

to calculate remainder of curve x must be measured from **PT**

6+00	$d = 1.2\,(3/4)^2 =$ same as 4+00
7+00	$d = 1.2\,(2/4)^2 =$ same as 3+00
8+00	$d = 1.2\,(1/4)^2 =$ same as 2+00
8+76	$d = 1.2\,(0.24/4)^2 = 0.004$ use 0.00

Sta.	Tan. Grade	d	Profile Grade
0+00	100.00		100.00
1+00 PC	100.20	0.00	100.20
2+00	100.40	-0.08	100.32
2+34	100.47	-0.13	100.34
3+00	100.60	-0.30	100.30
4+00	100.80	-0.68	100.12
5+00 PI	101.00	e=1.20(-)	99.80
6+00	100.00	-0.68	99.32
7+00	99.00	-0.30	98.70
8+00	98.00	-0.08	97.92
8+76	97.24	-0.00	97.24
9+00 PT	97.00	0.00	97.00
10+00	96.00		96.00



Example - Effect of temperature on tape

A line measured with a steel tape under a tension of 10 lbs was found to be 624.53 ft long when the mean temperature was 75° F. If the tape under a tension of 10 lbs at 68°F was 100 ft long, compute the correct length of the measured line:

$C = 0.0000065 \times 624.53(75^\circ - 68^\circ) = 0.028$ ft.

Corrected distance = 624.53 + 0.03 = 624.56 ft.

i.e., the correction is <u>added</u> to the measured distance because the tape is too long.

If the same line had been measured at 55°F, what would the corrected length be?

$C = 0.0000065 \times 624.53(68^\circ - 55^\circ) = 0.053$ ft.

corrected distance = 624.53 - 0.05 = 624.48 ft.

i.e., the correction is <u>subtracted</u> from the measured distance because the tape is too short.

Differential Level Homework Problem

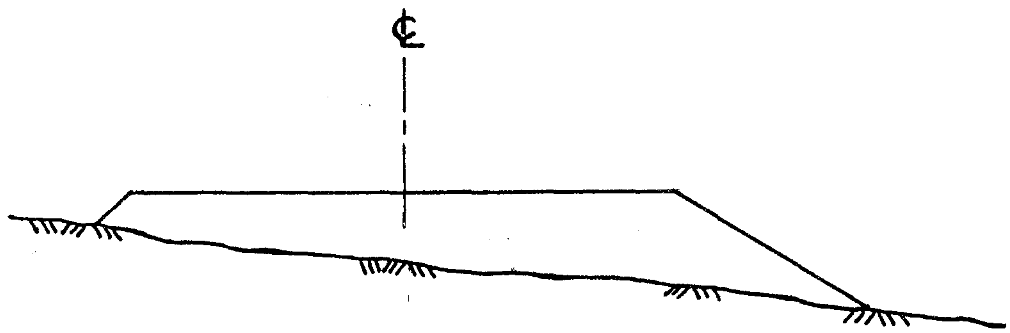
Fill in the missing readings and elevations. Show the checking procedure.

Sta.	B.S.(+)	H.I.	F.S.(-)	Elev.
B.M.#1	2.50			100.00
T.P.#1		101.21	4.54	97.96
T.P.#2	4.00	99.56	5.65	
B.M.#2			3.17	

Slope Stake Homework Problem

Given:	Grade elevation	=	99.25'(28' roadbed)
	H.I.	=	100.78'
	Rod reading Lt.	=	2.9
	Rod reading Rt.	=	7.5
	Rod reading ℄	=	4.6
	Side Slope		1.5:1

Required: Location of slope stakes from ℄ and ground elevation at slope stakes.



Vertical Curve Homework Problem

Calculate and complete notes for an 800 ft vertical curve. PI at Station 4 + 00 with elevation of 100.00 ft. Station 0 + 00 to 4 + 00 = -2% grade; Station 4 + 00 to 8 + 00 =+3% grade.

Station	Tang.Grade	d	Profile Grade
0 + 00			
1 + 00			
2 + 00			
3 + 00			
4 + 00	100.00		
5 + 00			
6 + 00			
7 + 00			
8 + 00			

HIGHWAY DESIGN I

General Remarks

A. Procedures for handling Highway Construction

The State Highway Department is primarily an organization for the construction and maintenance of highways. Under the Department's policy for the construction of proposed highway projects, there is open to the Engineer two methods for obtaining the desired results. These methods are:

(1) The enactment of a contract between the Highway Department and a responsible Contractor on the basis of a low bid submitted.

(2) The performance of the desired construction by State Maintenance forces on a day labor basis.

Both methods produce satisfactory results; however, there is a definite time and place where each should be used. As the type of plans and specifications to be prepared are dependent on the method of construction employed, it is necessary that this be given first consideration. The prime factor for consideration in determining the method of construction to be employed is economy and other factors having a direct bearing thereon. For a project of any size, the aforementioned factors would definitely indicate the enactment of a Contract. Construction by contract methods requires the preparation of a properly correlated set of plans and specifications in order to definitely outline what the Contractor will be expected to do, and also insure that the State will receive a properly constructed project. Where construction is to be performed by State forces, it is only necessary in the initial stage to submit design data forms and project estimates.

B. Elementary Purpose of Construction Plans

A set of plans from which a highway project is to be constructed can best be defined as an arrangement of parts in accordance with a fixed design. This can be further simplified to mean a definite method of procedure wherein it is stated or shown where the project is to be constructed and what is to be done. It can be said that basically the elementary purpose of construction plans is to portray the project and provide sufficient detail for the Engineer-Contractor team to construct the job. Items and drawings should be shown in enough detail to avoid causing a possible increase in bid prices because of an uncertainty as to required construction procedures. The plans also finally provide a record of the project as built. It can be seen that simplification can be effected by including in the plans only that which has direct bearing on the construction of the project. Specifications in conjunction with plans particularize or name in detail how the proposed work is to be done and, in some cases outline when the desired construction may be performed. Certainly, a properly correlated set of plans and and specifications are conducive to the construction of a good project.

Highway plans are usually prepared in a standard form, and the methods employed in graphically presenting the design are generally the same. Each integral part of a set of plans will be discussed recognizing that every project presents various problems as to what should be shown on the plans as well as how it should be shown.

II. Plan Elements

A. Title Sheet

1. Function

The title sheet and the first sheet of a set of plans are a rather important part of the plans. It is reproduced by photostating or blueprinting more times than any other single plan sheet. The function of the title page is several fold:

(1) It locates the project by limits and layout sketch to an indicated scale.

(2) It shows the type of work proposed.

(3) It defines the job with regard to project, control, and highway numbers.

(4) It summarizes project lengths of roadway and bridges.

(5) It shows detours.

(6) It indicates code number and location of detour, barricade, and warning signs.

(7) It denotes equations and exceptions.

(8) It presents an index of plan sheets.

(9) It signifies railroad delivery points.

(10) It locates base material source on the layout map.

(11) It shows a key to conventional signs used.

(12) It provides signature and date blocks for approving State and Federal officials.

This information when placed on the sheet in proper form fulfills all requirements for an adequately informative title sheet. Please refer to the sample title sheets; Plate 1 is used primarily on the more heavily traveled highways of the State and is 22" x 36" outside dimensions in size, and Plate 2 is used primarily on the Farm to Market Road highway system and is half scale in size.

2. Designation of the Project

In order to identify the project, a block of index data is shown in the upper right hand corner of the title sheet. The heading in this sheet index clearly shows the data which is to be placed therein. The project number, whether Federal project or State project, is shown in this index and shown at other points on the title sheet. The prefix designations and numbers used in identifying a project number will not be explained at this time due to the various items to consider in establishing a project number. The numbers appearing under the heading of State control number consist of three numbers. The first two numbers are part of the system of numbering highways and is known as the control-section numbering system. The primary purpose of the control system is to provide a practical and permanent system of recording which will permit ease of reference and positive identification of all information and statistical data pertaining to the maintenance and construction of State highways. In the control-section numbering system, the term "control number: means a definite section of highway with well-defined geographic termini. Control numbers vary in length, usually from 50 to 100 miles. The term "control section" means a definite portion of a control number with well-defined geographic termini within the established limits of a control number. Control sections also vary in length, usually from 10 to 15 miles. One or more control sections comprise a control number. The last number of this group of three numbers is the job number. The term "job number" means the number assigned to each contract or day labor job under a control section. As many job numbers may be assigned under a control section as there are different or successive contracts or day labor jobs entered into. The highway number completes the information shown in this block of index data. The prefix to the highway number may be any of the following: "I" for an Interstate highway, "U.S." for a U.S. numbered highway, "S" for a State highway, "P" for a park road, "L" for a loop, "SP" for a spur, and "F.M." for a farm to market road.

The title section of the title sheet is presented in the upper center portion of the sheet. This section includes not only such information as the repetition of the project number, county, highway number, and control section numbers, but also shows the limits of the project, the type of work proposed, and a summarization of the net length of project. The net length of a project is the end to end distance of the project, excluding lengths of exceptions and taking into account all equations. The lengths are shown in feet and miles. <u>Exceptions</u> are those areas in which no work is done and <u>equations</u> are those points on the highway centerline in which it is necessary to make one highway station number equal to another highway station number, a station being equal to 100 feet in distance. A list of equations and exceptions is generally found in the lower center portion of the title sheet. Referring to Plate 1 and the lower center portion of the sheet, a list of equations will be found. The first equation listed begins with Station 1096+23.80. This means 1,096 stations of 100-foot length each, plus 23.80 feet. This equation means that at one point on the highway centerline, Station 1096+23.80 is equal to Station 1096+25.13. The terms back and forward help determine whether or not the equation is a plus equation or a minus equation. In this particular case, this is a minus equation because the forward station is larger than the back station. The loss in distance is equal to the difference in the stations and this loss is considered in determining the length of the project. The total length of project on Plate 1 is separated into roadway and bridge length. This is true on all jobs. A structure is classified as a bridge if the clear span length is greated than 20 feet.

3. Index of Sheets

The upper left hand corner of the title sheet contains an index of plan sheets and offers a ready means of locating the needed part of the plans. This index is fairly well standardized, and it can be expected to follow the same order of plan presentation on all jobs.

4. Other Data

Recent practice has eliminated the showing of railroad delivery points and specification notes. Generally, the railroads serving an area are shown on the layout, and this will be sufficient to allow the elimination of the data called railroad delivery points.

5. Layout

The plan layout of the title sheet shows the project in such a manner that the location and limits can be easily identified. This is the most important function of this sheet. The information shown in the layout should be fairly obvious, considering the explanation given to other portions of this sheet; however, the item of barricades and warning signs requires some attention. The layout generally shows the location and types of barricades and warning signs for the protection of traffic attempting to use the road and for all traffic on intersecting highways, county roads, or city streets. The details, location and use are covered on standard plan sheets, and in the case of Plates 1 and 2 are identified in the sheet index by the prefix BW. The coding of the barricades and warning signs shown on the sample sheets is covered by the standard drawing. Projects having some types of construction and complicated detour problems may require the additional coverage of warning signs in other parts of the plans or coverage in a special provision, which will be discussed later.

B. Typical Cross Sections

1. Function

The typical cross section sheet is a graphic representation of a project as it will appear upon completion of the work in that contract. It is intended to describe what is to be done, and where it is to be done, yet sufficiently general to cover the various topographical conditions encountered. Generally, the roadbed portion of the section, that is, the width from crown line to crown line, will be constant throughout the project, and the other portions of the sections merely illustrate the methods employed in preserving this constant travel way. Three sample sheets are presented for illustrative purposes. Plate 3 might be used for a farm to market type road, Plate 4 shows the typical sections for a freeway, and Plate 5 illustrates what might be called a multi-purpose section.

2. Classification and Types

The typical sections are divided into three general classifications; rural, urban, and special, which, in turn, have four general types; regular, cut, fill, and side hill. Generally, the number of typical sections are reduced to a minimum. One method of accomplishing the reduction of typical sections to a minimum is illustrated by Plate 5 where for a given classification, rural under this condition, all the possible types of section have been combined into one section. This idea provides a method whereby all indispensable information can be portrayed. Duplication and unessential details are eliminated, and the best possible arrangement of data is provided so that the project can proceed from inception to completion in an efficient manner.

3. Governing Slopes

For each section, the governing slopes are shown as the maximum slope and the usual slope. The slope of the roadbed portion of the section is fixed except for specified variations. This is illustrated by Plate 3. Typical section number 2 shows the slope of the roadbed portion to be 5/16 of an inch per foot. This means that the line referred to falls 5/16 of an inch for each one foot of horizontal distance. The slopes leading away from the roadbed portion of the section are called the side slopes. The value of the slope shown as 6:1 is a ratio and is stated as 6 to 1. This means that the line referred to falls one foot for each six feet of horizontal distance. All of the slopes shown on these sections represent the various conditions encountered in designing the detailed cross sections. These typical sections are simplified to show at a glance the type of improvement and the general method of its execution. The detailed cross sections referred to are not part of the plans and will be discussed later. Another slope that is shown on this sheet might be mentioned at this time. This slope is shown under section number one and is adjacent to the right of way line and slopes from the back of the ditch. This slope is called the back slope.

4. Profile Elevation

The profile grade line or profile elevation as it is called on the sample sheets, is related to the grade line shown on the plan profile sheets. This is also true for ditch elevations and grades unless the ditches are constucted at a constant depth below the profile grade line. The profile grade line is usually the finished elevation of all work included in the contract and located at the center of the road as shown on Plate 5. There are exceptions to this condition as shown on Plate 4 under section number 1. The profile elevation is located at the inside edge of the pavement of the freeway main lanes, and in the case of the left frontage road where the base is not placed in the present contract, the profile elevation represents the top of the future base. In all cases, care must be taken to insure coordination between the typical sections and the grade line shown on the plan profile sheets. Also, the detail cross sections which are not part of the plans must be properly coordinated in the same respect.

5. Erosion Control

The sample typical section sheets do not show any type of erosion control. The longitudinal limits and other information necessary to provide erosion control are included elsewhere in the plans and specifications.

6. Surfacing

Most plans provide for what is known as a turnkey job. This type of project not only provides for the grading and structures, but also includes the surfacing. The term, surfacing, used at this point of the discussion, includes all of the layers of material placed above the dirt subgrade. Referring to Plate 3, section number 2, shows the dirt subgrade of the roadbed fixed by dimensions, slope and its relation to profile elevation. Section number 3 shows the proposed surfacing. Proposed is a 5-inch layer of Type B Roadbed Treatment to be placed to the dimensions shown and estimated that approximately 77 cubic yards per station will be required to obtain the section indicated, and the top layer of material is a foundation course estimated as shown with asphalt placed thereon.

C. General Notes and Specification Data

1. Function

The General Notes and Specification Data Sheet of plans is provided for the purpose of showing all essential information required to supplement the specifications and to show general project notes. This sheet is reduced in size, and incorporated into the proposal so that interested parties, such as material suppliers, can obtain material data along with the proposal. The proposal is part of the contract and is a form which includes, among other things, the offer of the bidder giving prices for performing the work described in the plans and specifications.

2. Specification Data

Plate 6 has been completely filled out in order to demonstrate maximum usage of the specification data form. In the upper portion there is a block provided for grading and soil constant requirements for various bid items in the contract. The item number and type of material is shown for each coverage. All other items on this chart are either required by the specifications to be shown on the plans, or they are provided as a supplement to the specifications. The items included in this chart will be explained in another lecture.

3. Other Data

The table in the center of the sheet shows the compaction requirements when the density control method of compaction is used. The ordinary and density control methods of compaction have been included in the embankment item and most of the flexible base items. The pay item, or bid item if you like, which is the phrase specified in the payment section of the specification under which payment will be made, will generally reflect the type of compaction method required. The two cases shown in the example require that all courses of the base material shall be compacted to the density indicated.

The table in the lower left hand corner is for describing the surface treatment to be used. This block of data is self-explanatory.

The block of data in the lower right hand corner includes information pertaining to an erosion control item. This specification item includes many types, and it is necessary to indicate the specific requirements on the plans, as in this case.

4. General Notes and Supplemental Data

The other half of the general notes and specification data sheet is shown by Plate 7. Presented on this sheet are the general notes covering the type and quality of work which will be required of the Contractor, including requirements not covered specifically by the standard or special specifications. The notes are usually numerous, and in order to provide a ready reference, each note opens with a reference to the affected specification item number.

The specification data sheet for farm to market road plans includes the same information presented in the last two examples, except that the arrangement is different.

D. Estimate and Quantity

1. Function

The Estimate and Quantity Sheet is the result of all the planning and work on all other plan sheets. This means that this sheet is the last one prepared in its final form. Here the quantities of the various classifications are combined to obtain a total estimate of the quantities from which the estimated cost of the project may be made.

The information shown is not only necessary to the Contractor, but helps insure the inclusion of all items of work in the contract. These reasons and others require the inclusion of this sheet in a set of plans.

2. Contents

Summaries usually appearing on these sheets, include the following: culverts, bridges, structures to be removed, basis of estimate, and last but not least, the estimate summary. A grading summary is often shown; however, since this is a direct duplication of information shown on the plan profile sheets, this summary may not be included in the plans. Plate 8 shows a common structure summary sheet, while Plate 9 shows a partly completed estimate summary sheet.

3. Summary of Culverts

Referring to Plate 8 and the summary of culverts shown on this sheet, it can be seen that this table includes many columns. The columns preceding the specification item columns include information that is usually obtained from the list of information shown on the plan profile sheets. The specification item columns usually appear from left to right in the order of specification item numbers. This order of quantity presentation provides not only an orderly sequence, but will insure the inclusion of all items and aids in avoiding errors. Most quantities in this table are tabulated from information shown elsewhere in the plans. The item of unclassified structural excavation, however, requires a computation utilizing information from various sources and careful consideration of the construction specification which specifies the methods and limits of measurement.

4. Summary of Bridges

The summary of bridges shown on the same sheet in this case as the summary of culverts, is accumulated in the same manner as the summary of culverts, except that very often there are two quantities to compute instead of one. The additional item to compute, riprap, involves a difficult computation, because the material is placed upon a surface known as a header bank, which is an area of irregular shape. Errors are possible in riprap quantities, not only because of the difficulty in computing, but often the plans are not clear if the riprap drains placed at the ends of curb and gutter approaches to bridges are included in the quantities shown in the table.

5. Estimate Summary

Plate 9 shows a typical estimate summary, even though the sheet is only partly complete. This summary is the result of all the planning and work on all other plan sheets. This summary is also the basic document or "root" from which all letting and contract information will be taken. The items are shown in numerical order, with the item description corresponding exactly to the terminology used under "Payment" in the specifications. They are abbreviated to correspond to the Index and code to specification bid items which is a supplement to the standard specification book. Separation of quantities indicated on this sheet are urban from rural, roadway from bridges, and other possible separations are participating from non-participating, and one project from another, where more than one project is included in the contract. The table is completed by showing the unit of measurement and the total of quantities. The decimal places usually involved in the showing of quantities is as follows: Clearing and Grubbing - to nearest 1/100 (0.01) acre, Excavation - only to nearest yard, Road Grader Work - to nearest 1/100 (0.01) station, Concrete - to the nearest 1/100 (0.01) cubic yards, etc.

E. Plan and Profile

1. Function

Probably the most important sheets of a set of plans are the plan profile sheets. While they alone are not sufficient for the construction of a project, the information shown thereon has a direct effect on the rate a project moves during construction. These sheets depict the vertical and horizontal planes along a centerline on which the project is to be constructed. Such features as are considered necessary to establish a clear outline of the work to be done are set up along these two planes.

2. Contents

The three components of the plan profile sheets are plan view, profile and quantity summary. This could be further subdivided into information shown lengthwise and crosswise of the sheet on both the plan and profile views. The information shown should be only that which has a direct bearing on the proposed construction. In order to discuss the information shown on plan profile sheets, Plate 10 is introduced as an example from a freeway set of plans and Plate 11 is from a farm to market road project.

3. Plan View

The plan view is commonly drawn to a scale of 1" = 100'; however, in the case of a congested area, where many factors will influence the construction as on Plate 10, the use of a 1" = 50' scale is justified. The plan view shows existing improvements such as houses, fences, utilities, roads, railroads, bridges, and culverts, and proposed features such as centerline of roadway with the stationing marked thereon, the bearing of tangents, the P.C. and P.T. of horizontal curves with the curve data, right of way lines and widths, channel easements together with typical sections of the proposed channel, bridges and culverts, north arrow, and equations and exceptions. There are several things to consider in analyzing the plan view of the sample sheets. The legend for showing features is the same as that shown on the title sheet, except for the additional coverage required for these sheets. One practice that is followed extensively is that of showing existing features to be removed, such as roads and drainage structures, with a dashed line. Very often, the plan view will not show all the existing improvements since the only improvements that should be shown are those that will have to be dealt with by the Contractor. A feature shown on Plate 11 that has considerable merit is the system for identifying and differentiating between the various categories of small structures. It will be noted that each structure is identified by a number and letter "A" or "B", the latter denoting whether it is a proposed new structure or a structure to be removed. This system eliminates the need of duplicating the description of each structure on the plan profile sheet and is a time saver. This system is carried into the summary sheets of the estimate and quantity section of the plans.

4. Profile View

The profile view is shown to the same horizontal scale as the plan view. The vertical scales for use with the aforementioned horizontal scales are 1" = 10' or 1" = 5'. The profile view shows in addition to the existing ground line, such proposed features as grade lines of the roadway and ditches, the per cent gradient and vertical curve data when required, location and description of structures, exceptions and equations, and ground and grade elevations. The legend for showing features in the profile is usually not shown in a set of plans, but common practice is represented by the two sample sheets. The centerline profile shown on this sheet should be coordinated with that shown on both the typical sections and the detailed cross sections in order to obtain the proper relationship. Other lectures will help explain some of the features in the profile view.

5. Quantity Summary

The quantity summary is restricted to that area of the sheet between the plan and the profile views. The usual items which are summarized on these sheets are:

(1) Clearing and Grubbing, with limits indicated left or right and usually shown by sheet total only.

(2) Earthwork, shown by the cubic yard for each station, or

(3) Road Grader Work, with scraper work shown by sheet totals.

(4) Channel Excavation by the cubic yard, usually shown at one point on the sheet with a reference to another sheet that shows the excavation by the cubic yard for each station.

(5) Overhaul, shown by sheet totals..

(6) Miscellaneous items, such as right of way markers shown by sheet totals.

On some occasions, the plan profile sheets include notes pertaining to unusual features. These notes and a list of the bench marks are commonly grouped in the lower right hand area of the sheet.

F. Haul Diagrams

1. Purpose

Haul diagrams are used for the purpose of either determining haul on earthwork or haul on flexible base material.

2. Flexible Base

At the present time, in this area, haul required on flexible base material secured from local pits is seldom paid for directly. The haul, when measured for payment, is paid for by the Additional Quarter Mile Haul which is measurement for hauling material into each quarter mile beyond the first quarter mile, based on the shortest practical haul route between the center of mass of the designated or approved material source or sources and point of delivery on the road. This computation in a condensed form is the multiplication of the average haul to the pit times the amount of material from the pit. The haul is usually shown by a table instead of diagram form and commonly placed on the summary sheets. The table may include the pit designation, station of entry, station limits to be used, dead haul, average haul, quantity of base material required, additional quarter mile haul and clearing and grubbing.

3. Earthwork

The haul on earthwork is paid for under the item of overhaul. This quantity is determined from what is known as the mass curve. These curves and the calculations may be shown on individual plan sheets or may be shown on the plan profile sheets in a location between the profile view and the summary of quantities. Plate 12 illustrates mass curves shown in the last mentioned position in the plans. The mass curve is essentially a series of lines connecting the accumulated total difference between excavation and embankment at the various stations. It is plotted from a base line which may be taken at zero excavation at any point on the highway length. The haul is the work done in moving excavated material to place it in the embankment. The overhaul is computed by multiplying the number of cubic yards of material hauled times the haul length (minus the free haul length of 600'), converted to quarter miles and/or fractions thereof.

G. Bridge Layouts

1. Function

The function of the bridge layout is to supplement and correlate the bridge details in a manner that can be understood by both the Engineer and the Contractor. The layout includes sufficient descriptive information to permit the ready determination of the design standards being used for the various substructure and superstructure units making up the completed bridge. In order to discuss the essential features of a bridge layout, please refer to Plate 13.

2. Plan View

Bridge layouts are provided for all structures over 20' in length; however, only in rare cases are they shown for multiple box culverts of bridge classification. The lines shown in the plan view of the layout that wiggle around and have figures shown through the line, are known as contour lines. These lines represent the form of the ground surface and pass through points of equal elevation. Contour lines will be found on the layout only in cases where the ground surface is irregular.

Two views of the proposed structure are necessary on the layout to convey the major part of the information. The plan view shows the structure as seen from above. The scale commonly used is 1" = 10' and 1" = 20' in both horizontal and vertical directions. Superimposed on the contour lines, if any, or on any existing topography that might be shown is the plan view of the proposed structure. This picture of the structure shows the centerline and general outline of the structure, curb lines, wingwalls, approach to the bridge features, and the outline and general makeup of the substructure. The superstructure of a bridge could be defined as that part of the structure covered on the span details while the substructure is that part covered on the bent details. The general outline of the superstructure is dimensioned, giving the clear roadway or curb to curb width, curb or sidewalk width, and the over-all width of the structure. The location and type of all expansion joints such as armored joints or finger joints, are shown in the plan. The header banks at each end of the bridge are shown along with the values of the slopes and the type of slope protection. Only a portion of the substructure is shown in a plan view. Considerable miscellaneous information also appears on this view of the structure. Notable among these items is the test hole for soil exploration.

3. Profile View

The profile view is located in the bottom one-half of the sheet and may show either a longitudinal section of the structure along the centerline of the roadway or a side elevation of the bridge. Either view shows the outline of the superstructure, including a portion of the railing, top of curb, profile grade line, main load-carrying girders, trusses, slabs, or other such members, the outline of the substructure, including bent caps, piers, abutments, columns, footings, shafts and piling, and finally the profile view shows the approach embankment with the abutment wings, header banks, and slope protection.

A large part of the information on the layout sheet is given on the profile view of the structure. The overall length of the bridge is given as well as the length and type of each structural unit making up the bridge. The type of railing is shown and dimensions are given to designate the rail post spacing on both sides of the bridge. The fixed or expansion condition at each end of each span is noted by the abbreviations "F" and "E". The top of cap of bridge seat elevations are given at the center of each bearing. The elevations may be given with a prefix "T/C" to indicate top of cap. If the top of cap is level or has a constant slope, the elevation of the top of cap or pier is labeled on the profile view. In the case of sloping caps, this elevation is the centerline of the cap unless indicated otherwise. There are conditions where the top of cap elevation may be given in a table on the sheet as in the sample sheet or may be given on the substructure detail sheets. Considerable miscellaneous information also appears on this view of the structure. As mentioned under the discussion of the plan view, notable among these miscellaneous items is the test hole boring showing the various materials encountered and the results of the pentrometer tests.

H. Other Plan Sheets

1. General Comments

The remaining sheets of a set of plans are identified and included in the sheet index of the title sheet under various headings. Some sheets are grouped under one heading and others are listed separately. The sheets commonly listed that have not been discussed in this lecture are: map of drainage areas, roadway details, and structural details and standards. Sometimes a sheet called cross sections at culvert sites is included in a set of plans, but usually these sheets are omitted, because the information concerning culverts shown on the plan profile sheets is sufficient for the Engineer and the Contractor. The map of drainage areas is invaluable in designing the structures required for drainage, but once the structure has been designed, this information usually has little or no bearing on how the structures are constructed and can be omitted from the plans.

2. Roadway Details

The roadway detail sheets include concrete pavement details, intersection layouts, and other roadway features for which special details are necessary. The concrete pavement details are standardized for this area but are modified at frequent intervals.

3. Structural Details and Standards

The structural details and standards include those sheets that are prepared for the project and those sheets that are used State-wide and modified for the project. The details and standards prepared for State-wide use are identified by symbols and can be easily identified in the sheet index of the sample title sheet. Referring back to the title sheet sample, Plate 1, sheet number 95, is a standard detail for concrete headwalls for pipe culverts and is identified by the symbol CH-11.

4. Example

These remaining sheets of a set of plans are numerous. Because of the lack of time, only one of these sheets will be discussed. This sheet will serve as an introduction to structural details and standards. Plate 14 is a standard detail of a multiple box culvert, recognized by the symbol MC 5-1. This structure is a reinforced concrete box culvert, and the quantities to be obtained from this detail are concrete by the cubic yard and reinforcing steel by the pound.

The standard covers the details for a multiple box culvert with 5' spans, heights from 2' to 5' and 2 to 6 spans. The sheet title in the lower right hand corner shows the span and height coverage and the height of fill allowable over the culvert. The span and height of the barrels on this detail are designated by the letters "S" and "H" in the various section views and in the table that summarizes the total quantities.

The plan and elevation views shown in the lower half of the sheet show the shape of the structure, the arrangement of the reinforcing steel, and indicates the size of the structure and the location of the reinforcement. The dimension to the reinforcing steel is to the center of the bar.

The bending diagrams for bent bars are shown to the left of the section views on this detail sheet. Bars that are not included in these diagrams are straight bars. Bars are designated by letter, except when bars are identical other than a variable dimension or location. In this case, they are designated by a letter with a numerical subscript. Bars which have a similar bending pattern are detailed only once and are dimensioned by two or more dimensions to distinguish between bars.

All bars are summarized in the bill of reinforcing steel shown in the upper half of this sheet. All of these tables are for 44' clear width of structure. See the dimension in the plan view for definition of clear width. Each type of bar is listed, and the number, size, spacing, length and weight is designated. The lengths in this table are to the nearest inch and the weight to the nearest pound. To compute the weight, use bar length in feet to two decimals and unit bar weight to three decimals. The unit bar weight can be obtained from the specifications or other sources in pounds per feet of length.

The quantities are summarized in a table in the right hand center of the sheet. This table, as noted, covers the quantities for a 44' clear width structure. Quantities for structures of any clear width, may be obtained by the use of the per linear foot figures that are given for concrete and steel. In determining the steel for structures greater than 44' clear width, consideration shall be given for lapping all bars greater than standard length, the amount of lap to be in accordan[illegible] with the sp[illegible].

Construction Specifications

A. Composition

Specifications should be clear, concise, complete and definite. They constitute an engineering document intended to convey to the Contractor the ideas of the Engineer, concerning the manner and requirements of doing the work. The drawings and specifications should supplement and duplicate each other, and together form complete instructions and descriptions for the work.

In general, specifications consist of:

(1) Clauses relating to the general conditions under which the work must be done.

(2) Provisions fixing the kind of the different materials and methods for determining such.

(3) Instructions for doing the various parts of the work to the required standards.

(4) Statements as to the standards required.

(5) Inspection, rejection, and replacement of defective or unsatisfactory parts.

(6) Method of measurement of the various parts for payment.

The modern and flexible specifications in use today make it possible to provide a set of plans that fit the standard specifications. The necessity for a large number of special provisions and special specifications has been reduced to a minimum.

B. General Remarks and Application

The Standard Specifications for Road and Bridge Construction bound in booklet form with a brown cover and part of the highway contract, can perhaps best be discussed by considering each item or groups of items in their order of appearance in the "little brown book."

1. Standard Specifications

The items from 1 to 9 give the general requirements and covenants for the contract. These items have been in use for many years without too much change. It is commended that these items be required reading for all personnel. Some changes of the previous specifications are involved, and it is recommended that those who might be familiar with the previous specifications and also those unfamiliar with either edition of the specifications read the portion of the digest and summary pertaining to these item changes in Administrative Circular No. 16-61.

The group of items in the 100 series covers the handling of earthwork. All of these items provide for some method of payment except the item of embankment, which is known as a reference item. A reference item is part of the contract and is included in the contract proposal on the list of specifications as shown on Plate 15. Here in the list of standard specifications, Item 132, Embankment, is shown in parenthesis after Item 110, Roadway Excavation. Item 132 is referred to in Item 110 as a reference to cover embankment provisions. All reference items are not non-pay items. An example of this is the providing of Item 102, Clearing and Grubbing, in parenthesis after Item 110. Item 102, itself, does provide for pay, but on this project, this item will not be paid for, but is required in the contract to cover the provisions for clearing and grubbing necessary in performing the items of work under Items 110 and 132.

Item 110, Roadway Excavation, is used on most jobs that require grading. This item gives three classifications of material. The material classification in this area except for rare occasions in the past, is common road excavation. This item provides for payment that may reflect either the ordinary or the density control methods of compaction of embankment. These methods of compaction are covered in the embankment specification. If the ordinary method of compaction is required, then the items of sprinkling and rolling required for compaction will be paid for. When the density control method of compaction is specified, required sprinkling and rolling performed will not be paid for directly. These two methods of compaction are not only included in the embankment item, but are also included in most of the flexible base items.

An item in the 100 series of specifications that is used at times, and will provide savings in time and labor, is Item 152, Road Grader Work. Care must be exercised, however, not to misuse this item. Reference is made to the opening clause in this specification for when to use. This item may be supplemented by the items of scraper work and/or bulldozer work under the conditions recommended on the specifications.

The 200 series of specifications covers subbase and base courses. The compaction items of rolling are included in this group of items and are numerous and flexible as can be seen by referring to this group of specifications. The opening clause of each specification describes where used.

The flexible base items in this group provide for the use of a material as specified in the specifications, or shown in the plans on the specification data sheet. As stated in the discussion of embankment, most of these items include the ordinary and density methods of compaction. Measurements under these items are by the cubic yard or the ton. Included in this group of specifications are items which provide for the stabilization with lime, cement, or asphalt of either existing or new base material. Several of these stabilization items are frequently used in this area.

The group of items in the 300 series includes surface courses or pavement. These specifications allow the Engineer a wide selection of asphalts and aggregates and different grades of material. The surface treatment specifications give a wide choice. The asphaltic pavement offers two classes of material with one of the types, Class AA, offering a high grade surface requiring density control and another offering a high grade material.

The first three items of this group of specifications are non-pay items and are referred to in the remaining asphalt specifications as reference items. However, the reference to these items is not restricted to the asphalt specifications alone since such items as Item 164, Seeding, for erosion control, and Item 280, Soil Asphalt Base, refer to the first item of this group of three.

Item 310, Prime Coat, is used along with the surface treatment and asphaltic pavement items, except in those cases where priming of the base is not necessary, such as when the base is a rigid-type pavement.

The Items, Surface Treatment and Asphaltic Pavement, provide for most of the asphalt wearing surfaces contracted in this area. The surface treatment items most commonly used in this area are Items 320 and 322. The items of asphaltic pavement proposed in this area are Items 330, 340 and 350. The surface treatment items provide a penetrating type of wearing surface and will be found in use on farm to market roads, frontage roads on freeways, shoulders, etc. The asphaltic pavement is used on higher-type roads other than those just mentioned. These specifications, as well as many others, require some close reading.

The 400 series of specifications is the structure items. By referring to the table of contents in the standard specification book, it can be observed that the structure items, in general, are grouped in a particular manner. This manner of grouping, in order of appearance, includes foundation items, concrete and kindred items, steel and kindred items, sewer and kindred items, and timber and miscellaneous items. This group of items includes many non-pay reference items. Also, many of the pay items in this group are used as reference items as discussed under the 100 series of specifications. The use of items as reference items prevails more in this group than in any other group of standard specifications.

A reference to Plate 15 and the reference items shown after Item 421 will reveal this condition.

The first two items of this group cover all structural excavation with the second item of this pair covering, in addition, a special backfill of sewers, which is stabilized with cement. The first item, Structural Excavation, provides that material be classified or not classified. In this area, excavation is commonly not classified and bid as unclassified structural excavation. By referring to Item 400, Structural Excavation, and to Plate 15, another condition is found for introducing a reference item. Item 400 includes a reference to Item 132, but since Item 132 is already in the contract as a reference to Item 110, then this item, Item 132, need not be included again under any bid item. The opportunity is taken at this time to explain the remaining and final condition of introducing a reference item on the list of governing specifications and special provisions. Plate 15 includes the Item 430, Extending Concrete Structures. Item 430 refers to Item 421, but since Item 421 is in the list of specifications as a standard item, then this specification need not be included as a reference item.

Use of some of the structure items is illustrated by reference to Plate 15. The 400 series of specifications shown on this sheet is used as the pay items for the construction of new culverts and the extension of old culverts.

The reference items needed on this project are those indicated on this sheet.

The last series of the standard specifications is the 500 series and is grouped under the heading of incidental construction. Item 500 of this group is set up to cover weighing and weighing devices. This is a reference item set up to cover many of the standard specifications. Some projects include quite a few of the 500 items; however, the example, Plate 15, illustrates the use of only two. The Item 580 shown on this plate is a non-pay item that is common to most projects.

2. Special Provisions and Special Specifications

Even though the standard specifications of today are most modern and flexible, there is always the special case where it is necessary to utilize a special provision to modify a standard specification. Or perhaps, it becomes necessary to prepare a complete special specification because none of the standard specifications cover the construction proposed. Specifications should be modified in cases where an economical advantage to the State will be realized if new developments make parts of the specification obsolete, or if flaws develop in the standards.

C. Indexing and Coding

In the previous discussion of the estimate summary, it was mentioned that the item descriptions corresponded exactly to the pay item as set out under payment in the specifications. It was also stated that they were abbreviated to correspond to the Index and code to specification bid items. This system of indexing and coding specification bid items is merely a method of doing several processes automatically. This system is explained in a most thorough manner in the 1961 Specifications Supplement No. 1, which came as an attachment to Administrative Circular No. 29-61. This material is recommended for reading.

CONSTRUCTION INSPECTION I

Fundamentals of Inspection

A. Duties of Inspector and Relationship with Contractor

Item 1.7 of the Standard Specifications defines an inspector as the authorized representative of the Engineer, assigned to supervise and inspect any or all parts of the work and the materials to be used therein. Items 5 and 6 of the Standard Specifications also include definite references to inspection requirements and the relationship between the Inspector and the Contractor. Item 5, Control of the Work, has a paragraph (Item 5.8) in which the authority and duties of the inspectors is outlined in detail. It is this paragraph that establishes the legal position of the Inspector within the contract between the State and the Contractor. Inspectors are authorized to inspect all work done and all materials furnished. Such inspection may extend to all or to any part of the work and to the preparation or manufacture of the materials to be used. The primary duty of the Inspector is to observe the work and to report to the Engineer as to the progress of the work and the manner in which it is being done. He must also report whenever it appears that the work being done or the materials being used fail to comply with the requirements of the plans or specifications and to point out to the Contractor any such failure. Item 5.8 further points out that this inspection does not relieve the Contractor of the responsibility or obligation to fulfill all terms and requirements. Naturally, in the normal course of events, there will be differences of opinion between the Inspector and the Contractor regarding the compliance to the specifications. In this event, according to our Item 5.8, the Inspector has the authority to:

(1) Reject the materials

(2) Suspend work until the question can be referred to and decided by the Engineer

This item very definitely places a limitation on the authority of an inspector. The Inspector shall not have the authority to revoke, enlarge, or release any specification or plan requirement, nor shall he have authority to approve or accept any portion of the work. He will, in no case, act as foreman or perform other duties for the Contractor nor interfere with the management of the work.

Item 6 of the Standard Specifications, entitled Control of Materials, sets out the authority of the Inspector insofar as inspection of sources of supply and quality of materials. Paragraph 6.3 of this Specification, entitled Plant Inspection, sets out the conditions under which the Engineer may undertake the inspection of materials at the source. It is understood however, that no obligation is assumed to inspect materials in that manner on any project.

The conditions under which plant inspection will be undertaken are as enumerated in Item 6.3.

Item 6.4, entitled Storage of Materials, sets out the authority of the Inspector in require that all materials shall be so stored as to insure the preservation of their quality and fitness for the work. All stored materials shall be so located as to facilitate prompt inspection.

Construction inspection insures that proper methods and materials are being incorporated into the work. Highway construction is a very costly item in the tax dollar. Therefore, the taxpayer is entitled to receive a dollar's value for a dollar spent. The construction inspectors and engineers must see to this. An inspector may be charged with the inspection of materials or work that costs many thousands of dollars. This is a large responsibility and each inspector must always conduct himself and be aware of all the requirements of both plans and specifications and to insure that the money spent by the taxpayers will receive fair value.

Proper inspection requires:

(1) Knowledge of plan and specification requirements.

(2) Individual initiative and judgment.

(3) Hard work.

It does not require:

(1) Hard-boiled attitudes.

(2) Constant bickering.

(3) Overbearing manner.

The vast majority of contractors are honest businessmen striving to make a profit in their line of work. Most of them are reasonable and all respect a skillful, competent, and hard-working State inspector. There will be disagreements between a contractor and an inspector, since no two people think alike. This should not, in any way, interfere with the fair and impartial inspection of job construction.

B. Governing Contract Requirements

The Plans, Specifications, Special Provisions, and Supplemental Agreements are essential parts of the Contrac and a requirement occurring in one is as binding as though occurring in all. In cases of disagreement, figured dimensions shall govern over scaled dimensions, plans shall govern over specifications, and special provisions shall govern over both specifications and plans. The plans will show, i detail, the work to be accomplished under the contract. All notes, and supplemental drawings, etc., are considered as part o the plans. The Proposal will contain a list of the applicable standard specifications as well as the special provisions and special specifications. It is these sources, the plans, special provisions, and standard and special specifications, that contain the requirements of a particular project.

In order to properly inspect a project, it is necessary that each inspector be familiar with all the requirements contained in the various sources. It is suggested that, prior to beginning operations, a general review of the Project Requirements and Plans be held. This review should familiarize each inspector with the overall job requirements as well as the particular items for which each will be responsible. In addition, each inspector should be equipped with the particular inspective tools he will need, such as 6' rule, tape, string, record book, etc. Prior review and preparation such as this, will enable the inspection crew to begin a project well-versed and prepared.

Grading Operations

A. Clearing and Grubbing

1. Specification Requirements

Item 102, Page 35, of the Standard Specifications contains the requirements for the operation of clearing and grubbing. Paragraph 102.2, Construction Methods on Page 35, gives the detailed requirements. Inspectors should be thoroughly familiar and well-grounded in these requirements.

2. Construction Methods

a. This item consists of the removal and disposal of trees, stumps, brush, roots, vegetation, logs, rubbish and other objectional matter from the right of way. The disposal of the material is subject to the approval of the Highway Department. Many times the Contractor has gotten permission from the adjacent landowners to pile the brush and trees, etc., on his land outside the right of way. The Highway Department must approve this method of disposal; permission of the landowner is not enough. The normal method of disposal is by burning all combustible material and hauling other material to authorized dump grounds. Inspectors are cautioned to confer with the Contractor's representative regarding the disposal of material in order that the necessary prior approval may be obtained.

b. Item 102 specifies certain construction methods for the operation of clearing and grubbing. In general, the entire right of way shall be cleared except for such trees and/or brush specifically designated by the Engineer to be left in place. Items left in place are to be trimmed as directed and exposed cuts painted with an approved asphaltic material.

c. In areas that are required for roadway, channel or structural excavation, all stumps, roots, etc., shall be removed to a depth of at least two feet below the level of excavation. It is obviously impossible to remove all roots prior to beginning excavation; however, the roots can be picked out of the excavation material by hand after it is dumped in its proper place. Inspectors are cautioned to see that sufficient "root pickers" are furnished by the Contractor to remove the roots and other material that were not removed at the excavation site. This is a continuation of the Item of Clearing and Grubbing and is definitely required.

d. On areas required for embankment construction, all stumps, roots, etc., are to be removed to a depth of at least two feet below the existing ground. Here again, it is impossible to remove all roots that lie below the ground without the use of hand labor. After all trees, stumps, etc., have been removed, and the area is cleared except for roots, etc., below the ground, all stump holes, etc., should be backfilled and tamped and the ground restored. Item 132, Embankment, then requires the fill or embankment area to be scarified or plowed. During this operation, the Contractor should furnish sufficient "root pickers" to remove all roots and and debris exposed by the plowing. In some cases, where an embankment is at least three feet high, the Specifications provide for leaving stumps, etc. This has to be noted on the plans and is, in fact, rarely done.

3. Inspector's Checklist

The following checklist can be used as a reminder guide in the inspection of Clearing and Grubbing.

a. Conspicuous flagging of all trees, etc., that are to be saved. This flagging should be visible on all sides.

b. Discuss disposal methods and plans with Contractor's representative prior to beginning operations. Report plans to the Resident Engineer for his approval.

c. Watch fire hazards during burning operations.

d. Check to see all stump holes, etc., are backfilled to avoid ponding water.

e. Check to see sufficient "root pickers" are available during subsequent operations to complete the Item of Clearing and Grubbing.

f. Check trees left in place to see all damage and pruning cuts have been properly repaired.

4. Measurements and Records to Keep

a. Clearing and grubbing is normally paid for by the acre. The areas to be cleared are measured in advance and shown on the plans as acreage to be paid for as clearing and grubbing. This pay quantity is fixed regardless of the actual land cleared unless additional work is required on additional right of way or material source areas.

b. Areas other than those set forth above will not be measured for payment regardless of where work was done.

c. Since the pay measurement is fixed on this item, the calculations are the same as shown on the plans. Any additional areas on additional right of way or material sources should be accurately measured and recorded for support of the payment. Any instructions or comments regarding this Item should be recorded in the job diary.

B. Channel Excavation

1. Specification Requirements

Item 120, Page 41, of the Standard Specifications contains the requirements for Channel Excavation. Item 120 refers to Item 132, Embankment, which contains the requirements for Embankment Construction. Paragraph 120.2, Classification, discusses the various classifications of the different types of material to be removed. Paragraph 120.3, Construction Methods, Page 42, gives the detailed requirements.

Construction Methods

a. If no classification is indicated in the description of the Item, it is "Unclassified Channel Excavation," and the Contractor shall be paid the bid price for all types of material excavated. In the event that the Item is "Classified" the description shall be either "Rock Channel Excavation" or "Common Channel Excavation" or both. "Rock Channel Excavation," of course, is meant for areas where rock will be encountered, and "Common Channel Excavation" is for all other material encountered. Since there is very little, if any, rock formation in District 12, Channel Excavation is normally classified as "Common Channel Excavation."

b. Unsuitable excavation, in excess of that needed for construction, shall be known as "Waste" and shall become the property of the Contractor to be disposed of by him outside the limits of the right of way. This designation of material as "Waste" is a decision to be made by the Engineer and is not normally a decision to be made by the Inspector.

c. The proposed channel excavation must be controlled as far as alignment and grade is concerned. This control usually consists of various types of stakes:

    (1) Alignment stakes

    (2) Elevation hubs

    (3) Final blue tops

The alignment stakes are usually set on the easement right of way line in the case of channel excavation outside the right of way. In order to set these stakes, the center line or an offset to the center line, must be staked on the ground. This line should be staked at even 100 ft. stations with the intersection of the center line as station 0+00. After this line is set, offset stakes set at right angles should be placed on the easement line at each even station or oftener if needed. The distance from these stakes to the centerline of the channel can be marked on the stake as well as the channel station number. Measurements can be made from the stakes as the work progresses, thus insuring that the excavation proceeds along the proper alignment.

The stakes for controlling the grade or elevation of the channel excavation are called elevation hubs. They are usually set flush to the ground at the base of the alignment stakes. The elevation of this hub is measured by running a series of levels and the difference in the actual elevation of a particular hub and the proposed flow line elevation of the channel at that station is the amount of cut necessary. Thus, by making vertical measurements by means of a level and level rod, the grade of the excavation is controlled.

d. Another type of stake is set, as the excavation progresses, to control the side slopes of the channel. The plans will normally designate the side slopes of the channel as being 2:1, 3:1, etc. A stake, called slope stake, must be set to indicate where the natural ground line intersects the side slope line. Normally, these points may be scaled directly from the plotted cross section sheets, or in some cases, directly from the Typical Section Sheet. However, in the case of deep cuts, where considered quantities are involved, this is not sufficient. Since the quantities involved may vary considerably with the side slope, it follows then that the side slope of cuts must be followed closely. Since it is humanly impossible to cut a slope exactly by eye, it is necessary to set slope stakes by use of leveling. The technical aspects of how to calculate the position of slope stakes will be covered in the Surveying portion of the training program.

Figure 1 shows a cross section of a proposed channel and the various types of control stakes. There are various methods of staking for construction control, but all basically are the same.

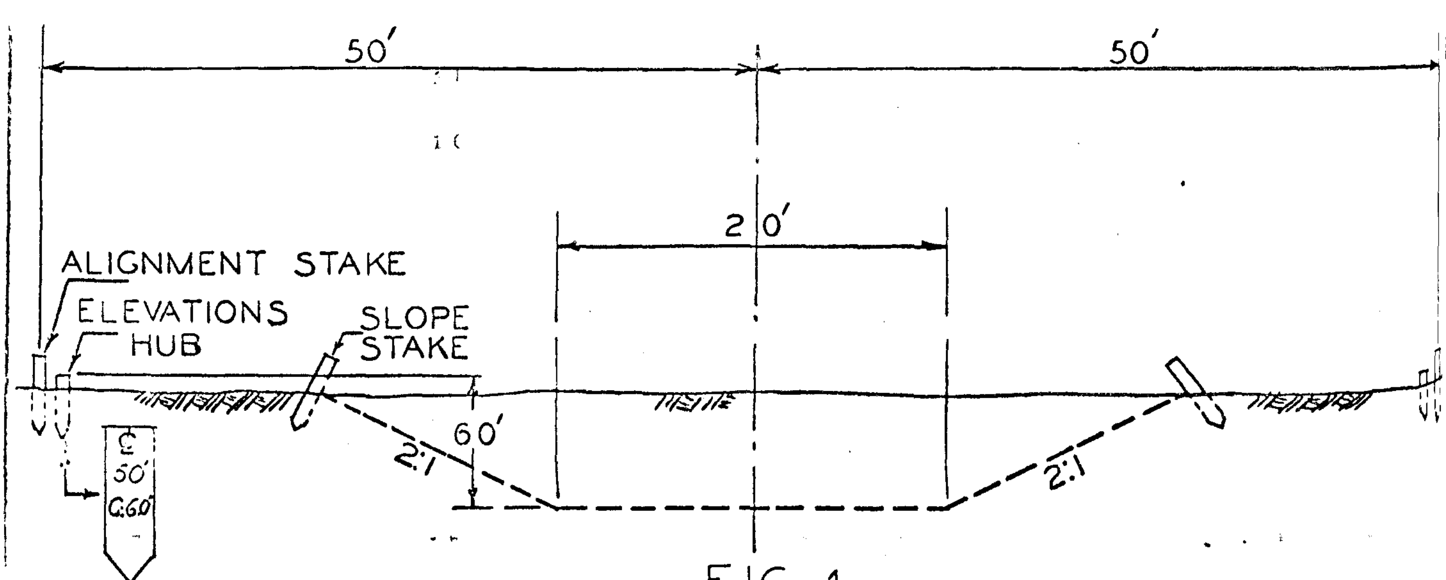


FIG. 1

3. Inspector's Checklist

a. Check to see that all channel specification requirements are being met.

b. Check to see if channel excavation is being hauled properly (covered in more detail in Highway Design II)

c. Check to see if sufficient root pickers are available in the area to which the channel excavation is being hauled.

d. Check to see if the channel cut is being cut in such a manner so as to drain in the event of rain.

e. Check to see that the channel excavation is being made in such a manner that the natural drainage of any streams or waterways is not blocked.

f. Check to see that the flow line of the channel excavation is being properly cut.

g. If at all possible, take the final cross sectional measurements for the computation of channel excavation quantities prior to the releasing of channel drainage water in the newly cut channel.

4. Measurements and Records to be kept

All channel excavation will be measured in its original position and the volume computed in cubic yards by the method of average end areas. This means that original cross sections must be taken prior to the work, and then final cross sections taken in the same place after the work is completed. The volume of excavation removed is then computed. The actual explanation of this type of computation will be covered in Highway Design II. The cross sections, original and final, will form the necessary records to support the final quantity of excavation. However, it is necessary that proper records be kept of all field work such as staking calculations, hub elevations, etc. The Surveying courses will cover the correct form for these notes.

C. Roadway Excavation and Embankment

1. Specification Requirements

Item 110, Page 38, of the Standard Specifications contains the requirements for Roadway Excavation. Item 110 also refers to Item 132, Embankment, Page 46, of the Standard Specifications which contains the requirements concerning Embankment Construction.

The construction of a roadway section normally involves two operations:

(1) Cut

(2) Fill or embankment

It is standard procedure that only the cut or excavation is paid for and the fill is not paid for. This is because the fill is constructed from the material removed from the cuts, so if both were paid for, the result would be duplicate charges. Therefore, the only pay item is Item 110, Roadway Excavation, but in order to insure that the fills are properly constructed, Item 110 refers to Item 132.

2. Construction Methods

a. Roadway Excavation, like Channel Excavation, is either "Classified" or "Unclassified" and if "Classified," it should be "Rock Road Excavation" or "Common Road Excavation." As pointed out previously, nearly all "Classified Road Excavation" in District 12 is "Common Road Excavation."

b. Unsuitable excavation in excess of that needed for construction shall be known as "Waste" and shall become the property of the Contractor to be disposed of by him outside the limits of the right of way. This designation of material as waste is a decision to to be made by the Engineer and is not normally a decision to be made by the Inspector.

c. It is essential that the Construction operations be oonducted in such a manner that the roadbed and ditches are properly drained at all times. It is also essential that cross drainage be maintained. This is a very important requirement and one frequently overlooked by both the Contractor and the Inspector. Before work is finished for the day, the entire project must be in condition to properly handle the runoff that may occur from rains during the night. In order to insure this condition, Contractors should be encouraged to begin their excavation operations at the low points in the drainage system and work toward the high points. In this way, the drainage will be kept open without unusual amounts of extra work on the part of the Contractor.

d. All embankments and roadway areas should also be prepared for rains at the end of the work for the day. If it is necessary to leave windrows of materials overnight, they should be in the center of the roadway where the runoff can be shed to both sides. If they are left on the sides, they will form a dam which will pond water, thus softening the subgrade. All sheeps-foot roller indentions should be wiped out and sealed with a blade and pnuematic rollers to avoid having water soak deep into the roadway material and resulting in an extremely lengthy drying-out process.

e. The proposed roadway excavation must be controlled as far as alignment and grade is concerned. This control usually consists of various types of stakes as pointed out previously.

(1) Alignment stakes

(2) Elevation hubs

(3) Final blue tops

After the clearing and grubbing operations have been completed on a section of road, it will usually be necessary to reset the centerline stakes. Elevation hubs and alignment or guard stakes should be set, opposite each station and on each right of way line, or well outside the grading limits. The elevation of the top of each hub should be determined to the nearest hundredth of a foot.

The alignment of the work is controlled by making horizontal measurements from the alignment stakes to various points on the roadway cross section and vertical measurements to those same points from the elevation hubs. There are many different viewpoints on exactly which is the best way to stake a project; however, this particular item will be covered in detail in a more advanced course.

3. Inspector's Checklist

a. Check to see that all Embankment Specification Requirements are being met before excavation starts.

b. Check to see if excavation is being hauled properly. (Covered in more detail in Highway Design II)

c. Check to see if sufficient "root pickers" are available.

d. Check to see if cut is made so it will drain.

e. Check to see that any private drives along cut area are closed a minimum of time. Arrange alternate entrances if necessary.

4. Measurements and Records to be Kept

All roadway excavation will be measured in its original position and the volume computed in cubic yards by the method of average end areas. This requires that original cross sections must be taken prior to the work and then final cross sections taken in the same place after the work is completed. The volume of excavation removed is then computed. The actual exploration of this type of computation will be covered in Highway Design II. These cross sections, original and final, form the record to support the excavation quantities.

D. Compaction of Earthwork

1. Specification Requirements

Item 132, Embankment, Page 46, Item 204, Sprinkling, Page 79, and Items 211 through 216, Rolling, Pages 82 through 92, are the governing Standard Specifications insofar as the compaction of earth work is concerned:

Item 132, Embankment, provides for the methods and requirements of embankment construction. Paragraph 132.2, Construction Methods, on Page 46, gives the detailed requirements. Each Inspector must be familiar with these requirements.

Page 48, Paragraph 132.2, provides for two methods of compaction:

(1) Ordinary compaction.

(2) Density control.

The provisions for each type of compaction are given in detail on Pages 48, 49, and 50.

Item 204, Sprinkling, provides for the methods and equipment requirements of sprinkling. Paragraph 204.3, Construction Methods, on Page 80, gives the detailed requirements.

The various items concerning rolling all contain detailed requirements; however, we will take up only the two most commonly used. Item 211, Rolling (Tamping), Page 82, provides for the methods and equipment requirements for "sheepsfoot rolling." Paragraph 211.2, Equipment, Page 82, gives the detailed requirements for acceptable equipment. Paragraph 211.3, Construction Methods, Page 83, gives the requirements for the proper operation of the equipment. Item 213, Rolling (Pnuematic Tire), Page 85, provides the methods and equipment requirements for "rubber tired" rollers. Paragraph 213.2, Equipment, Page 86, gives the requirements for acceptable equipment. Paragraph 213.3, Construction Methods, Page 87, gives the requirements for proper operation of the equipment.

2. Construction Methods

   a. In the preparation of the fill area, prior to beginning embankment construction, it is advisable to have small amounts of material in order to fill gullies, washes, or other low places. The material should be rolled into place, using ordinary compaction methods. In this way, the fill area will be made into a uniform plane on which to start the proposed fill. The fact that this beginning plane is or is not horizontal is of no importance.

b. The outline of the proposed fill should be marked with slope stakes (See Figure 2). This area then should be sprinkled and rolled and the embankment material hauled in. The material is usually placed by scrapers which dump and spread the material evenly. This method usually entails dumping an eight to ten foot width of material through the fill area in strips or "lands." The strips are laid side by side until the entire layer is in place.

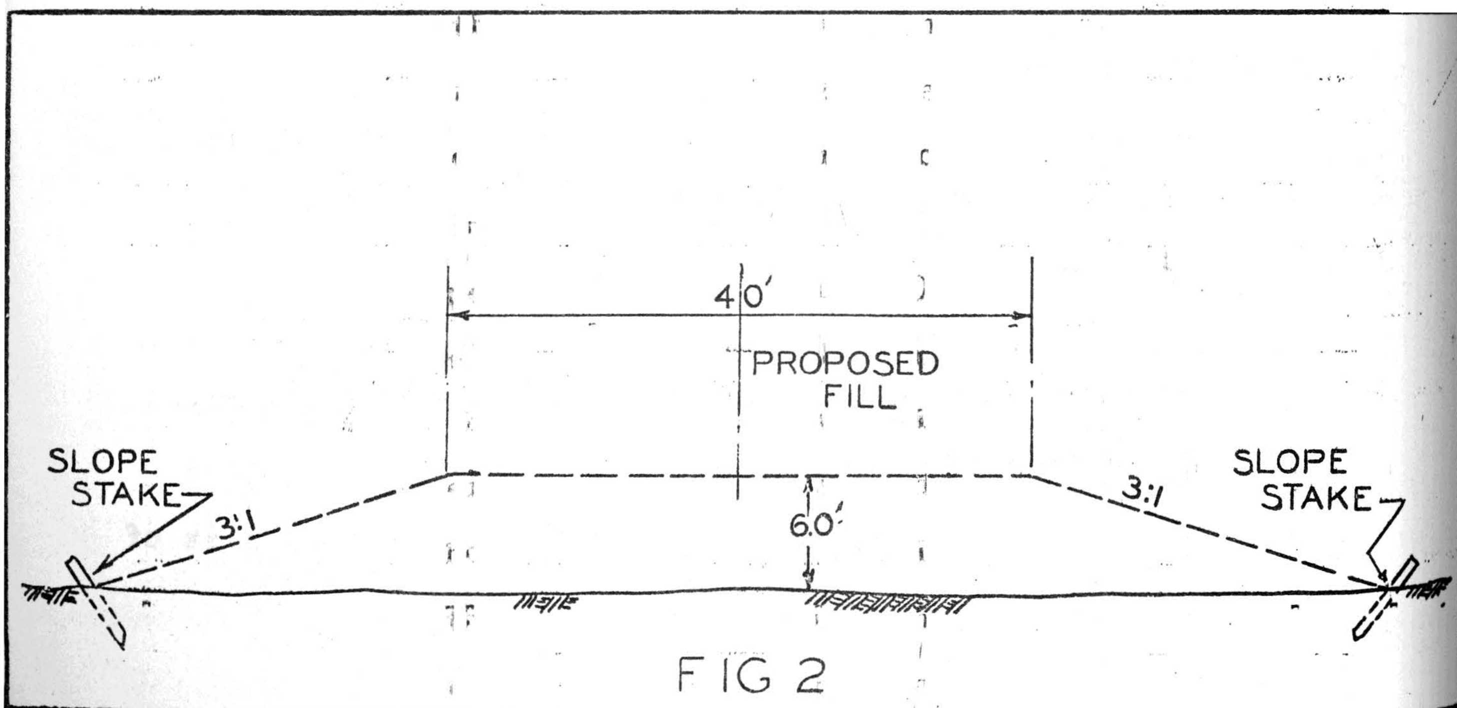


FIG 2

c. Rolling should not begin until the fill material is a uniform mass with a constant moisture content. Normally, material removed from an excavation will have a natural uniform moisture content. While it may be uniform, it may be too wet or too dry. In this case, the material must either be dried evenly or sprinkled evenly until the Inspector judges the moisture content is proper. It is normally advisable to start rolling slightly on the wet side if the weather is hot and dry. If, on the other hand, the weather is damp and cloudy, extreme caution should be exercised in applying water. The tendency should be on the dry side rather than the wet side.

d. In adding water to a "lift" or layer, it is extremely important that the water truck drivers position their vehicles in such a manner that they neither overlap or leave a gap between successive passes of the water truck. Failure to do this will result in a wet or dry streak throughout the fill which will present a non-uniform moisture content. Inspectors should be very strict in the matter of position during application. In this connection, it is usually advisable to apply water with several light applications rather than one heavy application. This is particularly true during damp, cloudy weather. Inspectors should designate the speed of the trucks during application. In applying the water, the water truck should make its first pass on one extreme side and proceed with successive passes across the fill, rather than going down one side and back up the other until the last pass is made in the middle. Usually the gap left in the middle will not fit the spray bars, thus giving an overlap or gap.

e. When the sheepsfoot rollers begin to roll in a lift, it is usually very important to have a blade working the fill at all times. The material is loose and has a tendency to "ball up" as the roller passes. After a short time, the material begins to compact and then it is usually not necessary to have a blade operation at all times. Many times in heavy clay, the material will "pick up" to such an extent that even a blade cannot operate properly. Many times, a loaded rubber-tired scraper can make several passes over the material and tighten it up to where the blade and roller can operate with more efficiency.

f. The metal roller drums should be checked to see that they are loaded properly prior to using. Water is normally used as ballast, but in some cases, sand has been used. This check may be made by requiring the Contractor to open the small port on the side of the drum. A quick daily check may be made by tapping on the side of the roller and determining by sound if the roller is properly loaded. Since it is easier to haul an unloaded roller, they will usually be empty when hauled in on a job.

g. Care should be taken that the rollers do not always turn in the same spot. This turning action of the tractor and roller unit has a gouging effect and if done repeatedly in the same place will leave a hole or soft spot.

h. As pointed out in the section on Roadway Excavation, care should be taken that the roadway is in proper condition for rains during the night. This preparation would normally consist of blading all sheepsfoot roller marks shut and sealing the surface with a pneumatic roller. All other drainage precautions mentioned previously should also be taken.

i. Under the Ordinary Compaction requirements, rolling shall continue until there is no evidence of further compaction. This is a matter of judgment on the part of the Inspector. The amount of rolling required to reach this point will depend a great deal on having the proper moisture content present in the material during rolling. The detailed relationship between moisture content and compaction will be taken up in the laboratory course.

j. Under Density Control requirements, rolling shall continue until the specified density and moisture content are reached. This point is determined by testing and additional fill material cannot be placed until the test is made and approved.

k. Slope stakes should be set as frequently as required to maintain a proper slope.

3. Inspector's Checklist

a. Check to see if all required equipment is available:

(1) Sufficient rollers of correct type.

(2) Sufficient water trucks, blades, and hauling equipment.

(3) Sufficient labor.

b. Check rollers for proper ballast prior to using.

c. Check and measure water trucks. Issue "strapping ticket" which indicates capacity of truck. Instruct truck drivers.

d. Check to see if blade is present to keep material leveled.

e. Check natural moisture content of material excavated. Decide what adjustment will be necessary. (Normally done when leveling fill area).

f. Check for sufficient "root pickers" during hauling and dumping phase.

g. Check to see if dumping area is in moist condition. See that it is kept that way until covered.

h. Check condition of lift before starting rollers. (depth, position, uniform surface, and moisture condition).

i. Check action of rollers when rolling begins. Decide what, if any, adjustment is necessary.

j. Check speed of rollers.

k. Check starting and stopping time of rollers. Notify Contractor's representative of any time "docked."

l. Check action of rollers during rolling phase. Make necessary adjustments as required.

m. Check compacted lift and begin preparations for next lift to be hauled in. (Ordinary Compaction or Density Control).

n. Be prepared to suspend work at once if Contractor fails to heed instructions.

4. Measurements and Records to be Kept

Since the Item of Embankment is not a pay item, there are no measurements required in this connection. However, original and final cross sections are taken in order to properly balance the fill against the cut.

Haul tickets should be issued daily by the Inspector for both roller time and water. A record, in detail, should be kept in a hard-backed field book of the various roller times and loads of water. A record should also be kept of the number of the tickets issued from the haul book. These records thereby support the payment for roller time and water. There are many different forms and ways of keeping these records. Confer with the project Engineer about his preference.

All official instructions issued to the Contractor should be recorded in the job diary and initialed by the Inspector giving the instructions.

1.01 DUTIES AND PURPOSE OF HIGHWAY TESTING LABORATORIES

A highway materials laboratory technician performs much the same duties as those performed in a medical laboratory or chemical laboratory. The similarity in duties is based on the theory that all three laboratories are generally concerned with the study of the properties of "matter." For clarification, MATTER is defined as anything that occupies space or has mass, which we measure by weight.

Technicians in the above laboratories learn to identify familiar forms of matter by certain characteristics such as color, odor, taste, hardness, size, shape, etc. These characteristics, by means of which we are able to distinguish one form of matter from all others, are called the properties of that material.

Although we have stated that the duties are similar, the technician in the highway materials laboratory studies only the engineering properties of construction materials.

In order that he may determine these properties, it is necessary that certain test procedures be performed, utilizing various laboratory equipment. The results of these test procedures can then be presented in either of two ways. One way would be to report the actual test value in a unit of measurement required by the Texas Highway Department Test Procedure Manual. (See Table 1 for typical units.) The second way would be to show the relationship between several engineering properties by plotting test values as ordinates and absicissae in graphs. (See Figure 1 for example of graph.

EXAMPLE OF THE RELATIONSHIP OF
SEVERAL ENGINEEING PROPERTIES

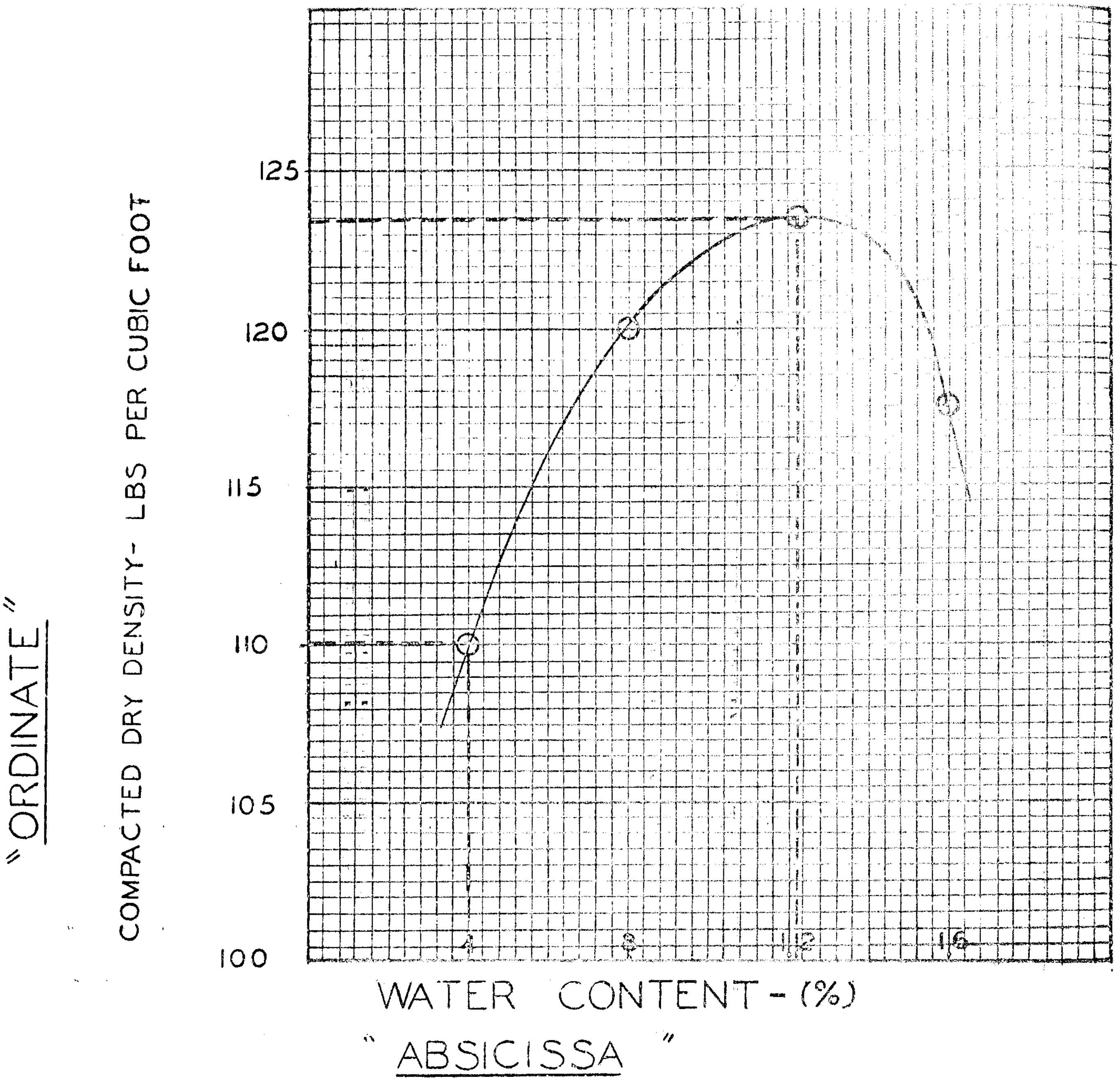


FIG. I

TABLE I

TABLE I

TYPICAL UNITS OF LABORATORY TEST MEASUREMENTS

Laboratory Test	Test Results Expressed in	Units of Laboratory Test Measurement Used in Calculating Test Result
Water Content	Percent (%)	The weight of material before and after oven drying is measured in grams or pounds.
Grain Size	Percent (%) Retained	The weight of material retained on successively smaller sieves is measured in grams or pounds.
Compaction	Pounds per Cubic Foot	The weight of material compacted in a mold of known volume is measured in grams or pounds. The volume is computed in cubic feet.
Strength	Pounds per Square Inch	A maximum load carried by a specimen having a known cross sectional area is measured by a testing machine in pounds. The cross section area is computed in square inches.
Specific Gravity	Ratio of the weight of a given volume of material to the weight of an equal volume of water	The weight of a sample of aggregate in a prepared condition is measured in grams or pounds. The weight of water displaced by this volume of aggregate is weighed in grams or pounds.

At this time, it should be pointed out that the measurements obtained from these test procedures are not themselves final results, but should be considered only as information that may be used as an aid in the design, construction, and maintenance of highways.

Simply stated, then, the purpose of the highway materials laboratory is to determine how certain "matter" will behave as an engineering construction material.

1-02 VARIOUS TYPES OF HIGHWAY TESTING LABORATORIES

As you have learned by now, the Materials and Tests Division, File D-9, has the responsibility of overseeing all sampling and testing and interpretation of test results of construction materials used on our highways. In order to accomplish this task as efficiently and economically as possible, they utilize the facilities of several laboratories to help them in this task. The various types of laboratories include the following:

a. State Highway Laboratory

The central testing laboratory of the Department located at Austin and under the direct supervision of the Materials and Test Engineer, generally tests and inspects all finished products from steel fabricating shops, pre-stressed concrete plants, rock asphalt plants in various parts of the State, and crushed stone and bituminous mixture plants in the vicinity of Austin. They also send inspectors to sample cement, lime, and asphalt produced in various mills and refineries so that quality tests may be run on these products before they are used on State projects. (See large District Map showing location of several of these mills and refineries in the Gulf Coast Area.)

b. Commercial Laboratory

A private testing laboratory under contract to the Materials and Tests Division samples, inspects, and tests several finished products such as treated timber, posts, piling, reinforcing steel, steel plate guard fence, structural steel, and reinforced concrete pipe.

c. District Laboratory

The laboratory located at this District headquarters and under the direct supervision of the District Engineer performs various sampling and testing work in conjunction with the design, construction, and maintenance of highways in this District. Most materials other than those checked by the above two laboratories may be tested in the District Laboratory prior to use on a project. In addition, field investigative work involving local soil and pavement materials is handled by this Laboratory and will be discussed in Section 1-05.

d. Resident Laboratory

The laboratory located in or near a county residency office and under the direct supervision of the Supervising Resident Engineer, performs various sampling, testing, and design work on construction projects handled by this office. Specific testing work performed by this Laboratory is discussed more thoroughly in Section 1-05.

e. Field or Plant Laboratory

A portable laboratory set up near the jobsite handles sampling and testing work on certain construction materials furnished to a project.

1-03 SEVERAL TYPES OF HIGHWAY CONSTRUCTION MATERIALS

All highways require large quantities of construction materials, particularly soils and aggregates for bases and pavements, and frequently borrow material for embankment or for backfill. The presence of local materials within reasonable haul distance of a project will have a major effect on the cost of construction. In our Gulf Coast area, there are several types of local materials and products that can be utilized very efficiently and economically on our projects. Some of these are included in the following types of highway construction materials which are on display in the District Laboratory:

a. Soils

It is advantageous to have some means of identifying soils and classifying them into groups which have distinct engineering properties. This enables engineering personnel in the office and field to speak the same language, thus facilitating exchange of information and experiences. For our purposes, therefore, we will classify a sample as "soil" or <u>fine-grained</u> when 50% of the particles are smaller than the eye can see.

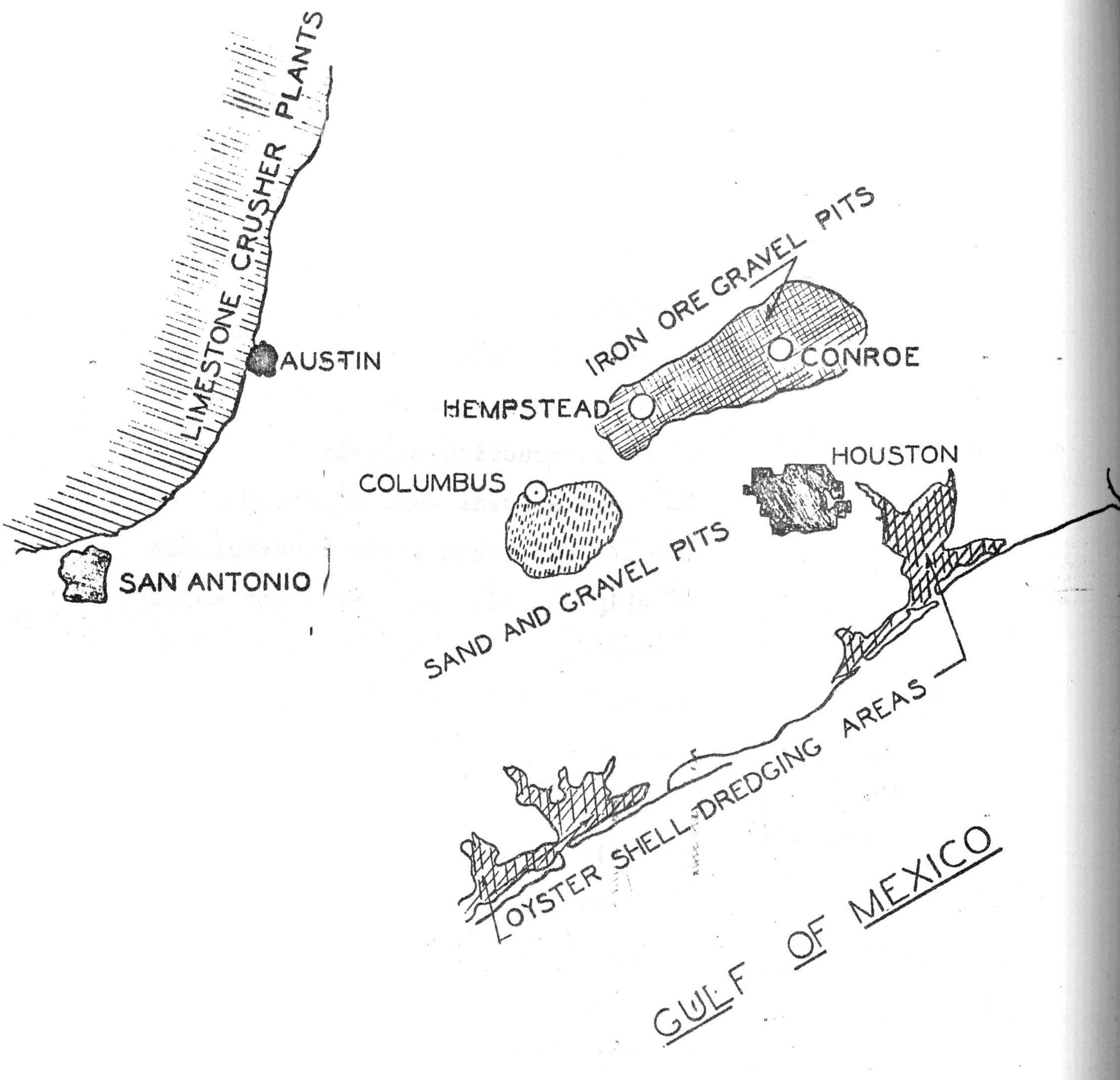
(1) SILT AND LOAM soils are generally called "topsoils" in most areas of this District. They have a smooth feel between the fingers

in contrast to the grittiness of coarse-grain sand. When dry, they can be pulverized easily under finger pressure in contrast to the resistance offered by a hard, dry clay. (See large scale District Map showing location of predominant silt and loam topsoils in the District.) This material is generally more valuable as a farming material than as a construction material.

(2) CLAY soils cover most of the Gulf Coast area. (See large scale District Map showing location of clay soils in the District.) As such, we generally do not have any trouble identifying them, particularly when they shrink and crack during drying periods. Since we depend generally on this type of material for our embankment and backfill, we try to minimize the shrinkage and cracking by covering the clay soil with "topsoil," St. Augustine grass, or other type of lining material.

b. Aggregates

When 50 per cent of the particles can be seen individually by the naked eye, we may classify the sample as "aggregate" or coarse-grained. (See Figure 2 showing sources of several types of aggregates that



SOURCES OF AGGREGATES USED ON PROJECTS IN DISTRICT 12

FIG. 2

are used on projects in this District.)

(1) SAND aggregates are generally all smaller than about $\frac{1}{4}$ inch size. Sand samples from our rivers in the Gulf Coast area usually contain particles of nearly the same size whereas samples from sand pits in fields not adjacent to a river may contain varying particle sizes.

(2) RIVER GRAVEL aggregates generally range in size from about 3 inches down to $\frac{1}{2}$ inch size.

(3) PIT GRAVEL aggregates from timberland areas are smaller than river gravel and are generally found mixed with sand, silt, and clay soils. The pit gravel may range in size from about 1-$\frac{1}{2}$ inch to $\frac{1}{4}$ inch size.

(4) IRON ORE aggregates removed from pits in the rolling hill terrain of the north and west areas of the District are smaller than pit gravel and are mixed with sandy soils. The iron ore is generally smaller than $\frac{1}{2}$ inch size.

(5) OYSTER SHELL aggregates dredged from dead oyster reefs in our coastal bays contain various amounts of fine sand, silt, and clay. It is the general practice to wash the shell as it is produced by dredging before mixing with a sand soil. The shell may range in size from about 2 inches to $\frac{1}{4}$ inch.

(6) CRUSHED LIMESTONE aggregates secured from quarries near Austin may be washed clean or may contain some fine size powder produced during crushing operations. The limestone is produced in varying sizes ranging from $1\frac{1}{2}$ inches to $\frac{1}{4}$ inch.

(7) CRUSHED BLAST FURNACE SLAG aggregates are produced in a plant near the Sheffield Steel Mills in Houston. The slag may be washed or may contain some fine size powder produced during crushing operations. The slag is produced in varying sizes ranging from 1 inch to $\frac{1}{4}$ inch.

(8) BURNED CLAY aggregates are produced in plants located in Fort Bend County. The light-weight aggregate is produced in varying sizes, generally smaller than 1 inch.

c. Asphalt

By definition, "A black to dark brown hydrocarbon material which may be in a semi-solid form at room temperature but will gradually liquefy when heated." Much of our asphalt is produced by the refining of petroleum found in the Gulf Coast Area. The asphalt may be produced in several forms, some of which are included in the following:

(1) ASPHALT CEMENT, a semi-solid, is prepared in a particular form of consistency or degree of hardness and must be used hot.

(2) LIQUID ASPHALT is prepared by dissolving asphalt cement in gasoline or kerosene to render it temporarily fluid for use. A form of liquid asphalt in which the asphalt cement is suspended in chemically treated water is known as EMULSIFIED ASPHALT.

d. Portland Cement

By definition, "A finely pulverized material consisting principally of certain definite compounds of lime or calcium oxide, silica, alumina, and ferric oxide, all in combined form." This material is produced by pulverizing and processing such materials as limestone, oyster shell, sand, and gypsum.

e. Asphaltic Concrete

Mixture of various sizes of aggregates coated and cemented together with asphalt cement.

f. Portland Cement Concrete

Mixture of various sizes of aggregates coated and cemented together with portland cement and water paste.

g. Other Materials

(1) Steel bars, railing, and structural shapes.

(2) Timber.

(3) Metal and concrete drainage pipes.

(4) Chemicals such as hydrated lime and curing compounds.

(5) Paint.

1-04 EXAMPLES OF WORK PERFORMED IN DISTRICT, RESIDENT AND FIELD LABS

a. Preparation of Samples for Laboratory Tests

Soil and aggregate samples brought into the Laboratory will be composed of solid particles of various sizes and shapes, occurring in every conceivable arrangement.

Where there is a large percentage of "aggregate" present, it is necessary to dry and slake down the sample in water to separate the soil coating from the aggregate.

When the sample contains a small percentage of aggregate, that can be distinguished readily by the eye, the sample, may be dried and prepared without the slaking process, provided the "hard lumps" are broken down by hand tools, or a suitable mechanical pulverizer.

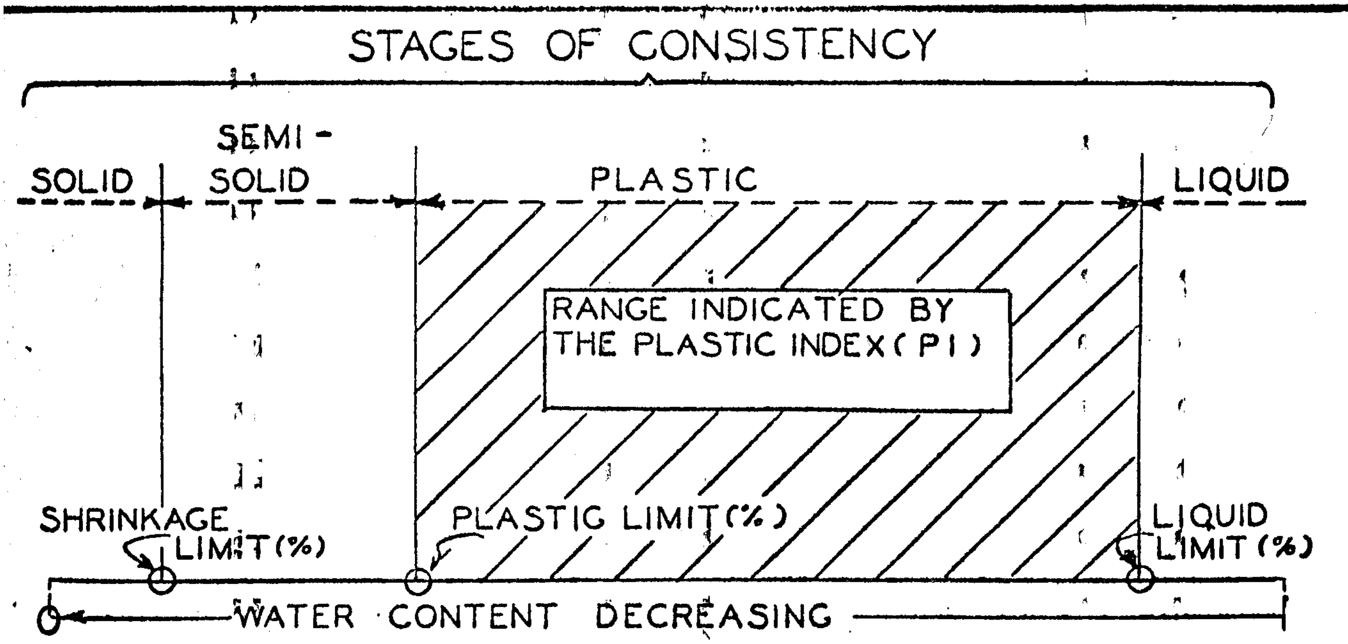
b. Separation of Prepared Samples into Different Grain Sizes

The amounts of the various sizes of grains present in a sample are determined by sieving a measured quantity of material through successively smaller sieves. (See Figure 3).

c. Differentiation of Soil Consistency with Varying Amounts of Water in the Sample

As a very wet, fine-grained soil dries, it passes progressively through different stages of consistency. Although the transition between each of the stages is gradual, test conditions have been established arbitrarily to delineate the water content as a precise point in this transition shown in Figure 4.

The liquid limit (LL) water content is determined at a point when the wet soil just starts to become fluid under the influence of a series of standard shocks. The <u>plastic limit</u> (PL) water content is determined at a point when the wet soil ceases to be plastic and becomes



DIFFERENTIATION OF SOIL CONSISTENCY

FIG. 4

brittle when rolled into a small thread toward the end of the drying process. The soil eventually reaches a "solid" state at which no further shrinkage will occur. The water content at this point is called the shrinkage limit (SL).

As shown in Figure 4, the difference between the liquid and plastic limits is called the plastic index. Silt and loam soils have low plastic indexes, while clays have higher indexes.

d. Determination of the Density or Unit Weight

The compression of loose soils or aggregates into a smaller cubic volume by mechanical means is termed "compaction." By measuring the weight of the material and the volume, the "density" may be computed by dividing the weight by the volume. By excluding the weight of the water in the sample, a "dry density" value is determined.

Different proportions of material and water, when pressed together will give different density values when plotted. The resulting plots are curved lines showing higher densities with increased water content up to some peak, and then lower densities with increasing water content values. (See Figure 1.)

e. Determination of the Strength of Materials

A strength test consists of measuring the load required to cause a sample to break or become permanently deformed with change in shape or size. Strength tests have varied test conditions such as rate of loading, temperature at time of testing, confining pressure, and methods of curing, to name a few. Depending on the strength obtained, engineering computations may be made that will furnish the performance characterestics of the material. The strength of a material is found by dividing the ultimate load applied, by the cross-sectional area of the sample and is usually expressed in pounds per square inch (p.s.i.).

f. Securing Representative Samples of Materials

Sampling is as important as the laboratory testing; therefore, the sampler must use precaution to obtain samples that will show the true nature and condition of the materials which they represent.

The proper method to use in sampling will depend on the place, the quantity of material, the proposed treatment, and the tests to be made in the laboratory. (See pictures of several types of sampling operations.)

Immediately after securing the samples, a sample identification form is completed prior to shipment to the lab. The results of tests on the sample are <u>meaningless</u> unless the sample is properly identified.

FIGURE 5

CHARACTERISTICS OF SOIL GROUPS

THAT DETERMINE ACCEPTABILITY

FOR USE IN THE HIGHWAY

Soil Type	Condition When Compacted and Saturated	Workability as a Construction Material	Chemicals Used With Soil to Improve Workability
Sand	Firm	Good	Cement Lime Asphalt
Silt and Loam	Compressible	Fair	Cement Lime
Clay	Soft and Plastic	Fair to Poor	Lime

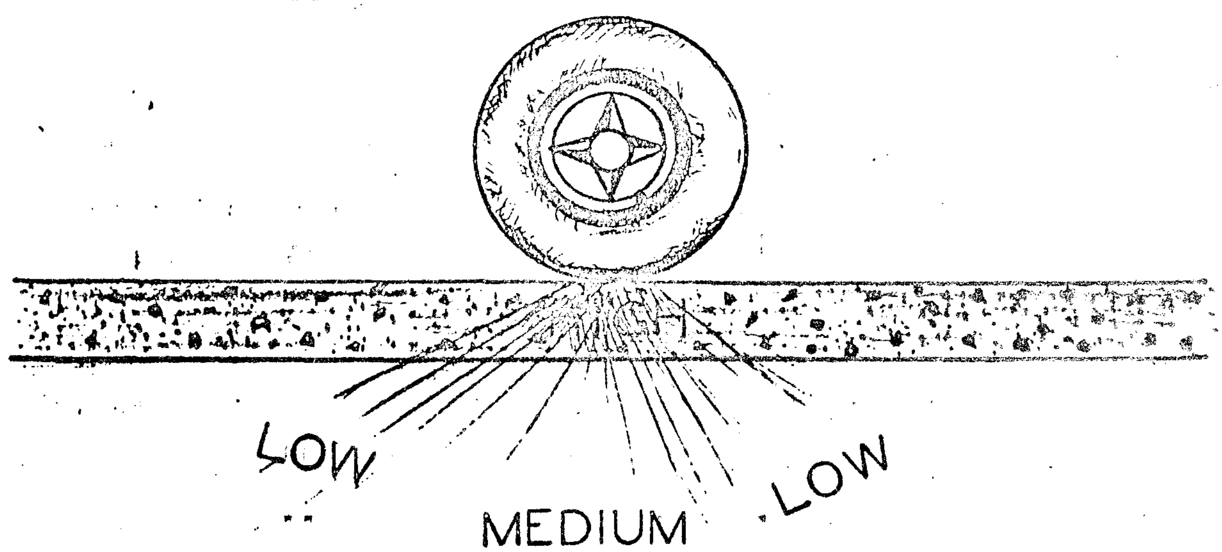
1-05 STAGES OF HIGHWAY DEVELOPMENT DURING WHICH VARIOUS LABORATORY WORK IS PERFORMED.

a. Planning Stage

During the initial surveys in the field for a proposed highway project, the various soil types visible on the ground surface are noted. The soil types may be recognized by observing the color and feel of the material. Several test holes may be made in which samples of each type of material are selected and tested separately in the District or Residency Laboratory for grain size and consistency limits. Consideration of these soil properties with past experiences, using these same materials will be reflected along with other factors in the construction budget proposed during this stage.

b. Design Stage

A sufficient number of test holes are made during this stage to outline the boundary of the soil types and conditions which determine acceptability of the soils for use in the highway. (See Figure 5). Since it may be economical to employ chemical admixtures to treat weaker soils, several laboratory tests, including strength determinations are run in the District Laboratory to determine the optimum quantity of chemical treatment. Those soils determined acceptable without chemical treatment are tested for strength values under loadings imposed by bridge foundations, bridge embankments, subgrade, subbase, and base courses. These values are used in analyses by Design Engineers to determine relative thicknesses of highway structures to adequately carry the anticipated traffic. (See Figure 6 for illustration of the effects of a wheel load.)



PATTERN OF WHEEL LOAD FORCES

FIG. 6

c. Construction Stage

The contractor designates the materials which he proposes to use on the project. After representative samples of the processed materials are taken at the manufacturing site, certain preliminary quality tests are performed, usually in the Austin Laboratory to determine if the samples contain ingredients not permitted in the specifications.

Job control tests are run in the Residency Laboratory or District Laboratory on most materials delivered to the site of the project in order to determine the ratio of various materials that must be mixed by the contractor to produce desired qualities. In the instances where mixtures of materials are supplied by commercial sources off the site of the project, it is necessary to run job control tests on their material in order to establish the proper ratio of ingredients in the mix.

Some in-place test measurements are made by Residency Laboratory personnel on completed layers of material for check of thickness, density, and final condition after placement by the contractor.

CONVERSION FACTORS.

To Convert From	To	Multiply By
Centimeters	Inches	0.39370
Cubic Cm.	Cubic Inches	0.06102
Cubic Ft.	Cubic Inches	1728
Cubic Ft.	Gallons	7.48051
Cubic Ft.	Cubic Yards	0.03704
Cubic Inches	Cubic Cm.	16.38716
Cubic Inches	Cubic Ft.	5.78704×10^{-4}
Cubic Inches	Gallons	0.00433
Cubic Inches	Liters	0.01639
Cubic Yards	Cubic Ft.	27
Feet	Meters	0.30481
Gallons	Cubic Inches	231
Gallons	Cubic Ft.	0.133681
Gallons	Liters	3.78533
Grams	Pounds	0.00221
Inches	Centimeters	2.54001
Kilograms	Grams	1000
Liters	Cubic Inches	61.025
Liters	Gallons	0.26418
Meters	Feet	3.28083
Meters	Inches	39.3700
Pounds	Kilograms	0.45359
Quarts	Cubic Inches	57.749

Soil Laboratory Homework Problems

1. Determine moisture content of the following soil.

   wet weight = 200 gr.

   water weight = 20 gr.

2. Determine the wet density in pounds per cubic foot of a soil which has been removed from a hole containing 0.0786 cubic ft. (measured by volumeter). The wet weight of the soil is 10.216 lbs.

3. The L.L. of a soil was found to be 57% and its P.L. 21%. Find its P.I.

4. Determine the strength of a soil which will support an ultimate load of 4000 pounds through a cross sectional area of 2 sq. in.

5. Convert the following:

700 grs. = ______________ lbs.

100 lbs/ft^2 = ______________ p.s.i.

600 cu. ft. = ______________ c.y.

1000 cu. ft. water = ______________ gallons

STATE OF TEXAS
STATE HIGHWAY DEPARTMENT

PLANS OF PROPOSED STATE HIGHWAY IMPROVEMENT

FEDERAL AID PROJECT
U.I. 200 (20)

NET LENGTH OF PROJECT = 21,435.23 FT = 4.059 MI

TRAVIS COUNTY

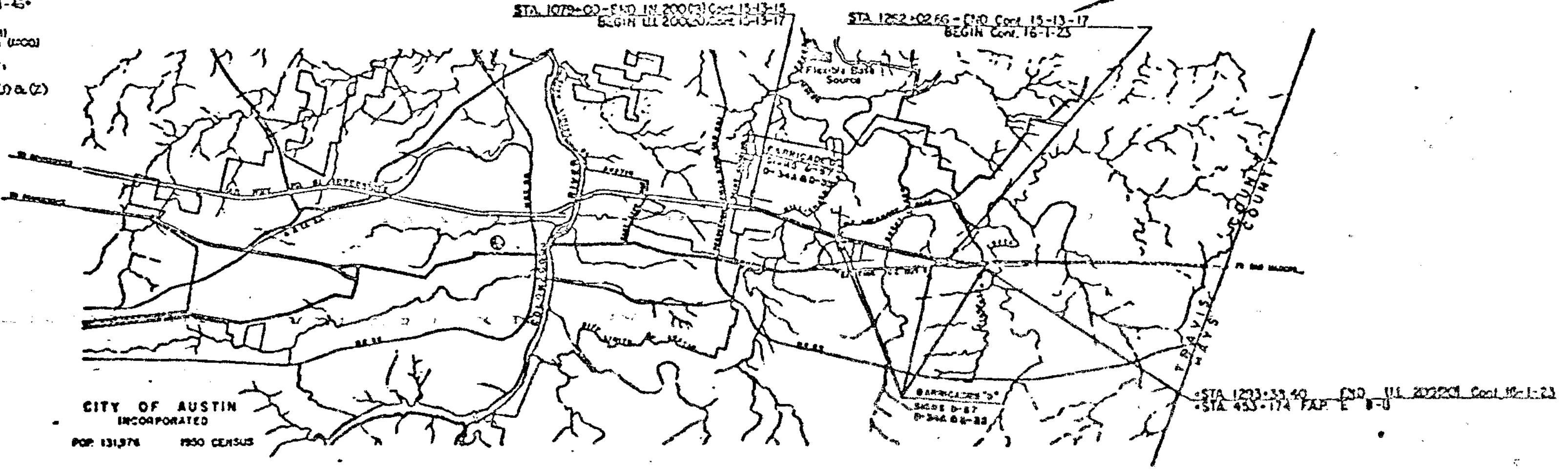
FROM 0.3 MI. SOUTH OF ST. ELMO ROAD
TO 0.4 MI. NORTH OF SLAUGHTER CREEK
GRADING, STRUCTURES, FLEXIBLE BASE, AND HOT MIX
ASPHALTIC CONCRETE PAVEMENT

CONTROL 15-13-17		
ROADWAY – RURAL	17,866.20 FT	= 3.383 MI
BRIDGES – RURAL	434.91 FT	= 0.082 MI
TOTAL 15-13-17	18,301.11 FT	= 3.465 MI

CONTROL 16-1-23		
ROADWAY – RURAL	3,135.54 FT	= 0.594 MI
TOTAL 16-1-23	3,135.54 FT	= 0.594 MI

INDEX OF SHEETS

SHEET No.	DESCRIPTION
1	TITLE SHEET
2	TYPICAL CROSS SECTIONS
3-5	ESTIMATE AND QUANTITY
6-14A	PLAN PROFILE
15-17	MASS DIAGRAM
18-20	ROADWAY DETAILS
21	LAYOUT-INTERSECTION WITH EXISTING US HWY 81
22-24	MAP OF DRAINAGE AREAS
25-29	STORM SEWER LAYOUTS
30-50	CROSS SECTION AT CULVERT SITES
51-57	LAYOUT AND STRUCTURAL DETAILS –WILLIAMSON CREEK BRIDGES
58-67	LAYOUT AND STRUCTURAL DETAILS –OLD LOCKHART ROAD UNDERPASS
68-70	LAYOUT AND STRUCTURAL DETAILS –BOGGY CREEK 4-10'x12'x350' MC10-15° EPU
71-82	LAYOUT AND STRUCTURAL DETAILS –US HWY 81 SEPARATION
[illegible]	CONCRETE CURB AND GUTTER
[illegible]	CURB INLET DETAILS
[illegible]	GRATE & FRAME INLETS AND MANHOLE DETAILS
[illegible]	STEEL PLATE GUARD FENCE
[illegible]	MC9-30° (SPU)
[illegible]	MC7-33° (SPU)
[illegible]	MC6-30° (SPU)
[illegible]	MC6-30° (SPU)
[illegible]	SC-H
[illegible]	FW-H
[illegible]	SC-40°A
[illegible]	FW-40°
[illegible]	CH-11
[illegible]	CH-11-8-30°
[illegible]	CH-11-8-45°
[illegible]	RR-8
[illegible]	RR-8
100	R10 (1954)
101	BCF-41 (1950)
102	MC7-1
103	MCW-P1
104	M-47
105-106	BW 54(1) & (2)



RAILROAD DELIVERY POINTS

EQUATION
1. Sta. 1096+23.80 Back = Sta. 1096+25.13 Fwd.
2. Sta. 1172+73.23 Back = Sta. 1172+79.70 Fwd.

NO EXCEPTIONS
NO RAILROAD CROSSING ELIMINATED
FEDERAL PROJECT MARKERS WILL BE PLACED AT END OF F.A.P. 200

LAYOUT SCALE: 1 IN = 3,200 FT

STATE HIGHWAY DEPARTMENT

5-23-55

5-24-55

DEPARTMENT OF COMMERCE
BUREAU OF PUBLIC ROADS

COUNTY — PROJ NO. —
HWY. NO. — LETTING DATE —
DATE ACCEPTED —

PLATE 1

INDEX OF SHEETS

TEXAS HIGHWAY DEPARTMENT
WILLIAMSON COUNTY
F. M. HIGHWAY NO. 1105

FROM: F. M. No. 487 IN SCHWERTNER TO: F. M. No. 972 NEAR WALBURG

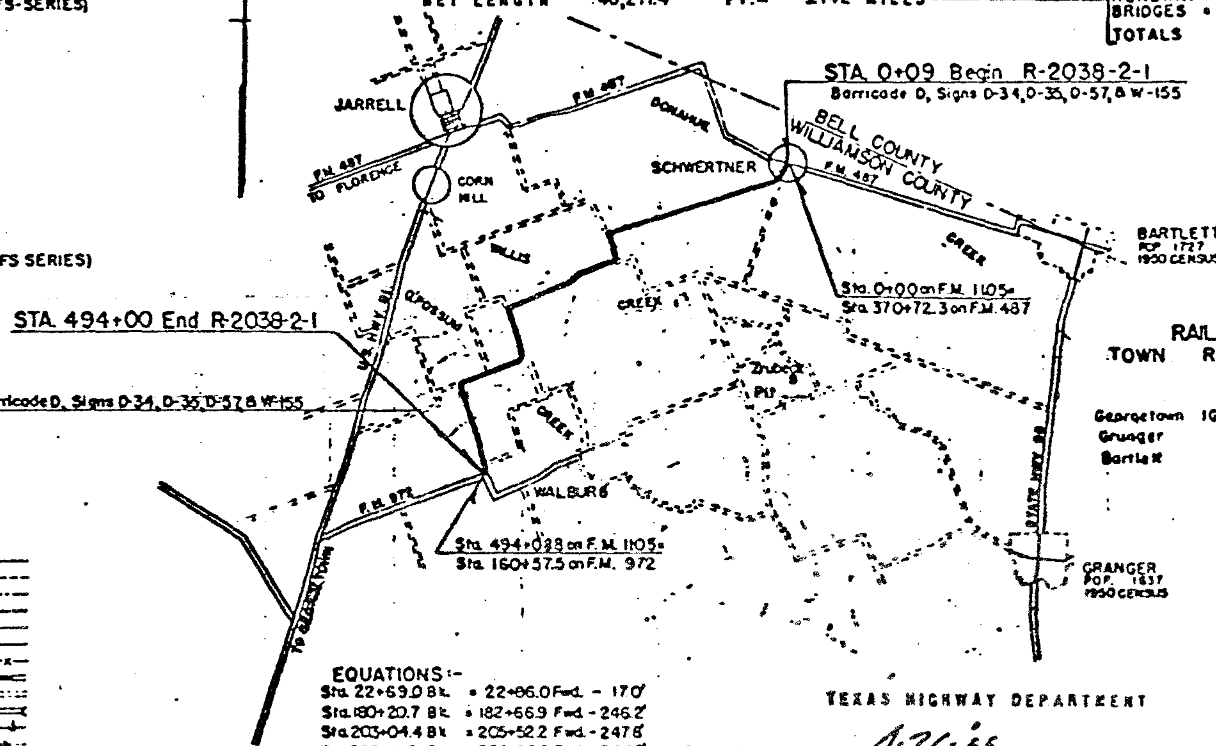
STATE PROJECT NO. R-2038-2-1

PLANS OF PROPOSED
GRADING, STRUCTURES, BASE, & SURFACING

FED. RD. DIV. NO.	STATE	PROJECT NO.			SHEET NO.
6	TEXAS	R-2038-2-1			1
STATE DIST. NO.	COUNTY	CONT.	SECT.	JOB	HIGHWAY NO.
14	WILLIAMSON	2038	2	1	FM 1105

NET LENGTH 48,271.4 FT. = 9.142 MILES

ROADWAY =	47,906.4 FT. =	9.073 MILES
BRIDGES =	365.0 FT. =	0.069 MILES
TOTALS	48,271.4 FT.	9.142 MILES



RAILROAD DELIVERY POINTS

TOWN	RAILROAD	DISTANCE FROM PROJECT	NEAREST STATION	CAPACITY
Georgetown	IGN & MKT	10 Miles	494+00	Ample
Granger	MKT	9 "	"	Ample
Bartlett	MKT	5 "	0+09	Ample

CONVENTIONAL SIGNS

- STATE OR NATIONAL LINE
- CITY OR VILLAGE LINE
- COUNTY LINE
- BASE OR SURVEY LINE
- RIGHT OF WAY LINE
- RIGHT OF WAY MARKERS
- FENCE LINE
- RAILROAD
- TRAVELLED WAY
- CULVERT OR BRIDGE
- POWER LINE
- TELEGRAPH OR TELEPHONE

EQUATIONS:-

Sta. 22+69.0 Bk.	= 22+86.0 Fwd. - 17.0'
Sta. 180+20.7 Bk.	= 182+66.9 Fwd. - 246.2'
Sta. 203+04.4 Bk.	= 205+52.2 Fwd. - 247.8'
Sta. 307+41.8 Bk.	= 309+86.0 Fwd. - 244.2'
Sta. 355+19.3 Bk.	= 357+24.2 Fwd. - 204.9
Sta. 415+36.4 Bk.	= 416+95.9 Fwd. - 159.5

SPECIFICATIONS ADOPTED BY THE STATE HIGHWAY DEPARTMENT OF TEXAS JAN. 2, 1951 AND APPROVED BY THE BUREAU OF PUBLIC ROADS JULY 25, 1951 AND SPECIFICATION ITEMS LISTED AND DATED AS FOLLOWS SHALL GOVERN ON THIS PROJECT.

NO EXCEPTIONS

SPECIAL LABOR PROVISIONS FOR STATE PROJECTS ADOPTED AUGUST 11, 1948.

SCALE: 0 — 2 MILES

TEXAS HIGHWAY DEPARTMENT

CORRECT: 4-26-55

RESIDENT ENGINEER

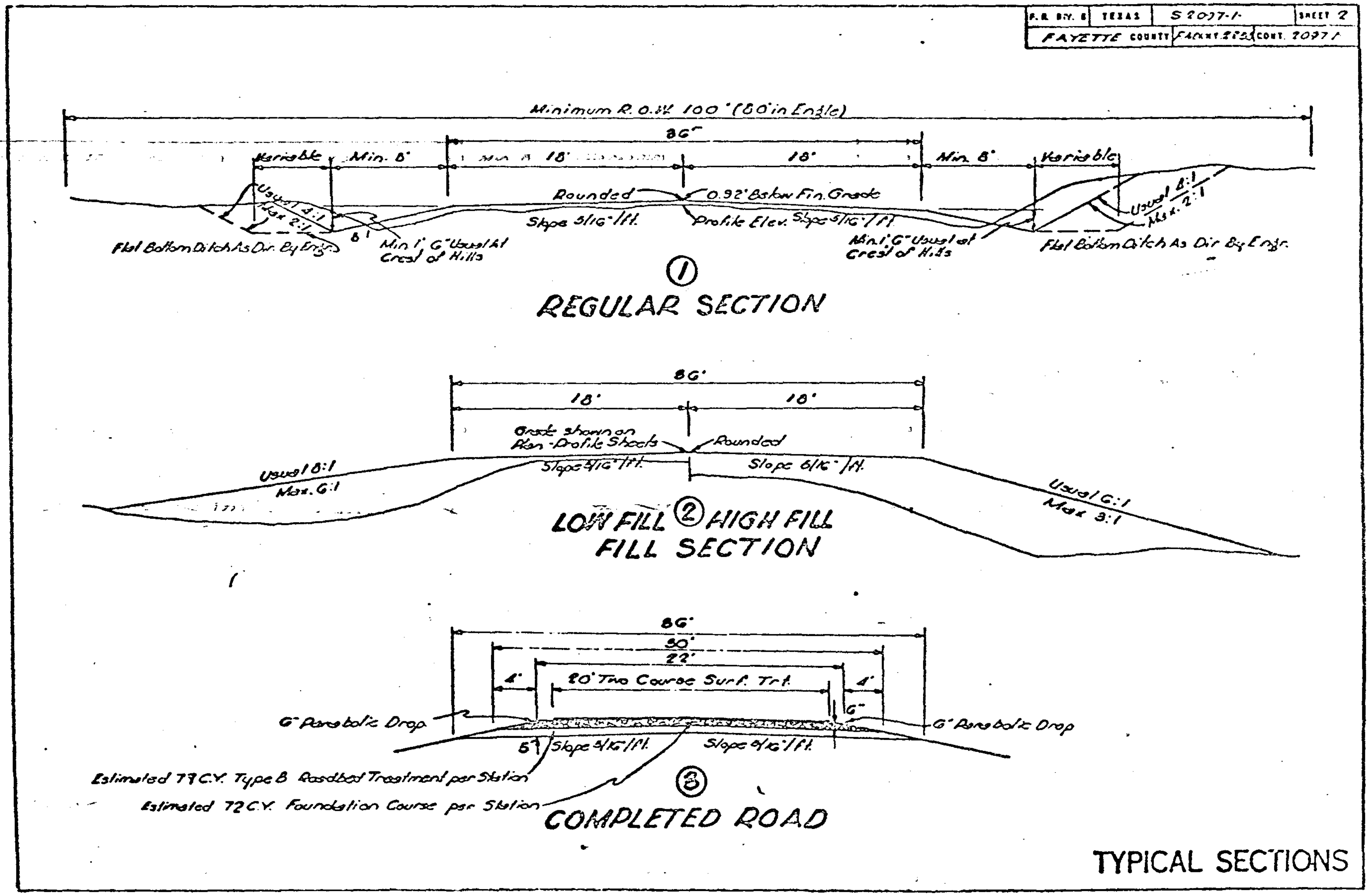
RECOMMENDED FOR APPROVAL: 4-26-55

APPROVED:

DISTRICT ENGINEER

ENGINEER LAND SERVICE ROADS

PLATE 2



F.R. DIV. 8 | TEXAS | S 2097-1- | SHEET 2
FAYETTE COUNTY | F.A.C.N.T. ... | CONT. 2097-1
Minimum R.O.W. 100' (80' in Engle)
86'
Variable
Min. 8'
18'
18'
Min. 8'
Variable
Rounded
0.92' Below Fin. Grade
Usual 4:1
Max 2:1
Usual 4:1
Max. 2:1
Slope 5/16"/Ft.
Profile Elev.
Slope 5/16"/Ft.
Flat Bottom Ditch As Dir. By Engr.
Min 1' G" Usual At Crest of Hills
Min 1' G" Usual at Crest of Hills
Flat Bottom Ditch As Dir. By Engr.
① REGULAR SECTION
86'
18'
18'
Grade shown on Plan-Profile Sheets
Rounded
Usual 8:1
Max. 6:1
Slope 5/16"/Ft.
Slope 6/16"/Ft.
Usual 6:1
Max 3:1
LOW FILL ② HIGH FILL
FILL SECTION
86'
30'
22'
4'
20' Two Course Surf. Trt.
4'
6"
G" Parabolic Drop
G" Parabolic Drop
5"
Slope 5/16"/Ft.
Slope 6/16"/Ft.
Estimated 77 C.Y. Type B Roadbed Treatment per Station
Estimated 72 C.Y. Foundation Course per Station
③ COMPLETED ROAD
TYPICAL SECTIONS

PLATE 3

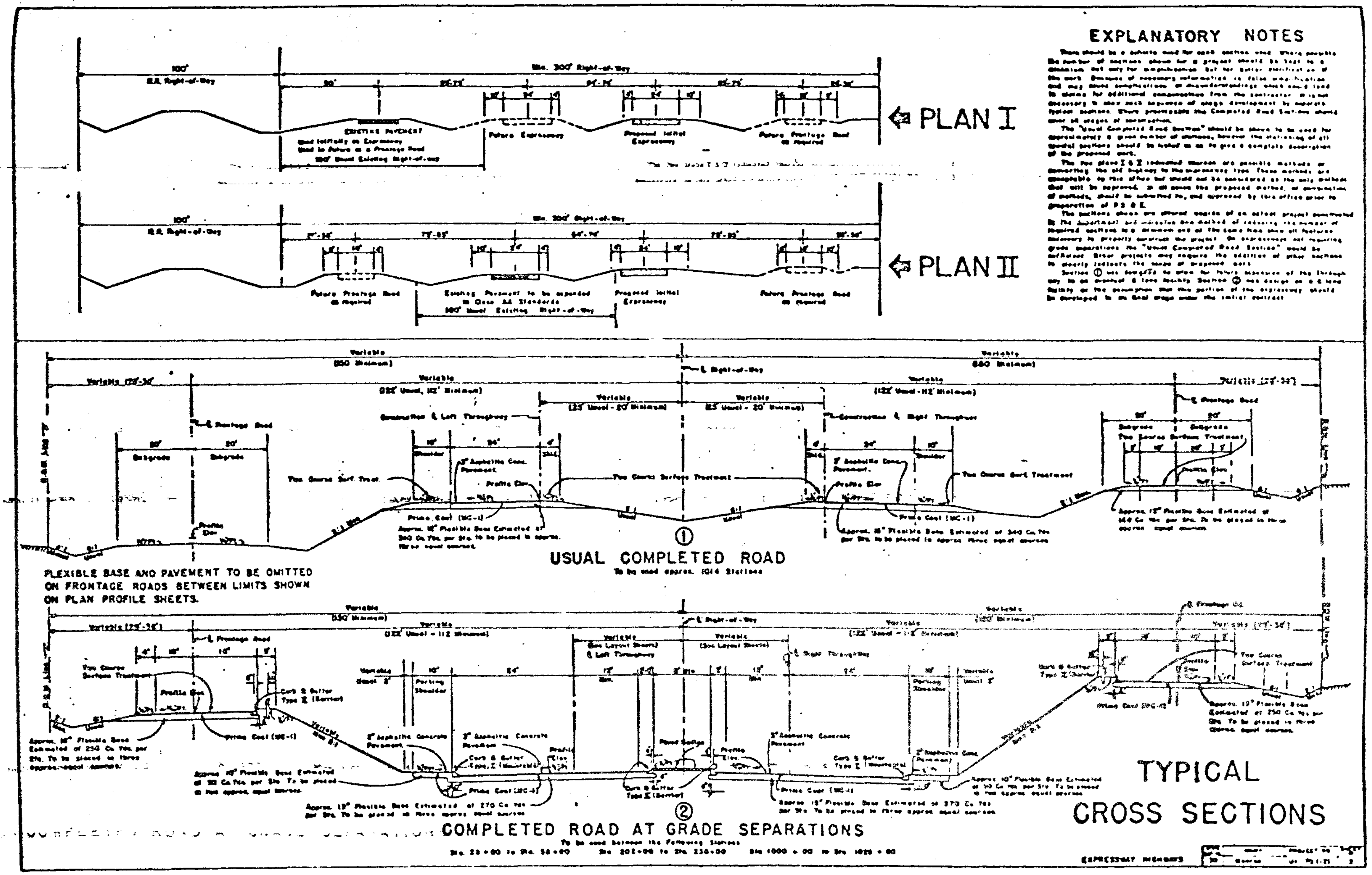
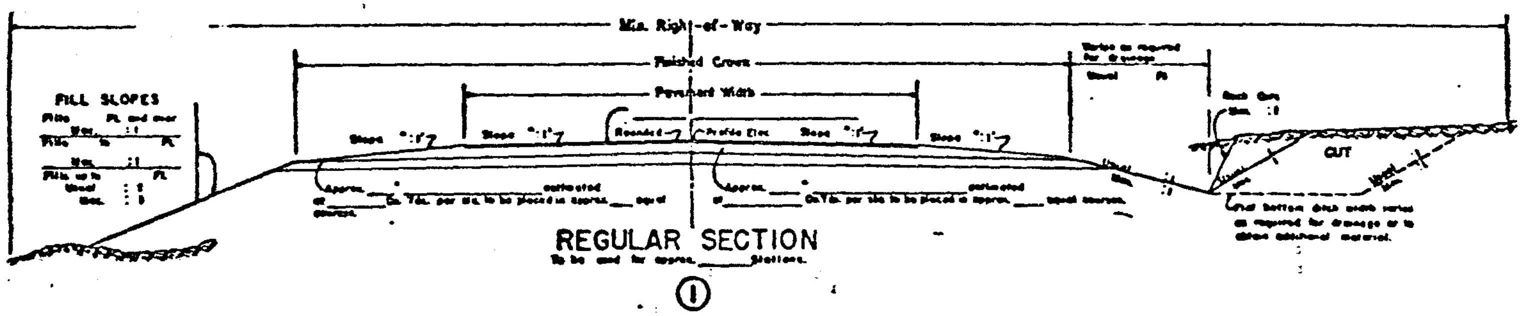

EXPLANATORY NOTES
PLAN I
PLAN II
USUAL COMPLETED ROAD
PLEXIBLE BASE AND PAVEMENT TO BE OMITTED
ON FRONTAGE ROADS BETWEEN LIMITS SHOWN
ON PLAN PROFILE SHEETS.
COMPLETED ROAD AT GRADE SEPARATIONS
TYPICAL
CROSS SECTIONS

PLATE 4



GENERAL NOTES

TYPICAL
CROSS SECTIONS

SPECIFICATION DATA

Test to be in accordance with Texas Highway Department Standard Test Methods

ITEM	DESCRIPTION	GRADING REQUIREMENTS Percent Retained, Sieves								SOIL CONSTANTS			WET BALL MILL	SEE NOTE
		2½"	2"	1¾"	1"	½"	#4	#10	#40	L.L. Max.	P.I. Max.	P.I. Min.	Max.	
990	Flexible Base (Ty D) Gr 4			0-10			45-65		45-65	35	12			1,2,3
990	Flexible Base (Ty F) Gr 4			0					60-80	35	12			1,2,3

NOTES:

1. FLEXIBLE BASE (TY. D OR TY. F) SHALL BE MIXED IN A STATIONARY PUGMILL MIXER.
2. IF BATCH-TYPE PUGMILL USED, HOPPER SCALE WEIGHTS WILL BE ACCEPTED.
3. WHEN TESTED IN ACCORDANCE WITH TEST METHOD TEX-116-E, THE RESULTING SOIL BINDER CONTENT (MATERIAL PASSING THE NO. 40 SIEVE) SHALL NOT EXCEED 45 PERCENT BY WEIGHT OF THE TOTAL SAMPLE TESTED.

BASIS OF ESTIMATE:

ITEM	DESCRIPTION	RATE
260	LIME (TY. A OR B)	3% BY WT. @ 110 LBS./CF
310	ASPH. MATL. (MC-1) (PRIME COAT)	0.25 GAL./SY
990	FLEXIBLE BASE (TY.D,GR.4)	120 LBS./CF
990	FLEXIBLE BASE (TY.F,GR.4)	130 LBS./CF

EARTHWORK COMPACTION FACTOR:

BEGIN OF JOB TO STA. 100± : 1.4
STA. 100± TO END OF JOB : 1.3

COMPACTION REQUIREMENTS FOR BASE COURSES

Percent of Density as Determined by Compaction Ratio (Tex-114-E)

ITEM	MATERIAL	Course	Density	Course	Density
990	Flexible Base	All	95		
252	Salv. Flex Base	All	95		

SURFACE TREATMENT DATA

ITEM	APPLICATION		
One COURSE SURFACE TREATMENT	Trav. Way	Shoulders	Third
Asphalt, Type	OA-175 or RC-5	OA-175 or RC-5	
Asphalt, Rate (gal/sy)	0.25	0.35	
Aggregate, Type	PB	B	
Aggregate, Grade	3	4	
Aggregate, Rate (cy/sy)	1:90	1:80	
Rolling 210 (Hrs/Mi.)	← 12 →		
Rolling 213 (Hrs./Mi)	← 12 →		

SURFACE TREATMENT AREA: Roadway 62,711 sy
Intersection [illegible] sy
Total [illegible] sy

SPECIFICATION DATA
Sheet A

F R DIV 8	TEXAS	S 2674 (7)	1	3
H Bend COUNTY		HWY FM 411	CONT 6-9	

GENERAL NOTES AND SPECIFICATION DATA:

GENERAL NOTES:

1. ALL CURVES SHALL BE SUPERELEVATED AS SHOWN ON CST-62.

2. ALL OBSTRUCTIONS WITHIN LIMITS OF RIGHT OF WAY TO BE REMOVED BY THE COUNTY UNLESS OTHERWISE NOTED.

3. IN THOSE INSTANCES WHERE FIXED FEATURE REQUIRE, THE GOVERNING SLOPES INDICATED HEREIN MAY BE VARIED BETWEEN THE LIMITS AND THE EXTENT DETERMINED BY THE ENGINEER.

4. ALL UTILITIES WITHIN LIMITS OF RIGHT OF WAY WILL BE REMOVED OR ADJUSTED BY THE OWNER.

5. THE CONTRACTOR WILL PROVIDE FACILITIES FOR PASSAGE AT STRUCTURE SITES AND AT ROADWAY CONSTRUCTION SITES. THIS WORK WILL BE CONSIDERED INCIDENTAL TO THE VARIOUS BID ITEMS.

6. ITEM 320 - AGGREGATES FOR THE 3-FT. SURFACED SHOULDERS SHALL BE OF DIFFERENT COLOR FROM THE 24-FT. TRAVELED WAY.

7. ITEM 420 - TYPE 3 SURFACE FINISH SHALL BE APPLIED TO CONCRETE STRUCTURES.

8. Brazos River Bridge will be under construction during construction of this project. Contractors will be required to conduct operations so as to hold interference between projects to a minimum.

9. Item 320 - Between November 1 and April 1, RC-5 shall be substituted for OA-175 Asphalt in construction of surface treatment.

10. Item 320 - If the Engineer so directs, the surface treatment will be constructed half-width at a time.

11. No asphaltic material, mixtures or surface treatments except MC-1 and RC-5 shall be placed between November 1 and April 1 unless specifically directed by the Engineer in writing.

PLATE 7

SPECIFICATION DATA

Sheet B

F. R. DIV. 8	TEXAS	S2574(2)	7
Ft. Bend	COUNTY	HWY.	CONT.

F.E. DIV. 8	TEXAS	R-891-2-9	SHEET 4
ANDERSON COUNTY	F.M. HWY. 323	CONT. 891-2-4	

SUMMARY OF CULVERTS

PLAN PROFILE SHEET NO.	STATION	DESCRIPTION		UNCLAS STRUCT EXCAV C.Y.	CLASS "A" CONC. C.Y.	REINF. STEEL LBS.	STD. REINF. CONC. PIPE			
		SIZE	DESIGN				18" DIA. L.F.	24" DIA. L.F.	30" DIA. L.F.	
7	595+70	1-18"x34' Pipe Culvt.	CH-78	4	0.98	46	34			
8	604+80	1-3'x3'x45' Box Culvt.	FC-2	32	11.58	1222				
8	611+28	1-4'x4'x44' Box Culvt.	FC-2	40	15.64	1675				
8	620+38	1-30"x32' Pipe Culvt.	CH-78	12	2.10	80			32	
9	639+95	1-5'x3'x32' Box Culvt.	FC-2	18	12.19	1436				
9	651+40	1-4'x2.5'x31' Box Culvt.	FC-2	10	9.35	1060				
10	676+15	1-24"x40' Pipe Culvt.	CH-78	8	1.52	68		40		
11	700+54	1-24"x36' Pipe Culvt.	CH-78	6	1.52	68		36		
12	723+90	1-8'x7'x32' Box Culvt.	SC-NA FW-N	50	38.40	4874				
12	731+00	1-24"x34' Pipe Culvt.	CH-78	7	1.52	68		34		
12	745+60	1-24"x38' Pipe Culvt.	CH-78	12	1.52	68		38		
13	766+60	1-8'x5'x40' Box Culvt.	FC-2	70	29.49	3530				
14	783+40	1-24"x32' Pipe Culvt.	CH-78	11	1.52	68		32		
14	804+17	1-6'x5'x31' Box Culvt.	FC-2	50	18.24	2092				
14	812+10-40 Rt.	1-18"x24' Pipe Culvt.	Sideroad	6	—	—	24			
15	820+00	1-24"x36' Pipe Culvt.	CH-78	14	1.52	68		36		
15	830+60	1-24"x56' Pipe Culvt.	CH-78	6	1.52	68		56		
15	840+65	1-30"x32' Pipe Culvt.	CH-78	6	2.10	80			32	
		TOTALS =		360	150.71	16583	58	272	64	

SUMMARY OF BRIDGES

PERM. STR. NO.	PLAN PROFILE SHEET NO.	STREAM NAME	STATION		LENGTH FT.	DESIGN.	DESCRIPTION	UNCLAS. STRUCT EXCAV. C.Y.	CLASS "A" CONC. CULVERT C.Y.	REINF. STEEL LBS.	STEEL H PILING (12"X53#)	CL. "A" CONC (Slab & Beam) C.Y.	CEMENT STAB. RIPRAP C.Y.
			BEGIN	END									
5	10	Turkey Cr.	682+62.07	683+00.0	37.93	23° Rt. Fwd Skew MC8-1 & MCW-32	4-8'x7'x32' Cl Rdwy Culv.	40	104.2	12,680			
6	14	Squirrel Cr.	796+15	798+40	225.0	FS-8-24-25	9-25 Concrete Slab Spans	14		33,458	1020	281.7	50
				TOTALS =	262.93			54	104.2	63,821	1020	281.7	50

STRUCTURE SUMMARY

14

SUMMARY

BRIDGES EST.	BRIDGES FINAL	ALT.	ITEM NO	DESC CODE	SP NO	DESCRIPTION	UNIT	TOTAL EST.	TOTAL FINAL
			102	001		Clear and Grub	Ac	6	
			110	005		Com Rd Excav (Ord Comp)	CY	4726	
			120	001	001	Uncl Chan Excav (Ord Comp)	CY	143	
			140	002	004	Ovrhl	YM	14,652	
			150	001		Blad	Hr	368	
			204	001		Sprink	MG	9610	
			210	001		Roll (Flat Wheel)	Hr	521	
			211	001		Roll (Tamp)	Hr	1010	
			212	001		Roll (Heavy Tamp)	Hr	44	
			215	001		Roll (Grid)	Hr	1205	
			230	003		Rdbd Treat (Ord Comp)(Ty B)	CY	12,424	
			230	013		Addl Qtr Mi Haul	CY	128,588	
		1	260	001		Lime (Ty A)	Ton	2115	
			260	008		Lime Treat Exist Base (Ord Comp)	SY	200,000	
			316	012		Aggr (Ty B Gr 6)	CY	436	
			316	123		Asph (OA-175)	Gal	16,339	
			320	038		Aggr (Ty PB Gr 2)	CY	1716	
		2	340	001		Asph	Ton	45	
		2	340	005		Aggr (Ty D)	Ton	848	
		2	340	008		Tack Coat	Gal	900	
			421	001		Cl A Conc (Culv)	CY	602.7	
			440	001		Reinf Stl	Lb	78,511	
			464	003		R C Pipe (Cl III)(18 in)	LF	36	
			464	005		R C Pipe (Cl III)(24 in)	LF	121	
			496	002		Remov Old Str (Small)	Ea	1	
			801	001		One Way Traf Cont	Hr	100	

ALTERNATES

BRIDGES EST.	BRIDGES FINAL	ALT.	ITEM NO	DESC CODE	SP NO	DESCRIPTION	UNIT	TOTAL EST.	TOTAL FINAL
						ALTERNATE No. 1A			
			260	002		Lime (Ty B)	Ton	2115	
						ALTERNATE No. 2A			
			330	002		Cold Mix LRA Pvt (Ty B)	Ton	893	
			330	005		Tack Coat (EA-11M)	Gal	900	
						ALTERNATE No. 2B			
			350	004		Hot Mix - Cold Laid ACP (Ty DD)	Ton	893	
			350	008		Tack Coat	Gal	900	

ESTIMATE & QUANTITY SHEET

FED RD DIV. NO.	STATE	FEDERAL PROJECT NO.	SHEET NO.
6	TEXAS		
STATE DIST. NO.	COUNTY	CONT / SECT / JOB	HIGHWAY NO.

ALT.	ITEM-CODE ITEM NO.	DESC CODE	S.P. NO.	ITEM DESCRIPTION	UNIT
	102	001		Clear and Grub	Ac
	110	005		Com Rd Excav (Ord Comp)	CY
	120	001	001		
	140	002	004		
	150	001			
	204	001			
	210	001			

The description should be limited to 39 space bars (letters and spaces).

The first three and last three digits will be used to identify special provisions. (The center three digits will be left blank on the special provision except when the unit of measurement or the description has been changed).

This is the special provision number. (This number will be assigned in the Austin Office as they develop).

This is the description code, found in this publication, for the desired description and units of measurement. (Numbers for descriptions and units of measurement not found in the listing will be assigned in the Austin Office).

This column indicates the item number. (Numbers for special specifications will be assigned in the 700, 800, and 900 series as they develop).

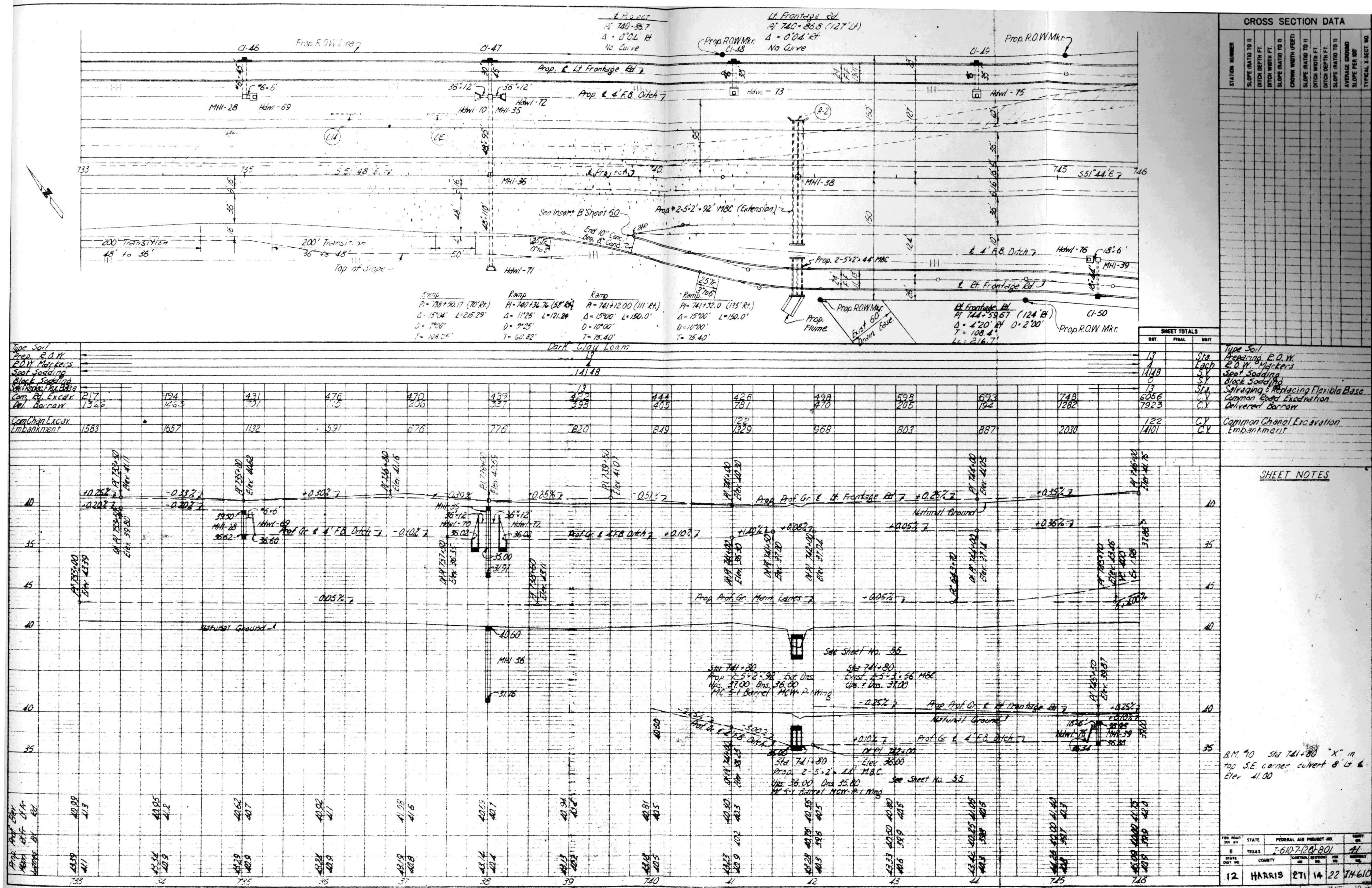

CROSS SECTION DATA
STATION NUMBER
SLOPE (RATIO TO 1)
DITCH DEPTH FT.
DITCH WIDTH FT.
SLOPE (RATIO TO 1)
CROWN WIDTH (FEET)
SLOPE (RATIO TO 1)
DITCH WIDTH FT.
DITCH DEPTH FT.
SLOPE (RATIO TO 1)
AVERAGE GROUND SLOPE PER 100'
TYPICAL X-SECT. NO.
Prop. R.O.W. Line
Prop. ℄ Lt Frontage Rd
Prop. ℄ 4' F.B. Ditch
Prop. R.O.W. Mkr.
Lt Frontage Rd
No Curve
S 51°48' E
S 51°44' E
MH1-28
MH1-35
MH1-36
MH1-38
MH1-39
See Insert 'B' Sheet 60
Prop. 2-5'x2'x92' MBC (Extension)
Prop. 2-5'x2'x44' MBC
Prop. Flume
Exist. 60' Drain. Ease.
200' Transition 45' to 36'
200' Transition 36' to 48'
Top of Slope
℄ 4' F.B. Ditch
℄ Rt Frontage Rd
Rt Frontage Rd
SHEET TOTALS
Type Soil
Preparing R.O.W.
R.O.W. Markers
Spot Sodding
Block Sodding
Salvaging & Replacing Flexible Base
Common Road Excavation
Delivered Borrow
Common Chanel Excavation
Embankment
Dark Clay Loam
Sta.
Each
S.Y.
C.Y.
Prop. Prof. Gr. ℄ Lt Frontage Rd
Natural Ground
Prop. Prof. Gr. Main Lanes
Prof. Gr. ℄ 4' F.B. Ditch
See Sheet No. 35
Sta 741+80
Prop. 2-5'x2'x44' MBC
Ups. 36.00 Dns. 35.80
MC 5-1 Barrel MCW-P-1 Wing
SHEET NOTES
B.M. #10 Sta 741+80 "X" in top S.E. corner culvert 8' Lt ℄ Elev. 41.00
STATE
FEDERAL AID PROJECT NO.
TEXAS
I-610-7(20)801
COUNTY
HARRIS
271 14 22 IH-610
PLAN - PROFILE - NEW STYLE

PLATE 10

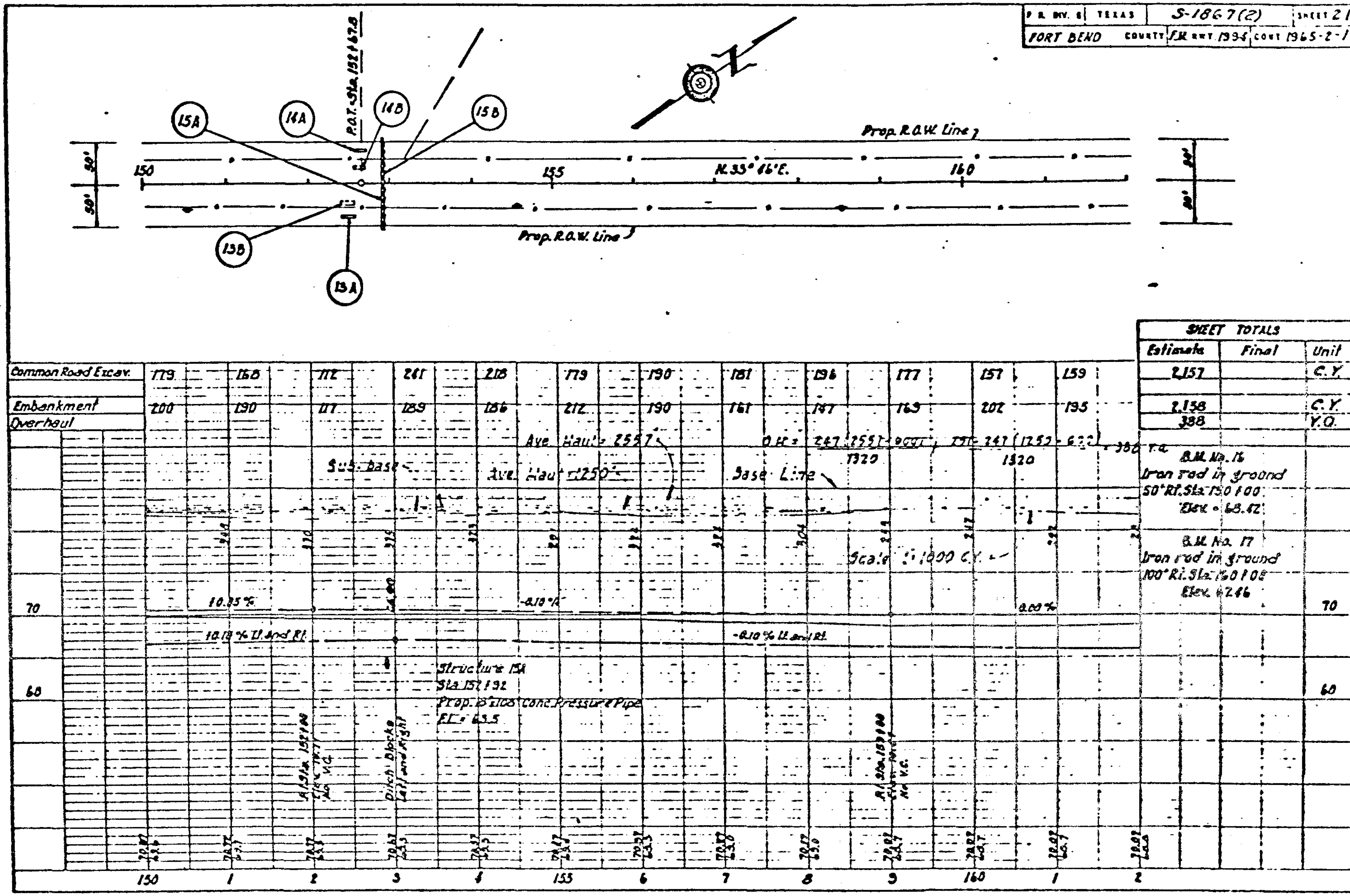

F.R. DIV. 6 TEXAS S-1867(2) SHEET 21
FORT BEND COUNTY F.M. HWY. 1994 CONT. 1965-2-1
Prop. R.O.W. Line
N.33° 46' E.
P.O.T. Sta. 152+67.8
15A
14A
14B
15B
13B
13A
150
155
160
SHEET TOTALS
Estimate Final Unit
2,157 C.Y.
2,138 C.Y.
388 Y.O.
Common Road Excav.
Embankment
Overhaul
Ave. Haul = 2557
Ave. Haul = 1250
Sub-base
Base Line
Scale 1" = 1000 C.Y.
B.M. No. 16
Iron rod in ground
50' Rt. Sta. 150+00
Elev. = 68.42
B.M. No. 17
Iron rod in ground
100' Rt. Sta. 160+00
Elev. = 67.46
Structure 15A
Sta. 152+92
Prop. 18" 1105 Conc. Pressure Pipe
FL = 63.5
Ditch Blocks Left and Right
70
60

PLATE 11

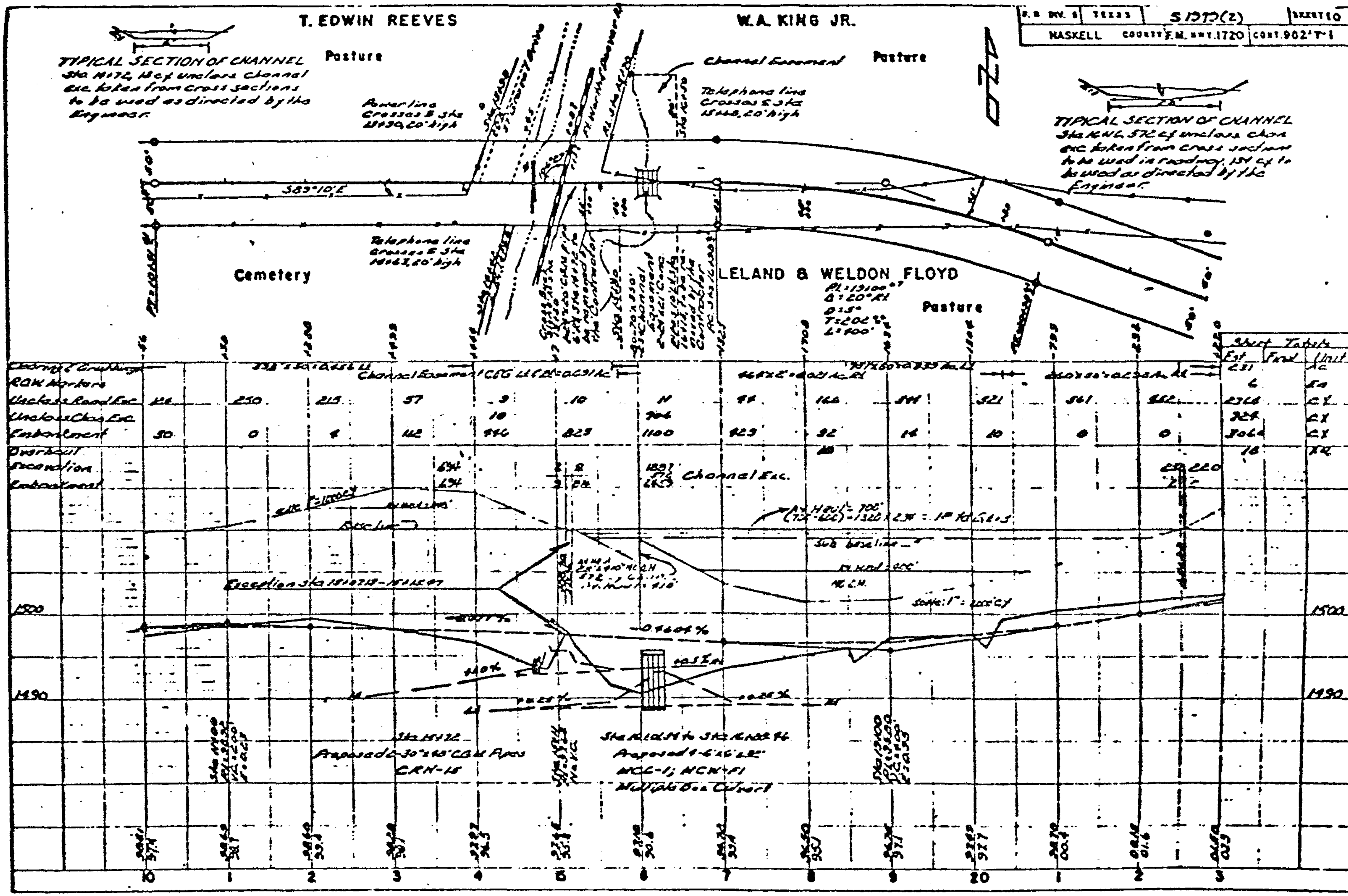
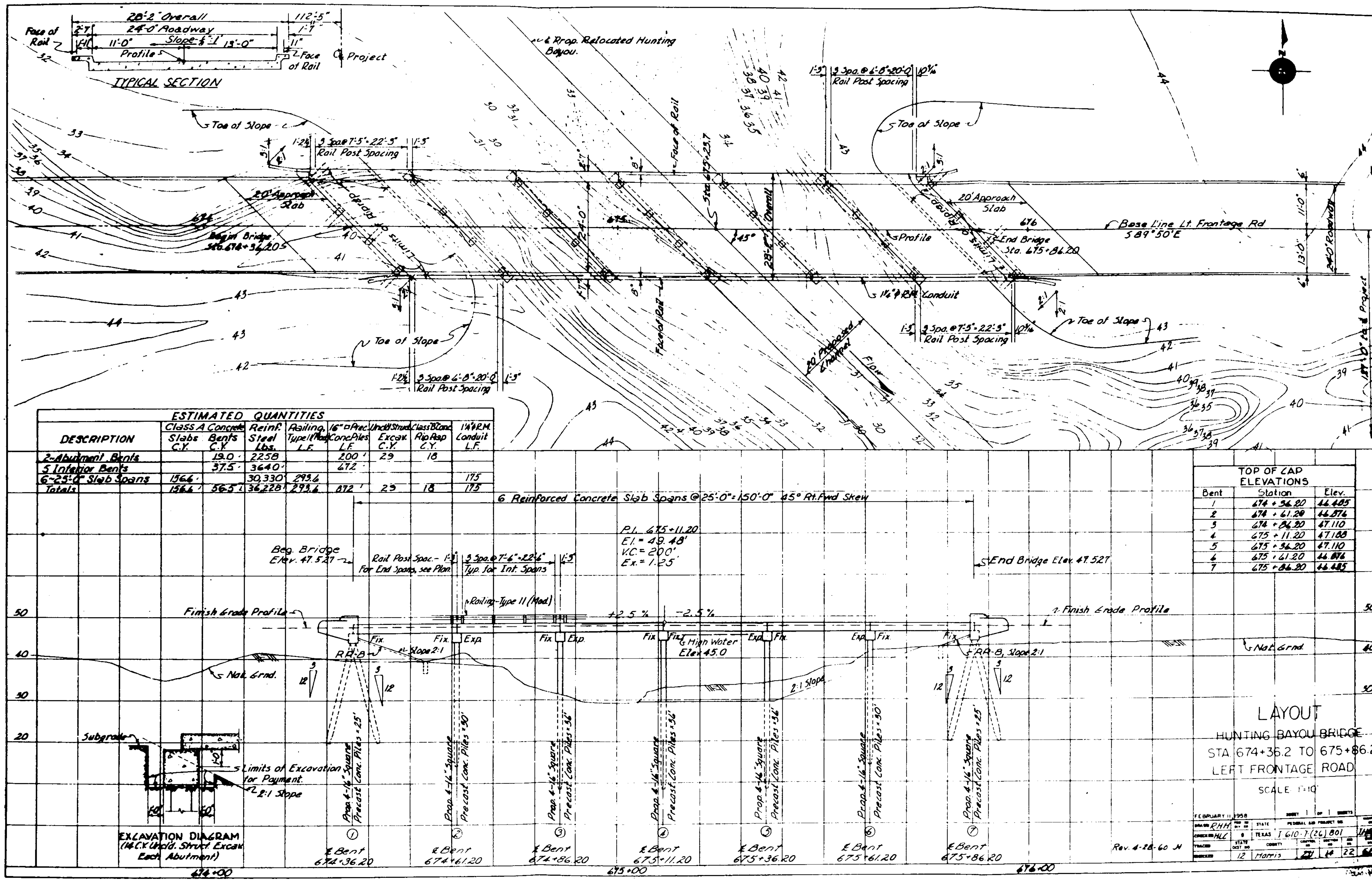

T. EDWIN REEVES
W.A. KING JR.
LELAND & WELDON FLOYD
Pasture
Cemetery
TYPICAL SECTION OF CHANNEL
HASKELL
TEXAS

PLATE 12



ESTIMATED QUANTITIES

DESCRIPTION	Class A Concrete Slabs C.Y.	Class A Concrete Bents C.Y.	Reinf. Steel Lbs.	Railing, Type II (Mod.) L.F.	16" □ Prec. Conc. Piles L.F.	Uncl'd Struct. Excav. C.Y.	Class "B" Conc. Rip Rap C.Y.	1¼" ∅ R.M. Conduit L.F.
2-Abutment Bents		19.0	2258		200	29	18	
5 Interior Bents		37.5	3640		672			
6-25'-0" Slab Spans	156.6		30,330	293.6				175
Totals	156.6	56.5	36,228	293.6	872	29	18	175

TOP OF CAP ELEVATIONS

Bent	Station	Elev.
1	674 + 36.20	46.485
2	674 + 61.20	46.876
3	674 + 86.20	47.110
4	675 + 11.20	47.188
5	675 + 36.20	47.110
6	675 + 61.20	46.876
7	675 + 86.20	46.485

LAYOUT
HUNTING BAYOU BRIDGE
STA 674+36.2 TO 675+86.2
LEFT FRONTAGE ROAD
SCALE 1"=10'

FEBRUARY 11, 1958
TEXAS I 610-7(26) 801
12 Harris

PLATE 13

BILLS OF REINFORCING STEEL — FOR 44' CLEAR WIDTH — BARRELS ONLY

5' × 2'

MARK	A	B	C	D	E1	E2	F1	F2	F3	Z	H	K
2 SPANS ~ 5' × 2'												
NUMBER	46	91	122	122	45	78	19	8	13	46	4	24
SIZE	#4	#4	#4	#4	#4	#4	#4	#4	#4	#4	#4	#4
SPACING	12"	12"	9"	9"	12"	7"	~	~	~	12"	~	12"
LENGTH	11'-4"	11'-2"	4'-10"	4'-1"	4'-8"	4'-8"	45'-0"	45'-0"	45'-0"	5'-6"	11'-2"	3'-11"
WEIGHT	348	679	394	333	140	243	572	241	391	169	30	63
3 SPANS ~ 5' × 2'												
NUMBER	46	91	122	122	90	156	29	12	19	92	4	36
SIZE	#4	#4	#4	#4	#4	#4	#4	#4	#4	#4	#4	#4
SPACING	12"	12"	9"	9"	12"	7"	~	~	~	12"	~	12"
LENGTH	17'-0"	16'-8"	4'-10"	4'-1"	4'-8"	4'-8"	45'-0"	45'-0"	45'-0"	5'-6"	16'-8"	3'-11"
WEIGHT	522	1013	394	333	281	487	873	361	572	338	45	94
4 SPANS ~ 5' × 2'												
NUMBER	46	91	122	122	135	234	39	16	25	138	4	46
SIZE	#4	#4	#4	#4	#4	#4	#4	#4	#4	#4	#4	#4
SPACING	12"	12"	9"	9"	12"	7"	~	~	~	12"	~	12"
LENGTH	22'-8"	22'-2"	4'-10"	4'-1"	4'-8"	4'-8"	45'-0"	45'-0"	45'-0"	5'-6"	22'-2"	3'-11"
WEIGHT	697	1347	394	333	421	730	1174	482	753	507	59	120
5 SPANS ~ 5' × 2'												
NUMBER	46	91	122	122	180	312	49	20	31	184	4	58
SIZE	#4	#4	#4	#4	#4	#4	#4	#4	#4	#4	#4	#4
SPACING	12"	12"	9"	9"	12"	7"	~	~	~	12"	~	12"
LENGTH	28'-4"	27'-8"	4'-10"	4'-1"	4'-8"	4'-8"	45'-0"	45'-0"	45'-0"	5'-6"	27'-8"	3'-11"
WEIGHT	871	1682	394	333	562	973	1475	602	933	676	74	152
6 SPANS ~ 5' × 2'												
NUMBER	46	91	122	122	225	390	59	24	37	230	4	68
SIZE	#4	#4	#4	#4	#4	#4	#4	#4	#4	#4	#4	#4
SPACING	12"	12"	9"	9"	12"	7"	~	~	~	12"	~	12"
LENGTH	34'-0"	33'-2"	4'-10"	4'-1"	4'-8"	4'-8"	45'-0"	45'-0"	45'-0"	5'-6"	33'-2"	3'-11"
WEIGHT	1045	2016	394	333	702	1217	1776	722	1114	845	89	178

5' × 3'

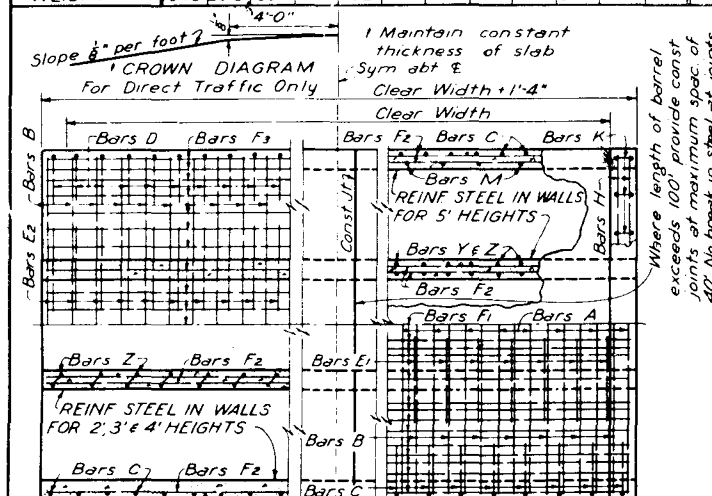
MARK	A	B	C	D	E1	E2	F1	F2	F3	Z	H	K
2 SPANS ~ 5' × 3'												
NUMBER	46	91	122	122	45	78	19	8	13	46	4	24
SIZE	#4	#4	#4	#4	#4	#4	#4	#4	#4	#4	#4	#4
SPACING	12"	12"	9"	9"	12"	7"	~	~	~	12"	~	12"
LENGTH	11'-4"	11'-2"	5'-10"	4'-1"	4'-8"	4'-8"	45'-0"	45'-0"	45'-0"	7'-6"	11'-2"	3'-11"
WEIGHT	348	679	475	333	140	243	572	241	341	230	30	63
3 SPANS ~ 5' × 3'												
NUMBER	46	91	122	122	90	156	29	12	19	92	4	36
SIZE	#4	#4	#4	#4	#4	#4	#4	#4	#4	#4	#4	#4
SPACING	12"	12"	9"	9"	12"	7"	~	~	~	12"	~	12"
LENGTH	17'-0"	16'-8"	5'-10"	4'-1"	4'-8"	4'-8"	45'-0"	45'-0"	45'-0"	7'-6"	16'-8"	3'-11"
WEIGHT	522	1013	475	333	281	487	873	361	572	461	45	94
4 SPANS ~ 5' × 3'												
NUMBER	46	91	122	122	135	234	39	16	25	138	4	46
SIZE	#4	#4	#4	#4	#4	#4	#4	#4	#4	#4	#4	#4
SPACING	12"	12"	9"	9"	12"	7"	~	~	~	12"	~	12"
LENGTH	22'-8"	22'-2"	5'-10"	4'-1"	4'-8"	4'-8"	45'-0"	45'-0"	45'-0"	7'-6"	22'-2"	3'-11"
WEIGHT	697	1347	475	333	421	730	1174	482	753	691	59	120
5 SPANS ~ 5' × 3'												
NUMBER	46	91	122	122	180	312	49	20	31	184	4	58
SIZE	#4	#4	#4	#4	#4	#4	#4	#4	#4	#4	#4	#4
SPACING	12"	12"	9"	9"	12"	7"	~	~	~	12"	~	12"
LENGTH	28'-4"	27'-8"	5'-10"	4'-1"	4'-8"	4'-8"	45'-0"	45'-0"	45'-0"	7'-6"	27'-8"	3'-11"
WEIGHT	871	1682	475	333	562	973	1475	602	933	922	74	152
6 SPANS ~ 5' × 3'												
NUMBER	46	91	122	122	225	390	59	24	37	230	4	68
SIZE	#4	#4	#4	#4	#4	#4	#4	#4	#4	#4	#4	#4
SPACING	12"	12"	9"	9"	12"	7"	~	~	~	12"	~	12"
LENGTH	34'-0"	33'-2"	5'-10"	4'-1"	4'-8"	4'-8"	45'-0"	45'-0"	45'-0"	7'-6"	33'-2"	3'-11"
WEIGHT	1045	2016	475	333	702	1217	1776	722	1114	1152	89	178

5' × 4'

MARK	A	B	C	D	E1	E2	F1	F2	F3	Z	H	K
2 SPANS ~ 5' × 4'												
NUMBER	46	91	122	122	45	78	19	12	13	46	4	24
SIZE	#4	#4	#4	#4	#4	#4	#4	#4	#4	#4	#4	#4
SPACING	12"	12"	9"	9"	12"	7"	~	~	~	12"	~	12"
LENGTH	11'-4"	11'-2"	6'-10"	4'-1"	4'-8"	4'-8"	45'-0"	45'-0"	45'-0"	9'-6"	11'-2"	3'-11"
WEIGHT	348	679	557	333	140	243	572	361	391	292	30	63
3 SPANS ~ 5' × 4'												
NUMBER	46	91	122	122	90	156	29	18	19	92	4	36
SIZE	#4	#4	#4	#4	#4	#4	#4	#4	#4	#4	#4	#4
SPACING	12"	12"	9"	9"	12"	7"	~	~	~	12"	~	12"
LENGTH	17'-0"	16'-8"	6'-10"	4'-1"	4'-8"	4'-8"	45'-0"	45'-0"	45'-0"	9'-6"	16'-8"	3'-11"
WEIGHT	522	1013	557	333	281	487	873	542	572	584	45	94
4 SPANS ~ 5' × 4'												
NUMBER	46	91	122	122	135	234	39	24	25	138	4	46
SIZE	#4	#4	#4	#4	#4	#4	#4	#4	#4	#4	#4	#4
SPACING	12"	12"	9"	9"	12"	7"	~	~	~	12"	~	12"
LENGTH	22'-8"	22'-2"	6'-10"	4'-1"	4'-8"	4'-8"	45'-0"	45'-0"	45'-0"	9'-6"	22'-2"	3'-11"
WEIGHT	697	1347	557	333	421	730	1174	722	753	876	59	120
5 SPANS ~ 5' × 4'												
NUMBER	46	91	122	122	180	312	49	30	31	184	4	58
SIZE	#4	#4	#4	#4	#4	#4	#4	#4	#4	#4	#4	#4
SPACING	12"	12"	9"	9"	12"	7"	~	~	~	12"	~	12"
LENGTH	28'-4"	27'-8"	6'-10"	4'-1"	4'-8"	4'-8"	45'-0"	45'-0"	45'-0"	9'-6"	27'-8"	3'-11"
WEIGHT	871	1682	657	333	562	973	1475	903	933	1168	74	152
6 SPANS ~ 5' × 4'												
NUMBER	46	91	122	122	225	390	59	36	37	230	4	68
SIZE	#4	#4	#4	#4	#4	#4	#4	#4	#4	#4	#4	#4
SPACING	12"	12"	9"	9"	12"	7"	~	~	~	12"	~	12"
LENGTH	34'-0"	33'-2"	6'-10"	4'-1"	4'-8"	4'-8"	45'-0"	45'-0"	45'-0"	9'-6"	33'-2"	3'-11"
WEIGHT	1045	2016	557	333	702	1217	1776	1084	1114	1460	89	178

5' × 5'

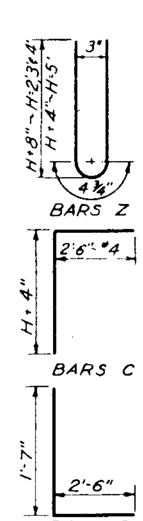
MARK	A	B	C	D	E1	E2	F1	F2	F3	Z	Y	M	H	K
2 SPANS ~ 5' × 5'														
NUMBER	46	91	122	122	45	78	19	24	13	46	46	62	4	24
SIZE	#4	#4	#4	#4	#4	#4	#4	#4	#4	#4	#4	#4	#4	#4
SPACING	12"	12"	9"	9"	12"	7"	~	~	~	12"	12"	18"	~	12"
LENGTH	11'-7"	11'-5"	7'-10"	4'-1"	4'-8"	4'-8"	45'-0"	45'-0"	45'-0"	10'-10"	3'-4"	4'-11"	11'-5"	3'-11"
WEIGHT	356	694	638	333	140	243	572	722	391	333	102	204	31	63
3 SPANS ~ 5' × 5'														
NUMBER	46	91	122	122	90	156	29	32	19	92	92	62	4	36
SIZE	#4	#4	#4	#4	#4	#4	#4	#4	#4	#4	#4	#4	#4	#4
SPACING	12"	12"	9"	9"	12"	7"	~	~	~	12"	12"	18"	~	12"
LENGTH	17'-4"	17'-0"	7'-10"	4'-1"	4'-8"	4'-8"	45'-0"	45'-0"	45'-0"	10'-10"	3'-4"	4'-11"	17'-0"	3'-11"
WEIGHT	533	1033	638	333	281	487	873	963	572	666	205	204	45	94
4 SPANS ~ 5' × 5'														
NUMBER	46	91	122	122	135	234	39	40	25	138	138	62	4	46
SIZE	#4	#4	#4	#4	#4	#4	#4	#4	#4	#4	#4	#4	#4	#4
SPACING	12"	12"	9"	9"	12"	7"	~	~	~	12"	12"	18"	~	12"
LENGTH	23'-1"	22'-7"	7'-10"	4'-1"	4'-8"	4'-8"	45'-0"	45'-0"	45'-0"	10'-10"	3'-4"	4'-11"	22'-7"	3'-11"
WEIGHT	709	1373	638	333	421	730	1174	1204	753	998	307	204	60	120
5 SPANS ~ 5' × 5'														
NUMBER	46	91	122	122	180	312	49	48	31	184	184	62	4	58
SIZE	#4	#4	#4	#4	#4	#4	#4	#4	#4	#4	#4	#4	#4	#4
SPACING	12"	12"	9"	9"	12"	7"	~	~	~	12"	12"	18"	~	12"
LENGTH	28'-10"	28'-2"	7'-10"	4'-1"	4'-8"	4'-8"	45'-0"	45'-0"	45'-0"	10'-10"	3'-4"	4'-11"	28'-2"	3'-11"
WEIGHT	886	1712	638	333	562	973	1475	1445	933	1331	409	204	75	152
6 SPANS ~ 5' × 5'														
NUMBER	46	91	122	122	225	390	59	56	37	230	230	62	4	70
SIZE	#4	#4	#4	#4	#4	#4	#4	#4	#4	#4	#4	#4	#4	#4
SPACING	12"	12"	9"	9"	12"	7"	~	~	~	12"	12"	18"	~	12"
LENGTH	34'-7"	33'-9"	7'-10"	4'-1"	4'-8"	4'-8"	45'-0"	45'-0"	45'-0"	10'-10"	3'-4"	4'-11"	33'-9"	3'-11"
WEIGHT	1063	2052	638	333	702	1217	1776	1696	1114	1664	512	204	90	183

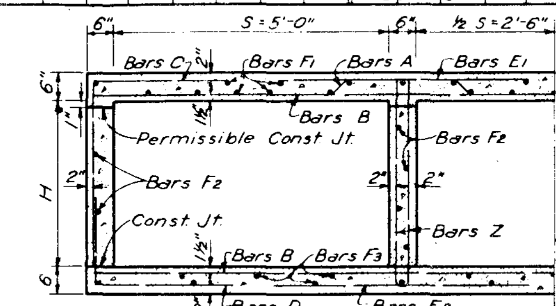


PART PLANS

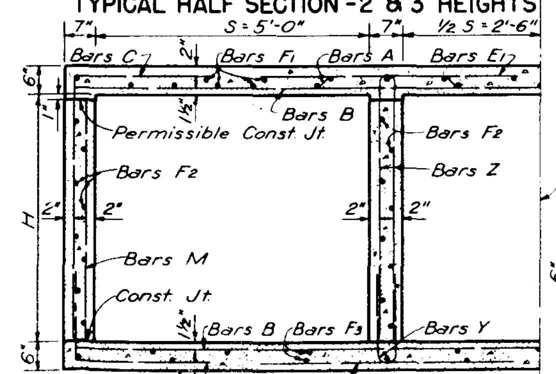
BOTTOM SLAB   TOP SLAB

NOTE: TOP & BOTTOM SLAB REINFORCING STEEL SIMILAR FOR CULVERT SIZES SHOWN ON THIS SHEET.





TYPICAL HALF SECTION - 2' & 3' HEIGHTS



TYPICAL HALF SECTION - 5' HEIGHT

BARREL QUANTITIES FOR 44' CLEAR WIDTH

CULVERT SIZE (S × H)	NO OF SPANS	LENGTH OF STRUCT.	*BARREL QUANTITIES CONC. CU.YDS.	*BARREL QUANTITIES STEEL LBS	QUANTITIES P.L.F. BBL. CONC. CU.YDS.	QUANTITIES P.L.F. BBL. STEEL LBS.
5' × 2'	2	11'-6"	24.91	3603	0.537	77.23
	3	17'-0"	36.10	5313	0.778	113.86
	4	22'-6"	47.31	7017	1.019	150.49
	5	28'-0"	58.46	8727	1.259	187.11
	6	33'-6"	69.65	10,431	1.500	223.75
5' × 3'	2	11'-6"	27.45	3745	0.593	80.34
	3	17'-0"	39.48	5517	0.852	118.34
	4	22'-6"	51.48	7282	1.111	156.28
	5	28'-0"	63.49	9054	1.370	194.24
	6	33'-6"	75.55	10819	1.630	232.20
5' × 4'	2	11'-6"	29.94	4009	0.648	86.13
	3	17'-0"	42.82	5903	0.926	126.77
	4	22'-6"	55.69	7789	1.204	167.41
	5	28'-0"	68.52	9683	1.481	208.04
	6	33'-6"	81.40	11,571	1.759	248.78
5' × 5'	2	11'-9"	34.99	4822	0.759	103.93
	3	17'-4"	49.55	6927	1.074	149.18
	4	22'-11"	64.10	9024	1.389	194.44
	5	28'-6"	78.66	11,128	1.704	239.69
	6	34'-1"	93.21	13,234	2.019	284.95

* These quantities do not include paving brackets, toe walls or wings.

PV'T BRKT. QUANTITIES

2 - PV'T BRACKETS 24'-0" LONG	
CONCRETE	STEEL
Cu. Yd	Lb
1.19	264

GENERAL NOTES :-

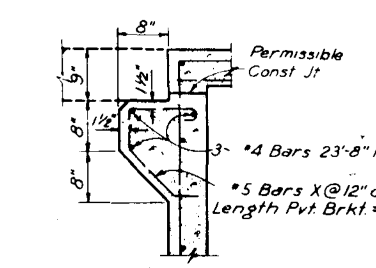
Design Loading: H20- or H20 S16- in accordance with A.A.S.H.O. 1957 Standard Specifications.

All concrete shall be Class A. Chamfer exposed corners 3/4".

All dimensions relating to reinforcing steel are to centers of bars.

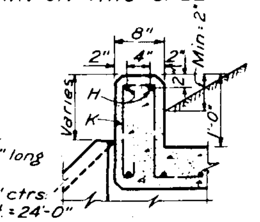
Quantities of reinforcing steel shown hereon are for 44'-0" clear width between headwalls.

Construction Joint shown at flow line may be raised a maximum of 6" at the option of the contractor. Adjust length of vertical steel as required.

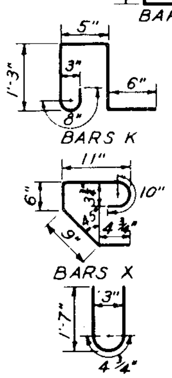


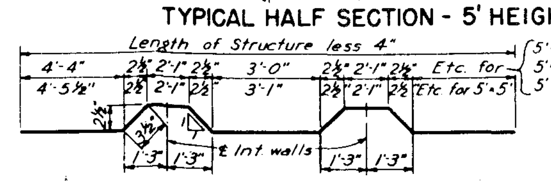
PAVEMENT BRACKET

To be used only when called for on plans.

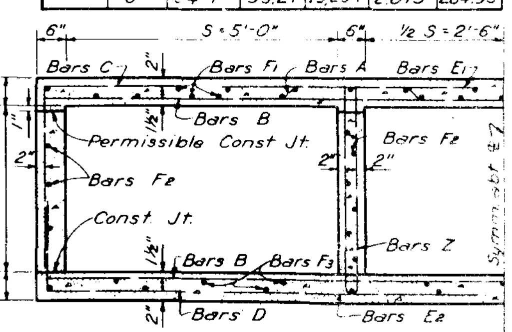


SECTION THRU CURB





BARS A



TYPICAL HALF SECTION - 4' HEIGHT

TEXAS HIGHWAY DEPARTMENT

MULTIPLE BOX CULVERTS

SIZES 5'x2', 5'x3', 5'x4', 5'x5'

DIRECT TRAFFIC TO 4'-0" FILL

MC5-1

DN W.H.	DRAWING	DATE	FED. ROAD DIV. NO.	STATE	FEDERAL AID PROJECT NO.	SHEET NO.
CK DN R.M.M.	Original	JAN 1958	6	TEXAS	T610-7(26)801	97
DW M.D.A.	Rev. Jan. 1959		STATE DIST NO.	COUNTY	CONTROL NO. / SECTION NO. / JOB NO.	HIGHWAY NO.
CK DW K.M.			10	HARRIS	271 / 14 / 22	T610
TR A.O.B.						
CK TR M.D.A.						

PLATE 14

Control 2697-1-2
S2712(?)
Hwy. FM 2668
Matagorda County

TEXAS HIGHWAY DEPARTMENT

GOVERNING SPECIFICATIONS AND SPECIAL PROVISIONS

All specifications and special provisions applicable to this project are identified as follows;

STANDARD SPECIFICATIONS: Adopted by the State Highway Department of Texas, January 2, 1962.

Items 1 to 9 Incl.	General Requirements and Covenants
Item 110	Roadway Excavation (102)(132)
Item 120	Channel Excavation
Item 140	Overhaul
Item 213	Rolling
Item 252	Salvaging and Replacing Base
Item 260	Lime Treatment for Materials in Place (264)(500)
Item 262	Lime Treatment for Base Courses
Item 310	Prime Coat (300)
Item 320	One Course Surface Treatment (302)(304)
Item 400	Structural Excavation
Item 464	Reinforced Concrete Pipe Culverts
Item 472	Relaying Culvert Pipe
Item 496	Removing Old Structures
Item 550	Right of Way Markers
Item 580	Structure for Field Office and Laboratory (Type D)

SPECIAL PROVISIONS: Special Provisions will govern and take precedence over the specifications enumerated hereon wherever in conflict therewith.

Required Provisions-Secondary Road Plan Projects-Federal-Aid Contracts
Approved September 6, 1962
Special Provision to Required Contract Prov. for Federal Aid Projects (Group Matagorda County)
Special Provision "Important Notice to Contractors" (000---237)(000--1218)
Special Provision to Item 6 (006---001)
Special Provision to Item 8 (008---026)
Special Provision to Item 213 (213---001)
Special Provision to Item 464 (464---005)
Special Provision to Item 1103 (1103---002)

SPECIAL SPECIFICATIONS:
Item 1103 Flexible Base (Delivered)(1103.000)

GENERAL: The above listed specification items are those under which payment is to be made. These, together with such other pertinent items, if any, as may be referred to in the above listed specification items, and including the special provisions listed above, constitute the complete specifications for this project.

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