PLAN PREPARATION

BOOK IV

Prepared By The Bridge Division

Of

The Texas Highway Department

Austin, Texas December 1952

FOREWORD

This pamphlet is Book IV of a five book manual on Plan Preparation that has been prepared jointly by the Road Design, Bridge, and Land Service Roads Divisions of the Texas Highway Department. The primary purpose of the manual is to present material covering plan preparation to selected District Representatives who in turn will become instructors for the entire District Personnel. Book III and Book IV of the Manual, which have been prepared by the Bridge Division, contain not only material always applicable to structure planning and plans, but also several of the subjects presented have been selected because of their frequent reoccurrence in planning improvements to the highway system in its present state of development. A careful study of the entire manual is particularly necessary in order that the Department may uphold established standards in plan preparation and continue to advance in that important phase of highway improvement.

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DEPARTMENTAL USE ONLY

WIDENING SINGLE AND MULTIPLE BOX CULVERTS

The widening of box culverts is part of our effort to salvage some of the good structures we now have in use, but because of limited roadway width, have become out of date for our modern highways. No one will deny that our country is rapidly approaching the time when we must salvage all things possible in order to conserve our natural resources and our highway investment. Culverts are not spectacular structures, but are the stepping stones to our large bridges and a very vital element in the highway system. Most of the culverts that are to be widened are good structures and are adequate except for length of barrel, or roadway width.

Preparing contract plans for culvert widening presents one of our most difficult problems. The problem is difficult because of the fact that they are small structures and we have so many of them to be widened; and also because of the fact that they present so many different problems in widening. We tend to feel that none of them are worthy of a great amount of plan work, and this is generally true. Too often our Engineers bog down and become disgusted with the great amount of time required to prepare plans for even a simple culvert widening. This is usually caused by the Engineer not having a simple and standard procedure for preparing widening plans for any type structure, and culverts are certainly no exception.

Good engineering calls for an adequate design at a minimum cost, and the present culvert standards have been prepared along these lines. Therefore, in preparing culvert widening details the fullest use should be made of the latest standard culvert details. It is most uneconomical to just widen a culvert using the old culvert dimensions and reinforcing steel as a pattern. In the unusual widening where special details must be drawn, the standards should still be used as a guide. It is a rare case where any special design is required. With the structural design taken care of, the biggest problem is presenting the details in clear and understandable language, and the efforts of this paper are directed towards that goal.

No claim is made that anything presented here is original. A study has been made of a number of past culvert widening details prepared in the Districts, and it is hoped that enough good ideas have been combined to present a good culvert widening procedure. Standardization of procedure in the structure widening business is certainly to be desired by all people involved. It has been found that some Engineers go into too much detail in their plan work, and show complete details for each culvert to be widened, which requires a great amount of repetition of detail and wasted time and effort on their part. On the other hand, there are those who do less than the minimum necessary, and it is often impossible to check their work or to know exactly what they want. A middle road should be found.

Some of the unusual problems encountered in culvert widening will be covered briefly. Occasionally it is found in widening multiple boxes that some of the openings are no longer needed. Rather than widen all of the boxes, it is better to plug the ones that are no longer needed and then widen only those actually required. Another problem sometimes encountered is a vertical drop in the stream bed just at the downstream end of the box. This can be taken care of by building a vertical drop box for the required drop or a short steeply sloped section, and then straightening out at the new stream bed elevation with the usual box culvert. Still another problem is a change in direction of the stream bed in the limits of the desired culvert widening. This will require a transition section for a change in direction.

All of the above problems are special conditions and must be handled by special structural details. In any case, the structural standards we have available should be used to the fullest extent, with special details only where needed. Using the culvert standards to work up widening details is done in the following manner. Reference is made to the standard being used as a basis for the widening, a bill of reinforcing steel is prepared, and quantities are tabulated. It is not necessary to draw a detail of the culvert or to detail the bars. The standard sheet is included in the plans, which will show these things. An example of this is shown on the sheet, "Typical Widening, Box Culverts," in the widening of a multiple box culvert. It is very important to use the same bar designations in the reinforcing steel table as are used in the standards.

The preparation of structural details for widening will now be considered. First, consider the widening of the single box culvert. This has been made easy by use of the standard SCL, which has been especially prepared for this purpose. Where the single box culvert has a straight line widening, it isn't even necessary to show any bill of reinforcing steel. Just show near the culvert cross section or in the culvert summary on the Estimate and Quantity Sheet the amount of steel and concrete under barrel quantities as taken directly from the SCL. The SCL shows quantities for a 10 feet extension, and quantities for a one foot extension. The quantities for the actual widening are computed and shown in the special table. The other necessary quantities, such as excavation and railing, are added to the table and all quantities totaled.

Next, consider the widening of multiple boxes. This would be quite a difficult operation without the use of the standard culvert details, as this is the key to culvert widening. Every possible use must be made of the standard culvert details. The first problem encountered in widening is that the slab and wall thickness of the present culverts are not as thick as the old culverts being widened. The different slab thickness will cause no dufficulty, usually, but the walls must be considered. In the even numbered boxes the center walls are centered on each other, and in the odd numbered boxes, the center barrels must be centered as shown on the sheet "Typical Widenings, Box Culverts." This can easily great as to prevent a good tie between new and old walls. As an example of this, assume the old culvert walls are eight inches thick and the new standards show a wall thickness of six inches. In a five box culvert with the center barrels in line, the outside faces of outside walls will be offset by an amount of 6", which is too much for a good tie. When this does occur, a modification must be made in the span length so that all interior walls are centered on each other. This will be discussed more in detail later. A simple sketch similar to that shown on the typical widening detail should be included to show how walls are to be matched. A smooth transition should be indicated where the walls do not exactly match. In making the tie of the old culvert to the new, it is necessary to have adequate bar lap to develop the steel, or the old steel must be welded to the new steel. The plans must clearly show the break back line of both slabs and walls sufficient for adequate joining the new construction to the old. For MBC extensions of 5 feet and less, existing bars should be exposed in the top and bottom slabs and all walls to tie the old to the new construction. For extensions greater than 5 feet, where good foundation conditions exist, it is not considered necessary to break back the interior walls to provide a tie. In any case, the following note should be placed on all culvert widening details: "All arc welding of reinforcing steel shall be done with electrodes of the E-6016 or E-7016 types."

The table shown at the top right of the sheet "Typical Widening, Box Culverts" shows all the information necessary for the widening.

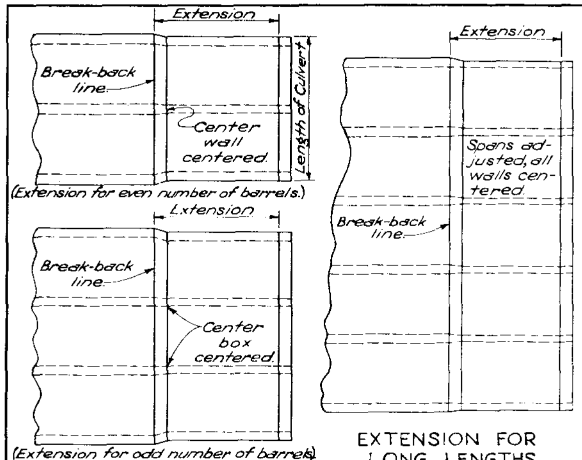
All of the bars shown in the table are taken from the standard MBC of this design, and this standard sheet should be included in the plans. In the example shown, assume that the widening had been 5 feet upstream and 8 feet downstream. In this case the longitudinal steel, Bars F, will have to be broken down with subscripts for the two different lengths of widening, as F_{1u}, F_{1d}, F_{2u}, F_{2d}, etc. The transverse steel is the same upstream and downstream except for the number of bars. No further detail of these bars is necessary. Next comes toewalls and wingwalls, and these are taken directly from the standard for this design. A total of all quantities completes the table. This is a lot of information, in a very compact table yet easy to prepare, easy to check and easy to use. As can be seen, as many as 10 or 12 culverts can be covered on one plan sheet.

In the case of the long length culvert, length being along the centerline of the roadway, where the accumulated wall offset is too great, the culvert span length must be changed so that all walls are centered on each other. The standard detail is still used as a guide, and a special detail is drawn showing the altered dimensions, a detail of the reinforcing steel, and the quantities. The same type table is used as for the standard multiple box culvert just discussed. No attempt should be made at redesign of the slab for the slightly longer spans; just lengthen the transverse bars to fit the new spans. This requires a complete special detail of the widening of a culvert based on the standard details.

The details have been prepared for the widening of a single box culvert 4' x 4' from a normal to a 30° skew and ending with a suitable wingwall. This is shown at the bottom of the sheet, "Typical Widening, Box Culverts." This example is a combination of standard details for the normal straight line lengthening and the 30° flared wingwalls, and special details for the transition sections as shown. The necessary special details are shown. The standard details are combined in the table to give a complete widening detail for a very difficult culvert. Notice that the longitudinal steel from the standard barrel extension also extends into the special transitions. The bars are detailed, billed, and then broken down to a quantity for the transition sections and a quantity for the normal sections. These total quantities for one structure as shown in the tables are now ready to be transferred to the "Summary of Structures" on the "Estimate and Quantity" sheet.

As a summary, the following plan sheets should be included in a good set of plans for culvert widening. First is the "Estimate and Quantity" sheet, then the "Plan-Profile" sheet, if this sheet is to be included. Next is the sheet "Cross Section at Culvert Site," followed by the most important sheets, the "Structural Details for Culvert Widening," and then the "Standards."

This outline of a method for preparing a set of culvert widening plans should be used as a guide, and from this a standard procedure established. This should be of great benefit to all concerned, and make culvert widening a bit easier.



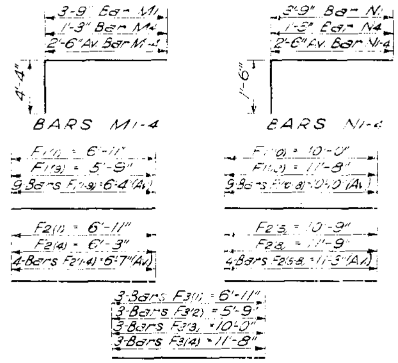
EXTENSION FOR SHORT LENGTHS

EXTENSION FOR LONG LENGTHS

BILL OF REINFORCING STEEL AND QUANTITIES FOR WIDENING MULTIPLE BOX CULVERTS

Station	Existing Design	Widening Design Bbl.	Widening Design Wing	Bar	A	B1	B2	C	D	E1	E2	F1	F2	F3	H	K	M	Y	Z	Barrel Quantities Reinf. Lbs.	Barrel Quantities Conc. Cu.Yds.	Toe wall Length	Wing & Toewall Quantities Reinf. Lbs.	Wing & Toewall Quantities Conc. Cu.Yds.	Total for one Structure Reinf. Lbs.	Total for one Structure Conc. Cu.Yds.
Two Spans @ 10'×8' Extended 5' Downstream & 5' Upstream																										
				No.																						
	MBC-26	MC10-1	MCW-F2	Size																						
607+10.3				Spa.																						
687+14.0				Length																						
				Weight																						
Three Spans @ 8'×8' Extended 28'-6 Downstream																										
				No.																						
	MBC-24	MC8-1	MCW-F2	Size																						
				Spa.																						
702+10.7				Length																						
				Weight																						

NOTE:
All arc welding of reinforcing steel shall be done with electrodes of the E-6016 or E-7016 types.

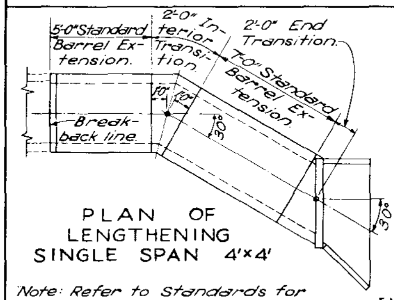


BARS F

BILL OF BARS F

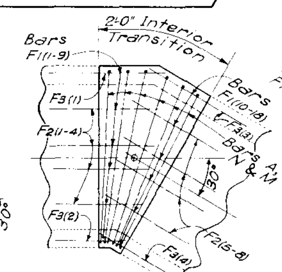
Bar	F1(1-9)	F1(10-18)	F2(1-4)	F2(5-8)	F3(1)	F3(2)	F3(3)	F3(4)
No.	9	9	4	4	3	3	3	3
Length	6'-4" Av.	10'-10" Av.	6'-7" Av.	11'-3" Av.	6'-11"	5'-9"	10'-0"	11'-8"
Length in Std. Lengthening	5'-0"	7'-0"	5'-0"	7'-0"	5'-0"	5'-0"	7'-0"	7'-0"
Length for Transitions	1'-4" Av.	3'-10" Av.	1'-7" Av.	4'-3" Av.	1'-11"	0'-9"	3'-0"	4'-8"

Note: For Bars K, M and N see SCL.

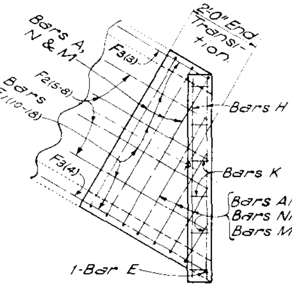


PLAN OF LENGTHENING SINGLE SPAN 4'×4'

Note: Refer to Standards for any details not shown.



DETAIL OF 2'-0" INTERIOR TRANSITION



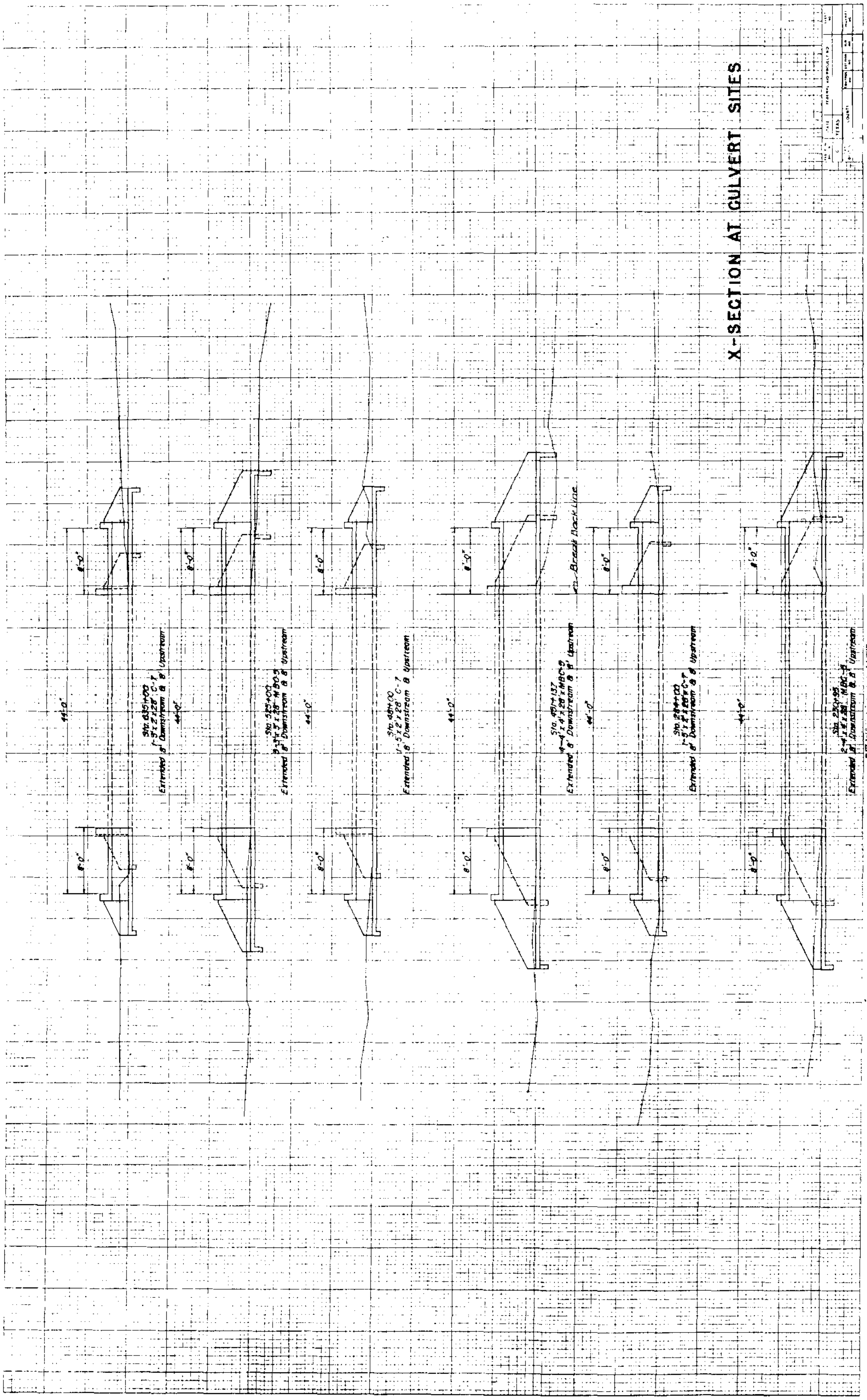
DETAIL OF 2'-0" END TRANSITION

SINGLE SPAN 4'×4' EXTENDED 16'-0" DOWNSTREAM (NORMAL TO 30° SKEW)

Station	Existing Design	Widening Design Bbl.	Widening Design Wing	Bar	A	A1-4 (1-ea)	E	F1(10-18)	F2(5-8)	F3(1-4)	H	K	M	M1-4 (1-ea)	N	N1-4 (1-ea)	Quantities 4'-0" Transition Reinf. Lbs.	Quantities 4'-0" Transition Conc. Cu.Yds.	Quantities 12'-0" Normal Barrel Lengthening Reinf. Lbs.	Quantities 12'-0" Normal Barrel Lengthening Conc. Cu.Yds.	Total Barrel Quantities 16'-0" Lengthening Reinf. Lbs.	Total Barrel Quantities 16'-0" Lengthening Conc. Cu.Yds.	Wing (FW-30°) Quantities Reinf. Lbs.	Wing (FW-30°) Quantities Conc. Cu.Yds.	Total for one Structure Reinf. Lbs.	Total for one Structure Conc. Cu.Yds.
	MBC-3	SC-NA	FW-30°	No.	9	4	1	18	8	12	4	6	9	4	9	4	292	1.60	515	4.00	807	5.60	298	2.59	1105	8.19
				Size	#4	#4	#4	#4	#4	#4	#4	#4	#4	#4	#4	#4										
435+28.0				Spa.	6"	6"	~	12"±	18"±	15"	Shown	12"	6"	6"	6"	6"										
				Length	4'-8"	2'-6" Av.	3'-11"	2'-7" Av.	2'-11" Av.	2'-7" Av.	5'-6"	3'-11"	13'-4"	6'-10" Av.	7'-8"	4'-0" Av.										
				Weight	28	7	3	31	16	21	15	16	80	18	46	11										

TYPICAL WIDENINGS BOX CULVERTS

6	TEXAS			


X-SECTION AT CULVERT SITES

WIDENING CONCRETE SLAB AND GIRDER BRIDGES

1. Introduction

During the preceding period instruction was given in the preparation of layouts and details for culverts that are to be widened. This period is to be devoted to the essentials necessary in the preparation of plans for the widening of reinforced concrete slab and reinforced concrete girder spans. Some portions of the following instructions may be a repetition of what has already been covered. This is to be expected since we are dealing with a similar type of construction, that is reinforced concrete.

The construction of new structures as well as the widening of existing bridges was almost discontinued during the war years. This was due principally to the shortage of critical material for highway construction. However, the improvement in roadways, that is, in pavements and shoulders, continued during this period, even though it was reduced to a certain extent. Thus the Department found itself with bridges that were inadequate and hazardous on many of the primary highways due to the fact that roadways had been rebuilt to modern standards and bridge construction and reconstruction deferred until such time as materials became available.

Since the War a large number of these structures have been widened, and we can expect this type of construction to continue for some time as the volume of traffic increases.

A short time ago a report was published on a certain section of highway, to the effect that due to the recent widening of pavement from 18' to 24' and the relatively high traffic count on this section it had become urgent that the structures along the route should be widened. With the improvement in the pavement the narrow bridges had become virtual bottle-necks which were extremely hazardous, particularly since the highway carries high speed traffic. Each of you can recall sections in your District on which this condition exists or has existed.

2. Nature and Extent of Widening

The extent to which our bridges should be widened will greatly depend on the roadway requirements. Short structures generally should be widened to full crown width, whereas, the width of longer structures will be governed by the width of the roadway pavement approaches. As we are primarily concerned with structural details, we will not go into a discussion of the geometric standards which will have to be considered in establishing the proper bridge roadway widths. There is one feature that should not be overlooked, however, and that is in widening large structures, it may be more economical to give consideration to making a change in the approach alignment in order that the widening operation can be made on one side of the structure only. By accomplishing this, the amount of old concrete that will have to be removed will be reduced by almost 50%. In addition, if the reinforcing steel is to be welded where it ties into the existing construction, the operation will be reduced by half. Additional saving, in some instances, may be made in the substructure reconstruction. This phase of the work will be discussed in a subsequent section.

3. Field Preparation of Details

The purpose of this school is the initial step in acquiring trained personnel in various phases of highway construction. The Bridge Division office has its troubles in employing and holding qualified engineering personnel. That is one of the reasons the policy has been adopted of letting the Districts prepare structure widening details wherever possible. It is realized that some of the Districts may lack personnel with this experience, and in those cases the Bridge Division will be glad to furnish design sketches showing the essential information. This procedure has been followed in many cases in the past, with very good results. In those Districts where men are available who with a little training could prepare satisfactory design and details, it is suggested that they prepare the design sketches first for subsequent review by the Bridge Division. This procedure will save time, particularly in those instances where your men have some doubt about their design. To use as a guide, there are attached sketches of both substructure and superstructure widenings, Plates No. 3 to No. 6.

4. Field Data

Whether the widening plans are to be prepared in the Districts or in the Austin office, it is essential, in order to be able to turn out a complete and accurate set of details that complete data about the existing structure be compiled. If plans of the structure to be widened are available, a great deal of the guess work can be eliminated. Nevertheless, even with these plans, a field survey should be made to ascertain that the bridge was built in accordance with the plans. Quite often field changes were made in some of the old structures which were not shown in the final plans.

As was suggested in the Bridge Circular No. 1-43, it may be wise to develop a form of questionnaire to be used in the collection of the required data for the widening. Some of the information to be secured may be listed as follows:

1. Correct stationing at bridge ends, with sketch giving measurements of each span along the outside of each curb.

2. Elevations at each end of span and tops of all substructure units.

3. Contour survey - where unusual siltation or erosion is evident, a contour map will be helpful in order that corrective measures may be provided when widening the existing structure.

4. Up-to-date information on high water and the performance of the bridge. Is the waterway adequate?

5. Reliable information on foundation materials under substructure. Boring information shown on old plans is not always reliable.

6. Type and dimensions of substructure.

7. Type and dimensions of superstructure - ballast or surfacing, if any.

8. Condition of existing structure.

Now with all of the above information pertaining to the existing structure, office personnel will be in a position to start the design calculations and details for the widening.

5. Types of Spans

Before getting into the design phase of the work a brief review will be made of some of the types of old standard structures that will be encountered in modernizing existing bridges.

First, consider the slab span type of construction. Typical of this type are the CT and CB series which were used between 1918 and 1923. These are similar in nature as far as the slab itself is concerned, the main difference being in the wheel load distribution reinforcing steel which is the steel transverse to the roadway center line. In CT-1 slabs these bars are not bent-up into the curb, whereas, in the CT-2 to CT-7 standards, they do extend into the curbs. These bars are ½" sq. spaced at 24" centers, which according to our present design specifications is not a large amount for distribution steel at that spacing.

The CB-Slabs have all the transverse bars bent-up into the curbs. However, their location varies from the front face of the curb to the back face. Also the spacing of these bars varies from 12" to 18". The location of the bent bars determines how much of the curb will have to be removed in order to use the existing steel for doweling into the new slab.

The CB-6 standard slab has the bars in the front curb face so that in order to be able to make use of this steel for doweling it will be necessary to remove all of the curb and railing. Should it be desirable to keep the rail in place until the slab is extended, there is an alternate method by which the new construction can be tied into the existing slab. A groove may be cut in the outside face of the slab to serve as a shear key, and in addition, holes drilled in the slab for dowels. A sketch showing the various curb sections for the CB and CT Standards is being included for reference, Plate No. 1.

Existing structures consisting of Concrete Girder spans will, in a big percentage of cases, be the G260 and DG Series, with an occasional Standard G-1 span. These span lengths vary from 16' to 26' with roadway widths 16' to 20'. With the exception of the G-1 type, girder spans do not present any special problems when it comes to widening the roadway. The overhanging curb with the slab reinforcing steel extending beyond the outside girder stems makes it ideal for anchoring the new slab and also makes it possible to keep the railing in place until after the deck has been widened. The G-1 Standard span will however be more difficult to widen since the transverse reinforcing steel terminates over the girder stem. If the concrete appears to be in good condition, the most satisfactory method of widening is to remove only enough of the old concrete to expose the ends of the hooks on the slab reinforcing, cut the bars, and butt weld the new bars to this steel. Trying to expose all of the hook for use as a lap with the new bar would require the removal of a large portion of the girder which is not considered good practice. Attached is a sketch showing the curb conditions for the various standards, Plate No. 2.

6. Loading

The live load for which the concrete slab and girder spans were designed, varied from a roller type of loading to the present truck load. However, they were more or less equivalent to our present H15 loading which is a 15 ton truck with 0.2 of the truck load on the front axle and 0.8 on the rear axle. The design stresses were the same for all of the old span designs; 650 pounds per square inch for concrete and 16,000 pounds per square inch for the reinforcing steel. The principal difference between our present designs and that of the old standard spans, is the method of load distribution. If the rating or capacity of the old slab and girder spans is checked, using our present day load application and design stresses, it will be found that most of these spans are equivalent to our H20 designs. That is one of the reasons we are able to keep these old bridges in service on our primary highways, even though they may need widening to accommodate present day traffic.

The Bureau of Public Roads has adopted a policy of requiring that portion of the structure that is to be widened to be designed for an H20 loading regardless of what the existing design rating may be. That fact should be kept in mind when preparing plans for bridges that are on the primary system and when the project is to be partially financed with Federal funds.

7. Cutting Old Concrete

The first principal to follow in widening any concrete structure is to keep the amount of cutting of old concrete to a minimum. Not only will this result in the most economical construction, but it also tends to retain the maximum strength of the part of the old structure that is to remain in place. Second, the break in the old concrete should be made in such a manner as to be able to make use of any reinforcing steel in the existing spans. In many cases the break can be located so that the old railing may be kept in place until after the substructure and the deck have been placed. Construction procedure of this nature reduces the hazard to both the traveling public and to the contractor's forces, eliminates the need of providing temporary railing on the structure, or the handling of traffic over detours.

8. Design

In order to prepare adequate design sketches or details of widening, it is necessary to have some knowledge of the theory of Reinforced Concrete design, to be able to calculate moments and shears and to be familiar with the A. A. S. H. O. Standard Design Specifications for Highway Bridges. Each District has at least one copy of these specifications and the Bridge Division will supply additional copies when needed. Practically all of the widenings done up to date have been simple spans which do not present a particularly involved or complex design problem. If the designer has not had an opportunity recently to make use of his structural design knowledge, a little study of texts or reference books in the sections devoted to slab and T-Beam Design will be refresher enough to enable him to cope with most concrete widening problems.

(A) Concrete Slabs

The best method by which to explain the steps necessary to develop a slab design, is to work through a slab problem.

Assume an old CB-4 slab with a 10' - 0" clear span, 16' - 0" roadway which is to be widened to 24' - 0" on one side only. Design loading is to be H20, and allowable stresses f_c = 1200 lbs. per sq. in. and f_s = 18000 lbs. per sq. in.

The first step is to determine the slab thickness and the amount of reinforcing steel needed in the new 8' - 0" section of roadway. In slab design, a one foot wide segment is considered for all of the calculations. To arrive at the dead load, a 10 inch slab thickness will be assumed; if the assumption is in error, the preliminary results should be modified. The dead load per foot of a 10" slab is 125 pounds, and the bending moment = $1/8 \times 125 \times 11^2$ = 1890 lbs. The 11' - 0" span length is considered the distance center to center of bearing or in this case 1' - 0" more than the clear distance. Next is needed the moment due to live load. Referring to the A. A. S. H. O. Specifications, Sec. 3.3.2 - Case B, Main reinforcement parallel to traffic, the distribution formula for spans

2 to 12 feet, which is within the limits of this span is E = .175 S + 3.2 or .175 x 11 + 3.2 = 5.1 feet. That means that the wheel load can be spread over a width of 5.1 feet of slab. As this span is 11' - 0" in length, only the rear axle will be located on the span in determining the maximum live load stresses. Note that the specifications stipulate that a 24,000 lb. axle load, or 12,000 lb. wheel load, is to be used when span length is less than 18 ft. Therefore the live load per foot of slab width = 12000 ÷ 5.1 = 2350 lb. and the maximum bending moment due to this load is 1/4 x 2350 x 11 = 6460 foot pounds. In designing concrete and steel structures, impact has to be added in the amount determined from the impact formula given in Sec. 3.2.12 of the specifications. For timber structures impact is omitted. Impact in this case is 30% of the live load, or 6460 x .30 = 1940 foot pounds. Summarizing the bending moments, D. L. 1890 + L. L. 6460 + Impact 1940 = 10,290 foot pounds. For a balanced design, by which is meant developing the stresses in the steel and concrete up to the allowable permitted by the specifications, $d = \sqrt{\frac{M}{\frac{1}{2} f_c k j b}}$ or $d = \sqrt{\frac{M.}{bR}}$ From the tables of coefficients, which can be found in any standard handbook on reinforced concrete, the value of R for f_c = 1,200 p. s. i. and f_s = 18,000 p. s. i. is found to be 208; therefore the required net depth of slab is $\sqrt{\frac{10{,}290 \times 12}{12 \times 208}} = 7"$, and with a 1 3/4 inch cover for the reinforcing steel, the overall depth is 8 3/4". Correcting the dead load on the basis of a 8 3/4" slab in place of 10" as originally assumed, the new total bending moment is 10,054 foot pounds. The reinforcing steel

required for this moment is $\frac{10{,}054 \times 12}{18{,}000 \times .88 \times 7} = 1.08$ sq. in. per foot of slab width. Our general policy is to space the bars in slabs between 5 and 7 inches, and in this case, you could use #6 bars spaced at 5" on centers or #7 spaced at $6\frac{1}{2}$" centers. Either will be satisfactory. The bond and shear stresses can be considered satisfactory if the slab is designed by the above method. Reinforcing steel in the curbs will depend on the type of curb that is to be used on the widened structure. It is suggested that the details shown on various spans in the book of mimeographed standards, be followed, these include 9" and 18" wide curbs, and also slabs without curbs.

The amount of transverse reinforcement or distribution steel to be provided in all slab spans shall be the percentage of the main reinforcing steel required for positive moment as given by the formula in Sec. 3.3.2 (c) of the A. A. S. H. O. Specifications.

The next step is to tie onto the existing slab. The curb section on the CB-4 standard is such that a portion of the concrete can be removed, exposing the transverse reinforcing steel, and at the same time keep the concrete railing in place. On the detail plans it should be noted that the curb bars are to be bent down into the plane of reinforcing in the new slab. If the bars are long enough to provide a 30 diameter lap, no welding need be done. However, if the lap is short, the bars should be lap welded or butt welded.

In almost all cases, the new slab that is added is not as deep as the existing slab This is principally due to the fact that our present design specifications permit higher concrete stress than those in use when the existing structure was designed. To avoid an abrupt change in depth at the point of break, it is good practice to provide a transition for a short distance by sloping the bottom of the slab. The final note on the detail is to remove the rail and curb to the top of slab.

(B) Concrete Girder

The design of a concrete girder span is a little more complex, since the individual girders are designed as T-Beams. However, in almost any text book on concrete, will be found formulas or curves which will assist in solving the stresses in the concrete and reinforcing steel, and determining the amount of steel required.

In order to illustrate the procedure, and to interpret the design specifications as they apply to a concrete girder, a span of this type will be considered in the next example. Assume an old G263 standard girder, span length 24' - 0" with a 20' - 0" roadway is to be widened to a 28' - 0" roadway. The widening is to be done all on one side and designed to carry H20 loading. The first step is to make a preliminary sketch to determine how many girders you will need for the extension and their spacing. The design of the slab section is similar to the problem just completed; the only difference being in the distribution of the live load. The formula to be used in this case is for reinforcement perpendicular to the traffic, as given in Sec. 3.3.2, Case A, of the A. A. S. H. O. Specification, and as the span will be less than 7' the distribution E = .6S + 2.5. Some time may be saved by using one of the slabs in the Book of Standards which has a corresponding span length. In almost all cases where the outside girder is under the curb and it is proposed to leave the girder in place, it will be necessary to place a new girder adjacent to the existing girder. This is a design requirement, since the curb on the old span serves as part of the edge beam of the span. Having to remove the curb to widen the roadway, reduces the strength of the girder to such an extent that an additional girder has to be provided in order to be able to carry the design live load. Again it is important to tie the existing slab reinforcing steel to the steel in the new slab, otherwise, the two girders will not act together and distribute the wheel loads between them. The policy of the Bridge Division has been to design the new girder that is to be next to the old curb girder for one half of a wheel load plus the dead load from new construction but not to use less reinforcing steel than is in the existing girder. For a widening of 8' - 0", one additional girder will be required, located about 2' - 0" inside the curb line. Since in the design of stringers the wheel is not to be placed nearer than 2' - 0" of the curb, the outside girder will be designed for one full wheel load. Note that the design wheel load for girders is a 16,000 lb. load rather than the 12,000 lb. load used for short slabs. In those instances where the new width requires the use of more than two new girders, the inside girders are designed for a live load as determined in accordance with Sec. 3.3.1 (b) of the specification. To illustrate, if the girder spacing center to center is 6' - 6", then the wheel loads to the inside girders would be equal to S/5.0 or 6.5/5 = 1 .3 wheels.

Getting back to the problem, one girder is a T-Beam and one that has a flange on one side only. In T-Beam design, the slab is considered as an integral part of the beam, but its effective width as a flange shall not exceed the following:

1. One fourth of the span length,
2. The distance center to center of beams,
3. Twelve times the slab thickness, plus the girder stem width.

For beams having a flange on one side only, the overhang shall not exceed one-twelfth of the span, nor six times the slab thickness, nor one half the clear distance to the next beam. As a rule, the girder depths for widenings are pretty well tied down. The new slab and bent cap are simply an extension of the existing construction which requires the new girder to have approximately the same depth as on the existing span. A quick method of determining approximately the reinforcing bars needed in the beams is to use the rectangular beam formulas and assume "j" to be between 0.90 and 0.95. After selecting the proper bars a check can be made of the resisting moments of the T-Section. The spacing between bars shall be in accordance with Section 3.7.7 of the A. A. S. H. O. Specification.

When the allowable unit shearing stress for concrete is exceeded, web reinforcement of some type must be provided. For T-Beams stirrups shall always be used to take the shear in excess of that what is allowed for the concrete. Some of the longitudinal bars may be bent up in combination with the vertical stirrups, see Sec. 3.7.3 (c) and Sec. 3.7.9 of A. A. S. H. O. Specifications for design and maximum allowable spacing. Maximum shear from dead load, live load and impact shall be used to determine the stirrups required. In calculating live load shear, the 16000 lb. wheel is placed at the point where the maximum shear is required and if the front wheel is on the span it should be added to the resulting shear. Where the girders are spaced more than 6' - 0" centers, the live load on the girder shall be the reaction of the two wheel loads assuming the floor between the girders to act as a simple beam.

9. <u>Widening Substructures</u>

The substructures that are commonly found in the old bridges can be classified into three types. They are the pile bents, columns on spread footings, with or without foundation piling, and the cantilever, or wing type abutments. Of these, the pile bents are the less troublesome to widen. The first operation is to ascertain how much load can be carried by each pile, and from this information, determine how many piling will be needed in each bent. In spacing the piling, due consideration should be given to the effect that the added load may have on the existing outside piling or support. If the span is a concrete girder, placing a pile under the girder stems will simplify the cap design. With a slab span, the cap should extend to the outside edge of the span, and the pile placed at least 1' - 9" from the end. For determining the cap reinforcement, the slab and the weight of the bent cap should be applied as a uniform load, supported by the piles, with one wheel placed at the mid-point between piling for the live load. Moments due to this loading will determine the area of steel required. In the bridge office, we have adopted a policy of using a minimum of four one inch round (1" ϕ) bars in the bent caps, two in the top and two in the bottom. If possible, the steel in the existing cap should be exposed and bonded into the new construction, or butt welded if the amount of concrete that can be removed is limited to only exposing the ends of the bars.

Spread footing column bents that have to be widened will consist of either one or two column additions, depending on the roadway to be added. For single column construction, it is a good policy to locate the column so that the dead load of the widened portion of span will be almost centered on the column. By accomplishing this, the reinforcing steel that is welded or bonded with the existing bars will only have to take the stress due to live load. With a two column addition, the design can be treated as an independent bent merely providing dowels in the cap ends to keep them in line. The footings for the new construction generally should not be carried below the elevation of the existing footing. This is particularly important if the excavation has to be done adjacent to the old footing. Disturbing the foundation material, with the added load from the widened span, may cause damaging settlement in the bent. Of course, there may be exceptions to the above statement, such as where scouring action around existing bent, or the existence of unsuitable foundation material at the elevation of old footing may require the new footings to be carried to greater depth. It also will not apply where the existing footings are resting on foundation piling. The footings will not need reinforcement if the projection from face of column to edge of footing does not exceed 2/3 of the footing depth. Otherwise, determine the required steel by considering the footing projection as a cantilever beam and using the calculated footing pressure as a uniform load. For the longitudinal column reinforcement, the minimum specification requirement of 1% of the gross cross section for tied column will, in the majority of cases be sufficient.

The wing type abutments are the most difficult to widen; or maybe one should say, most objectionable, from a detailers standpoint, since there is a large quantity of variable length bars to be listed. Should the width of roadway added not exceed about 2' - 0" on either side, there is no need of constructing new wall sections. Instead, the outside girder can be designed for a slightly longer span and made to bear on the existing wing. The only modification necessary is building-up the wing height and extending the ends to provide for the wider embankment and take care of the slopes. If the abutments have to be extended to accommodate a wider roadway, there are various methods by which this can be accomplished, depending on the conditions at the bridge ends. One is to drive piling and make a cap and earwall extension, or a new wing may be constructed parallel to the existing wing with a backwall which should be anchored, or tied, to the old wall. One point should be remembered, and that is that some of the old wing type abutments were designed as a unit and breaking away of the wings from the bearing walls would disrupt the stability of the abutments. In those cases, only the minimum amount of old concrete should be removed so as to expose the existing reinforcement and permit welding or bonding on the extension. At the junction where the old concrete was removed, it should be replaced so that the old wings will continue to function as a support for the bearing wall. Tops of the wings will have to be removed so as to clear the widened embankment and pavement.

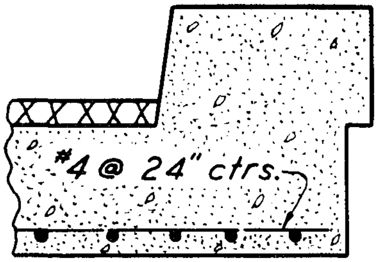
In detailing the new wing extensions, the size of the footings and walls and the amount of reinforcement required can be patterned after the sloping standard wings provided for our multiple box culverts. Care should be taken to use the same height standard as the wing height being detailed. If it is necessary to make calculations for a design of the wings, refer to sections 3.5.3 and 3.5.4 of the A. A. S. H. O. Design Specifications for the requirements to be considered. The earth pressure due to the retained fill shall be determined by Rankine's formula but shall not be less than an equivalent fluid pressure of 30 lbs. per cu. ft.

Quite often, the existing bridge slabs are covered with 4 to 8 inches of ballast, or surfacing material, and it is proposed to continue this over the widened portion of the roadway in order to keep from having to modify the bridge approach grades. This should be shown on the details by means of a section across the bridge roadway and also the additional dead load of the surfacing should be included in the design of the slab and girder.

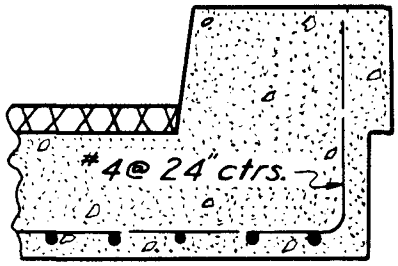
Most of the old structures have curb drains which should be plugged after the slab is widened. The plans should contain a note requiring the contractor to fill the drain holes with concrete.

The preparation of the old concrete surfaces which are to be in contact with the new construction, as well as the clearing of the old reinforcement, is covered in our standard specification Item, 415 "Extending Concrete Structures." The following note should appear on the detail sheets where welding of old reinforcing steel to the new steel is to be done. "The contractor shall use E-6016 or E-7016 electrodes for all welding of reinforcing steel." These are low hydrogen electrodes and are better suited to welding the reinforcement which the steel fabricators generally furnish for most of our jobs. The Highway specifications permit the use of structural, intermediate, hard grade or rail steel, however only the structural grade has a carbon content low enough to be welded by the more conventional types of electrodes. Most of the bars furnished on our projects are either intermediate grade or rail steel and, to be certain the welds develop the strength of the bar, the low hydrogen electrodes are specified.

OLD SLAB SPAN STANDARDS

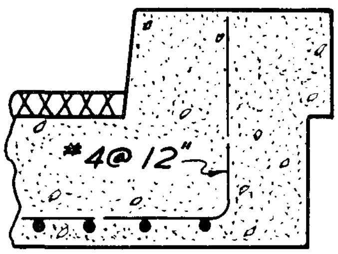


CT-1

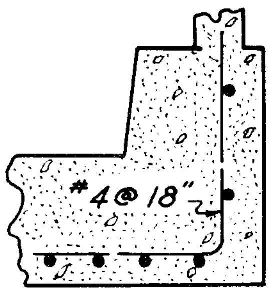


CT- 2 to 7

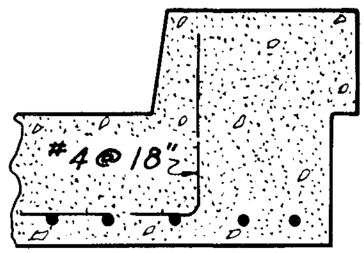
Spans : 12'-0" to 20'-0"
Roadway : 18'-0"
Design : 1921 - 1924 $f_s = 16{,}000$ $f_c = 650$



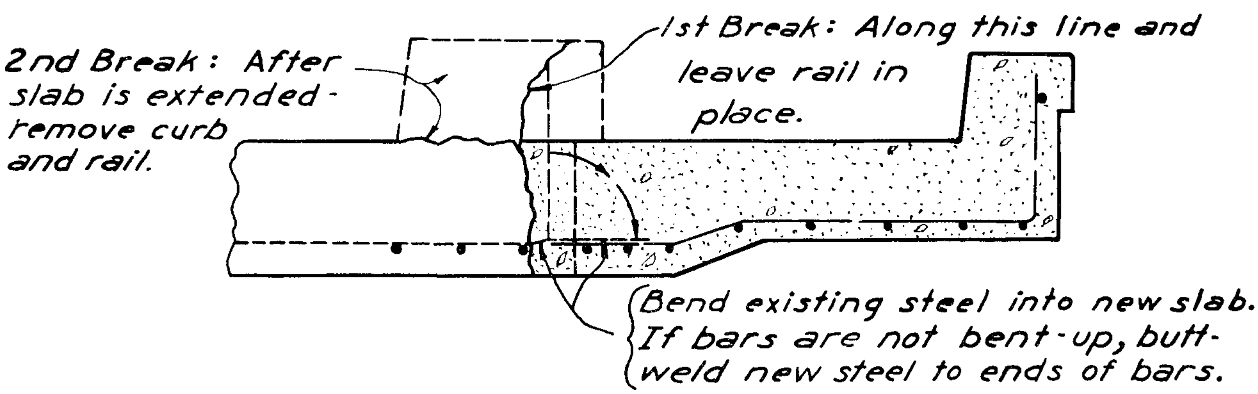
CB-1
(1918)



CB-3 to 5
(1919-1921)



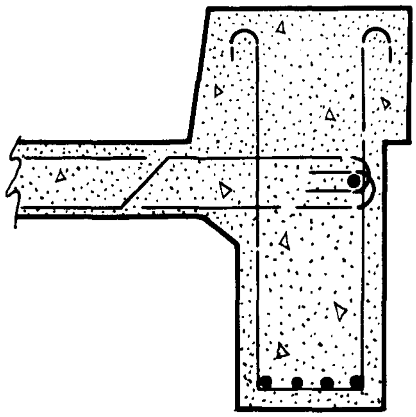
CB-6
(1923)



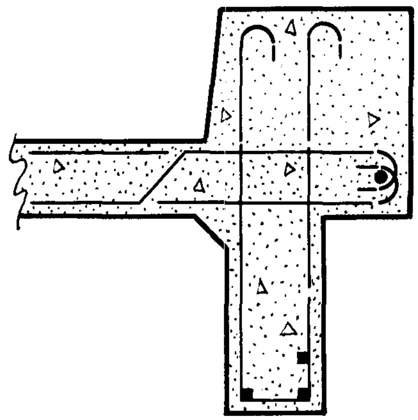
SLAB WIDENING

PLATE I

OLD-CONCRETE GIRDER SPANS

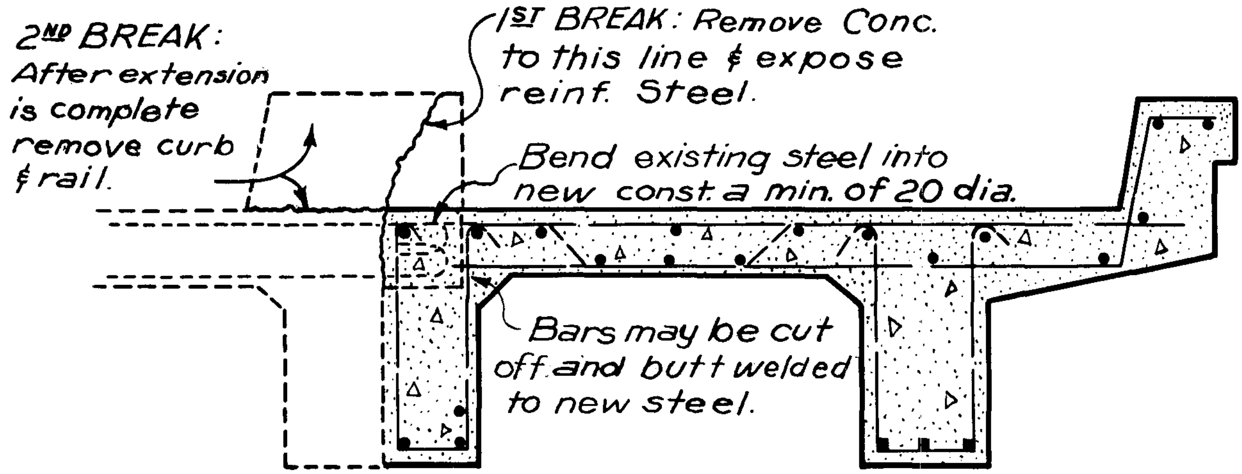


G-1-Series
(1918)



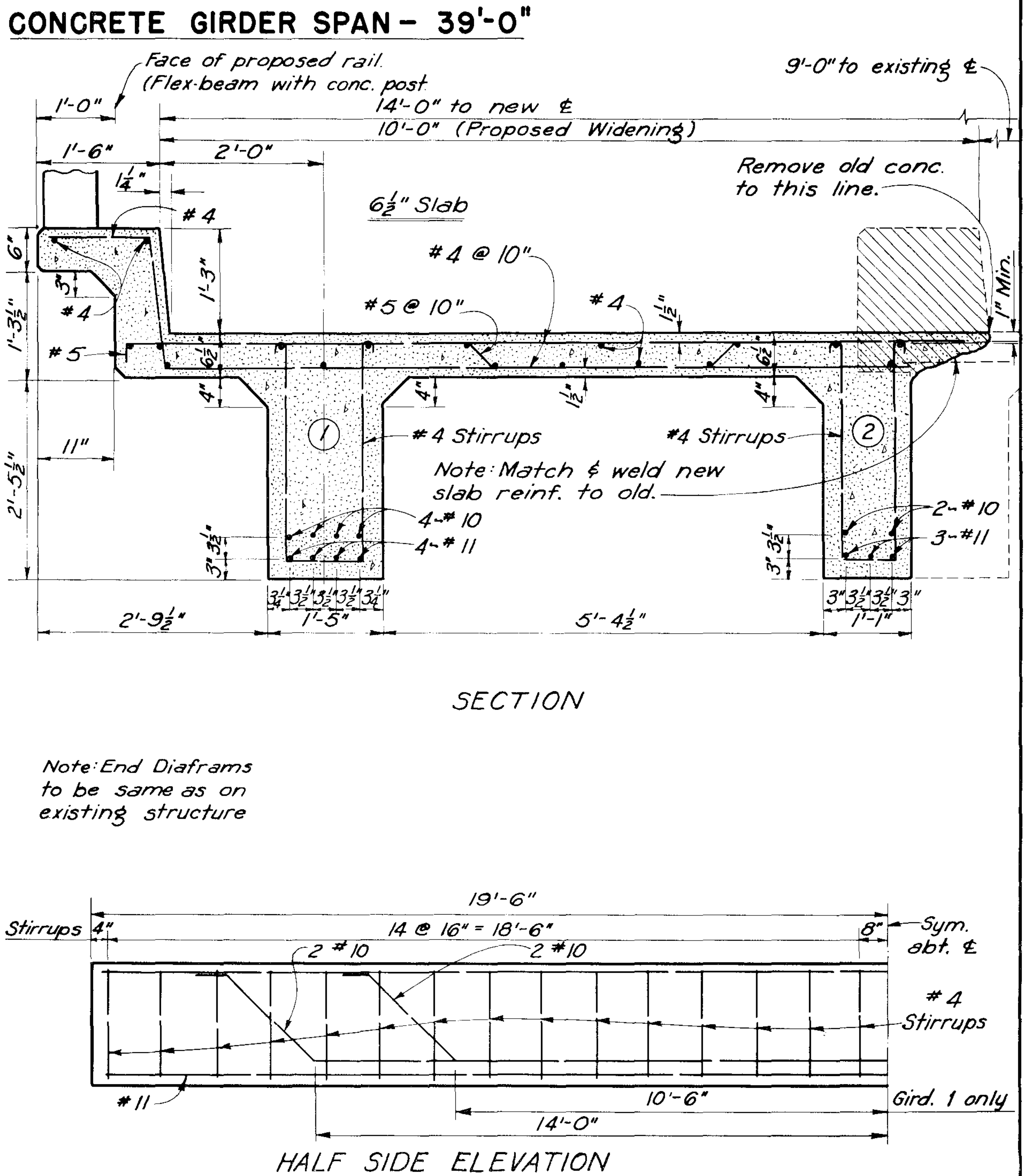
G 260-Series or DG-5
(1920) (1929)

Spans : 16'-0" to 26'-0"
Roadway : 16'-0" to 20'-0"
Stresses : fs = 16000 fc = 650



GIRDER WIDENING

PLATE 2



CONCRETE GIRDER SPAN - 39'-0"
Face of proposed rail (Flex-beam with conc. post
9'-0" to existing ℄
1'-0"
14'-0" to new ℄
10'-0" (Proposed Widening)
1'-6"
2'-0"
Remove old conc. to this line.
6½" Slab
#4
#4 @ 10"
#5 @ 10"
#4
#5
1" Min.
#4 Stirrups
#4 Stirrups
Note: Match & weld new slab reinf. to old.
4-#10
4-#11
2-#10
3-#11
2'-9½"
1'-5"
5'-4½"
1'-1"
SECTION
Note: End Diaframs to be same as on existing structure
19'-6"
Stirrups 4"
14 @ 16" = 18'-6"
8"
Sym. abt. ℄
2 #10
2 #10
#4 Stirrups
#11
10'-6"
14'-0"
Gird. 1 only
HALF SIDE ELEVATION

PLATE 3

INTERIOR BENTS

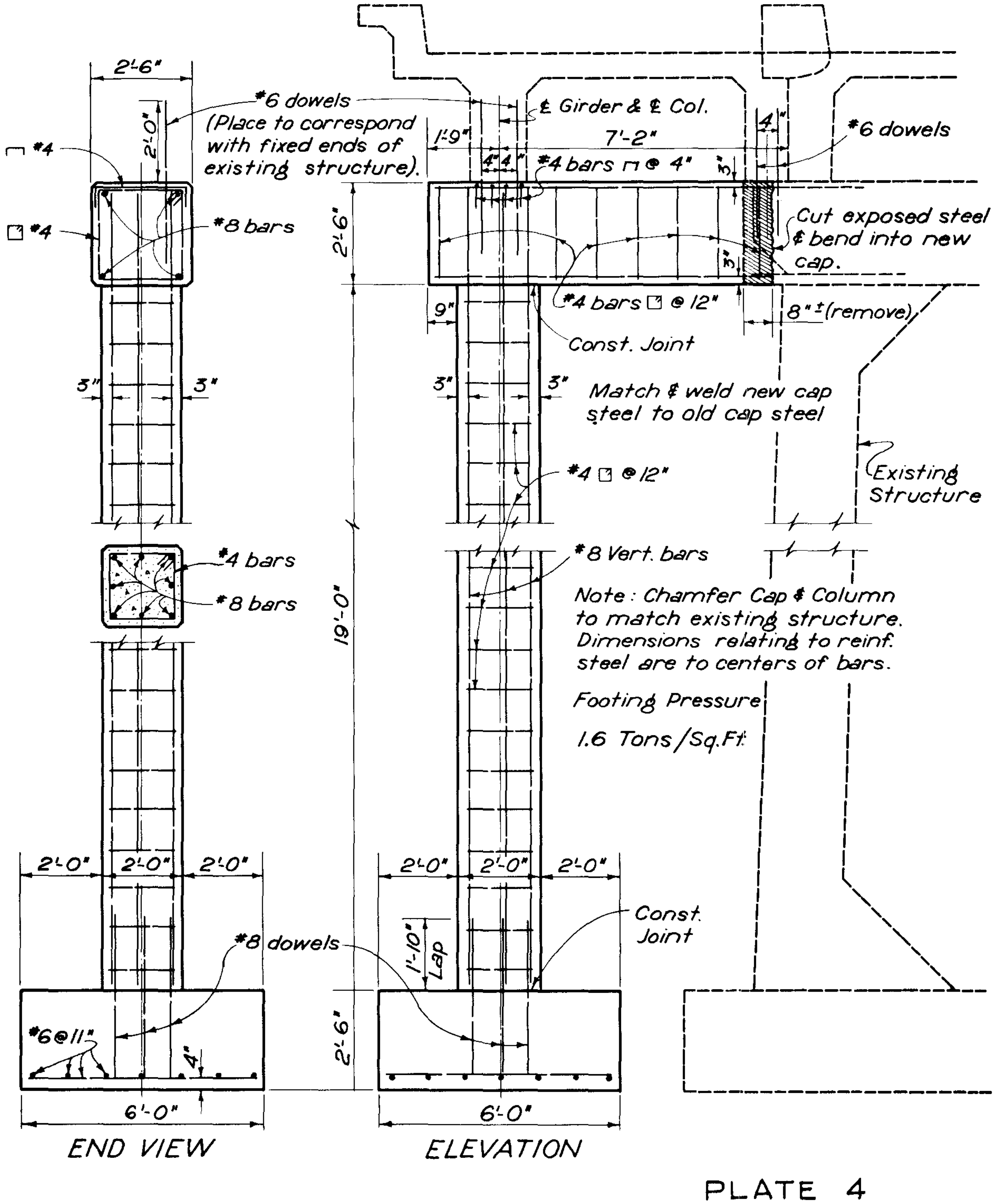
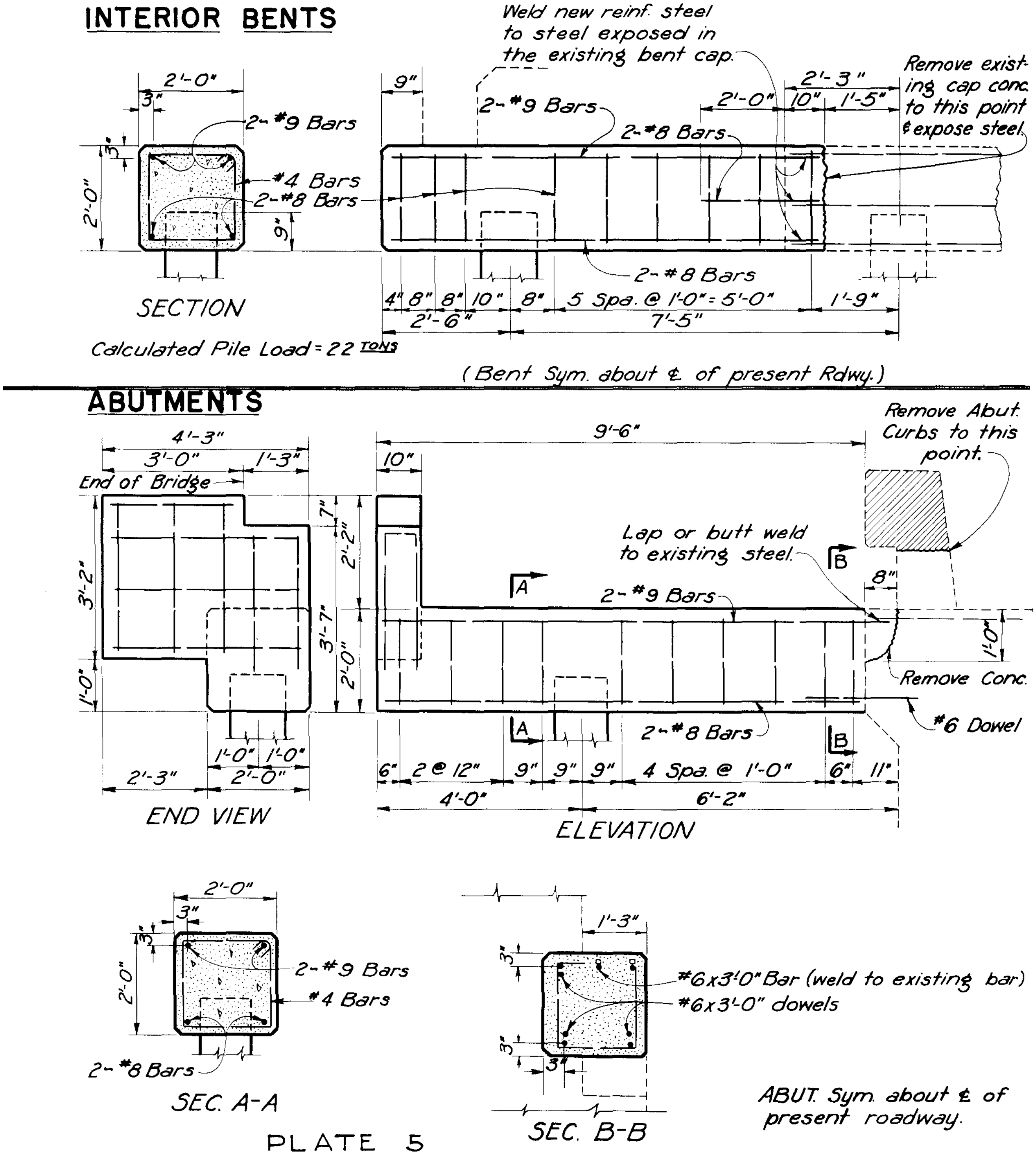


PLATE 4


INTERIOR BENTS
Weld new reinf. steel to steel exposed in the existing bent cap.
Remove existing cap conc. to this point & expose steel.
2'-0"
3"
2-#9 Bars
#4 Bars
2-#8 Bars
2'-0"
9"
9"
2-#9 Bars
2-#8 Bars
2'-0"
10"
1'-5"
2'-3"
2-#8 Bars
4" 8" 8" 10" 8" 5 Spa. @ 1'-0" = 5'-0" 1'-9"
2'-6"
7'-5"
SECTION
Calculated Pile Load = 22 TONS
(Bent Sym. about ℄ of present Rdwy.)
ABUTMENTS
4'-3"
3'-0"
1'-3"
End of Bridge
3'-2"
1'-0"
7"
2'-2"
3'-7"
2'-0"
1'-0" 1'-0"
2'-3"
2'-0"
END VIEW
9'-6"
10"
Remove Abut. Curbs to this point.
Lap or butt weld to existing steel.
2-#9 Bars
8"
1'-0"
Remove Conc.
#6 Dowel
2-#8 Bars
6" 2 @ 12" 9" 9" 9" 4 Spa. @ 1'-0" 6" 11"
4'-0"
6'-2"
ELEVATION
2'-0"
3"
2'-0"
2-#9 Bars
#4 Bars
2-#8 Bars
SEC. A-A
1'-3"
3"
#6x3'-0" Bar (weld to existing bar)
#6x3'-0" dowels
SEC. B-B
ABUT. Sym. about ℄ of present roadway.
PLATE 5

ABUTMENT BENTS

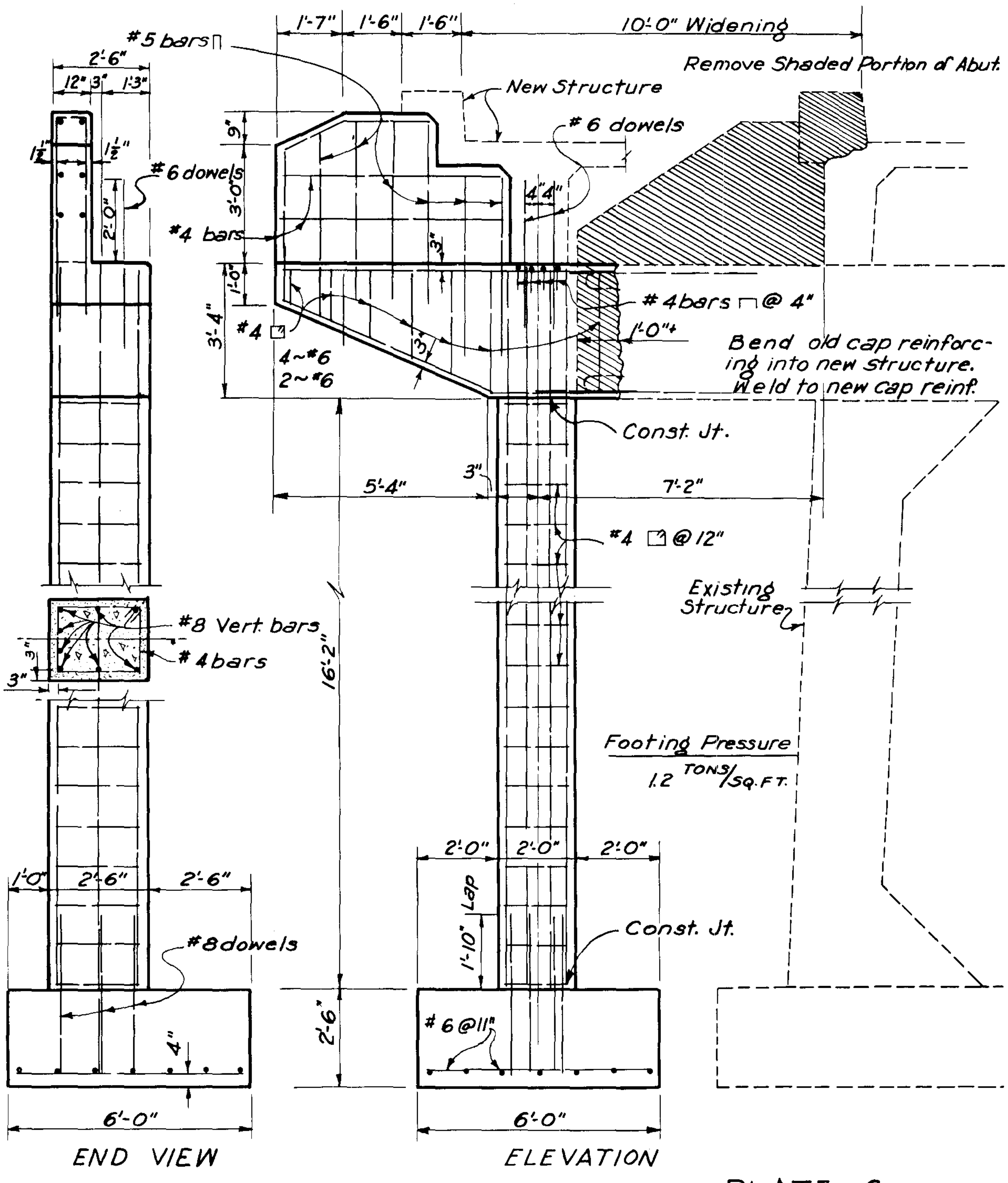


PLATE 6

RAILROAD GRADE CROSSINGS AND EASEMENTS

Primarily this paper will deal with the Department's policies, practices and procedures pertinent to railroad-highway grade crossings that are at present being followed. It might be helpful first, however, to briefly mention a few facts about railroad right-of-way.

During the early years of development of our State, the railroad companies were encouraged by the public to construct their lines. Much right-of-way was furnished and our State legislature enacted laws giving railroads the right of eminent domain, since railroads were essential to the public welfare. They were given the power to acquire right-of-way property by condemnation if necessary, provided they made just conpensation therefor. The law permitted the railroads to acquire right-of-way not exceeding 200 feet in width in the rural areas and whatever additional property that was needed to accommodate depot facilities, switches, spur tracks and freight yards for the operation of the railroad. The statutes also placed certain obligations on railroad companies with respect to public roads or highways that cross their right-of-way. A public highway is defined as a road or street maintained by the public for the general convenience and use of the public and as such it also has the right of eminent domain. The law obligated the railroad companies to construct and maintain the public road crossings for the entire width of the railroad right-of-way. Crossings were to be not less than 30 feet wide and were to be constructed to permit the free and easy passage of vehicles and domesticated animals. The railroad companies could be forced to permit crossings at one and one half mile intervals, if necessary.

Under the law establishing the State Highway Commission in 1917 and through subsequent laws by our legislature many of the State's County roads have been placed on the system of State maintained highways and are now the responsibility of the Highway Department. On October 1, 1952, 41,476 miles of highway were being maintained by the State. At the beginning of this year the Department's crossing log indicated 1544 locations where these highways cross railroads.

One can readily understand that in negotiating with the various railroad companies in connection with that number of crossings; principally regarding the easements, crossing pavement and crossing protection; close mutual cooperation and understanding between the Department and the railroad companies was highly essential. Splendid cooperation is prevailing. Throughout these many years since the establishing of the Department the negotiations have been handled through the Chief Engineers of the various railroad companies with satisfactory results. Several meetings have been held in Austin between Highway Department officials and the Chief Engineers or other representatives of Texas railroad companies in order to discuss and solve problems of mutual interest. Through such joint meetings much of the present procedure in handling our negotiations with the railroad companies developed, particularly with respect to policies pertaining to railroad-grade crossings. Agreement as to divisions of responsibility of the interested agencies in connection with the crossings has been attained.

In instances where the highway is to cross an existing railroad, and the State through the Highway Department makes the request, it is the usual practice, under the current handling, for the State to assume the expense of construction of the highway grading and surfacing up to the ends of the railroad ties and the Railroad Company to assume the expense of planking the railroad crossing from end to end of ties for the full crown width of the highway. The cost of adjusting the pole lines, fences, cattle guards etc., at the grade crossing within the limits of the encroachment area, is the responsibility of the agency furnishing the right-of-way, usually a County or City. When such expense is to be encountered in order to provide a clear right-of-way, the easement agreement is made a three-way party agreement to include the County or City as the party responsible for bearing the cost of such adjustments.

Let us enumerate essential information that the District Engineer should furnish the Bridge Division so that negotiations may be opened and a request made for the easement from the railroad company. By the term easement, we mean the right acquired by public authority to use or control property for a designated highway purpose.

Consider first the easements for grade crossings. A suitable sketch showing the general location and tie in with a railroad mile post or major railroad structure and complete field notes describing the encroachment area should be furnished. The sketch should show the angle between the highway and railroad, the profile or gradient of the railroad, profile of highway with elevation of rails, any track adjustments required to smooth the highway grade, the location and ownership of pole and wire lines and their vertical clearance over the highway together with any proposed adjustment. Also, the drainage structures required should be shown and who is to install and pay for same; width of highway crown; width, depth and type of surfacing; width of crossing planking; right-of-way fence or cattle guard adjustments that are required; any railroad facilities that are to be relocated; and the type of crossing protection proposed. At the time the District Engineer submits the sketch showing the crossing, he should also furnish information relative to the train count and vehicular count (actual count for existing crossings and estimated if the crossing is a new location). This information is required to determine whether the crossing justifies flashing light signal protection. A full discussion of crossing protection will be made later in this paper. Let us cover some of the above mentioned items in detail.

TRACK ADJUSTMENTS.

Costs of adjustments of the railroad grade, switch points, etc., which are incurred because of construction of the highway are usually assumed by the State. The project agreement estimate of the roadway project should include an item of railroad force account work, since the railroad company performs the work for the State.

POLE LINE AND WIRE LINE ADJUSTMENTS

The cost of pole and wire line adjustments is borne by the County or City and the easement agreement will be made a three-way party agreement. The poles usually are moved out to within a foot of the highway right-of-way line. The wires for telephone and telegraph lines should have a minimum clearance of 18 feet above the finished highway; power lines a minimum vertical clearance of 22 feet as required by Law.

CROSSING PAVEMENT

As previously stated the railroad companies are required to furnish and install at their expense the crossing pavement between ends of ties for the crown width of the highway. Timber crossing pavement is being required generally. The Department's experience has been that the full timber crossing pavement gives reasonably good results. The installation of asphalt type crossings has been discouraged because they have not proven satisfactory, they break up under heavy rail traffic and the railroad companies have failed to keep them maintained adequately. In some instances, the Department has requested railroad companies to install concrete crossings. These were on important highways carrying a large volume of traffic and also where new railroad spur tracks cross highways. But the railroad companies have installed such concrete crossings with considerable protest. However, the Department has been willing to cooperate with the railroad companies in search for a better type crossing that will be economical and at the same time will stand up under highway and rail traffic. Within the last three years permission was given the Texas and New Orleans Railroad Company to install several crossings on an experimental basis. The performance of these crossings is under observation by the Department. These crossings are composed of cement stabilized shell subgrade from about 6 inches below the bottom of the railroad ties up to within 1 1/2 inches of the surface of the highway. An inch and a half of asphaltic concrete surfacing is applied.

RELOCATION OF RAILROAD FACILITIES

In many cases especially where the highway is being widened the railroad falshing light signals require relocating. This work is usually done by the railroad company's forces on a force account basis at the State's expense. The project agreement estimate should be prepared accordingly to include an item for railroad force account work.

CROSSING PROTECTION

The minimum protection for any grade crossing on Farm to Market Highways is the standard railroad crossing sign installed by the railroad company with the Department installing reflectorized advance warning signs. The minimum protection for State and Federal Highways of other than Farm to Market classification is the reflectorized crossbuck signs. These signs are furnished and installed by the State but maintained by the railroad company. The Department has a standard crossbuck signs agreement which is executed with the railroad company in each instance. The agreement provides for the State's contractor to install the reflectorized crossbuck signs. The railraod company agrees to maintain the signs after installation. This means if the signs are knocked down or damaged, it is the responsibility of the railroad company to have them replaced or repaired. The State furnishes and installs advance warning signs. The railroad company cannot move the crossbuck signs to another crossing without the approval of the State Highway Engineer.

Now let us continue with the matter of the grade crossing easements. The Bridge Division, with the information mentioned previously, submits the request for the easement to the railroad company. Prints of the crossing location sketch, the field notes and if reflectorized crossbuck signs are to be installed, the crossbucks signs agreement copies are submitted for execution by the railroad company. It usually takes from two to six months to secure an easement. The easement agreement is prepared by the respective railroad company. If there is to be no expense incurred in removing obstructions from right-of-way within the encroachment area of the crossing, then the agreement is a two-way party agreement between the Railroad Company and the State. If however, right-of-way clearance expense is involved, the agreement will include the respective County or City, as the case may be, as the third party. Upon receipt of the easement agreement the Bridge Division reviews it and compares it with the original request. Any unacceptable provisions are watched for. Each railroad company has its own particular form of crossing agreement, but in general they include the following: (a) Usual statement licensing the State to use designated railroad property for highway purposes and including a description of the encroachment area or an Exhibit on which the area is shown. (b) The railroad company's obligation to install the crossing pavement between the ends of ties for the width requested, usually the crown width of the highway. (c) Several provisions outlining what the site is to be used for; restricting the State from assigning the property to other parties, without the railroad company's consent; placing on the State obligation for constructing the highway up to the ends of ties and constructing the necessary drainage structures. (d) A statement reserving the legal right of the railroad company to build, maintain and operate future tracks and appurtenances upon and across the land licensed. (e) A statement reverting the easement or license to the railroad company in the event the highway is abandoned or closed by the State. (f) If the railroad company is to perform work of adjusting their track or relocating their protective devices for which the State is to reimburse the railroad company, then an appropriate provision is included. However, some of the railroad companies prefer not to include such a provision in the easement agreement. In that event a separate agreement is prepared by the Department to cover the construction work that the railroad company is to perform for the State and it is submitted to the railroad company for execution.

If the easement agreement is found to be satisfactory by the Bridge Division, the copies are forwarded to the District Engineer for his review and approval and for handling with the County for execution if the county is involved. After the agreement is executed by the county it is returned to the Bridge Division for handling with the State's Assistant Attorney General for approval as to form; after which the State Highway Engineer's approval is obtained, which completes the execution of the agreement on the part of the State. Normally an easement agreement is not executed on the part of the Railroad Company until after it has been executed by the State and County. Therefore, the copies are returned to the Railroad Company for final approval. The Railroad Company makes distributions of the copies of the fully executed easement agreement to the interested parties. The Bridge Division procures photostatic copies of the agreement and makes distribution to the District and D-7 (Aid Division) if force account work is involved. The State's original copy of the easement is permanently placed on file in the right-of-way section of the Road Design Division. The various steps that an easement agreement passes through in being executed have been outlined in detail in order that you might understand why it is essential to start negotiations for railroad easements as early as possible prior to the time the crossing right will be needed. The process of obtaining an easement requires a considerable amount of time as you can see.

There are other kinds of easements which the Department requests from the railroad companies, namely, common drainage ditch easements, easements for channel improvement and drainage structure adjustments on railroad property and easements for right-of-way encroachment. The information required to be furnished for use in obtaining the kind of easements mentioned above are being included in the printed copies of this paper in tabulation form, for your future reference. There was previously covered in detail the information required for easements for grade crossings, but it is being listed below in tabulation form also for your reference.

EASEMENTS FOR GRADE CROSSINGS

(1) Provide a suitable sketch for exhibit attachment in agreement showing general location and tie-in with railroad mile post.

(2) Complete field notes describing the encroachment area.

(3) Angle between highway and railroad.

(4) Profile or gradient of railroad.

(5) Profile of highway with elevation of rails.

(6) Show any track adjustments required. Costs of adjustments of railroad grade, switch points, etc., are usually assumed by the State.

(7) Location, ownership of pole lines and vertical clearance over highway and proposed adjustments. A minimum vertical clearance of 22 feet for power lines crossing highways is required by law. The Department has adopted a policy of requiring a minimum clearance of 18 feet for telephone and telegraph lines.

(8) Show drainage structures required advising who should install and who should bear costs.

(9) Give width of highway crown and width, depth, and type of surfacing.

(10) Crossing plank are usually crown width and installed by the railroad at its expense. For any other type of crossing desired give your recommendations as to who should install and who should bear costs.

(11) Show any right-of-way fence or cattle guard adjustments required.

(12) Show any railroad fixtures to be relocated and your recommendations as to who should bear costs.

(13) Are reflectorized cross-buck signs required?

EASEMENT FOR COMMON DRAINAGE DITCH

(1) Provide a sketch suitable for exhibit attachment in agreement showing general location and amount of ditch encroachment.

(2) Stationing tie-in to railroad mile post.

(3) Typical section through highway and railroad embankments showing location, width and depth of common ditch.

(4) Location and ownership of any pole lines and any contemplated adjustments.

EASEMENT FOR CHANNEL IMPROVEMENT AND DRAINAGE STRUCTURE ADJUSTMENTS OF RAILROAD PROPERTY

(1) Provide suitable sketch for exhibit attachment in agreement showing general location.

(2) Stationing tie-in to railroad Mile Post.

(3) Show location, length of channel and general cross-section dimensions.

(4) Give details of any structure or any structure adjustments required.

(5) Give your recommendations as to what portion of cost should be borne by State and by Railroad.

It might be well to comment briefly about this type of easement, particularly drainage structure adjustments on railroad property, which usually involve reconstructing or placing larger or new drainage structures under the railroad track. Some of the railroad companies do not permit the State's Contractor to do work under their track. In this case the railroad company does the work on a force account basis, and the easement is made in the form of an agreement, whereby the railroad company furnishes and constructs the structure at the State's expense. Here again the project estimate should reflect railroad force account work. At the final distribution of the copies of the fully executed easement agreement the Bridge Division also furnishes the Aid Division with a copy of the agreement along with railroad company's estimate of cost for the work. This is done in order that funds may be set up to cover the force account work and later when the work is complete to permit reimbursing the railroad company. When railroad forces perform such work for the State they do it on a force account basis and the State only reimburses the railroad company for the actual costs incurred. We request the railroad company to include a provision in the easement agreement stating that the billing is to be made in accordance with General Administrative Memorandum No. 299 issued by the U. S. Bureau of Public Roads and revisions thereto in effect as of the date of the agreement.

Some of the railroad companies will permit the State's Contractor to perform the work of constructing the drainage structures under their track or ditch construction work close to their track, especially if an unimportant track, not a main line, is involved. In such cases the railroad company requires the State to place in its contract with its Contractor, provisions whereby the Contractor has to reimburse the railroad company for flagging service it performs and it also requires the contractor to carry certain insurances to protect the railroad company while he is undertaking work on railroad right-of-way. Contractor's Public Liability and Property Damage Liability Insurance, Contractor's Protective Public Liability and Property Damage Liability Insurance and Railroad's Protective Property Damage Liability Insurance are required.

You can see the importance of prompt beginning of negotiations with the railroad companies for easements, particularly this type, in order to obtain the information from the railroad companies regarding the requirements they will make of the State's Contractor early enough to permit the contract proposal to include the necessary special provisions when bids are requested for the highway project. These provisions will be prepared by the Bridge Division.

EASEMENT FOR RIGHT OF WAY ENCROACHMENT

(1) Provide suitable sketch for exhibit attachment in agreement showing general location and tie-in with railroad mile post.

(2) Provide field notes describing area of property desired.

(3) Show all adjustments of railroad track, fixtures and fences due to proposed encroachment. Adjustments in this case are usually considered as clearance of right-of-way with the cost of adjustments the responsibility of the County or City involved.

This type of easement covers encroachment on railroad property, usually parallel encroachments not involving a grade crossing. Because of the difficulties experienced by the Bridge Division in negotiations relative to this type of easement we have been requesting the Districts recently to have the County or the City involved obtain parallel right-of-way free of all encumbrances. The railroad companies quite often wanted to be paid for the property involved and therefore asked to include the County as a party to the agreement in order to be reimbursed. As you know, the Highway Department does not buy right-of-way. It is the responsibility of the counties or cities to provide the right-of-way clear of all obstructions. So much delay was encountered in handling the matter of payment by the County or City to railroad companies that it was decided that procuring such parallel right-of-way can best be handled directly by the counties or cities with the railroad companies. However, occasionally a railroad company, will prefer to grant an easement for the parallel right-of-way and not charge the County or City for the property. In these instances the Department has been willing to execute the easement agreement. If there are any pole line or fence adjustments required to clear the right-of-way then the County or City is included as the third party. In this type of easement the State does not accept the trackage reservation clause as it does for grade crossing easements. That clause permits the railroad to build whatever future additional tracks and facilities on and over the property that it deems necessary for its operation. As was stated before, it is best to have the counties or cities negotiate direct with the railroad companies for such parallel right-of-way, but in the event it develops that the railroad company prefers to grant an easement, made in favor of the State, then the above listed information should be furnished the Bridge Division by the District.

Earlier in this paper mention was made of the protection for railroad grade crossings and it was proposed to return later to a discussion thereof, particularly flashing light signals. If any of you have had occasion to note the volume of correspondence that is exchanged in connection with flashing light signal projects, the Bridge Division usually furnishes the District with copies of a great portion of its correspondence, you will understand why a section of this discussion has been reserved for them. First, to explain how a signal project is originated. When a highway construction project is being developed and the highway crosses a railroad track, it is the policy of the Department to determine the type of protection to be installed. The traffic conditions at the crossing are studied with respect to the volume of highway and train traffic as well as the visibility of the location. The District Engineer is requested to furnish traffic counts, either actual or estimated, if the highway is at a new location, along with recommendations. If the counts indicate that installation of signals are justified the Bridge Division makes recommendation to the Programming Division to program the signal project. You may wonder as to the method used in determining whether flashing light signals are justified. The hazard rating of the crossing is the major determining factor. Based on information gathered regarding accident at grade crossings over a period of approximately 5 years covering some 5,000 grade crossings in the State, hazard expectancy curves were developed. From these curves the hazard rating is determined by the volume of train and vehicular traffic. A hazard rating of 0.083 has been established by the Department as a minimum rating in justifying signals. Upon programming a signal project the railroad company is notified. For most projects of this kind the railroad company contributes 10% of the cost of the project. After the signals are installed the railroad company maintains them. At a preliminary inspection by representatives of the Department, the railroad company and the Bureau of Public Roads if the signal project is a Federal Project, the location of the signals and instrument case as well as the lengths of the approach warning circuits are determined. The design of operation is studied, such features as additional lamp assemblies for side approaches and timing out features for locations where there are switching train movements, are agreed to. The District Engineer's Office prepares the title sheet and layout sheet of the plans, while the railroad company prepares the wiring diagram sheet. The fourth sheet of the plans is a standard showing details of the protection device. Upon approval of the layout sheet of the plans by the State, railroad company and Bureau of Public Roads, the railroad company prepares the wiring diagram and the estimate. Flashing light signal projects are installed by the railroad on a force account basis, consequently a standard state-railroad agreement has been developed to include regulations contained in General Administration Memorandum No. 299 issued by the U. S. Bureau of Public Roads, May 1, 1946 and subsequent additions and revisions. If the project is within the limits of an incorporated city an appropriate ordinance is passed by the City and an indemnification agreement between the State, railroad company and City is executed. Complete plans, specification and estimate along with copies of the State-railroad agreement are submitted to the Bureau of Public Roads for approval. Upon receipt of that approval the Department authorizes the railroad company to assemble the material needed and requests them to notify the District Engineer when they are ready to make the installation. The locations of the signals and appurtenances are staked out by the District Engineer's representative. Usually it takes from a week to a months time for the railroad forces to make the actual installation. It takes considerably longer, at least six months, to assemble the material before the actual installation starts. Federal regulations require the railroad company to obtain competitive bids for signal assemblies. The Federal Government will reimburse the railroad company only for the amount of the low bid. If the railroad company chooses to use a manufacturers material other than that of the low bidder, the railroad company is required to bear difference in cost of that material. When the project is completed and is accepted by the State, the railroad company compiles a complete list of material used for the project and materials retired and salvaged. The joint final inspection is made. If the installation is accepted the railroad company prepares its bill of cost of material and labor actually used in the installation. There is a considerable amount of paper work invòlved in checking and handling the final bill and supporting papers with the various offices; Bridge Division, the District, Aid Division and finally the Bureau of Public Roads. After the federal auditor has audited the records of the railroad company for the project the final settlement of reimbursement is made to the railroad company.

You might be interested to know that since V-J Day, approximately 193 protection device projects have been programmed. All but two of these projects were the flashing light signals only. The other two were arm gate projects,that is, flashing light signals supplemented with short arm gates. The average cost of 144 flashing light signal projects which have been completed is $4,740. The flashing light signals with short arm gates averaged $14,600 each.

While still referring to crossings of existing railroads by highways it might be added that a considerable amount of negotiations are necessary between the Department and the railroad companies in connection with the execution of agreements pertaining to grade separations, that is, underpasses and overpasses. These agreements which are standard, include a license clause granting to the state the right to cross the railroad company's property for construction and use of the structure and highway. The railroad force account work in connection with overpass and underpass projects are covered by a state-railroad agreement similar to the protection device agreement. A section on railroad-highway separations will follow this discussion.

Previous to this, these remarks have dealt with procedures and practices being followed in connection with easements requested by the State. Now, let us mention briefly the procedures being followed when it is the reverse, that is, when a railroad company requests a permit to cross a highway with a track, usually an industrial spur track. You will note we did not say easement because the State Highway Commission cannot grant an easement for State property. It only has authority to give permission for the use of highway right-of-way, such as, the right of a railroad to cross highway right-of-way with a spur track, for use in operating its trains. In these cases the railroad companies initiate the negotiations with the Department, either through the District Engineer's office or the Bridge Division giving their reasons for the request, stating what the spur track is to serve and how necessary it is to the public. The request is investigated in the District and the District Engineer's recommendation is obtained, prior to presenting the request to the State Highway Engineer for a decision as to the requirements. As was stated earlier the railroad companies have the power of eminent domain. However, the Highway Department, by the Highway Act of 1917 and later by an act passed by the legislature in 1931, was given full jurisdiction and control over the State's highways. Under that authority the Department in granting the crossing permit, specifies certain requirements that must be met by railroad companies. Those requirements are with respect to the type of railroad crossing pavement, the crossing protection and the drainage structures in the highway ditches under the track.

For many years we have been requiring the installation of concrete crossings under spur tracks, either of the rigid slab type, in which the ties are entirely encased in the reinforced concrete slab or of a type composed of reinforced concrete slab the thickness of the height of the rails and placed on clean ballast from the top of the ties to 8 inches below the ties with a sub-base of grouted ballast 12 inches thick. Our observations have been that the railroad companies quite often neglect the maintenance of their crossing pavement, especially on unimportant tracks, such as spur tracks where there is comparatively a small amount of train traffic.

With respect to the type of protection that is required for new spur tracks, the Department considers the importance of the highway being crossed and the amount of vehicular traffic together with the expected number of train movements. If those counts develop a hazard rating sufficient to justity flashing light signals then the railroad company is required to install signals when the crossing is initially made. Reflectorized crossbuck signs are the minimum protection requirement and in the agreement the Department includes a clause placing upon the railroad company responsibility to install flashing light signals later if traffic conditions increase enough to warrant their installation, providing of course, the Department deems signals are necessary to adequately protect the crossing. Drainage structures under the spur track and in the highway ditches are required if they are necessary. The design and size are to be approved by the Department. The agreements for the permit for spur track crossings are prepared by the Department. In addition to the special requirements the agreement also contains several standard requirements, such as, flagging the crossing, protecting the public during construction of the spur across the highway and later making any alterations in the crossing pavement, protection and elevation of the spur track which are caused by widening and reconstruction of the highway in the future. The railroad company is to bear the costs of revisions in their facilities. Finally the agreement requires the railroad company, when the operations of the spur permanently cease and a track is abandoned, to remove the track from the highway right-of-way and to replace the highway pavement at the railroad company's expense.

In conclusion it can be said that the Highway Department and railroad companies operations are such as to cause many contacts and contracts between them, some of which have been touched on in detail.

In addition to those, mention should be made of two other types of agreements which are frequently being executed; they are easements covering permits for wire lines and guy poles placed on a railroad property and also agreements covering snychronization of operations of a highway traffic lights with the operation of adjacent railroad flashing light signals.

HIGHWAY-RAILROAD GRADE SEPARATIONS

INTRODUCTION

During the early period of its history, the Highway Department had no established procedure for uniform handling of highway-railroad grade separations. We negotiated with the railroad on each project on the basis of its individual merits. Usually the railroad paid half the cost of an underpass structure. The Department paid for the approaches and the other half of the structure cost. In the case of overpasses, the railroad usually paid one-half the cost of crossing the railroad right-of-way and the Department paid the remaining cost.

About 17 years ago the Congress began the appropriation of Federal funds to pay for the total cost of projects intended to reduce or eliminate the hazards of highway-railroad grade crossings. These projects included the separation of grades, where justified. Uniformity of procedure was established at that time, and has been continued with such modifications as experience dictated.

The railroads contributed no part to these projects financed in whole with Federal funds until the Highway Act of 1944. At that time the Congress imposed a liability on the railroads to contribute an amount not to exceed ten per cent of the project cost in certain cases where the project was deemed to be of benefit to the railroad company. The handling of benefits requires no action on the part of the field forces, but is a matter which the Bridge Division takes up with the Bureau under established rules.

With this brief introduction to the manner in which we became involved in building grade separations at highway-railroad crossings, we will now consider the various problems which may arise and our current practices in dealing with such problems in the development of plans, specifications and estimates.

WARRANTS

There are no established warrants to dictate whether or not highway and railroad grades should be separated except those contained in the current AASHO Design Standards for the National System of Interstate Highways, which are quoted as follows:

1. "Where railway operation involves two or more main-line tracks, separation should be provided regardless of traffic volumes on the interstate highway.

2. "Where the railway operates six or more train movements per day on a single track, separation of grades may be justified regardless of traffic volumes on the interstate highway.

3. "When the railway has five or less regular train movements per day, grades should be separated when an economic analysis indicates justification, proper weight being given to both hazard and delay."

Aside from these requirements for crossings on interstate highways, separation of grades may be warranted to avoid undue interruption to traffic while trains occupy the crossing or to prevent accidents or a combination of these two factors. An analysis of the traffic volume and the time while trains are blocking the crossing will give an indication of whether or not the separation can be justified solely to eliminate time loss. The hazard to traffic may be evaluated by considering the speed of trains and highway vehicles, and the time which the driver has to anticipate the arrival of a train after it enters his field of vision. Highway and railway alignment, together with sight obstructions may materially reduce the driver's time of perception. In some cases neither of these factors, when considered separately, will justify grade crossing elimination, but the time loss and traffic hazard combined, will warrant the physical separation.

OVERPASS VS. UNDERPASS

Having determined that highway and railroad grades are to be separated, our next problem is to decide whether the highway should be carried over or under the railroad. In general, we attempt to plan the type of separation which is most nearly adaptable to local topography. Obviously, we want to go under a railroad on a fill and over a railroad in a cut, other things being equal. A study of possible grades for each type of separation will usually show that one type has a distinct advantage over the other. Comparative cost estimates will verify the choice of the most economical separation. Each type of separation has certain inherent advantages which should not be overlooked in making the final selection of type.

When the terrain in the vicinity of a railroad crossing is fairly level and the track is near normal ground surface, highway traffic must climb, on an average, about seven feet more when going over a track than when going under. This is caused by the increased vertical clearance requirements for structures crossing over a railroad. It results in either steeper or longer approach grades on overpass construction. In cities, in particular, an overpass may be objectionable because of increased right-of-way width to contain fill slopes or requirements for heavy retaining walls on the structure approaches, in case such right-of-way width is not available. In the northern parts of the State, overpasses are subject to more frequent and severe icing conditions because of their exposed nature. Frequently, overpasses are of such length that they fall within the Department's limitations for restrictive roadway bridges. The approved underpass sections included in the Department's design standards generally afford more lateral clearance to the edge of traffic lanes than is provided by our standards for restrictive bridges.

Underpasses occasionally require expensive provisions for disposing of surface drainage. Unless the railroad is located on a ridge or side hill, the cut must be drained by a gravity storm sewer or an automatic pump installation. Drainage requirements should be thoroughly investigated in the early stages of project development as they may be of such nature as to justify changing the type of structure from underpass to overpass. In some of the western and northwestern parts of the State, underpass cuts are subject to being blocked by drifting snow.

Facilities varying widely in cost are required for handling rail traffic during construction. Particularly when it is not feasible to detour rail traffic around the structure site, the hazard of working under and around rail traffic will result in higher construction cost because of precautions which the contractor must take to insure the safe passage of trains, and because of frequent interruption of his operations by rail traffic.

The above discussion lists some of the disadvantages of each type structure. Obviously, the disadvantage of one type is usually an advantage of the other type. Underpass structures are maintained by the railroad in all cases and overpass structures are maintained by the Department. In either case, the maintenance of the approaches is our responsibility.

RAILROAD GRADE REVISIONS

Any major revision of railroad grades is to be discouraged usually. However, in some cases a study of the track profile will reveal that an improved facility will result from a grade revision. Obviously, if the railroad grade is to be revised, we would want to raise the track for an underpass and depress the track for an overpass.

Let us consider an overpass location crossing a railroad at or near a grade summit. In such an instance, it may be found economically feasible to lower the track as much as ten or twelve feet, thereby improving both the highway and the railroad grade line as well as reducing the required embankment and possibly the structure length. It has been our experience that grade reductions of less than about six feet cannot be economically justified. Before making a final decision to revise the railroad grade, it is always necessary to secure approval of the Chief Engineer of the railroad.

Railroad grade reductions are accomplished by constructing a temporary track which is known as a shoo-fly. Rail traffic is routed over the shoo-fly while the contractor is performing the excavation necessary to lower the grade. Upon completion of the grade reduction, the track is replaced and traffic is re-routed over the main line. Following this, the shoo-fly track is removed and the contractor may then proceed with construction of the overpass.

After the main line track has been removed within the limits of the shoo-fly, the ballast under the track is subject to disposition. It has been our experience that the cost of removing, cleaning and replacing old ballast usually exceeds the cost of new ballast. Consequently the old ballast may be stock-piled by the contractor for use as shoulder material or as the Engineer may direct.

Raising of railroad grades at an underpass site may be desirable to facilitate gravity drainage or to meet the grade of intersecting streets on the approaches in urban areas. A railroad track may be raised a maximum of about two feet without intèrruption to rail traffic. This is accomplished by forking additional ballast under the ties in a series of several lifts. More extensive track raises have been undertaken by this Department only a few times in its history. These have always been in urban areas where other solutions were impracticable. In all cases to date, the work has involved not only raising the track, but also revision of buildings or other railroad facilities. Such projects have been quite expensive. It is recommended that major grade raises be confined to those few instances where an exhaustive study reveals no other feasible solution.

ALIGNMENT, GRADES & SIGHT DISTANCE

The standards for alignment, grades and sight distance at highway-railroad grade separations should be at least as high as the design standards for the classification of highway involved. There may be a tendency to lower standards in order to effect construction economy. However, this tendency should be resisted because of the possible sense of restriction resulting from the presence of piers, abutments, curbs and railings.

It should be remembered that the function of an overpass or underpass structure is to separate the grades of highway and rail traffic.

This function is served equally well whether the structure is normal or skewed. Naturally, the most economical structure will result from a crossing at or near right angles. However, the wisdom of sacrificing a satisfactory alignment in order to obtain a near normal crossing is questionable. Quite often it will be found that a satisfactory alignment and overall economy will more than offset the cost of a skewed, more expensive structure. In some cases it has been found economical to skew grade separation structures as much as sixty degrees. This is particularly true of the reconstruction of old structures having excessive approach curves, as it permits maximum re-use of the old roadway approaches.

The gradient of roadways approaching separation structures should be kept to a reasonable minimum and should not exceed the maximum allowed by current design standards. Generally, we try to limit approach grades to a maximum of four or five per cent. Approach grades in excess of five per cent should be used only when the study of the design as a whole indicates that other factors are more important, and therefore overrule the gradient limit.

The sight distance provided at grade separations should conform to the current design standards of the Department for the applicable classification of highway. Sight distance on approaches to overpasses are examples of crest vertical curves and may be determined by referring to the sight distance chart included as a part of the current design standards. This chart is not applicable to underpass sight distance. Here, the line of vision is obstructed by the structure deck. Sight distance through underpass cuts may be determined by methods presented on pages 28 and 29 of the current AASHO manual entitled "A Policy on Grade Separations for Intersecting Highways."

PROJECT LENGTH

It has been mentioned previously that Federal funds are available to pay the entire cost of grade separation projects, except in cases where the railroads are required to contribute a maximum of ten per cent. Except in unusual cases, the Department takes full advantage of this privilege by establishing a separate project for the maximum length eligible for such 100 per cent Federal financing. A project of this nature may include the total cost of all items of work on either side of the crossing structure for such length as may be necessary for proper approach grades and vertical curves. This usually means that the project may begin at the beginning of the vertical curve on one approach and end at the end of the vertical curve on the other approach. Representatives of the Bridge Division will discuss project limits with the local office of the Bureau in unusual cases and arrive at a mutual understanding. It is important that the project limits be established at an early date, soon after the final grade line has been selected, so that the proper separation of quantities may be made during the development of plans, specifications and estimates.

OVERPASSES

a. Clearance. An Act of the Texas Legislature requires that all structures over and adjacent to railroad tracks must provide at least twenty-two feet vertical clearance above the top of rails and eight and one-half feet horizontal clearance from the center of track. This clearance must be maintained twenty-four hours daily, including the entire construction period. In actual practice, the Departmental policy establishes a minimum of twenty-two and one-half (22.5) feet vertical clearance above the top of rails and nine (9.0) feet minimum horizontal clearance from the center-line of track to the nearest edge of the substructure units. The extra six inches of vertical clearance is allowed to facilitate future re-ballasting by the railroad. The extra six inches horizontal clearance is allowed for concrete forms for the substructure units. In case the substructure units are not parallel to the track, care should be taken to insure that the end of cap does not impair the standard clearance rectangle. In case the track is on a superelevated curve, the clearance rectangle must be tilted accordingly. Tracks on a curve should also be checked to ascertain that the standard clearance rectangle is not impaired for a straight line distance of at least sixty feet.

b. Roadway Width. Since an overpass is merely a bridge over a railroad track, the current standards of design will govern for the selection of roadway and curb widths.

c. Excavation. Plans and specifications should make adequate provisions for protection of excavated holes in the immediate vicinity of a railroad track. It should be remembered that the tendency to cave is much more prevalent adjacent to a railroad, because of vibration resulting from the passage of trains. When spread footings are required adjacent to a track, plans and specifications should require the contractor to shore holes properly to prevent caving. In the case of drilled shaft type foundations, the plans may require the contractor to provide casing for holes adjacent to the track. Such casing may be withdrawn as the hole is filled with concrete. The top of all holes near the track should be covered except during periods while the contractor's forces are working in and around the holes.

d. Flagging Protection. The railroads are permitted to furnish the services of flagmen for certain periods during which the contractor's operations might endanger the safe passage of trains. For overpass construction, flagging is usually limited to periods while the contractor is erecting beams over the track and while he is placing and removing forms for the span over the track. Rules of the Bureau of Public Roads require that such protective measures, which are required solely because of the contractor's work, shall be paid for directly by the contractor. It is our customary practice, on overpass projects, to include a special provision to Item 7 of the standard specifications outlining the periods when the contractor may be expected to pay for flagging. This special provision gives the rates of pay for railroad employees serving as flagmen.

e. Blast Plates. Steel beams exposed to the blast from a steam locomotive are subject to excessive corrosion. In the past we have placed plates directly over the track to prevent the locomotive blast from discharging directly on the beams. Originally these plates were made of wrought iron or special corrosive resistant alloy steel. In the past few years we have been using corrugated cement asbestos for blast plates rather generally, because of the extremely high cost of metal plates. At the present time most railroads are in the transition process from steam to diesel-electric power. Since blast plates are not required over diesel engines, we now ascertain from the railroad their estimate of the time when they will remove steam locomotives from the section of track in question. As a result of this information, blast plates are now being omitted in some cases. It is expected that the future use of blast plates will be severely curtailed.

UNDERPASSES

a. Design. The structure design for underpasses, in most cases, is prepared by the railroad company. However, by special agreement, underpass structures are occasionally designed by the Bridge Division.

b. Number of Tracks. The Department will include, as a part of its project, an underpass superstructure wide enough to accommodate existing tracks and such other tracks as the railroad might be constructing at the time the project is undertaken. In the case of spur tracks that begin or end in the vicinity of the highway crossing, efforts should be made to persuade the railroad to revise its track layout so as to remove the need for carrying these tracks across the structure. At the request of the railroad, we may make provision for future tracks provided the railroad bears the additional cost of the structure.

c. Structure Walkways. Safety regulations of the railroads require walkways on structures located within certain distances of switches. The Department will allow the cost of walkways as a part of the project when such provisions are required for safe passage of trainmen. Usually walkways are required in the vicinity of railroad yards in urban areas.

d. Clearances. The standards of the American Association of State Highway Officials for interstate highways contain the following clearance requirements for underpasses:

> "The clear height of all structures shall be at least fourteen feet over the entire width of traffic lanes and at least twelve and one-half feet over the effective shoulder width. The lateral clearance from the right edge of pavement of the through traffic lanes to the face of walls or abutments and piers at underpasses shall be at least six feet. The lateral clearance between the left edge of the pavement and the face of a center pier shall be at least four and one-half feet."

It is the policy of the Department to provide a minimum of fourteen feet six inches vertical clearance between low steel of the underpass superstructure and the roadway pavement under the structure. The current standards of design of the Department include typical sections showing recommended horizontal clearance for various conditions on both two lane and four lane roadways. It is believed one of these typical sections can be adapted to most situations with possibly some slight modification. In special cases where these are obviously inappropriate, the designs divisions may be consulted for recommended sections.

e. Drainage. It is highly desirable to exclude as much surface drainage from the underpass cut as is physically and economically possible. Roadway drainage outside the cut may be controlled effectively if it is feasible to provide grades which ascend toward the beginning of the cut on either side. Drainage from the sides of the cut may be eliminated by a dike or combination ditch and dike in back of the top of cut, in cases where the drainage collecting along such dike can be disposed of on the surface. Often the drainage in back of a dike will require the installation of a pipe culvert under the railroad. If rail traffic is routed over a shoo-fly track during construction, the pipe may be installed under the main line in an open cut while the shoo-fly is in operation. If rail traffic is carried on a falsework trestle during construction of the underpass, rail traffic remains on the main line, in which case the pipe may be placed by jacking methods. The railroads have generally required extra strength concrete pipe for a permanent installation. The top of pipe should be placed about three feet below the elevation of bottom of ties.

There are three methods employed for the disposition of surface drainage collecting in an underpass cut. If the railroad occupies a side hill location, it is often possible to collect and dispose of drainage in roadway ditches. Typical Section # 2, included in the current design standards of the Department, shows an example of handling surface drainage in roadway ditches. This is the most economical method of handling drainage where existing topography will permit.

In cases where the drainage cannot be removed in surface ditches, the most satisfactory method of handling drainage is to collect the water in inlets and dispose of it through a gravity storm sewer. A storm sewer draining an underpass is generally considered to be an obligation of the Department since our construction creates a drainage situation which would not exist otherwise.

Automatic pumping installations are employed in cases where it is not economically or physically feasible to dispose of drainage by one of the other methods discussed previously. It should be remembered that pumps and their power source, being mechanical devices, are not entirely reliable. Electric motors, as a source of power, are cheaper and less subject to mechanical failure but, as you know, electric service may be disrupted during a storm at a time when the pump may be needed most. In order to overcome this difficulty, we have occasionally used internal combustion engines with natural gas as a source of fuel. Internal combustion engines cost substantially more initially, and in addition they require frequent maintenance inspection to insure they remain in proper operating condition.

f. Superstructure. The depth of the superstructure, from base of rail to low steel, together with the vertical clearance below low steel, fixes the elevation of roadway grade under the structure. The clearance, as previously mentioned, is fixed by Departmental policy. Some latitude is permitted in the depth of superstructure. A deck type span will require a greater depth, from base of rail to low steel, than will be required for a through girder span. A deck type span is the most economical and is preferred. Where it is necessary to keep the roadway grade as high as possible, to facilitate drainage or meet grades of intersecting roads or streets on the approaches, a through girder span may be employed.

A span consisting of rolled beams is the most economical type. The maximum length for I-beam spans is about 50 feet overall. Such spans will usually vary from about four and one-half to five feet depth. When spans exceed the maximum allowable for I-beams, plate girders may be used. For an approximate estimate, it may be assumed that the girder depth will be 1/12 of the span length. To this should be added eighteen inches minimum in order to obtain the total span depth. The depth of through girders, from base of rail to low steel, will vary from eighteen inches to three feet for a single track structure. As this depth is decreased below three feet, the cost will increase due to uneconomical floor beam requirements. Not more than two tracks may be placed on a through girder span.

The depth of various spans, as discussed above, is approximate and is given for purposes of fixing a temporary grade line. The depth of span must be checked with the railroad before a final grade line can be established.

g. Cut Section. An open cut with sloping sides and flanking spans across the slopes, is the preferred section in usual cases. In urban areas, you may find that the cost of extra right-of-way to permit an open cut is prohibitive, in which case a retaining wall section may be required. Before making a final decision to utilize retaining walls, it is recommended that the cost of extra right-of-way to permit an open cut be compared with the cost of retaining walls in order to establish the overall economy of design.

h. Rail Traffic. The project plans must make provision for handling rail traffic while the underpass is being built. For reasons outlined above, the preferred and most economical method of handling rail traffic is to construct a shoo-fly track around the structure site, where topography and available right-of-way will permit. We have found the shoo-fly method of handling economical even in cases where relatively large embankment quantities are required, with or without a temporary trestle across an existing road. In cases where the project requires the reconstruction of an old underpass and a trestle is needed to carry rail traffic over the existing highway, it may be found to our advantage to move the span from the old structure and utilize it in the temporary trestle for spanning the road. In a recent case requiring this handling, highway traffic was disrupted for three and one-half hours and rail traffic was disrupted for a total of four hours. Actual time for moving the 40 foot steel span from the old structure to its position in the new trestle was two and one-half hours. The construction of the trestle and moving of the old span was accomplished as a contract item.

In shoo-fly track construction, the grading operations are performed by the contractor. Track work is performed by the railroad as a force account item chargeable to the project. Usually ballast specifications are not as strict as those required for a permanent track. Ballast may be furnished by the railroad company or by the contractor, depending on which method of supply is the most economical. If the railroad furnishes ballast, the contractor's work is limited to preparation of the embankment section to the elevation of the bottom of ballast. If suitable ballast can be furnished more economically by contract, the contractor places ballast to the bottom of ties and furnishes enough additional ballast in windrows beyond the ends of ties to fill between the ties. The track is then laid by the railroad and their forces place the ballast between the ties.

A shoo-fly track affords minimum interference and hazard to railroad operations. Usually connections to the main line can be made between the passage of trains.

The railroad may then operate their trains without undue hazard from the contractor's work. The contractor is permitted to prosecute his work with relatively little interference from train operation. The superstructure can be erected and painted in place and foundation piling, if required, may be driven by the contractor.

Occasionally crossings are so located that shoo-fly construction is prevented by inadequate right-of-way or other conditions peculiar to the site. It then becomes necessary to construct a falsework trestle to carry rail traffic while the permanent structure is being built. The first step in the construction of a falsework trestle is the driving of piling through the track by the railroad. Hand excavation is then required to cap the piles and place the stringers. Rail traffic must be maintained during these operations, so that frequent interruptions by passage of trains must be expected. When the railroad has completed construction of the falsework trestle, the contractor may proceed with the excavation and construction of the substructure. If foundation piling are required for the substructure units, these are usually driven by railroad equipment and forces because the railroads usually will not permit the contractor's equipment to occupy the track. Since the superstructure spans cannot be erected and painted in place, this work is performed on temporary erection bents adjacent to the piers and abutments. Upon its completion, rail traffic is stopped while the falsework is removed and the permanent superstructure is rolled or lifted into place. Placing of the superstructure is done either by the railroad or by the contractor who is assisted by the railroad forces, as may be agreed upon during the planning stage. From this you will observe that not only are the construction methods costly, but both the contractor and the railroad interfere with the operations of the other party.

Construction procedure for the two methods of handling rail traffic has been described in detail in order to show the relative advantages and disadvantages of each and because it is necessary to outline such procedure by plans and specifications.

i. Excavation Diagrams. Construction of an underpass requires roadway excavation and structural excavation. The plans should include a diagram showing the limiting lines for measurement of each type of excavation. Attached is a drawing showing typical examples of excavation diagrams for projects where rail traffic is carried by a shoo-fly and by a falsework trestle. You will observe that more structural excavation is allowed when a falsework trestle is required.

j. Lighting. An underpass crossing under several tracks in an urban area presents a special problem for police protection by the local authorities. The long covered area provides secluded sections which may not be illuminated properly by adjacent street lighting. In such cases, the local authorities may request that provisions for subsequent illumination be included as a part of the construction project. Administrative Circular #28-41, dated June 18, 1941, states in effect that, if so requested by the municipality, the Department will install conduit and pull boxes as a part of its construction project, to permit lighting by the City without subsequent alteration of the structure. This does not apply to the lighting of certain expressway projects covered by Commission Minute #28464.

SPECIFICATIONS

In addition to the usual specifications for contract items, grade separations require certain special provisions which are used only on work of this nature. In the case of an overpass, we use special provisions to Item 7 which give the rates of pay for railroad flagmen and describe certain insurance which the contractor is required to carry.

Work on an underpass is performed by forces of the railroad company and the contractor. Each has certain specific duties to perform. In order to avoid a misunderstanding, we include a special provision to Item 4 outlining the specific operations which will be undertaken by the railroad and by the contractor. A special provision to Item 8 describes the sequence in which the various operations will be performed. In addition, an underpass requires a special provision to Item 7, describing special insurance which the contractor will be required to carry.

Special provisions to Item 7 for both overpasses and underpasses will be prepared by the Bridge Division. Special provisions to Items 4 and 8 should be prepared by the District Engineer, but representatives of the Bridge Division will assist, if requested.

FORCE ACCOUNT

It has been mentioned previously that a certain portion of the work required to complete a grade separation project, is performed by forces of the railroad. The cost of this work is directly chargeable to the project and the railroad is reimbursed in accordance with the terms of a formal agreement between the State and the railroad company.

As a part of an overpass project, the forces of the railroad usually install inner guard rail and make such adjustments of signal and communication lines, owned or operated by the railroad company, as may be necessary to accommodate the temporary and permanent construction.

As a part of an underpass project, the railroad may, if required, undertake the adjustment of its signal and communication lines; construct and maintain a falsework trestle; drive permanent piling; place the superstructure; remove and replace the main line track within the limits of the structure; construct, maintain and remove a shoo-fly track; install inner guard rail; furnish ballast for the main line and shoo-fly tracks; and adjust cattle guards and fences. These are the usual force account items. Others may be required in special cases.

BALLAST

It is required that ballast be secured from the most economical source. During the preliminary stages of developing the project, the railroad furnishes an estimate showing prices at which they can furnish ballast. A local investigation is then made to ascertain whether or not we might expect the contractor to furnish acceptable ballast at a lower price.

PS&E DEVELOPMENT

Bridge Circular Letter #5-44, dated May 30, 1944, outlines the procedure which we now follow in the development of plans, specifications and estimates for a highway-railroad grade separation project. The first step in planning one of these projects, is the preparation of standard size plan sheets showing the essential features of the design. Existing features should be shown in ink and the proposed construction should be shown in pencil.

a. Overpasses. For an overpass project, the preliminary submission should consist of a plan-profile sheet showing the following:

(1) The highway station at the centerline of each track crossed.

(2) The location of railroad fences or right-of-way lines with respect to the centerline of main track.

(3) The location of each pole line, the number of cross-arms and wires and the owner of each line. In cases where the owners of the

various wire lines cannot be ascertained locally, the desired information will be obtained by the Bridge Division from the railroad company.

(4) The alignment of the highway and railroad and the angle of intersection.

(5) The top of rail profile for approximately 500 feet each way from the highway. If the railroad is on a curve, the profile should be taken along the high rail. In the case of a superelevated curve, the profile along the highway centerline should show the top of each rail.

(6) A tie-in to some fixed feature of the railroad such as a structure (giving the bridge number), a mile post or the point of a switch. The railroad station number is an acceptable tie if it can be readily obtained locally. We have been cautioned by the Santa Fe that a mile board sign on a telegraph pole is not a reliable tie as these are placed on the nearest pole. The Santa Fe mile post is a section of rail, five feet long, set in the ground seven feet six inches from the near rail.

(7) Roadway grades and line drawing of the structure.

(8) The location of any railroad facilities which might require adjustment.

(9) The horizontal and vertical clearances provided by the span over the track. These are generally shown as minimum 22 feet 6 inches vertical and minimum 8 feet 6 inches horizontal, even though the actual clearances may be in excess of these dimensions.

In addition to the plan-profile sheet discussed above, the preliminary submission should include a standard size bridge layout sheet showing the nine items listed above, within the limits of the drawing, together with the following additional information:

(1) Contours.

(2) Layout of the structure, including the location of toe of slope at each bridge end.

(3) Boring data.

(4) Location of communication and signal line poles adjacent to the structure and elevations of low wires.

(5) The proposed roadway section, including pavement and structure widths and sidewalks, if required.

(6) Proposed sight distance.

Upon completion of these two drawings, the original tracings should be forwarded to the Bridge Division for review by the designs divisions. After a mutual agreement has been reached within the Department, prints will be forwarded to the railroad and the Bureau of Public Roads for their review and comment. When agreement has been reached with these latter two agencies, preparation of the project plans may proceed in the normal manner.

b. Underpasses. For an underpass project the preliminary submission should consist of a standard size plan-profile sheet showing the following:

(1) The highway station at the centerline of each track crossed.

(2) The location of railroad fences or right-of-way lines with respect to the centerline of main track.

(3) The location of each pole line, the number of cross-arms and wires. We are particularly interested in the location of poles in and near the underpass cut and in the area where a shoo-fly track might be located.

(4) The alignment of the highway and railroad and the angle of intersection.

(5) A profile of the base of rail for at least 600 feet away from the centerline of highway and for a greater distance if a revision of the railroad grade is proposed. In case the railroad is on a superelevated curve, the profile should be taken along the base of low rail.

(6) A tie-in to some fixed feature of the railroad such as a structure (giving the bridge number), a mile post or the point of a switch. The railroad station number is an acceptable tie if it can be readily obtained locally. Attention is directed to previous comments in the discussion of overpass preliminary, concerning the location of mile posts on the Santa Fe.

(7) Contours adjacent to railroad and highway and highway profile with elevations shown for the base of rail of each track crossed.

(8) Proposed highway grade line.

(9) Proposed section at the underpass showing clear span, pavement width, vertical clearance, horizontal clearance to edge of pavement, type of curbs if required and side slopes of the roadway cut. Typical sections shown in the current standards of design may be used as a guide in most cases.

(10) The location and description of any railroad facilities which might require adjustment.

(11) Indicate the proposed method for handling surface drainage in the underpass cut.

(12) Boring data.

(13) In case it appears feasible to handle rail traffic during construction over a shoo-fly track, indicate the most appropriate location for a shoo-fly.

(14) Proposed sight distance.

(15) Indicate any proposed revision of the railroad grade.

Upon completion of a drawing showing these preliminary data, the original tracing should be forwarded to the Bridge Division for review by the designs divisions. After a mutual agreement has been reached within the Department, prints will be forwarded to the railroad and the Bureau of Public Roads for their review and comment.

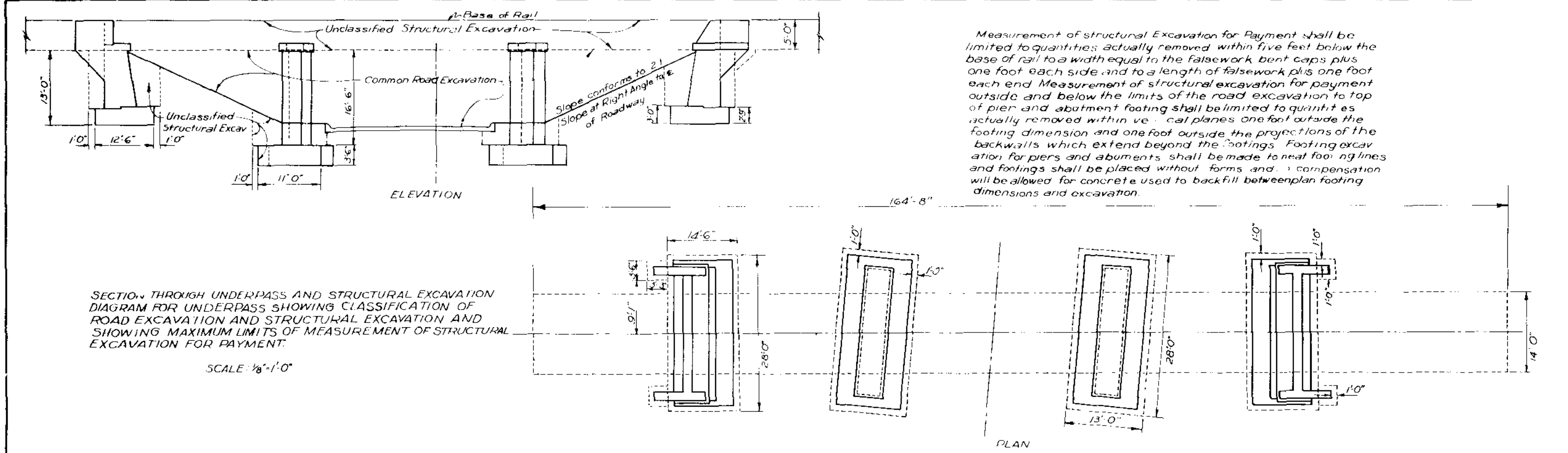
After approval of the preliminary data by these two agencies, the next step is the preparation of a preliminary study sketch showing the depth of span and other essential features of the structure design. If the railroad is to prepare the design of structure, they will be asked to prepare the study sketch and submit prints for review by the District Engineer, the Bureau of Public Roads and the Bridge Division. If the Bridge Division is to prepare the structure design, this handling is reversed insofar as the railroad is concerned.

When the study sketch has been finally approved by all interested parties, the District Engineer may proceed with the roadway plans based on data shown on the study sketch.

If structure plans are prepared by the railroad, preliminary prints of the completed details will be furnished for review by the District Engineer and the Bridge Division. Following this review and any corrections deemed necessary, final prints will be furnished to the District Engineer for use as a part of the project plans.

It is believed that a preliminary inspection at the site by all interested agencies is not necessary in the usual case. If an inspection is desired by one or more agency, appropriate arrangements will be made by the Bridge Division.

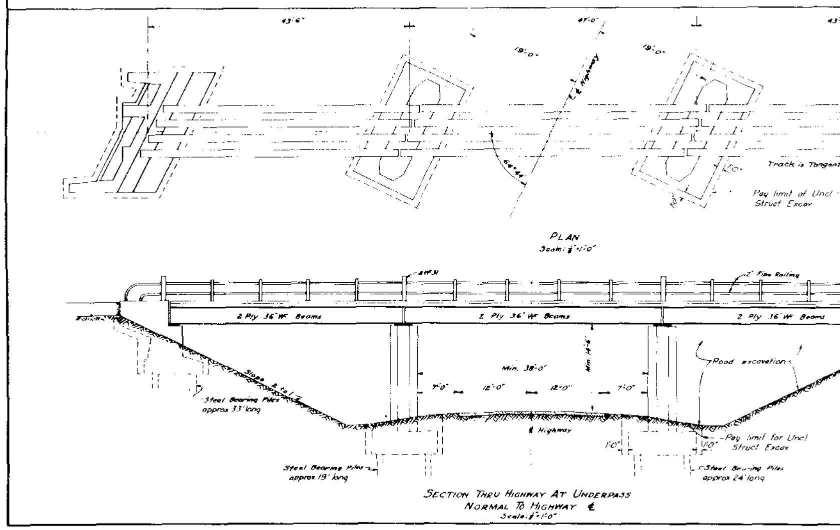
In order to establish uniformity of handling, the Administration has delegated the responsibility for correspondence with the railroads to the Bridge Division. Consequently this Division will initiate all contacts with railroad Chief Engineers leading to the development of grade separation projects.



Measurement of structural Excavation for Payment shall be limited to quantities actually removed within five feet below the base of rail to a width equal to the falsework bent caps plus one foot each side and to a length of falsework plus one foot each end Measurement of structural excavation for payment outside and below the limits of the road excavation to top of pier and abutment footing shall be limited to quantit es actually removed within ve cal planes one foot outside the footing dimension and one foot outside the projections of the backwalls which extend beyond the footings Footing excav ation for piers and abuments shall be made to neat foo ng lines and footings shall be placed without forms and compensation will be allowed for concrete used to backfill betweenplan footing dimensions and excavation.

EXCAVATION DIAGRAM

TYPICAL FOR FALSEWOK
TRESTLE COUSTRUCTION



EXCAVATION DIAGRAM

TYPICAL FOR SHOO-FLY
CONSTRUCTION

DRAFTING

THE IMPORTANCE OF GOOD DRAFTING

Some excellent papers have been presented in this school telling of the preliminary investigations and planning that is required to properly design roadways and structures. All of these are veryimportant aspects of highway work. But, important as this work is and no matter how thoroughly it may have been performed, all the work will be of no use unless it is possible to convey these ideas to persons who are unfamiliar with the roads and bridges that have been visualized in the designs. This is done by preparing a set of plans, supplemented by appropriate specifications, which completely and accurately describe the proposed project. The plans and specifications are used as a basis on which contracts are let, and construction proceeds in the field using the contract plans and specifications to determine what workis required and how it is to be done. Finally, the ideas conceived in the designs become a reality, and the plans and specifications then become a permanent record of the work performed.

It is obvious that a poor set of plans can ruin what is otherwise a well planned project. It is essential that a set of plans, along with the specifications, be complete, accurate and clearly presented. A good set of plans will save much time of both the engineering forces and the construction crew in trying to determine the intention of the designer and will avoid errors caused by misunderstanding what is meant.

In addition, a good set of plans will leave a favorable impression on everyone who has to use them. The purpose of this paper is to describe certain fundamental principles of drafting, which, when practiced, are most likely to result in good plans.

THE FIELD OF DRAFTING

First, let us find out what a draftsman is. Webster defines a draftsman as "one who draws plans and sketches, as of machinery or structures; one who makes drawings." It can readily be seen that the field of drafting covers a lot of territory.

Drafting is an art that began a long way back in history. The Temple of Solomon was built of stones cut to size and shape in the quarries and transported to the building site for erection. Certainly some sort of drawings were required to make this possible. The Roman aqueducts and highways and the ancient Greek temples, so complex in arrangement and refined in detail, could not have been constructed without accurate drawings to guide the artisans in forming the structural elements and the builders in assembling them. As early as 30 B. C., a treatise on architecture appeared which described the use of projection drawings for structures.

As our civilization became more complex the work of the engineer became more specialized, and the different branches of engineering developed. So did drafting, a unique means of communication among engineers, become more specialized until today there is a type of drafting to correspond with each of the different branches of engineering.

The architectural draftsman portrays the work of the architect according to his own individual style. Architects themselves specialize in the various branches of architecture, resulting in a further subdivision of the field of drafting. Machine drafting, electrical drafting, aircraft drafting and ship drafting are each types of drafting which have procedures and peculiarities distinctly their own.

Draftsmen employed by the Texas Highway Department will be required to do work of various types. Office buildings, warehouses and laboratory buildings require plans prepared by a draftsman familiar with the techniques of architectural drafting. Map drafting, which requires special skills of its own, constitutes an important item in the planning phases of highway construction. However, the drafting work of field engineers consists primarily of the preparation of plans for roadways and bridges. Due to the limited scope of this paper, this discussion will be confined to the type of drafting which is required in the preparation of an average set of project plans.

THEORY OF DRAFTING

Now let us try to determine what makes a draftsman a <u>good</u> draftsman. First of all he must understand the principles used to represent objects on drawings. That is, to be able to draw plans, a person must be able to read plans. He must know how to use and care for the instruments and materials with which he works. He must also know what factors contribute to making drawings effective and easily read.

An explanation of each of these qualifications now seems to be in order.

To represent objects on engineering drawings the method of multi-view orthographic projection is most often used. By this method, an object is represented by projections of the object on planes parallel to its principal faces by means of perpendiculars dropped from the object to the projection planes. That is, in simpler language, the projection of an object is the view that an observer would get looking directly at one face of the object from an infinite distance. When projected in this manner, surfaces parallel to the projection plane appear in their true dimensions, and surfaces perpendicular to the projection plane appear as lines. Lines which are hidden from the view of the observer are indicated in the projection by a broken line. By the selection of a sufficient number of projections an object can be accurately portrayed as to its form.

Normally, an object could be shown by six views; that is, the top (or plan) view, the front view (or elevation), the right side view, the left side view, the rear view, and the bottom view. When arranged on an engineering drawing, the top view should appear above the front view, the right side view to the right of the front view, the left side view to the left of the front view, and the bottom view below the front view. Almost always the plan, elevation, and side view are needed to accurately portray an object, but sometimes only two views, the plan and elevation, are sufficient. The views should always be placed on the drawing in the proper relation to each other.

Very often the details of an object can be shown to advantage by cutting a section through the object. Frequently, this is necessary. In such cases the location of the cutting plane must be indicated and the sectional view identified with the cutting plane.

The form of an object is portrayed by selecting the necessary views and sections. Of equal importance on an engineering drawing is defining the size of the object. This is done by dimensioning. An object should be dimensioned so that the size and position of all of its features are fixed. While it is imperative that all necessary dimensions be given, it is also poor practice to over-dimension. Never try to show the same information in more than one way.

The following are a few general rules regarding dimensioning:

(a) Dimensions should be shown on the view which most clearly pictures the form of the feature dimensioned.

(b) Dimensions which apply to two views should be placed between the two views. That is, the height of an object should be placed between the front view and the side view.

(c) Over-all dimensions should be placed outside the dimensions of included details.

(d) Horizontal and vertical dimensions should be placed so that they may be read from the bottom or the right of the drawing. Inclined dimensions should be placed so that they may be read by turning the drawing through the smallest possible angle.

(e) All dimensions should be legible. The numerals should be carefully executed and be of sufficient size to be read at a glance. Dimension lines should never be crowded into a restricted space. The legibility of dimensioning cannot be overemphasized.

Notes are placed on a drawing to give information not otherwise shown, such as, specifying finishes or methods of performing certain operations. Notes should be clear and concise. Abbreviations and symbols should be of standard usage to avoid the possibility of errors.

TECHNIQUES OF GOOD DRAFTING

So much for the theory of drafting. Let us now consider good drafting practice. A draftsman needs good instruments and materials to work with and he must know how to use and care for them. His drawing board must be smooth and have straight edges. His T-square and triangles must be true. In addition the use of all other instruments, such as scales, compasses, dividers and French curves, must be understood. The drawing paper should be fastened to the drawing board with thumb tacks or staples. Work should be done with well sharpened pencils of the correct grade. Hard pencils should be used for preliminary light lines and soft pencils should be used for final lines.

When detailing in pencil, the draftsman must decide what views and sections are required and the best scale to use. Then he draws the principal center-lines and blocks in all views to secure a balanced arrangement on the sheet. He proceeds to detail the drawing by adding the important circles and curves, object lines, hidden lines, and dimension lines in that order. Finally the arrow heads and dimensions are inserted and the notes and title block are lettered.

In performing ink work, the draftsman must be taught a number of different operations. The tracing cloth should be mounted with the glossy surface toward the drawing board and the dull surface upward. The cloth should be dusted with tracing cloth powder and well rubbed. Any excess powder should be removed before ink is applied to the drawing. The draftsman must learn to fill the ruling pen properly and to draw lines with the pen in a vertical plane inclined slightly forward in the direction of the line. The ruling pen is the most important instrument used in ink work and should be of good quality. Ruling pens and ink compasses should be kept clean at all times, and when they become dulled by use they should be properly sharpened.

When tracing in ink the same general procedure is followed as in detailing in pencil. First, center lines are inked, then circles and curves, followed by horizontal lines, vertical lines, and inclined lines. Then sections are cross hatched. Dimensions are inked, including arrowheads and numerals. Finally notes and the title block are lettered.

The completed tracing should be checked for errors and omissions.

Both the detailer and the tracer must bear in mind the different types of lines conventionally used for different purposes. Lines used to represent the visible edges of an object should be heavy solid lines. Lines appearing in the view as hidden lines should be medium weight broken lines consisting of short evenly spaced dashes. Center-lines are light weight lines consisting of alternate long and short dashes. Extension lines and dimension lines are light weight lines. The most common mistake is not to make object lines heavy enough. Very seldom can a drawing be criticized for the object lines being too heavy. To secure the most effective results, lines used for the same purpose should be of uniform weight throughout the drawing, and the contrast between heavy weight, medium weight, and light weight lines should be distinct. An example of the correct use of the different types of lines is illustrated in Figure 1.

Now a few words about that all important subject, lettering. Lettering on engineering drawings must be legible and easily executed. To satisfy both requirements, single stroke Gothic letters are used. The term "single stroke" means that each letter is composed of one or more straight or curved parts, each of which is formed by a single stroke. This style of lettering is illustrated in Figure 2.

It is possible for any draftsman to learn to letter well, for good lettering consists of just a few simple fundamentals. Lettering must first of all be of uniform height and uniform slope, making the use of guide lines a must for all lettering. Next the draftsman must know the form and proportions of the individual letters and study the order and direction of the strokes which compose them. Then he must develop the sense of spacing the letters properly in the word and spacing the words properly in sentences. Knowing these fundamentals, the draftsman acquires the ability to letter well only through diligent and conscientious practice. This must be followed by a continuous effort to improve.

There are a number of lettering devices available which aid the draftsman in making uniformly spaced guide lines. A common type is the lettering triangle, which is illustrated in Figure 3. Horizontal guide lines correctly spaced are formed by inserting a pencil point in the holes and sliding the triangle along a straight edge. Inclined guide lines are rapidly made using the slot in the triangle. These devices are very helpful and should be used whenever possible. The draftsman should learn to letter with a well sharpened pencil of the correct grade. The pencil should be soft enough to give a distinct black letter, but not so soft that unsightly smudges will result. There are many types of pens to be used when lettering in ink. A pen should be selected to give a clean sharp line, depositing enough ink to insure a good print. The pen must be cleaned frequently to allow a steady flow of ink on the tracing, thus resulting in uniform work.

It has been found through experience that letters 5/32" high, or No. 5 on the lettering triangle, are best suited for drafting on roadway and bridge plans. Drawings are reproduced at a reduced size to be included in the contract and for permanent records. Lettering smaller than 5/32" high becomes illegible on the small reproductions. Lettering for general purposes is usually executed at a slope of about 67 1/2 degrees with the horizontal. This is for all practical purposes 1" horizontal to 2 1/2" vertical. Titles and sub-titles are made with vertical letters of greater height depending on their importance. Sometimes mechanical lettering is used for this purpose, using the Wrico or Leroy lettering sets. After understanding the procedure to be followed and with a little practice, a draftsman can readily learn to use these mechanical devices.

APPLICATIONS OF GOOD DRAFTING

The principles that have been discussed are the fundamentals which apply to all types of drafting. Let us see how they apply to a problem likely to be encountered in highway work, for example, a reinforced concrete bridge slab. Assume that the structural unit has been designed. The draftsman should first receive some brief instructions from the designer as to the type and general features of the work to be detailed. These instructions may be either a brief written description or design sketches showing all major essential features. The detailer must decide what plans, elevations, and sections, will be necessary to depict the structure and what supplementary details and schedules will be required. He must select scales that will show all details clearly and at the same time determine the number of sheets necessary to properly present the work. Now he is ready to begin the actual drawing.

Ordinarily the plan view is placed in the upper part of the sheet and to the left, with the elevations below in correct position according to orthographic projection. Below the elevations, on the left hand side of the sheet, the sections and details of special features are shown. These views, taken together, must show completely the shape of the structure, the arrangement of the reinforcing steel and must be fully dimensioned to indicate the size of the structure and to show the location of the reinforcement. In the upper right hand corner details of bent bars are given with the schedule of reinforcing steel. The general notes are placed in the lower right hand corner above or beside the title block.

For unusually large structures which require more than one sheet, the plan, elevation, sections and special details are frequently shown on one sheet, and the details of bent bars and schedules of reinforcing steel are shown on a second sheet. This arrangement will present a structure in a clear logical manner. There are cases when a different arrangement can be used to advantage. The guiding principle should always be to detail the structure completely, accurately and clearly.

Bending diagrams should be shown for all bent bars. Bars which are scheduled but not detailed are assumed to be straight. As indicated in the general notes appearing on all structural designs it is the practice of the Texas Highway Department, although not universally accepted practice, to dimension reinforcing steel from center to center of bars. Bent bars are fully dimensioned, giving radii of bends, bevels and slant distances. Bars are not necessarily drawn to scale. Certain features, such as bends or hooks, can be shown to advantage drawn to an exaggerated scale.

Bars are designated by letter, and with a numerical subscript when bars are identical except for a variable dimension. Bars which have a similar bending pattern are detailed only once and are dimensioned by two or more lines of dimensions to distinguish between bars.

All bars are summarized in the "Bill of Reinforcing Steel." Each type of bar is listed and the number, size, spacing, length and weight is designated. The weights are totaled to secure the quantity of reinforcing steel.

The same fundamental principles of drafting apply to the detailing of steel structures. However, there are a few significant differences which it may be well to point out. The elements of a steel structure are limited to those plates and shapes which are rolled by the steel mills. Therefore it is sufficient to designate the section and its length, for example a 30WF108 x 20'-0" means a wide flange beam 30" deep, weighing 108 pounds per foot and twenty feet long. Dimensioning the width and thickness of the web and flanges of the member is unnecessary. The designation of the various sections has become standardized by steel fabricators and erectors. It is important that the draftsman understand and use this standard system of designation.

Connections of members is a major item in the detailing of structural steel. Here again conventional symbols have been developed to designate riveted and welded connections. These symbols can be found in the American Institute of Steel Construction handbook, "Steel Construction." So that the plans can be understood by all who use them it is essential that the draftsman understand and use these symbols.

Also standardized in the fabrication of steel is the nomenclature regarding certain shop processes. Cuts, copes, and blocks mean definite operations performed on I-Beam and channel sections. These terms are defined in the handbook of the A. I. S. C. The different methods of forming holes is often specified by the designer and this information must be shown on the drawing in a manner that can be clearly understood.

CONCLUSION

In this brief presentation of the art of drafting, it has been impossible to cover the subject in detail. Only a summary has been made of the fundamentals of a subject with which all are more or less familiar. In addition, points that apply to work in the Highway Department have been stressed. Teaching an inexperienced man to become a draftsman requires careful explanation and demonstration on the part of the instructor, followed by diligent practice by the student. The use of a good standard text on the subject is strongly recommended. Any one of the following publications cover the subject thoroughly:

T. E. French, "Engineering Drawing" (McGraw-Hill)

French & Svensen, "Mechanical Drawing" (McGraw-Hill)

Giesecke, Mitchell & Spencer, "Technical Drawing" (Macmillan)

THICK LINE

Used for Outline of Surfaces and varied to suit size of drawing.

MEDIUM LINE

Used for Reinforcing Steel and Outline of Structural Steel, also Hidden Lines.

26'-8"

THIN LINE

Used for Center Lines and Dimension Lines

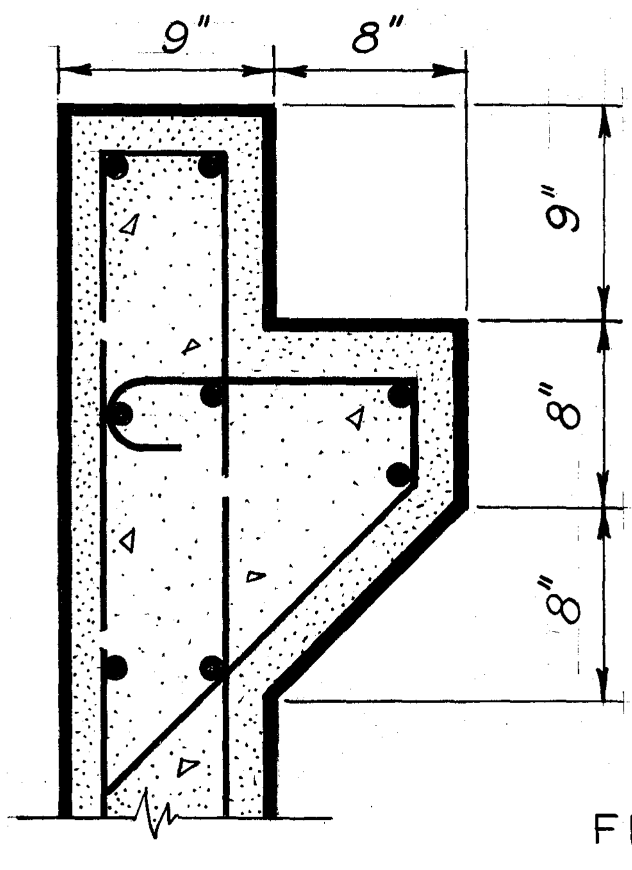


FIG. 1

A B C D E F G H I J K L M O P Q R S T U V W X Y Z & & &
a a b c d e f g h i j k l m n o p q r s t u v w x y z z & &
1 2 3 3 4 5 6 7 8 9 0 0 0 ½" ¾" ¼" ⅞" 3'-8"

GENERAL NOTES :-

The Style of the above Lettering is known as Single Stroke Gothic and has been adopted by the Engineering Profession as Standard Engineering Lettering.

Inclined letters ~ 68°, "CAPS" & lower case are used for - Notes, Bars and all general purposes. Letters should be 5/32" high.

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z
1 2 3 4 5 6 7 8 9 10

VERTICAL "CAPS" ARE USED FOR TITLES AND SUB-TITLES

TEXAS HIGHWAY DEPARTMENT

40'0" I-BEAM SPAN

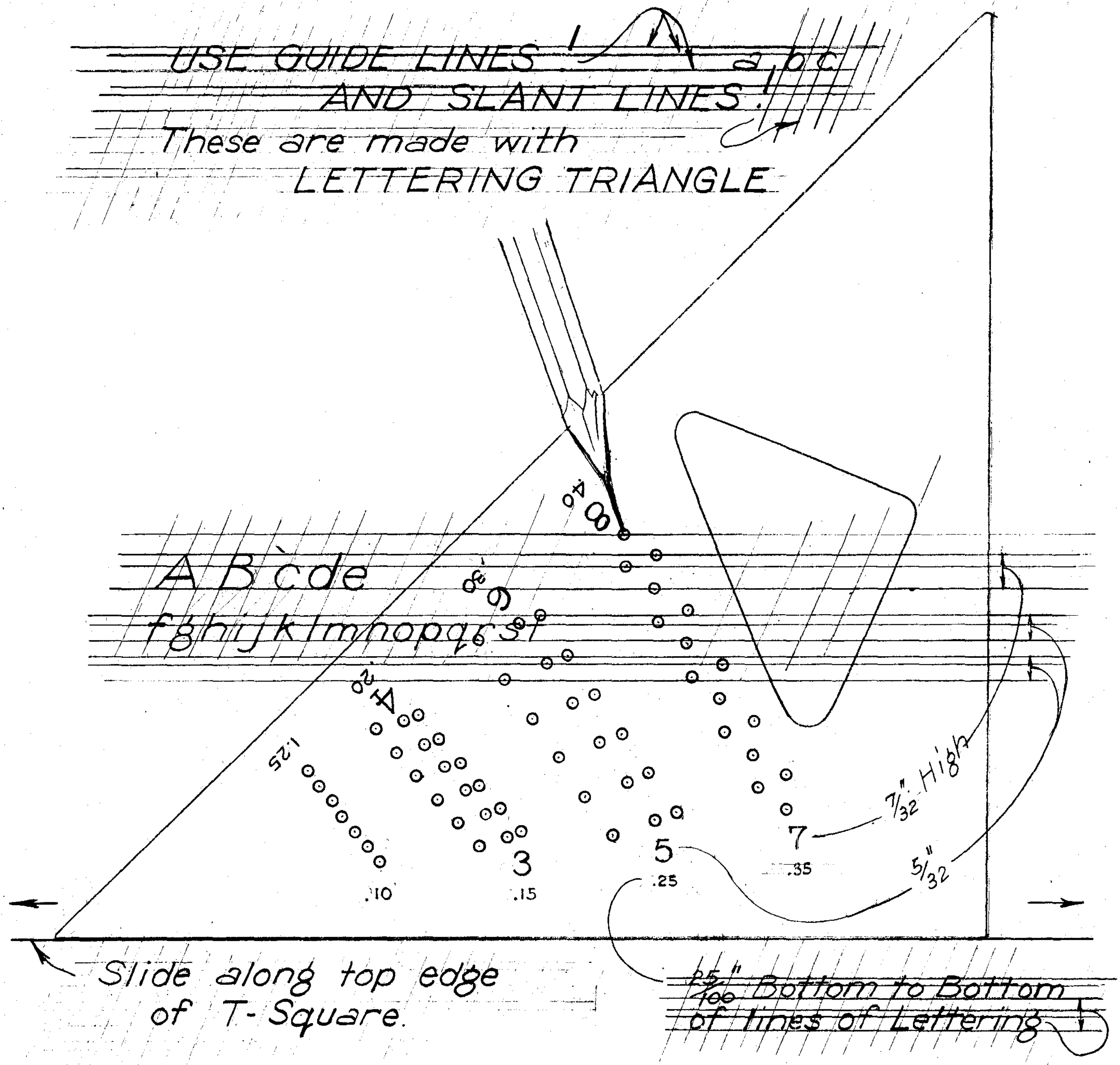
28'-0" RDWY. 18" CURBS

SECTION A-A **ELEVATION**

FIG. 2

The ability to do good FREEHAND LETTERING is <u>not</u> a GIFT.

It is acquired only through diligent PRACTICE and A CONTINUOUS EFFORT TO IMPROVE.



A GOOD DRAWING MAY BE RUINED BY — THE APPEARANCE OF SLOPPY LETTERING

FIG. 3

PREPARATION OF BRIDGE LAYOUTS

The Bridge Layout forms a very vital part of a set of project plans. Its function is to supplement and correlate the bridge details in a manner that can be understood by both the Engineer and the contractor. The layout together with the structural details should present clearly the essential design information as well as the governing features and make-up of the bridge. It is not the object of this paper to distinguish between the role that the field forces play in preparing bridge layouts and the role played by the Austin Office, but rather to outline and discuss the essential features of the completed bridge layout. This is because the degree of work done by the field offices varies widely between different Districts and for different jobs within the same District. The custom has been for the field to prepare the complete layout on small structures and for the Bridge Division to prepare the layouts and structural details on large structures, with varying degrees of joint participation for intermediate size structures. Although this policy has proven satisfactory, it is emphasized that the field personnel should make their layouts as complete as possible on all bridge plans.

Bridge Layouts are required for all structures over 20 feet in length except multiple box culverts and may be used on these and smaller structures if the Engineer feels they are needed to clarify the structural plans. The principal types of bridges for which layouts are required are drainage and stream-crossing structures, railroad and highway underpasses and overpasses, and projects calling for widening or altering of existing bridges. Although each different type of layout has special requirements, there are a large number of features common to all.

The layout sheets should be made with ink on linen tracing cloth, using a full plan size sheet (22" x 36") for all structures, except simple farm-to-market bridges for which the half-size sheet (11' x 18") is preferred. Where the structures are very short, two or more may be placed on the same layout sheet. A scale of 1" = 10', in both horizontal and vertical direction, is preferred and should be used in all instances except where the use of such a large scale would overcrowd the sheet because of the unusual height or width of the bridge. In such cases a scale of 1" = 20' is permissible. Scales smaller than this should never be used and the use of distorted scales should be avoided. At a 1" = 10' scale, one full size plan sheet will accommodate 320' of bridge. However, if a bridge is near 320' in length, two layout sheets should be used instead of one to allow for proper presentation of the bridge approach features. In general, the bridge should be positioned on the layout sheets to give maximum clarity and allow ample room for all necessary drawings, tables and notes.

Two views of the bridge are presented on the layout to convey the major part of the information. The plan view is centered in the upper one-half of the sheet and shows the structure as seen from above. The profile view is located in the bottom one-half of the sheet and may show either a longitudinal section of the structure or a side view. The bottom one-half of the sheet is cross-sectioned at 10 feet intervals horizontally and vertically and sometimes at 1 foot intervals vertically. Stations are given at the bottom of the sheet at 50 feet intervals and elevations are given along the right and left margins at 10 feet intervals. Care should be taken in designating the elevations so that the space below the grade line of the structure will be ample to show the substructure and borings and so that the space above the grade line will be ample for railing and dimensions. Further care should be used in designating the stations to avoid the splitting of a substructure unit by the end of a sheet and, as mentioned earlier, to allow ample room for approaches, notes and tables. The stations selected for the profile view are projected vertically upward and used in drawing the plan view.

The plan view should show contours plotted in the vicinity of the structure. These contour lines are usually at 1 foot intervals but may be at larger intervals in rugged terrain to avoid unnecessary crowding of the sheet. If the bridge is over a stream, the name of the stream, the bank lines, and the direction of flow should be indicated. Wherever there is an existing bridge within the limits of the area covered by the plan view, the position and makeup of this structure and its approaches should be shown (using dotted or dash lines to distinguish it from the proposed structure). If such procedure would destroy the clarity of detail of the proposed structure, a layout of the existing bridge should be shown on a separate sheet. Detour bridges should be handled in the same manner. In addition, any other existing topography which might influence the design, construction and maintenance of the bridge should be accurately positioned and labeled on the layout. For overpass structures all existing highways and railways should be accurately shown. Also, all utility lines, gas and water mains and similar installations which might interfere with the proposed bridge should be drawn on the plan to indicate that horizontal clearance will exist between the existing facilities and the proposed construction.

Superimposed on this existing topography is the plan view of the proposed bridge. This should be composed of the centerline and general outline of the structure, curb lines, wingwalls, approach features and the outline and general makeup of the substructure. If the centerline is on a horizontal curve, it should be accurately drawn to the proper degree of curvature and all necessary curve data should be given in a convenient location on the plan. Centerlines that are on tangent should be labeled with the reference bearing along the centerline. In order to orient the layout a north point is shown on each layout sheet. Further orientation is achieved by noting the principal town or city toward which traffic flows from either end of the bridge. The general outline of the superstructure should be labeled with clear roadway widths, curb or sidewalk widths and a dimension giving the overall width of the structure. In addition, the location and type of all expansion joints, such as armored joints or finger joints, should be given in the plan. Other dimensions should give the width of the approach pavement and shoulders and the overall crown width. All special or standard approach slabs, curbs or drains are to be indicated. Each apex, or point where the crown line intersects the plane of the header bank, should be accurately shown along with the amount of the side slope normal to the centerline of the roadway and the slope of the header bank normal to the centerline of the abutment bent. The line showing toe of slope of header bank should be plotted accurately around its entire periphery and the type and limits of the riprap or other slope protection are to be indicated on the header bank underneath the bridge, on the conical return around the apex and on those portions of the side slopes which are to receive protection.

Substructure units should be indicated in the plan view with dotted or hidden lines showing the graphic location of piling, columns, shafts, footings, caps and the like. In a structure where steel piling are to be used, care should be taken to properly orient the webs of the pile sections in the plan view. In the instance of complex or involved piers, their indication in this view of the layout may be considerably abbreviated or simplified, leaving the job of depicting the pier or bent to the structural details.

Considerable miscellaneous information also appears on this view of the structure. The beginning and end of the bridge should be labeled and stationed. For skewed bridges the angle of skew should be indicated. The test holes for soil exploration are also to be labeled and numbered on the plan and should be completely located either on the plan or profile view by giving their station, distance off centerline and top of hole elevation. Also, the width, type and location of any traffic stripe to be included in the contract should be marked. If a particular pile is to be designated as a test pile, the indication should be made on the plan view. On pile trestle bents, one of the outside piles should be designated as the test pile rather than an inside one except when the pile is to have a static load test. This positioning will facilitate a respacing of piles if test driving indicates the necessity for additional piles in the bent.

It is frequently helpful to note the one hundred feet station points along the centerline of the structure so that the stations will be readily accessible as reference points for those who use the layouts during planning and construction. On layouts for widening projects, the widened or new portion should be clearly dimensioned and labeled to distinguish it from the existing structure. Where a bridge spans a navigable stream, any pier protection, such as a fender system, is to be indicated on the plan. On layouts for highway or railway overpasses, any critical horizontal clearances are also to be dimensioned on the plan. The exact nature of the miscellaneous information accompanying the plan view is to some extent unique for each different project and considerable engineering judgment will be necessary to determine the adequacy of the material presented in this view.

The profile view should contain a profile of the existing ground line taken along the centerline of the bridge or highway. This ground line should be dated when it represents the cross-section of a stream channel which shifts or "silts-up" with each rise of the stream. Railway tracks and highways or roads which cross the profile should be correctly positioned and labeled. As a general rule, an existing structure is not shown on the profile view where it coincides with the proposed bridge or where it might confuse the presentation of the new bridge. The same idea is followed on widening projects. However, any portion of the existing bridge may be shown in the profile view if it adds to the overall clarity of the plans.

The view of the bridge to be shown is usually a longitudinal section of the structure along the centerline of the roadway but may in many instances be presented more advantageously as a side elevation of the bridge. One such instance where the use of the side elevation is preferred is on a layout for the widening of an existing structure. Either view selected should show the outline of the superstructure including railing, top of curb, profile grade line, main load carrying girders, trusses, slabs or other such members; it should show the outline of the substructure including bent caps, piers, abutments, columns, footings, shafts and piling; and finally the profile view is to show the approach embankment with any approach curbs and drains, the abutment wings, the header banks and the riprap or other slope protection underneath the bridge and on the sides of the embankment.

A large part of the information on the layout sheet is given with relation to 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. Where a backwall forms a part of the roadway surface, its thickness parallel to the centerline of the roadway is included in the overall length of the bridge. Further dimensions are given to designate the rail post spacing on both sides of the bridge. Special care should be taken in spacing the rail posts to miss all construction joints in the slab and to be consistent with the structural details. The beginning and end of bridge stations are given as well as the finished grade elevations at the beginning and end of bridge. Also the tangent grades of the approaches are given along with the accompanying vertical curve data or parabolic camber for the profile grade of the bridge. The vertical curve data consists of the station and elevation of the P. I. (point of intersection of the approach grades), the length of the vertical curve and the external distance, "e", measured vertically from the P. I. to the vertical curve. If a parabolic camber is used, the rise at the center of the bridge is given with this rise diminishing in parabolic fashion toward either end of the bridge. A camber or vertical curve is desirable on all bridges except on multiple box culverts and on bridges with a constant increasing or decreasing grade.

The type of railing should be labeled on the profile view and a sufficient portion of the rail and rail posts should be drawn to present a clear picture of the railing. The railing is commonly designated as one of the highway department standard types or as a special or pedestrian railing.

The fixed or expansion condition at each end of each span must always be noted except in the instances of rigid frames or culverts and occasionally on some widening projects, where the fixed or expansion ends will not be designated but will be required to match the condition of the existing structure. Further, the top of cap or bridge seat elevations should be given at the center of each bearing. If the top of the cap is level or, as in the case of some slab spans, has a constant slope, the elevation of the top of the cap or pier may be labeled on the profile view of the bridge. In the case of sloping caps, this elevation is understood to be at the centerline of the cap unless some other location is specified. Where a more complicated arrangement exists, the top of cap elevations at each bearing should be given in a table on the layout sheet. In rare special instances, the top of cap elevations will be given on the substructure detail sheets.

Each substructure unit should be numbered from end to end of the bridge for reference purposes and the view of the substructure shown should be consistent with that selected for the entire bridge. The heights of all bents or piers (except pile trestle bents) should be shown on vertical dimension lines adjacent to each substructure unit. Where spread footings are used, this height generally extends from the top of the cap to the bottom of the footing, but in any event the terminal points of this dimension should be clearly indicated on the layouts and on the structural details. If drilled shafts are used, the height given on the layouts may represent the distance from the top of the cap to either the bottom or top of the drilled shafts but in any case must be consistent with the dimensioning shown on the structural details. On abutments with shafts or piling no heights are required. In addition to the heights, the station of the centerline of each bent shall be given. Where the bents are skewed, this station usually is given for the intersection of the centerline of the bent with the centerline of the roadway. It is preferred that the centerline station of the abutments be given for pile or shaft abutments but this is not mandatory since the location of the abutments can be readily determined from the beginning and end of bridge stations.

Considerable information is given about the construction below the ground line. Where spread footings are used, it is desirable to dimension them in the plan or in the profile view. Elevations should not be referenced to footings where the location of the footing is fixed by the top of cap elevation and the bent height. In the case of drilled shafts, the length and diameter of each shaft and the number of shafts per bent should be noted adjacent to the shafts on every bent. Where bell footing are used in conjunction with the shafts, it is desirable to show their diameter in the profile view.

Where piles are used, the type, size and length of piles shall be indicated for each substructure unit as well as the number of piles per unit. The length specified for the pile should include the embedment of the pile in the cap or footing. If any batter is used, it is desirable that it be specified in this view. Also, test piles should be designated as to number, type, size, length and location. In the profile view the location of the test pile need not be any more definite than to show that it accompanies a particular substructure unit.

Another important feature of the profile view is the presentation of the logs of the test borings. It is highly desirable to have these boring on the layouts, but under rare conditions of over-crowding, they may be plotted on separate sheets. The boring log should consist of a column of graphic data about one-quarter of an inch wide and extending for the full length of the boring. The top of the test hole should be plotted to the correct elevation and the log should be located at the proper station. When the depth of the boring causes the plotting to extend below the bottom of the grid, the column is broken near the bottom of the sheet and the remainder of the log is shifted horizontally and upward vertically in a manner to allow the complete log to be placed on the sheet. The broken ends of the log should be related with some note to show that the two columns represent a continuous boring. Occasionally a log will have to be shifted horizontally in the profile view to avoid coincidence with a substructure unit. The top of hole elevation and test hole number should always be given in the profile view and, as stated earlier, each boring should be completely located either on the plan or profile view by giving its station and distance off centerline.

In the past, the symbols used on the logs to depict the various materials encountered in soil exploration have had little uniformity or standardization. Hence, they have served to convey little or no meaning to the designers and builders. Accompanying this paper is a sheet giving standard symbols which are recommended for use in representing the soil formations on the boring logs. In using these symbols, it is assumed that the Engineer in charge of the exploration work has classified each formation into one of the seven basic groups. In any formation where more than one of the basic groups is present, the dominant formation should be shown dark and the minor formation should be shown light in representing them on the log. Where a large number of different formations are given for a particular test hole, the plot of the boring is apt to become over-crowded and the symbols difficult to read. It is thus highly desirable that adjacent formations which fall into the same basic groups and which have only minor differences of color or texture be recorded on the log of the test boring as one formation. This condensation, if intelligently done, will add greatly to the clarity and usability of the boring data when presented on the layout. Some examples are given on the accompanying sheet illustrating the use of these symbols.

Along with the log plot is a description of each formation. As mentioned in the chapter on foundation exploration, the most important information about a particular stratum is the kind and condition of the material. The description should be concise and should preferably end with a word expressing the predominant group into which the material has been classified, such as "red sandy clay." Any particularly unusual material, such as mineral deposits, should be described but no symbol should be shown in its location on the log. Also the elevation of ground water should be labeled on the log if such is encountered in the drilling.

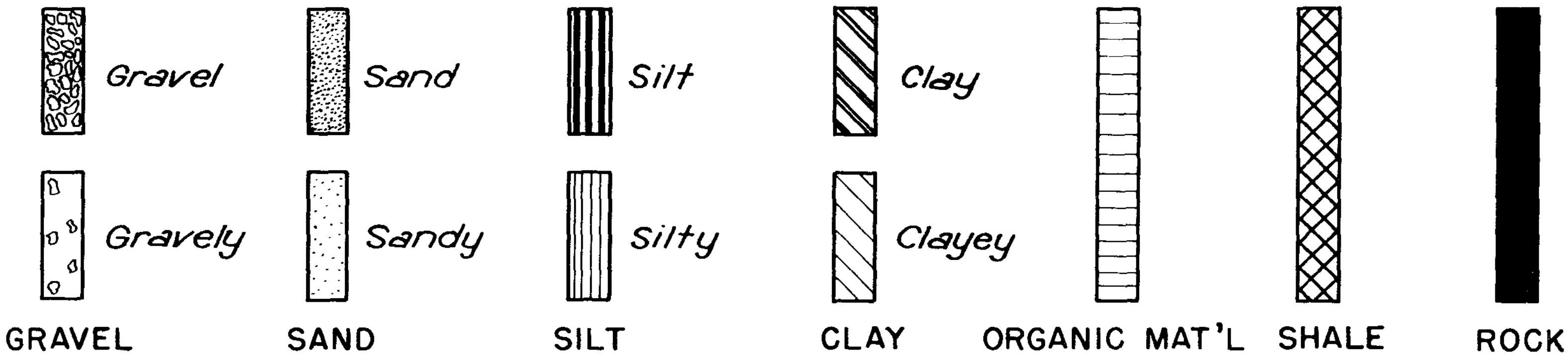
Finally, the boring log should be labeled at the proper elevations with the results of the penetrometer tests. These results are expressed as a fraction, the numerator of which represents the number of blows required to drive the pin twelve inches into the particular formation and the denominator of which represents the weight of the drill rod and collar used in the driving operation for this particular test. In hard formations where more than one hundred blows are required to penetrate twelve inches, the numerator of the fraction is used to record the depth of penetration caused by one hundred blows. This is illustrated in the accompanying example. Special care should be exercised in locating the boring log on the sheet. It should not be assumed that the top of a boring coincides with the centerline profile shown on the layout. The borings may be made off the centerline of the structure or may be taken at a different time from the centerline profile, either of which can cause the top of the hole to be above or below the centerline profile. In general, the test borings should extend below the depths of the substructure and justify the type of substructure selected.

A considerable amount of specialized information is given on the profile view. For multiple box culverts and other small drainage bridges the hydraulic data justifying the structure should be given on the roadway plan-profile sheets. For larger stream-crossing structures the observed or calculated high water elevation and the mean low water elevation are to be indicated in the channel underneath the structure. Any observed high water elevation should be accompanied with a date of occurrence. Also any contemplated channel change should be indicated on the profile. On a navigable stream, the width of the navigable channel is to be shown and labled along with any fender system adjacent to the piers. On overpass structure layouts, all proposed and existing railways and highways passing under the structure must be properly shown in section on the profile view. It is necessary to show the minimum vertical clearance between the under side of the structure and any highway or railway under the bridge. This clearance is given at the point where the top of the railroad rail or the surface of the pavement is the least distance vertically from the underside of the superstructure.

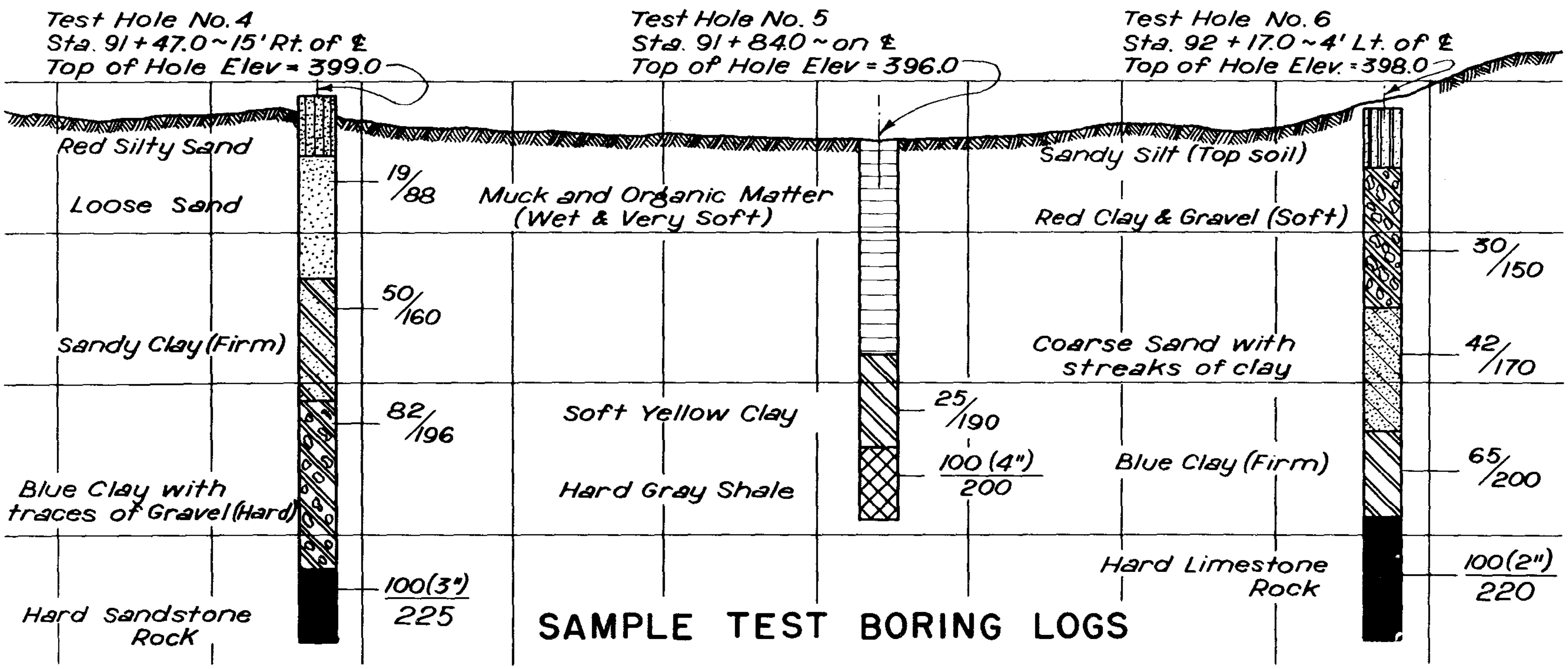
An excavation diagram is usually shown on the layout for the abutment bents, but such a diagram may be shown on the detail of the abutment when it is complicated or involved. At a convenient place on the layout sheet a table should be provided for an estimate of the quantities which will be involved in the construction of the bridge. From left to right, columns in this table should provide for a description of the structure units and for quantities of excavation, concrete, steel, railing and other bid items entering into the bridge. The structure should be divided into its various units for the listing of the quantities with the totals for each quantity listed at the bottom of the table. It is emphasized that wherever possible some vacant space should be left for future additions to the table both horizontally and vertically. At a convenient location in the lower right hand corner an appropriate title should be provided on each layout sheet. This title should give the designation "Layout" or "Bridge Layout" followed by the name of the structure and occasionally by limiting stations at either end of the sheet. The stations need be given in the title only when they help relate the layout to the remainder of the plans. Where more than one layout sheet is required for a bridge (say 5 sheets), the sheets should be numbered successively, sheet 1 of 5, sheet 2 of 5, etc.

Although each bridge layout is a special case and may have some features which are quite unique, the guiding principles are the same for all such drawings. This paper has enumerated most of the features commonly presented on our bridge layouts and has attempted to convey to you the principles essential to layout preparation. However, good engineering judgement can never be replaced by rules and regulations but must instead be guided and governed by them.

The final step in layout work occurs during construction. It is very important that the finalled plans shall include any features incorporated in the completed structure which differ from the original plans. Some of the common construction changes are those occurring in length of piling and drilled shafts, changes in heights of bents and accompanying alterations of footing elevations, and occasionally changes in types of footings and types of substructure. Other changes will sometimes be necessary because of errors in plans or because of unforeseen circumstances. All such changes should be noted on the tracing of the layout so that the finalled plans will present the correct picture of the structure as built. Thus, with the proper team work and cooperation existing between office and field forces, the bridge layout can be made to perform its essential role in a set of project plans.

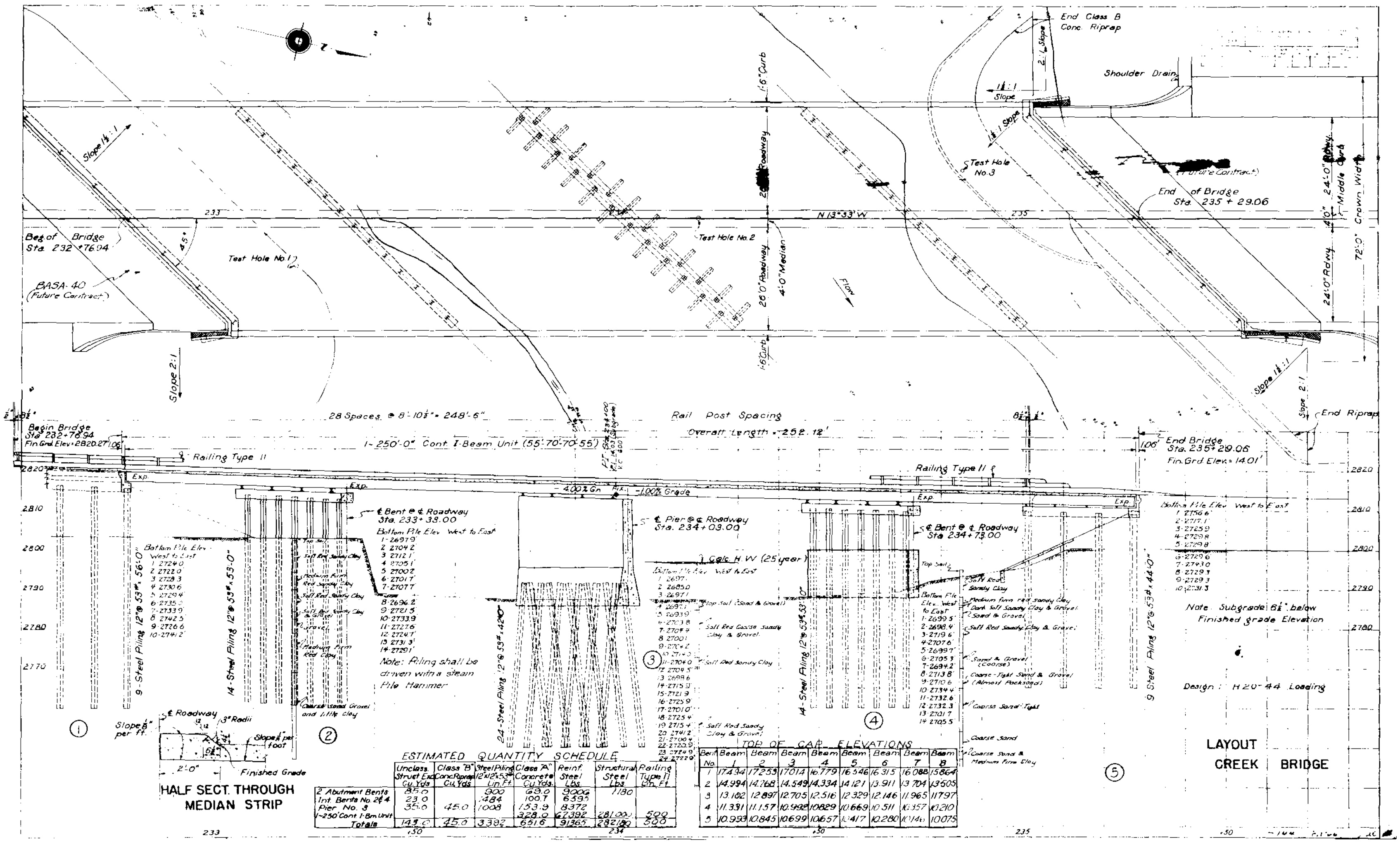


BASIC SYMBOLS FOR TEST BORINGS



SAMPLE TEST BORING LOGS

120

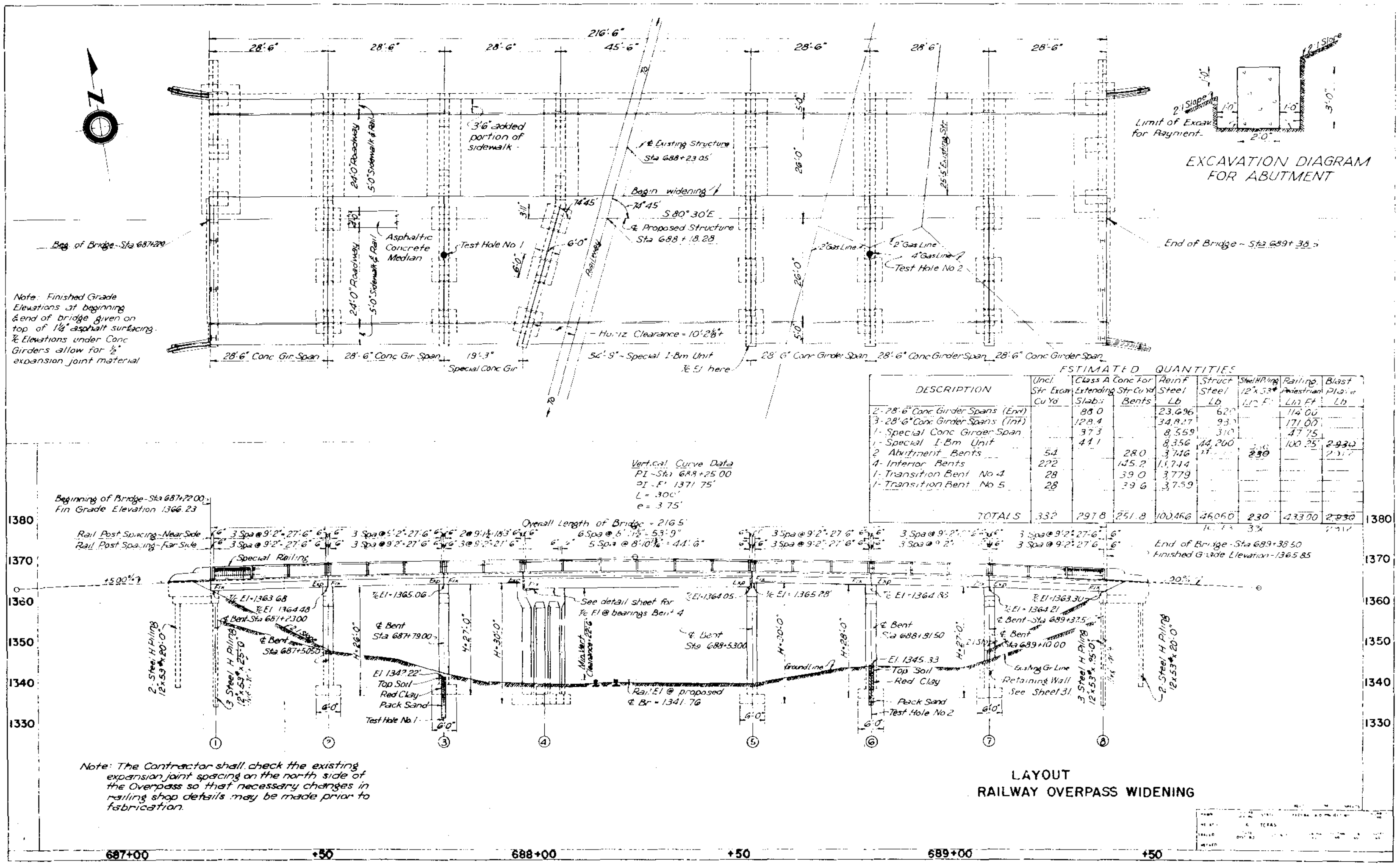


ESTIMATED QUANTITY SCHEDULE

	Unclass. Struct. Exc. Cu. Yds	Class "B" Conc. Riprap Cu. Yds	Steel Piling 12"x12"x53# Lin. Ft.	Class "A" Concrete Cu. Yds.	Reinf. Steel Lbs.	Structural Steel Lbs.	Railing Type II Lin. Ft.
2 Abutment Bents	85.0		900	69.0	9006	1180	
Int. Bents No. 2 & 4	23.0		1484	100.7	6595		
Pier No. 3	35.0	45.0	1008	153.9	8372		
1-250' Cont. I-Bm. Unit				328.0	67392	281000	500
Totals	143.0	45.0	3392	651.6	91365	282180	500

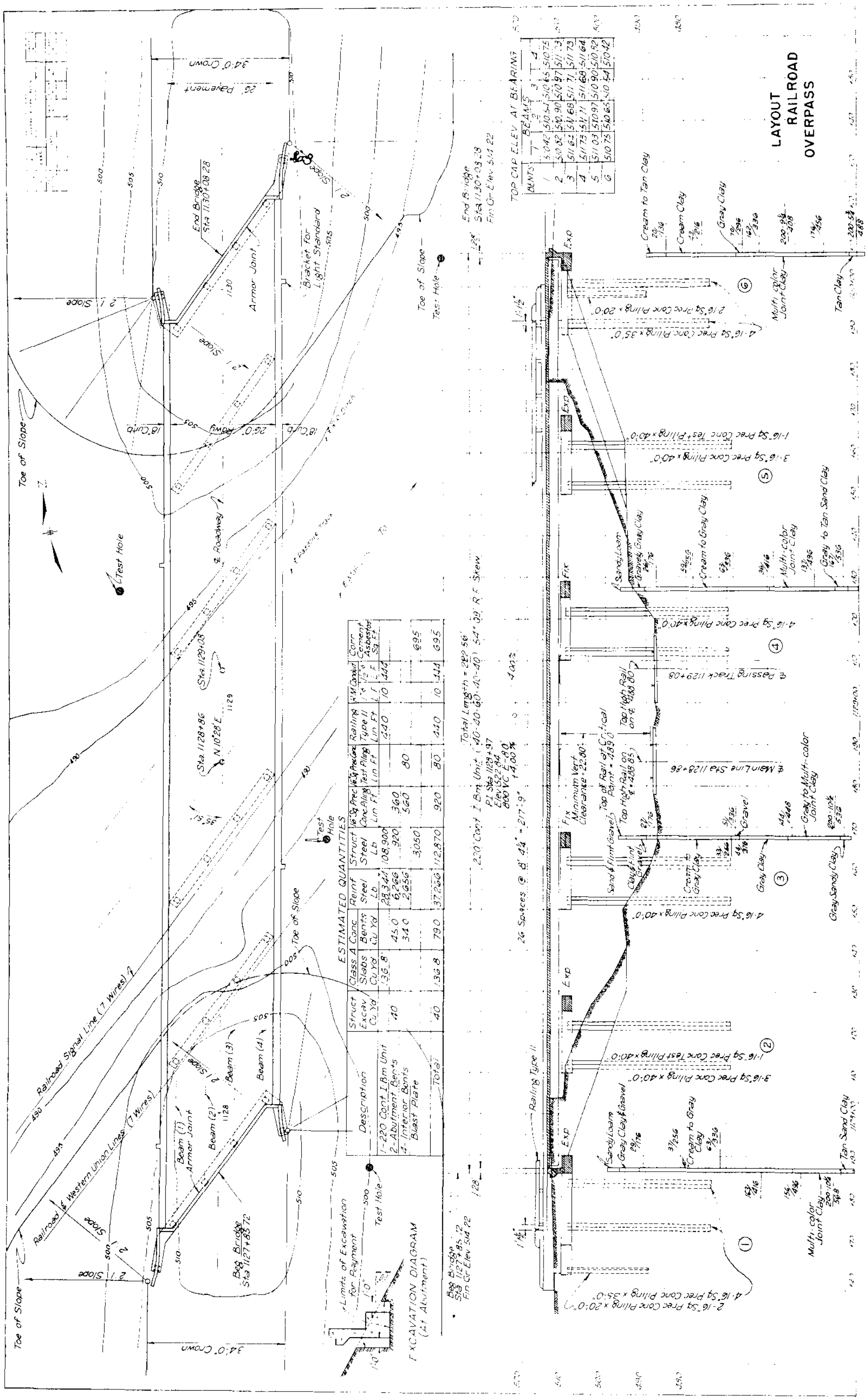
TOP OF CAP ELEVATIONS

Bent No.	Beam 1	Beam 2	Beam 3	Beam 4	Beam 5	Beam 6	Beam 7	Beam 8
1	17.434	17.253	17.014	16.779	16.546	16.315	16.088	15.864
2	14.994	14.768	14.549	14.334	14.121	13.911	13.704	13.505
3	13.102	12.897	12.705	12.516	12.329	12.146	11.965	11.797
4	11.331	11.157	10.992	10.829	10.669	10.511	10.357	10.210
5	10.993	10.845	10.699	10.657	10.417	10.280	10.146	10.075



ESTIMATED QUANTITIES

DESCRIPTION	Uncl. Str Excav Cu Yd	Class A Conc For Extending Slabs	Class A Conc For Str Cu Yd Bents	Reinf Steel Lb	Struct Steel Lb	Steel H Piling 12"x53# Lin Ft	Railing, Pedestrian Lin Ft	Blast Plate Lb
2-28'-6" Conc Girder Spans (End)		88.0		23,696	620		114.00	
3-28'-6" Conc Girder Spans (Int)		128.4		34,827	930		171.00	
1-Special Conc Girder Span		37.3		8,559	310		47.75	
1-Special I-Bm Unit		44.1		8,356	44,200		100.25	2,930
2 Abutment Bents	54		28.0	3,746		230		
4-Interior Bents	222		145.2	13,744				
1-Transition Bent No 4	28		39.0	3,779				
1-Transition Bent No 5	28		39.6	3,759				
TOTALS	332	297.8	251.8	100,466	46,060	230	433.00	2,930


LAYOUT
RAILROAD
OVERPASS
ESTIMATED QUANTITIES
EXCAVATION DIAGRAM
(At Abutment)
TOP CAP ELEV AT BEARING
Toe of Slope
Test Hole
Railroad Signal Line (7 Wires)
Railroad & Western Union Lines (7 Wires)
Armor Joint
Bracket for Light Standard
Railing Type II