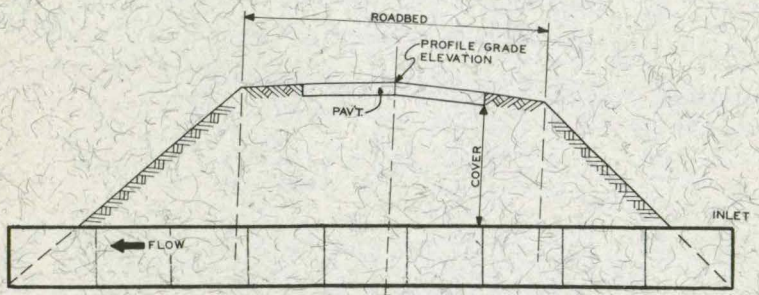
INSPECTOR'S HANDBOOK

PIPE CULVERTS



IOWA STATE HIGHWAY COMMISSION

AMES, IOWA

1969

PIPE CULVERTS

E. J. Shaffer

INTRODUCTION

This handbook is an inspector's aid. It was written by an inspector to bring together all of the most-often-needed information involved in his work.

Much care has been taken to detail each phase of construction, with particular attention to the requirements and limitations of specifications. All applicable specification interpretations in Instructions to Resident Engineers have been included.

The beginning inspector should look to the handbook as a reference for standards of good practice. The Standard Specifications and Special Provisions should not, however, be overlooked as the basic sources of information on requirements and restrictions concerning workmanship and materials.

CONTENTS

Pipe Culvert Inspection

The inspector should take time to study plans and supplementary material before going into the field. This allows him to become familiar enough with a project to ask questions about details he may not understand. Errors in the field are thereby minimized.

A pipe culvert inspector needs the following equipment to perform his duties:

1) 6 foot Folding Rule.
2) 50 foot Tape.
3) Hand Level.
4) Standard Specification Book.
5) Set of Plans.
6) Special Provisions (if applicable).
7) Field Books.
8) Pencils.
9) Protective Safety Hat.

Project Plan

Special features on pipe culverts are included on the project plans. Near the front of the project plans, a tabulation headed "Estimated Project Quantities" lists items and quantities on a project. All items pertaining to pipe culverts are listed there and on tabulation 104–3, Drainage Structures by Road Contractor (Figure 1). Before work starts, the quantities listed on the plan tabulation should be compared with the contract for uniformity.

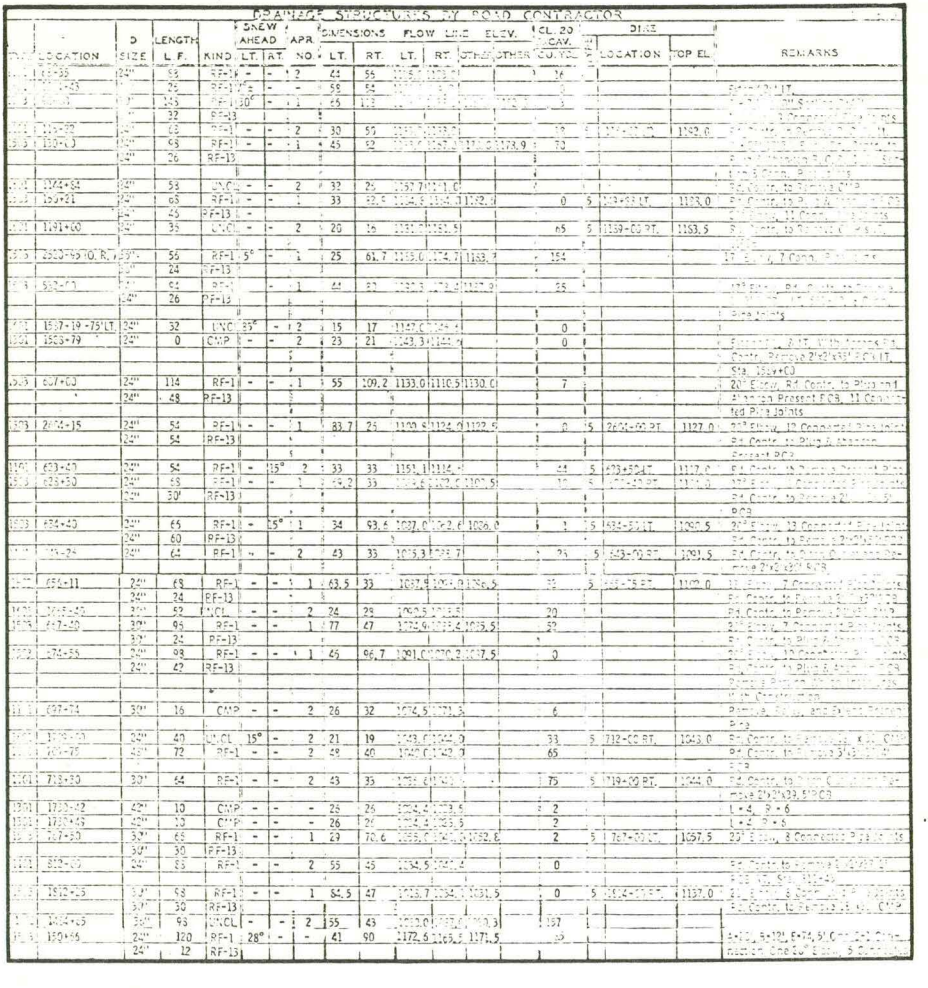
All pipe culverts listed for the project are shown on the centerline drawing of the plan and profile sheets (see Figure 2). Note the flow of drainage (indicated by the arrows) to and from the inlet and outlet ends. The location, size, type, and other necessary information needed for installation is listed below each pipe.

Under the column heading "Type" at the left of Figure 1, is a number which refers to pipe culvert standard sheets (Figures 3, 4, and 5). Each pipe culvert used in the project is of the type number shown on these drawings. On the first pipe culvert listed in Figure 1 under the column heading "Kind" is the identification RF–1. The standard road plan sheet, such as Figure 6, shows the dimensions of pipe culverts as manufactured. All pipe

listed on the project has references to standard road plan sheets, with the exception of metal and unclassified culvert pipes. Unclassified culvert pipes can be either metal or concrete at the contractor's option. Specific information for each culvert pipe is noted under the column heading "Remarks", as in Figure 1.

As indicated by these sample sheets, materials of a more specialized nature are also documented; information appears on pipe aprons, tee sections, dikes, special connections, and adaptors.

The inspector's familiarity with project plans and specifications dealing with culvert pipe construction is vital for quality workmanship.



DRAINAGE STRUCTURES BY ROAD CONTRACTOR

LOCATION	SIZE	LENGTH L. F.	KIND	SKEW AHEAD LT.	SKEW AHEAD AT.	APR NO.	DIMENSIONS LT.	FLOW LINE ELEV. RT.	FLOW LINE ELEV. LT.	FLOW LINE ELEV. RT.	FLOW LINE ELEV. OTHER	FLOW LINE ELEV. OTHER	CL. 20 EMBKMT. CONC. CU. YDS.	DIKE LOCATION	DIKE TOP EL.	REMARKS
1+55	24"	58	RF-1	-	-	2	44	56	[illegible]	[illegible]			36			
[illegible]	24"	76	RF-1	-	-		58	54	[illegible]	[illegible]			[illegible]			[illegible]
[illegible]	[illegible]	133	RF-1	30°	-	1	65	113	[illegible]	[illegible]			[illegible]			[illegible]
[illegible]	24"	32	RF-13	-	-											[illegible]
1+39	30"	62	RF-1	-	-	2	30	55	[illegible]	[illegible]			19	[illegible]	1162.0	[illegible]
1+50	30"	68	RF-1	-	-	1	45	52	[illegible]	[illegible]	1170.0	1178.9	30			[illegible]
[illegible]	24"	26	RF-13	-	-											[illegible]
1+44	24"	58	UNCL	-	-	2	32	26	[illegible]	[illegible]						[illegible]
1+21	24"	65	RF-1	-	-	1	33	28.6	[illegible]	[illegible]	1192.6		0	5	1139+00 LT.	1163.0
[illegible]	24"	45	RF-13	-	-											[illegible]
1+00	24"	35	CMP	-	-	2	20	16	[illegible]	[illegible]			65	5	1139+00 RT.	1163.5
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2+00+19.0 R.	30"	56	RF-1	5°	-	1	25	61.7	[illegible]	[illegible]	1183.7		164			[illegible]
[illegible]	24"	24	RF-13													[illegible]
2+62+13	24"	62	RF-1	-	-	1	44	22	[illegible]	[illegible]	[illegible]		35			[illegible]
[illegible]	24"	26	RF-13													[illegible]
1+97-19-75 LT.	24"	32	UNCL	35°	-	2	15	17	[illegible]	[illegible]			0			[illegible]
1+63+79	24"	0	CMP	-	-	2	23	21	[illegible]	[illegible]			0			[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
0+00	24"	114	RF-1	-	-	1	55	109.2	1133.0	1110.5	1130.0		7			[illegible]
[illegible]	24"	48	RF-13													[illegible]
2+74+15	24"	54	RF-1	-	-	1	83.7	25	[illegible]	[illegible]	[illegible]		0	5	2+00+00 RT.	1127.0
[illegible]	24"	54	RF-13													[illegible]
4+53+43	24"	54	RF-1	-	35°	2	33	33	[illegible]	[illegible]			44	5	4+53+50 LT.	1117.0
4+58+50	24"	48	RF-1	-	-	1	45.3	33	[illegible]	[illegible]	[illegible]		30	5	4+53+00 RT.	1117.0
[illegible]	24"	30	RF-13													[illegible]
4+54+45	24"	65	RF-1	-	25°	1	34	93.6	[illegible]	[illegible]	[illegible]		1	5	4+32+50 LT.	1090.5
[illegible]	24"	60	RF-13													[illegible]
4+54+24	24"	64	RF-1	-	-	2	43	33	[illegible]	[illegible]			93	5	4+53+00 RT.	1091.5
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
6+54+11	24"	68	RF-1	-	-	1	63.5	33	[illegible]	[illegible]	[illegible]		32	5	6+55+75 RT.	1109.0
[illegible]	24"	34	RF-13													[illegible]
7+15+42	30"	52	UNCL	-	-	2	24	29	[illegible]	[illegible]			20			[illegible]
7+47+20	30"	95	RF-1	-	-	1	77	47	[illegible]	[illegible]	[illegible]		59			[illegible]
[illegible]	30"	24	RF-13													[illegible]
7+74+58	24"	98	RF-1	-	-	1	45	96.7	[illegible]	[illegible]	[illegible]		0			[illegible]
[illegible]	24"	42	RF-13													[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
8+97+74	30"	16	CMP	-	-	2	26	32	[illegible]	[illegible]			6			[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
9+00+20	24"	40	UNCL	15°	-	2	21	19	[illegible]	[illegible]			33	5	7+12+00 RT.	1048.0
9+00+75	24"	72	RF-1	-	-	2	49	40	[illegible]	[illegible]			65			[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7+18+30	30"	64	RF-1	-	-	2	43	33	[illegible]	[illegible]			75	5	7+19+00 RT.	1044.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
17+55+42	42"	10	CMP	-	-	-	25	26	[illegible]	[illegible]			2			[illegible]
17+55+45	42"	10	CMP	-	-	-	26	26	[illegible]	[illegible]			2			[illegible]
7+67+50	30"	65	RF-1	-	-	1	29	70.6	[illegible]	[illegible]	[illegible]		2	5	7+67+00 LT.	1057.5
[illegible]	30"	30	RF-13													[illegible]
8+12+42	24"	85	RF-1	-	-	2	55	45	[illegible]	[illegible]			0			[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7+12+25	24"	98	RF-1	-	-	1	84.5	47	[illegible]	[illegible]			0	5	7+12+00 RT.	1137.0
[illegible]	24"	30	RF-13													[illegible]
2+68+45	24"	93	UNCL	-	-	2	35	43	[illegible]	[illegible]	[illegible]		187			[illegible]
1+50+66	24"	120	RF-1	28°	-	-	41	90	[illegible]	[illegible]			69			[illegible]
[illegible]	24"	12	RF-13													[illegible]

Figure 1 — Drainage structures by road contractor.

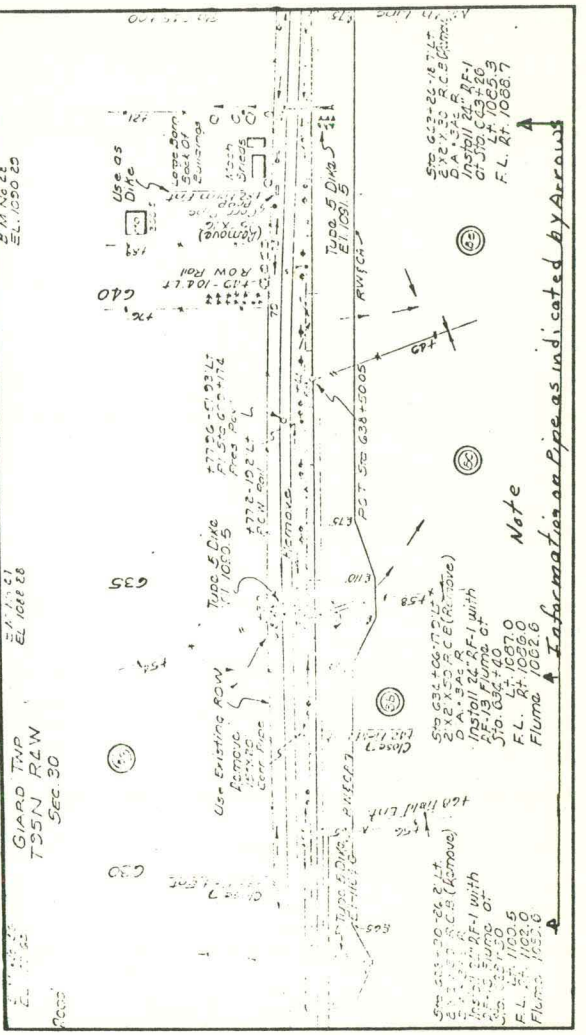
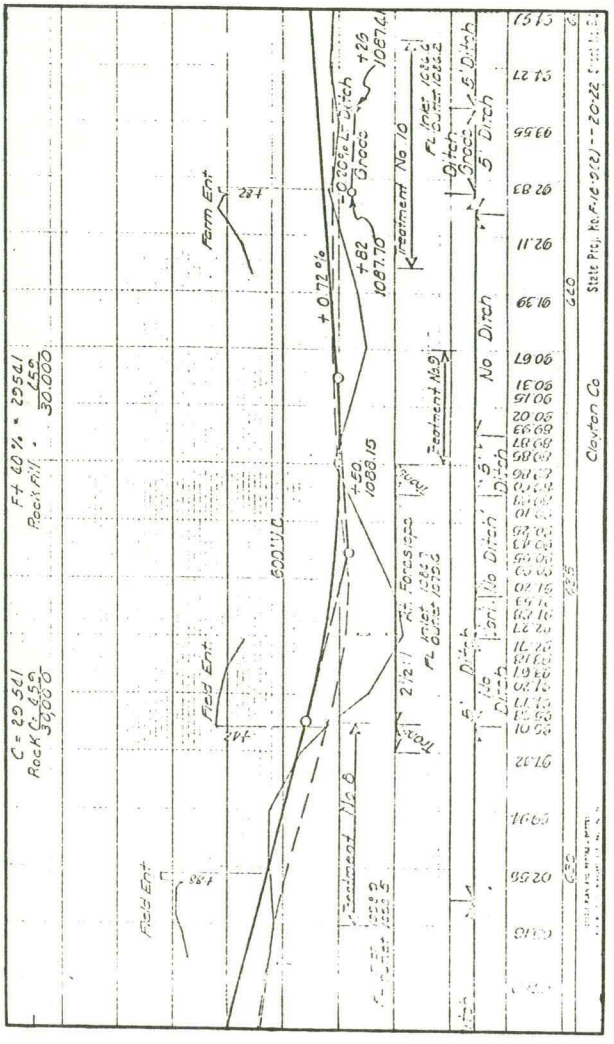


Figure 2 – Centerline



drawing and profile sheet.

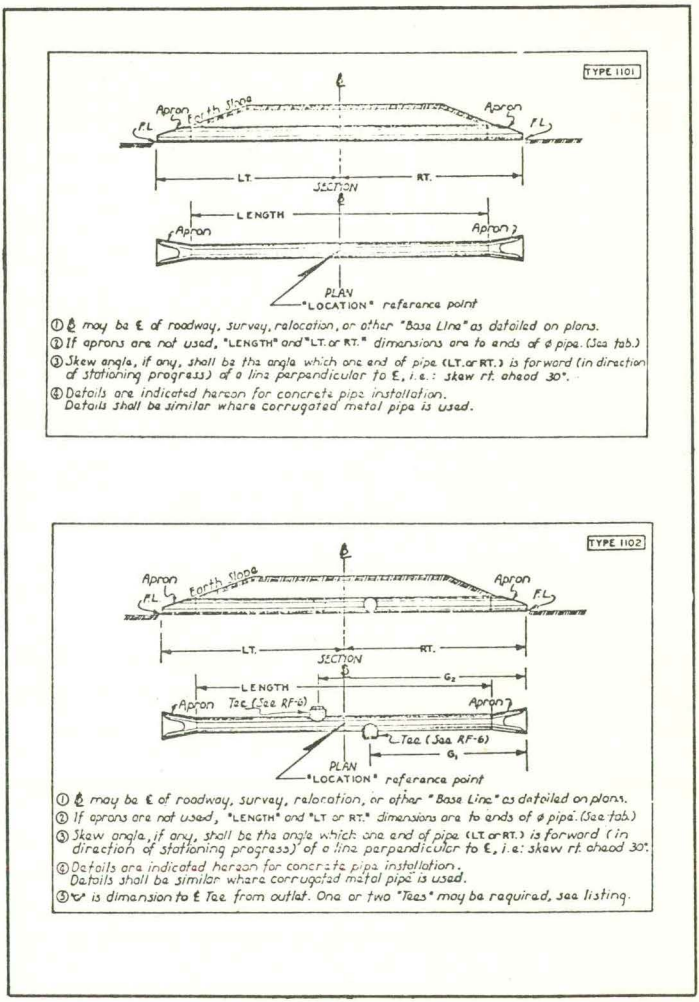


Figure 3 – Pipe culvert standard plans 1101 and 1102.

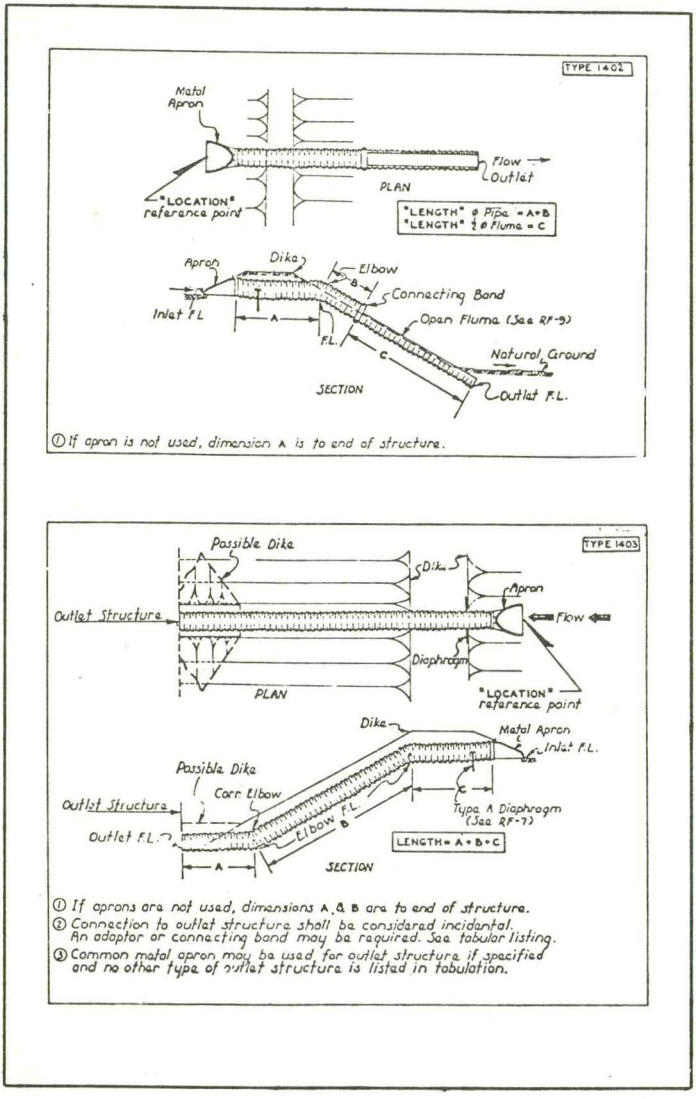


Figure 4 — Pipe culvert standard plans 1402 and 1403.

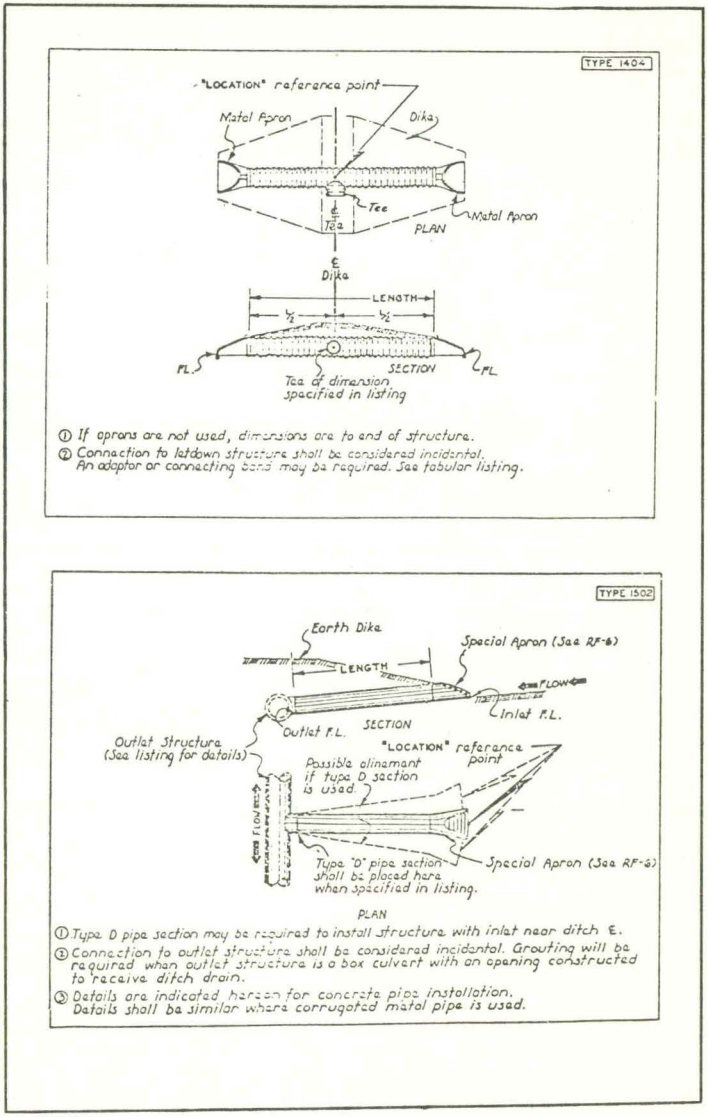
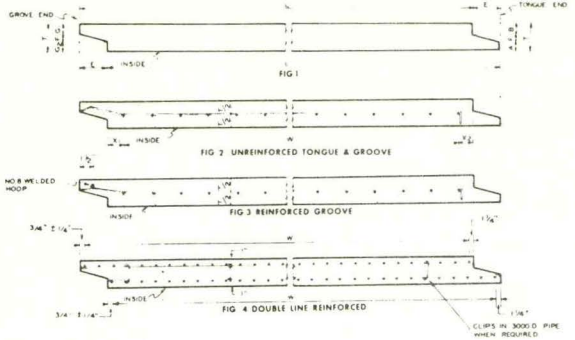


Figure 5 — Pipe culvert standard plans 1404 and 1502.

Figure 6 — Standard road plan RF–1.



GENERAL DIMENSIONS

D	AREA IN SQUARE INCHES	APPROX WEIGHT	T	A	B	C* G1	G2	C*	E	F	APPROX WEIGHT	T	A	B	G1	G2	C	E	F	D
				1000 AND 2000 D										1500 D						
12	.78	92	2	5/8	3/4	5/8	3/4	1/8	2	5/8										12
15	1.23	127	2 1/4	3/4	1	7/8	7/8	1/8	2	1/2	111	2	3/4	7/8	3/4	7/8	1/8	2	3/8	15
18	1.77	168	2 1/2	7/8	1 1/8	1	1	1/8	2 1/2	1/2	149	2 1/4	7/8	1	7/8	1	1/8	2	3/8	18
21	2.41	210	2 3/4	1	1 3/8	1 1/4	1 1/8	1/8	2 1/2	5/8	197	2 1/2	1	1 1/8	1	1 1/8	1/8	2 1/2	3/8	21
24	3.15	265	3	1 5/16	1 5/16	1 1/8	1 1/8	5/16	3	3/4	229	2 5/8	1	1 5/16	1	1 5/16	5/16	2 1/2	7/16	24
27	3.98	327	3 1/4	1 5/16	1 7/16	1 1/4	1 1/4	5/16	3 1/4	3/4	280	2 3/4	1 1/16	1 1/4	1 1/16	1 1/4	5/16	2 3/4	1/2	27
30	4.91	394	3 1/2	1 5/16	1 9/16	1 3/8	1 3/8	5/16	3 1/2	3/4	324	2 7/8	1 1/8	1 5/16	1 1/8	1 5/16	5/16	3	9/16	30
33	5.94	452	3 3/4	1 1/4	1 11/16	1 1/2	1 1/2	1/4	3 3/4	3/4	385	3 1/4	1 1/8	1 3/8	1 1/8	1 3/8	1/4	3 1/4	5/8	33
36	7.07	524	4	1 3/8	1 7/8	1 5/8	1 5/8	1/4	4	3/4	439	3 1/2	1 1/8	1 3/8	1 1/8	1 3/8	1/4	3 1/2	3/4	36
42	9.62	660	4 1/2	1 5/8	2 1/8	1 7/8	1 7/8	1/4	4	3/4	562	3 3/4	1 1/4	1 1/2	1 1/4	1 1/2	1/4	3 1/2	3/4	42
48	12.57	867	5	1 5/8	2 1/8	2 1/8	1 7/8	1/4	4	3/4	727	4 1/4	1 5/8	1 7/8	1 5/8	1 7/8	1/4	4	3/4	48
54	15.90	1071	5 1/2	1 13/16	2 5/16	2 1/16	2 1/16	1/4	4 1/2	3/4	888	4 3/4	1 13/16	2 1/16	1 13/16	2 1/16	1/4	4 1/2	3/4	54
60	19.64	1298	6	2	2 1/4	2	2 1/4	1/4	5	3/4	1064	5	2	2 1/4	2	2 1/4	1/4	5	3/4	60
66	23.76	1542	6 1/2	2 1/4	2 1/2	2 1/4	2 1/2	1/4	5	3/4	1272	5 1/2	2 1/4	2 1/2	2 1/4	2 1/2	1/4	5	3/4	66
72	28.27	1818	7	2 1/2	2 3/4	2 1/2	2 3/4	1/4	5	3/4	1512	6	2 1/2	2 3/4	2 1/2	2 3/4	1/4	5	3/4	72
84	38.48	2620	8	2 7/8	4 3/8	3	3 1/4	3/8	5	3/4	2080	7	3	3 1/4	3	3 1/4	3/4	5 1/2	3/4	84

* Permissible variations from dimensions given for old molds (sizes 48" to 84") shall be ± 1/4".

* Permissible variations from dimensions given for old molds (sizes 48" to 84") shall be ± 1/2".

x C is clearance between edges of adjacent tongue and groove (G2 - A).

REINFORCEMENT-WELDED STEEL WIRE FABRIC

D	MINIMUM CIRCUMFERENTIAL SQ. INCH PER FT. OF PIPE						MINIMUM LAP WIDTH (A) (1 - UNLESS SHOWN BELOW)			SUGGESTED OVERHANG				
	1500 D		2000 D		3000 D					GROOVE END		TONGUE END		
	SINGLE	DOUBLE	SINGLE	DOUBLE	SINGLE	DOUBLE	1500 D	2000 D	3000 D	STD. WALL 2000 D 3000 D	THIN WALL 1500 D	STD. WALL 2000 D 3000 D	THIN WALL 1500 D	1500 D
12	.062	--	.062	--	.062	--	5	5	5					
15	.062	--	.062	--	.087	--	5	5	5	3 1/2	3 1/2	1 3/8	1 3/8	1 1/4
18	.062	--	.066	--	.116	--	5	5	5	3 1/4	3 1/2	1 1/2	1 1/2	1 3/8
21	.074	--	.116	--	.148	--	5	5	5	3 1/4	3 1/4	1 5/8	1 5/8	1 1/2
24	.087	--	.145	--	.187	--	6	6	5	4 1/4	4 1/4	1 3/4	1 3/4	1 5/8
27	.098	--	.159	--	.216	--	6	6	5	4 1/4	4 7/8	2	2 1/8	1 5/8
30	.116	--	.187	--	--	.174	6	6	5	5 7/8	5 5/8	2	2	1 3/4
33	.145	--	.229	--	--	.174	6	6	5	5 7/8	5 5/8	2 1/4	2 1/8	1 7/8
36	.148	--	--	.174	--	.187	6	6	5	6 1/4	5 7/8	2 3/8	2 1/4	2
42	--	.174	--	.187	--	.239	3	3	2	3/4	3/4	1 1/2	1 3/8	1 3/8
48	--	.187	--	.229	--	.280	3	2	2	3/4	3/4	1 1/2	1 1/2	1 1/2
54	--	.239	--	.280	--	.365	2	2	2	3/4	3/4	1 1/2	1 3/8	1 3/8
60	--	.280	--	.325	--	.377	2	2	2	3/4	3/4	1 1/2	1 1/2	1 1/2
66	--	.325	--	.377	--	.443	2	2	2	3/4	3/4	1 1/2	1 1/2	1 1/2
72	--	.325	--	.443	--	.443	2	2	2	3/4	3/4	1 5/8	1 1/2	1 1/2
84	--	.377	--	.516	--	.516	2	2	2	3/4	3/4	1 5/8	1 1/2	1 1/2

GENERAL NOTES

The wall thickness and reinforcement shown are minimum requirements. If the wall thickness is increased, only dimensions indicated by T, B, & G1 shall be changed. 1500 D pipe, in 12", 15", 18" and 21" diameters, when made with wall thickness for 2000 D pipe need not be reinforced if strength requirement can be met. All other 2000 D pipe shall have the minimum reinforcement specified.

No circumferential reinforcement shall be required in tongues or grooves of 12", 15", 18" and 21" pipe of all classes or 24" pipe of 1500 D class. See Fig. 2.

All other pipe with single line reinforcement shall have five grooves reinforced by one welded hoop of not less than X gage wire. This hoop shall be secured to the cage by welding or by hetgling the transverse wire around the hoop a minimum of 180° as in Fig. 3.

Pipe having two lines of reinforcement shall have circumferential wires extending into tongues and grooves as shown in Fig. 4.

The difference between K1 and K2 shall not be more than 1/2".

The spacing of transverse wires shall not exceed 8" and the size shall be that specified by the U. S. Department of Commerce Simplified Practice Recommendation No. Z34-48 effective August 1, 1948. The spacing of circumferential rings shall not exceed 4".

The overhangs specified are approximate and may need to be changed due to the tightness of bends, wire diameter, cage width, and the exact location of cage within the tolerances permitted. The bend as shown in Fig. 2 requires approximately 1/8" extra overhang for all sizes except the 30" pipe which will require about 1/4". When the groove end hoop is welded to the transverse wires, approximately 1 1/8" less overhang will be required. Tongue end overhang is required only when it is used for placement of reinforcement.

All material and construction to conform to the Iowa State Highway Commission Specifications and welded wire fabric shall conform to A. S. T. M. A-185.

NOTE

When so specified for individual pipe culvert installations identified within the project plans, the joints between sections of concrete pipe shall be sealed. This seal shall be accomplished by application of a product commercially produced for such purpose. The seal shall be of a type as to remain in a flexible state after application, shall be of a type and manufacture approved by the engineer and shall be installed according to methods recommended by the manufacturer and approved by the engineer.

Change Mat'l by Joint Sheet	7-1-57 DATE
LAST REVISION	

IOWA HIGHWAY COMMISSION
STANDARD ROAD PLAN (RF-1)

RECOMMENDED: J. C. Wetherby, ROAD ENGINEER, 7/1/57 DATE; J. T. Griffin, DESIGN ENGINEER, 7/1/57 DATE

APPROVED: R. H. Dawson, DEPUTY, CHIEF ENGINEER, 7/1/57 DATE

CONCRETE CULVERT PIPE

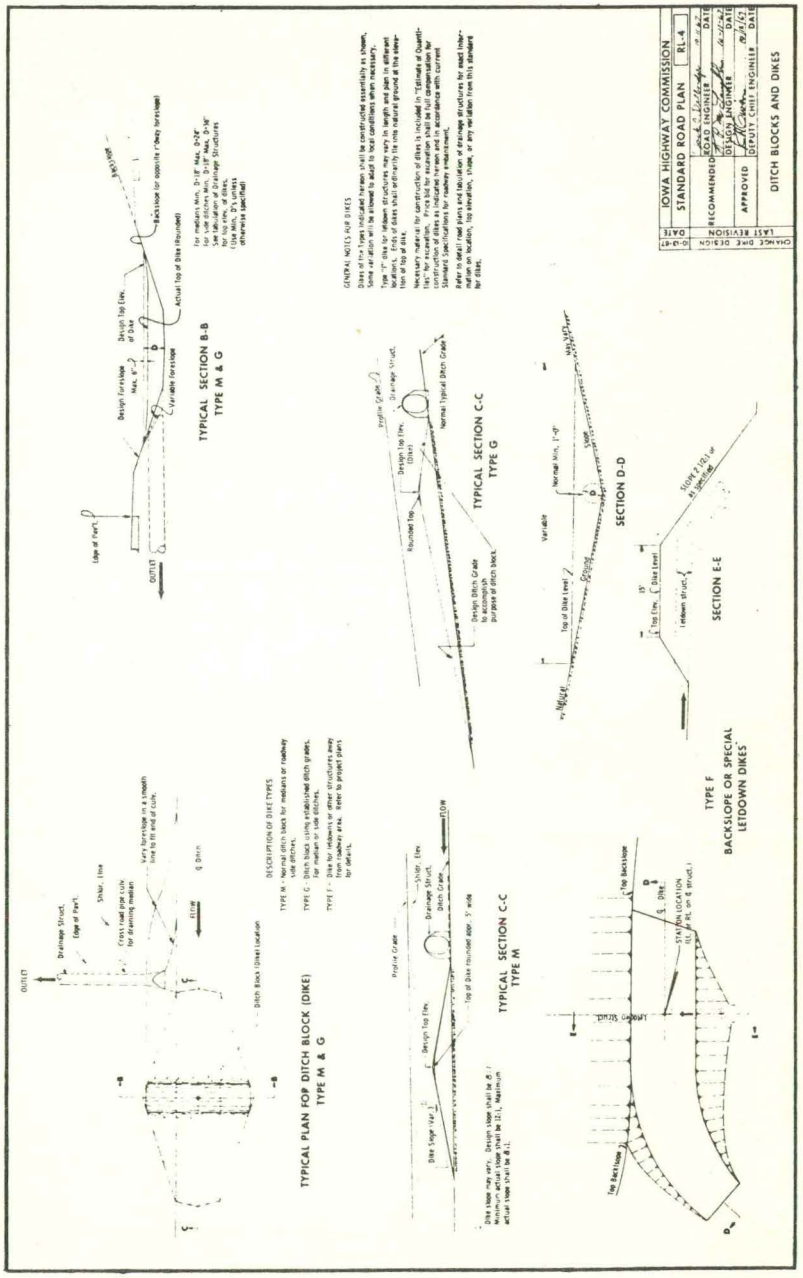


Figure 7 – Standard road plan RL–4.

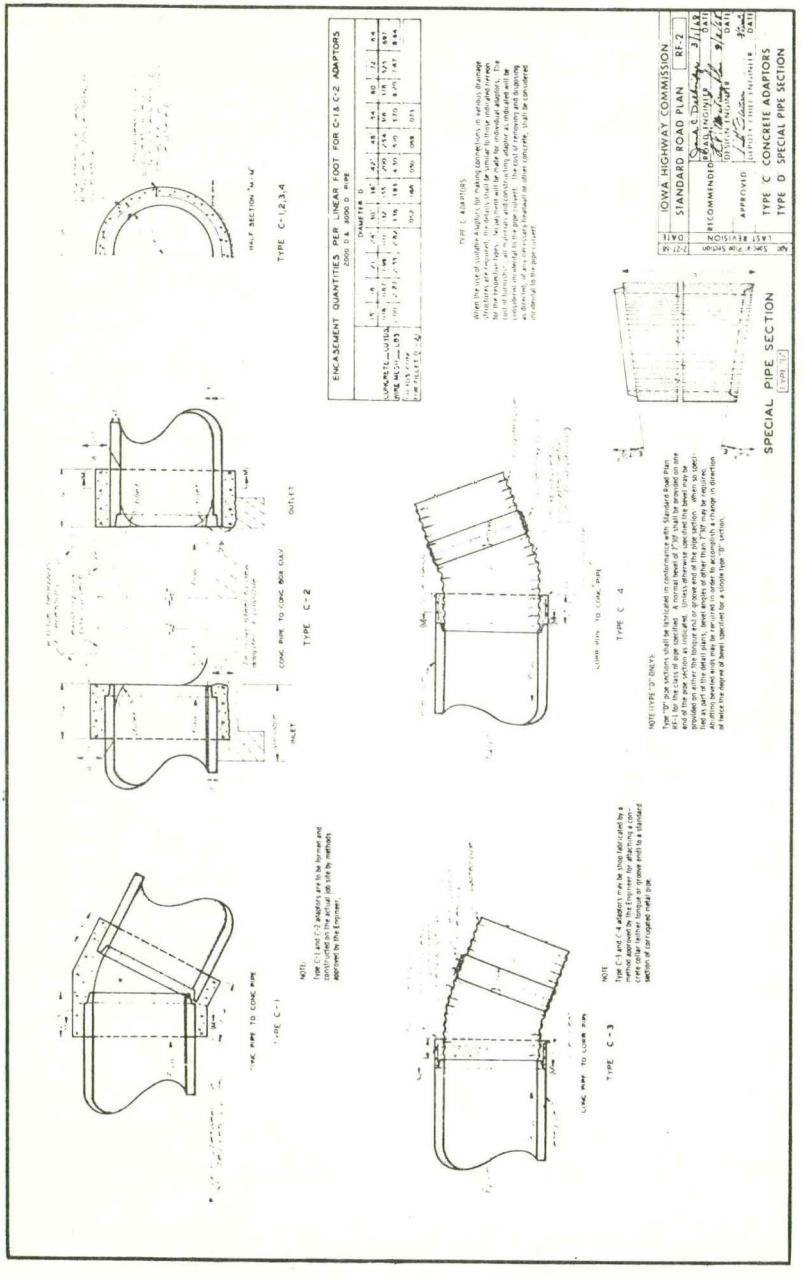


Figure 8 – Standard road plan RF–2.

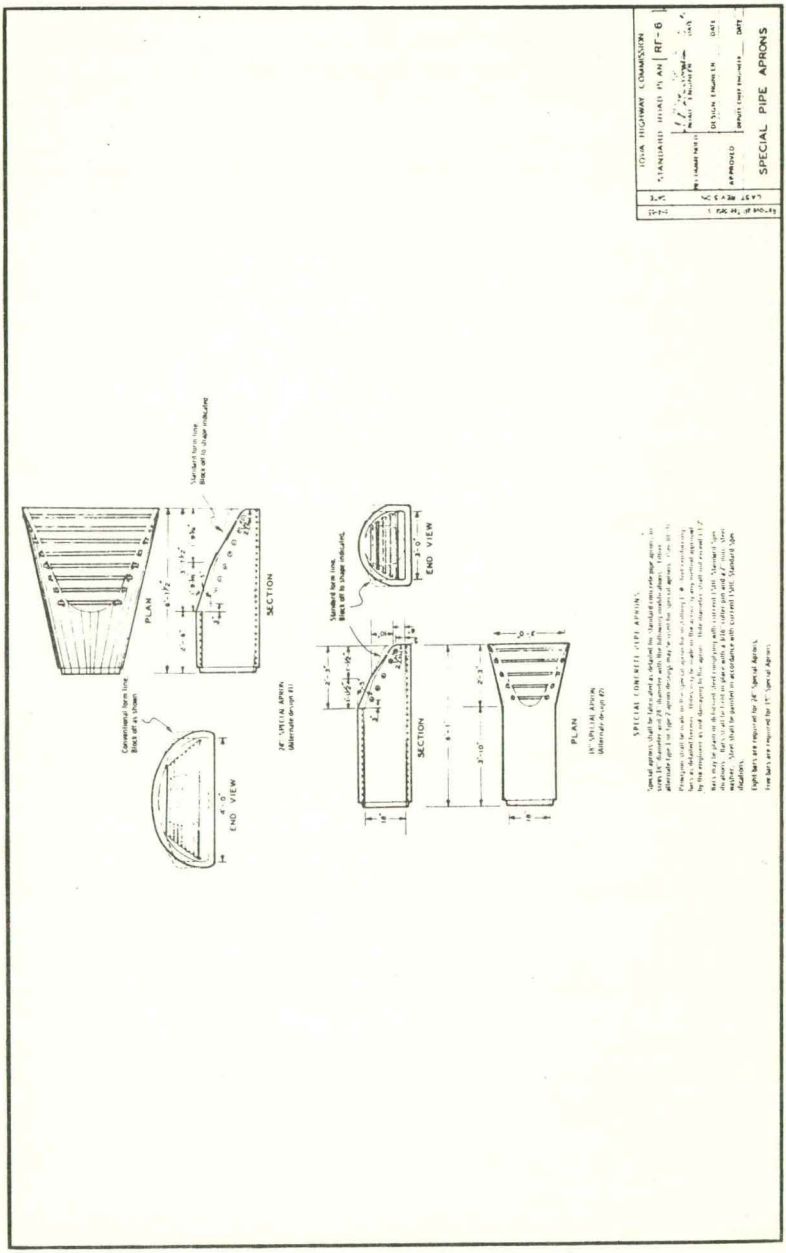
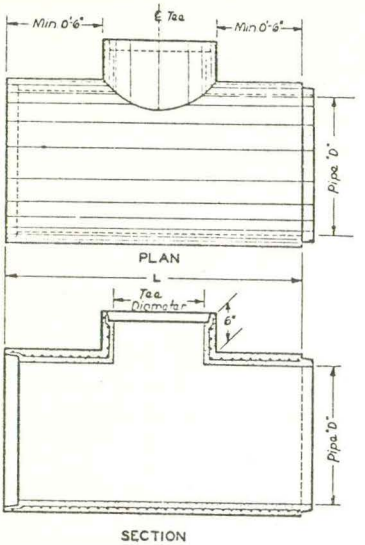
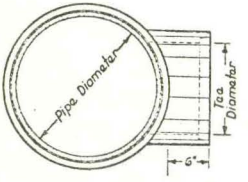


Figure 9 – Standard road plan RF–6.





CONCRETE PIPE TEE SECTION

Pipe Wall thickness and reinforcement both in the pipe and the tee shall be same as the minimum requirement for concrete pipe as detailed on Standard plan RF-1 for the appropriate size.

Length of pipe section (L) shall be a minimum of 2'-0" and maximum 6'-0". Length of pipe section shall be included in total length of pipe for structure.

Bid price for "Tee Section shall be for the fabrication of the Tee and the joining of the Tee to a section of standard concrete pipe.

Tee Sections may be required in all sizes from 12"ø to 48"ø (in 6" increment) on pipe sections equal to or greater in diameter (up to 84"ø) than the diameter of the Tee.

PART 2 OF 2

IOWA HIGHWAY COMMISSION		
STANDARD ROAD PLAN	RF-6	
RECOMMENDED	ROAD ENGINEER	DATE
	DESIGN COMMITTEE	DATE 11-1-61
APPROVED	CHIEF ENGINEER	DATE
CONCRETE PIPE SPECIAL APRON & TEE SECTION		

Figure 10 — Standard road plan RF–6.

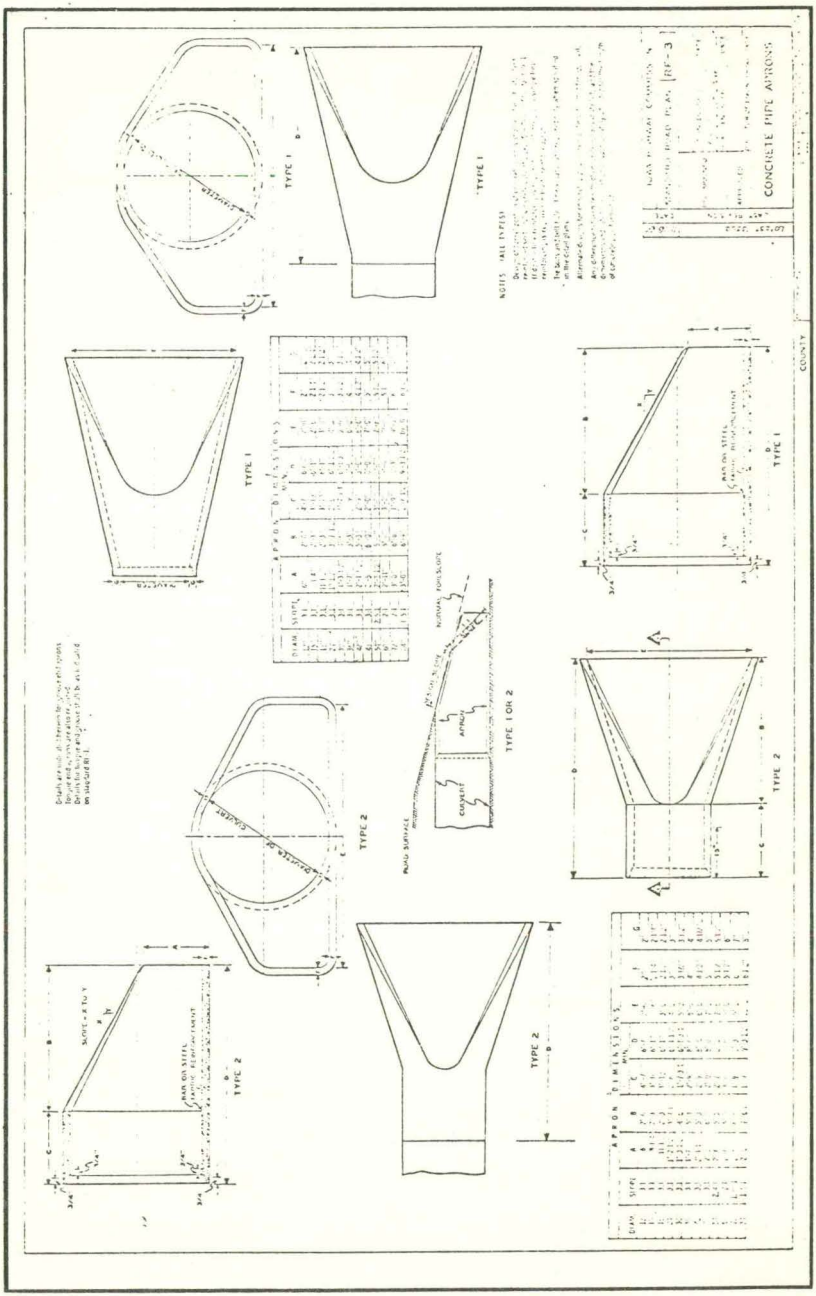


Figure 11 — Standard road plan RF—3.

Field Inspection of Materials

Before materials are used on the project, they must be approved. Concrete culvert pipe is inspected and stamped "Approved" on the inside wall at the fabrication plant by a materials inspector. At the time of shipment, all items and lengths are listed on Form No. 286 and forwarded to the office in charge of the project.

Before laying of pipe begins, the inspector should check concrete pipe for cracks or broken ends caused by handling. Any damaged pipe must be rejected before placement. Metal pipe is also inspected and tagged "Approved" at the manufacturing plant. At time of shipment, approval reports are forwarded to the Resident Construction Engineer. Again, the inspector should check for damage caused by handling before the laying of pipe begins. Pipe not damaged and tagged "Approved" can be placed prior to submitting reports.

All incidental materials used on projects are subject to approval by the Materials Department through either certified shipment tickets or another acceptable means. Occasionally it is necessary to expedite approval by telephone to avoid delay.

Inspectors must keep records of material approved in project field books. The contractor is responsible for ordering approved materials and the inspector should keep the contractor informed of any materials not approved. This practice saves construction delays.

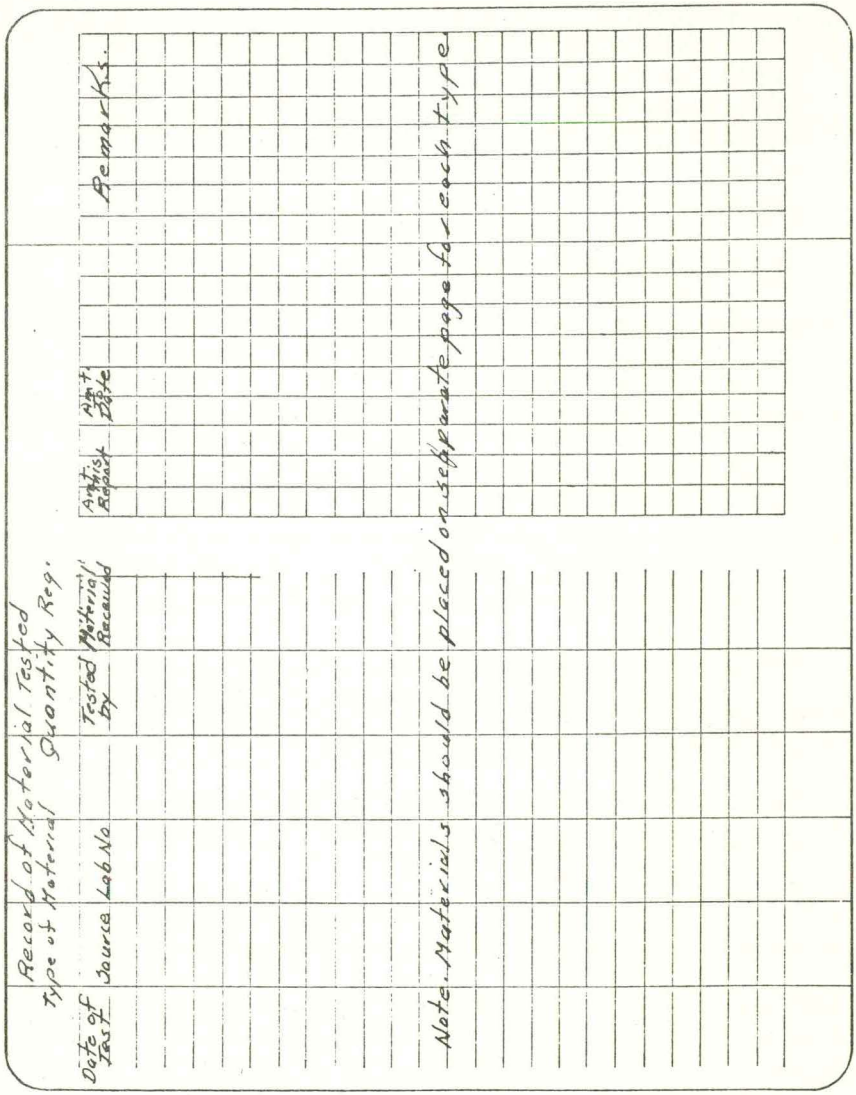


Figure 12 — Material test record.

Staking and Location

Staking the location of culvert pipe is done by a survey crew. The inspector should study the stakes to become familiar with the grades. Special attention should also be directed to the situation of the staking, taking special notice of the inlet and outlet. It should conform to the contour and drainage of the area. Care should be taken when laying pipe to maintain the existing drainage at outlets and inlets in order to avoid ponding of water in ditches. There are occasional special cases where there is a high inlet or a low outlet. Questionable grades and locations should be checked before construction starts.

The samples show staking diagrams done by a survey crew and noted in the survey field book. Figure 13 shows a 30" Concrete Roadway Pipe to be located at Station 100+10, a straight line pipe with 50 feet placed left and 40 feet right of centerline of roadway. In laying out this pipe, offset hub stakes are placed 10 feet and 20 feet from each end and used for alignment and flowline grade. The cut or fill dimension to the flowline elevation is marked on stakes placed beside each hub. The offset can be any distance indicated on the stakes.

In Figure 14, the same process is employed. The pipe is laid out on a 45 degree skew angle from a line perpendicular to the centerline of the roadway.

In Figure 15, the same situation exists with the addition of a 20 foot stub flume outlet. In addition to the regular stakes at each end, offset stakes are placed perpendicular to the point where the flume joins the concrete roadway pipe. These flume stakes are also graded for flowline elevation.

Figure 16, illustrates a 24" Corrugated Metal Pipe Letdown design. This type of pipe handles drainage out on the right of way in hilly, large cut and fill areas. It is distinguished by breaks in the flowline elevation from one end to the other. The example shows two elevation changes or breaks at intermediate points along the pipe; the design calls for one 25 degree elbow to be placed at each elevation change. These intermediate points are staked with offsets perpendicular to points of flowline elevation change. The inlet and outlet ends are staked and graded in the manner previously described.

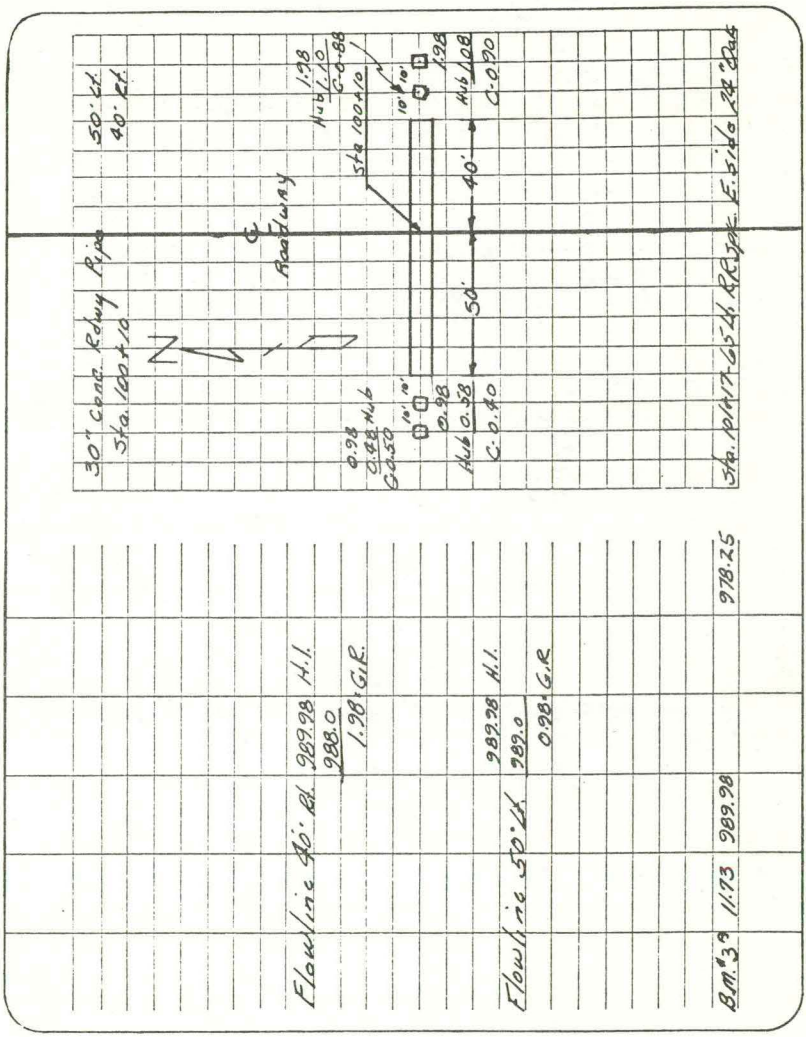


Figure 13 — Survey diagram.

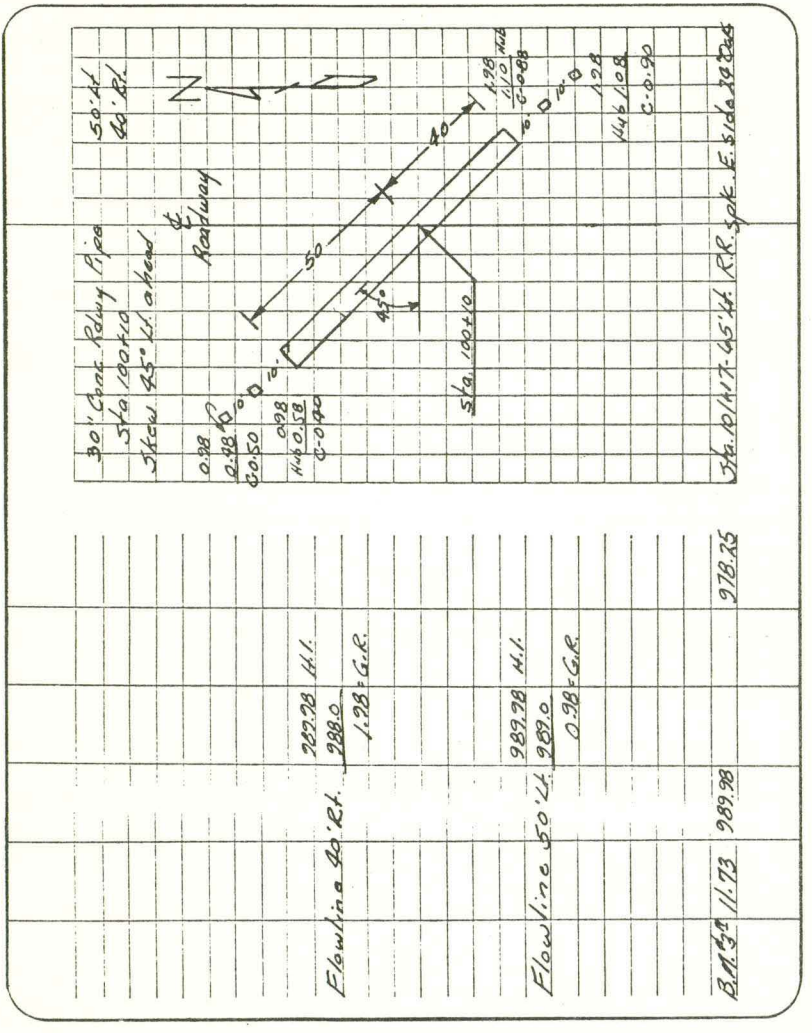


Figure 14 — Survey diagram.

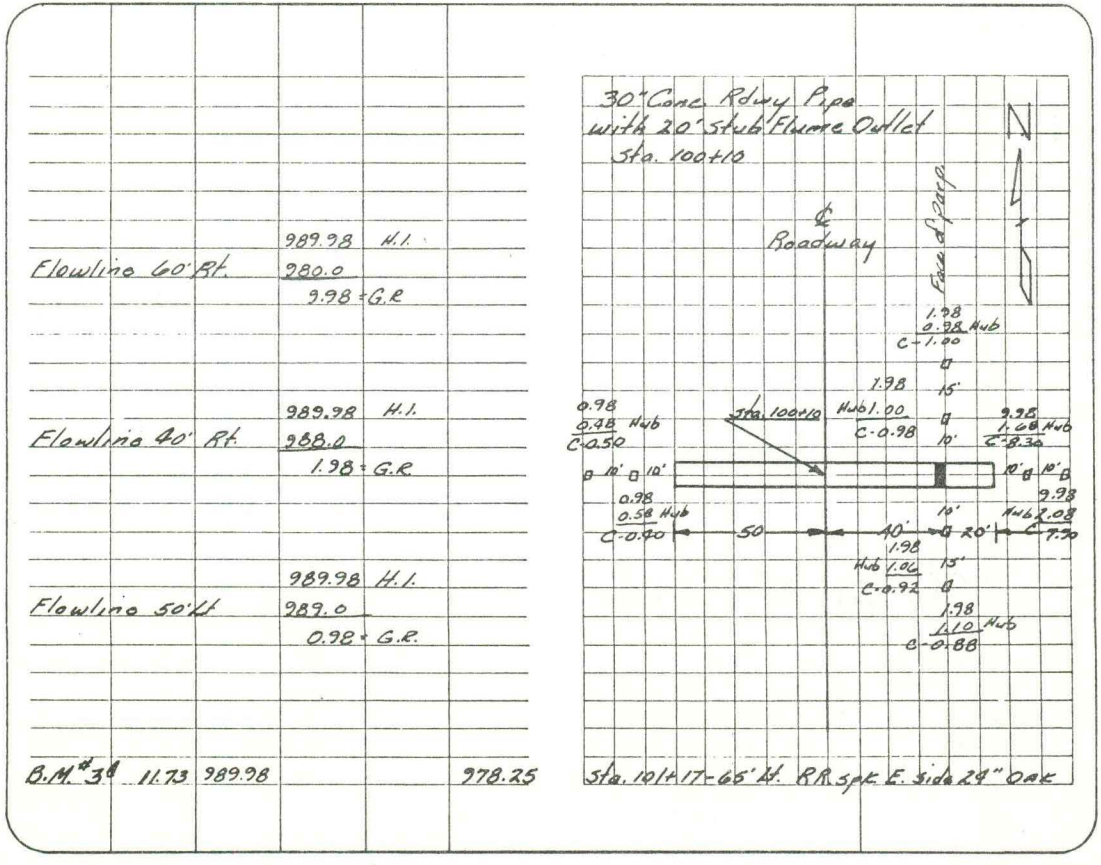


Figure 15 – Survey diagram.

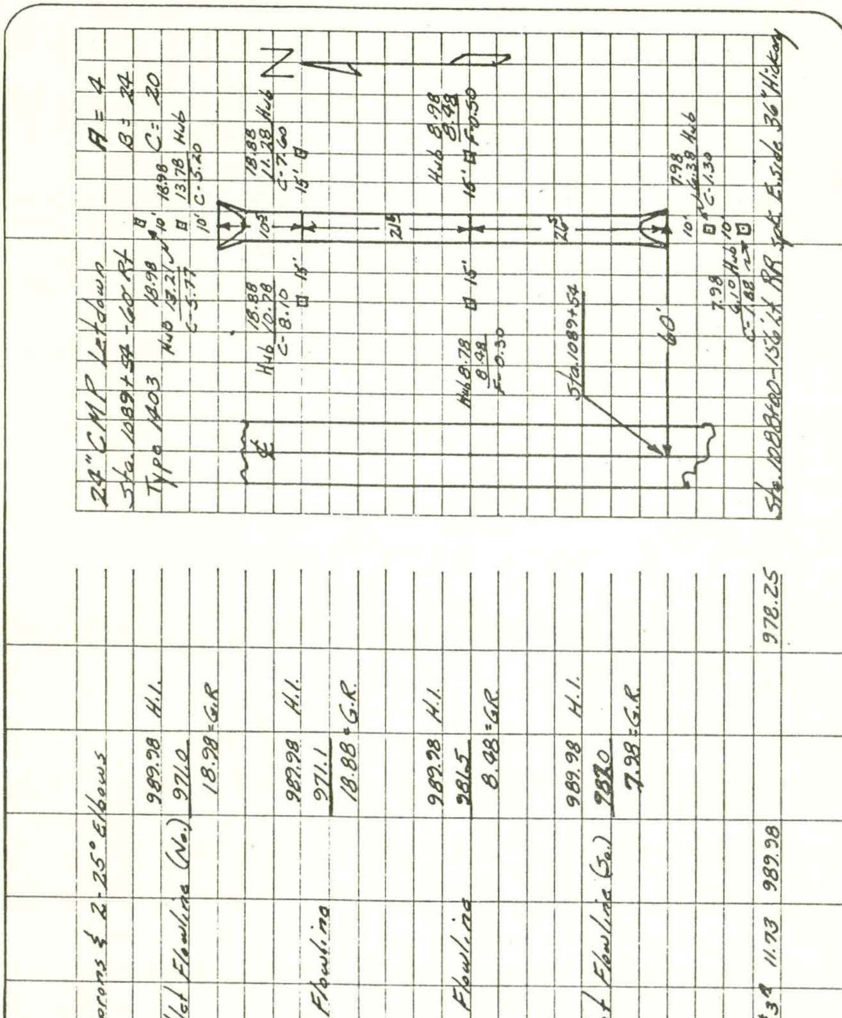


Figure 16 – Survey diagram.

Excavation

The quantity and class of excavation is listed in the tabulation "Drainage structures by Road Contractor" for each structure in the project. The quantity shown is used for payment if no change is made in alignment or grade during construction.

In case changes are made in alignment or grade during construction, the excavation is measured by cross section methods or by other appropriate methods; this is then used as the basis of payment for the class of excavation removed. The method of excavation for pipe culverts may vary in some aspects between different contractors. The base can be excavated in two ways:

1) The surface for the pipe can be excavated two or three inches below grade and backfilled with good material to the grade and camber required. This material need not be compacted.
2) The surface upon which the pipe rests can be trimmed to fit the grade so the pipe is bedded in firm material.

Rough grading for pipe is generally done with a bulldozer or a trenching machine. Fine grading is done by hand from stringlines offset above the flowline of pipe and with the proper amount of camber placed in the grade. Camber placed in the pipe culvert varies with the type of soil. It must be maintained under the full width of the roadway top. The flowline of the pipe is raised to compensate for the yield factor (settlement of the pipe) after roadway fill is placed. The camber values must be adjusted for different types of soil. (See Figure , Standard Plan RF 4).

The width of trench for any pipe must be adequate to permit thorough tamping under and around the pipe.

Unstable material or rock in the bottom of footings must be handled according to Standard Specifications. No foundation material should be placed for payment without the approval of the engineer in charge.

It is the inspector's duty to see that the contractor places the pipe at the grades indicated on the stakes. Accurate flowline grades should be obtained before laying operations begin.

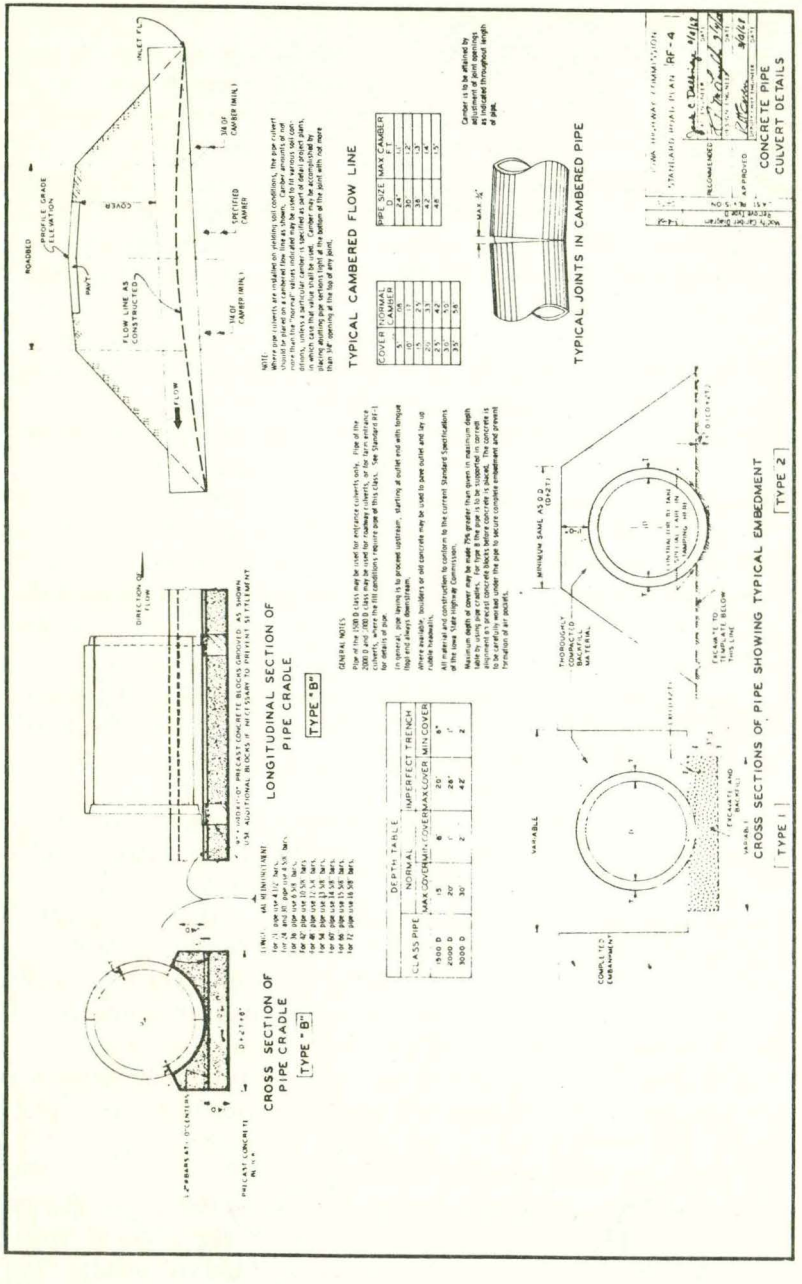


Figure 17 – Standard road plan RF–4.

Pipe Bedding and Installation

The bedding on which culvert pipe lays must be accurately cut to the proper grade before any pipe is placed. A carefully graded base is very important in obtaining good alignment and close-fitting joints in the completed installation.

Care must be taken in the handling concrete pipe to prevent damage to the tongue and groove ends. It is desirable for the contractor to use a lifting boom mounted on a piece of equipment (dozer, tractor, or truck) to move the pipe sections. Many contractors build pipe hooks that work well in lifting smaller sizes of pipe. Larger sizes of pipe are fabricated with lift holes for handling by the manufacturer; the lift holes should be used. After placing the pipe, the lift holes are grouted full with cement-sand pipe damaged through carelessness during placement.

Installation should start at the outlet end and proceed upstream to the inlet end, with the bell end of each section placed upstream. Each individual section should be checked for grade and alignment as it is placed. Specifications require that joints between sections fit with openings no larger than 1/8 inch at the bottom, 5/8 inch at the top, and 3/8 inch at the sides. If the sections cannot be made to fit tightly and maintain the proper line, it is necessary to encase the joint with a Type C-1 connection at the contractor's expense. There are cases where rotating the pipe secures tighter joints. Tight joints must be obtained at the time of placement to avoid water seeping through and undercutting the embankment around the pipes causing settlement in the roadway.

Corrugated metal pipe is bedded in the same manner as concrete pipe. It is handled more easily, but care must still be taken to avoid denting, bending, or damage to the protective coating. In cases where the protective coating is damaged in small areas, the contractor can mend in the field with tar.

It is important that grading of the flowline and bedding be done carefully in order to obtain good joints during installation.

Pipe Joints and Connections

Some pipe culvert construction designs show existing concrete box culverts extended with concrete pipe. The extension is connected to the box with a C-2 adaptor (See Standard Plan RF 2). A Type C-2 adaptor is built by removing old headwalls and placing a concrete collar around the joint. Other types, C-1, 3, and 4, are used with breaks in flowline grade alignment and for connecting of metal pipe to concrete pipe. All materials for connections must meet current specifications.

Special connections not on standard road plans are shown in the project plan sheets with details on type, size, and other special features. Most adaptors are formed and poured at the job site.

Structural Concrete and Reinforcing Steel

Special designs in pipe culvert construction incorporate structural concrete and reinforcing steel bars or wire mesh. These situations occur on designs ranging from concrete collars at pipe joint connections to special flumes and box culvert inlets and outlets.

All material used in reinforcing must be approved for use by the Materials Department. It is the contractor's responsibility to arrange for concrete to be delivered to the jobsite and to order the required reinforcing material before construction begins.

Before any concrete or reinforcing material can be incorporated, approval receipts must be in the hands of the inspector or filed in the office in charge of construction.

The contractor can choose any Class "C" concrete mix number conforming to specifications. The inspector must then calculate the correct proportions for the mix number selected. Moisture content of sand and rock must be determined to calculate the weights required. Structural concrete is handled by the unit cubic yard.

Concrete sources are almost entirely ready-mix, dispatched in mixer drum trucks. All plants supplying ready-mix concrete for state construction projects must be calibrated and approved each year by the Materials Department.

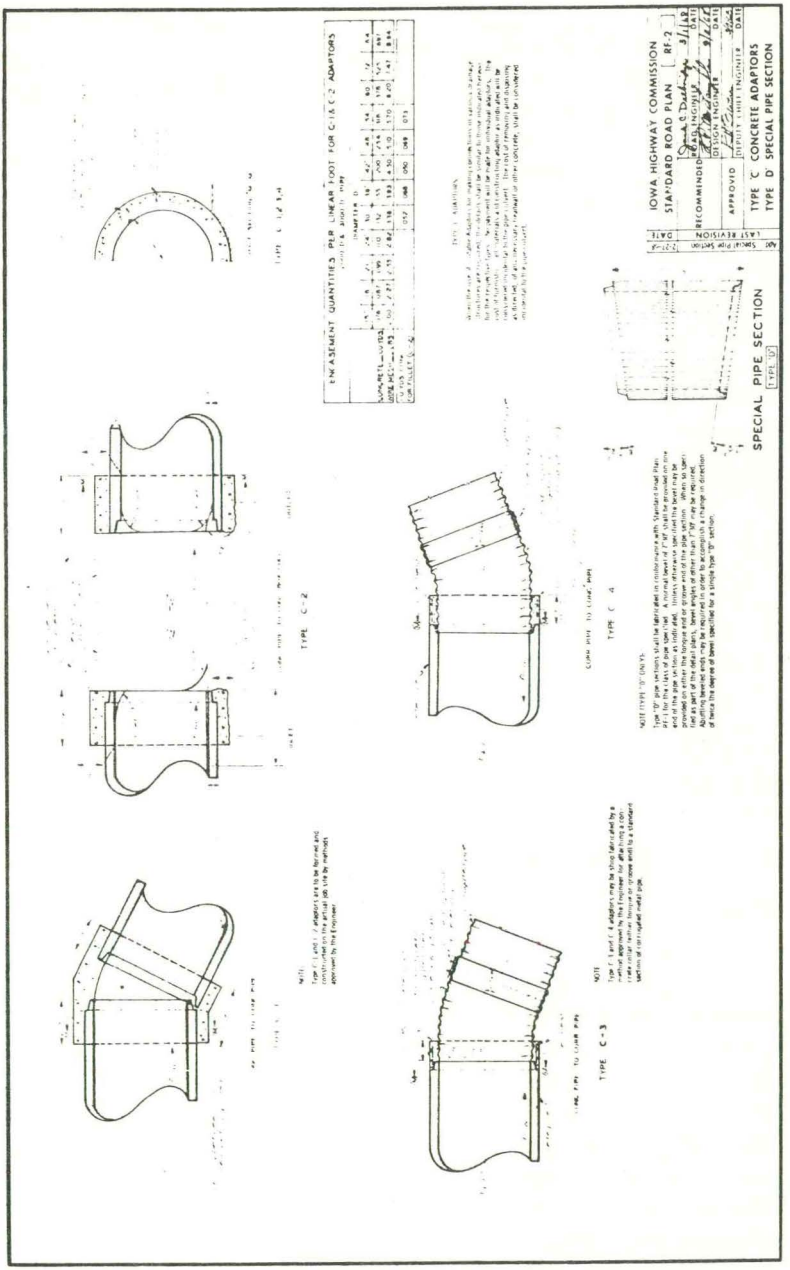


Figure 18 – Standard road plan RF–2.

The performance of mixer trucks must be calibrated and certified. Calibration sheets for mixers are found in the truck. Mixing speeds and other pertinent information are found on these sheets. Mixers must not be used if not certified and equipped with revolution counters. An inspector must be at the ready-mix plant to observe batching and mixing operations.

There should always be an inspector at the jobsite to observe pouring operations and to run air and slump tests. In some instances, it is necessary to make test beams that are later tested for strength. This si required for structures; carrying loads and for substantial backfilling operations. Two beams are required, tested on the 7th and 14th days. Care must be taken in handling and storing beams before testing. Information on beam making and testing must be pa part of the permanent project records, reported to the Central Office on Form No. 617. Needed information on beams can be found in the current year paving manual.

The inspector must be able to read plans and understand the types, sizes, number, and spacing of reinforcing. This knowledge, along with good forming techniques, produces neat, structurally sound pipe culverts. Details on structural concrete are covered in the Ready-Mix Concrete Inspection and Culvert Construction handbooks.

Backfilling Pipe Culverts

Backfilling is a critical step in pipe culvert installation. Carelessness can cause settlement in the finished road that can never be eliminated.

Specifications state that "Suitable Material" must be used for backfilling. Suitable material is free of lumps, rocks, and vegetation; it contains enough moisture to compact well. Avoid material too wet to compact. If suitable backfill material is not available at the pipe location, and the grading contractor is working, suitable backfill material can be hauled to the site. Material must be placed and tamped under the lower sides of the pipe and brought up in no more than 8 inch lifts. It is placed in even lifts along the full length so the fill on both sides of the pipe remains equal. Material must not be bulldozed around the pipe in heavy lifts that cannot be handled in a workmanlike manner.

If the trench is wide enough, sheeps foot rollers can be used in conjunction with mechanical tampers and patrol wheels. The wheels of the motor patrol should be used to compact only the one foot of material adjacent to the pipe. Backfill should be compacted to at least one foot above the top of the pipe with the slopes required by specification. Good compaction under the haunches of the pipe is very important in backfilling to eliminate seepage of water.

Backfill for roadway pipe placed after the roadway fill is completed must give results equivalent to the methods used for construction of the roadway fill.

Safety

Safety is considered one of the most important factors in pipe culvert construction. It is the inspector's responsibility to inform the contractor of careless and dangerous work habits.

In all cases, inspectors working on excavations are required to wear protective safety hats. Excavation depths exceeding six feet below natural ground must either be braced or have the sides sloped at an angle which prevents cave-ins unless the trench is cut in solid rock or hard shale.

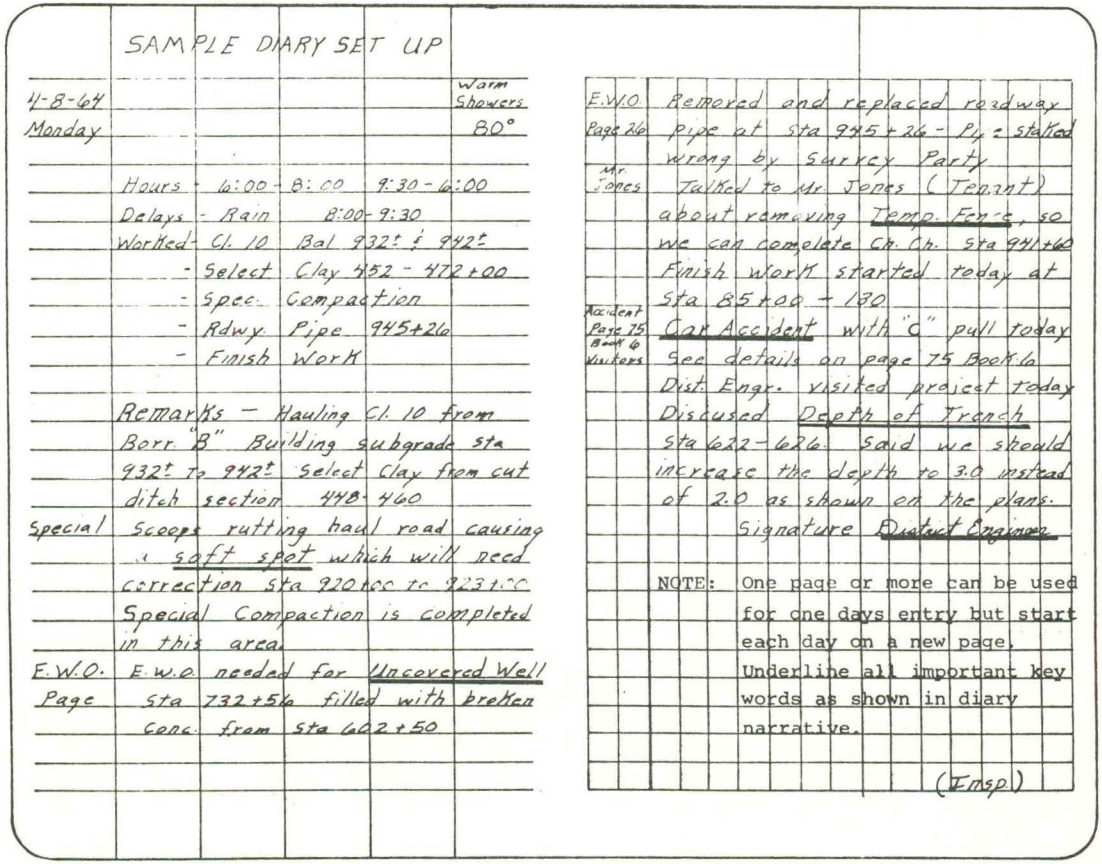
Equipment used in pipe culvert construction must be maintained in good working condition. Cables, chains, and hooks must be strong enough to handle the loads. Cables should be checked periodically for broken strands. Workmen should never stand directly beneath an elevated load. Dragline or crane operators should exercise caution near power lines.

The inspector has to exercise care in working around construction to avoid becoming involved in an accident. Serious hazards should be brought to the attention of one's supervisor, who in turn can help promote safer conditions.

Records and Reports

In addition to ensuring that work is done in accordance with the plans and specifications, accurate records show that work was properly performed and measured for payment. All documentation entries must be initialed.

Field books for the project should be titled, indexed, and numbered before a final estimate is completed. Separate pages should be used for the different types and sizes of pipe used in a project. To avoid confusion, final measurement of the completed work is made following each segment of work to keep records complete, up to date, and accurate.



SAMPLE DIARY SET UP

4-8-64 Monday — Warm Showers 80°

Hours - 6:00 - 8:00 9:30 - 6:00
Delays - Rain 8:00 - 9:30
Worked - Cl. 10 Bal 932+ & 942+
- Select Clay 452 - 472+00
- Spec. Compaction
- Rdwy. Pipe 945+26
- Finish Work

Remarks - Hauling Cl. 10 from Borr. "B" Building subgrade sta 932+ to 942+ Select Clay from cut ditch section 448-460

Special — Scoops rutting haul road causing a soft spot which will need correction sta 920+00 to 923+00 Special Compaction is completed in this area.

E.W.O. Page — E.w.o needed for Uncovered Well sta 732+56 filled with broken conc. from sta 602+50

E.W.O. Page 26 — Removed and replaced roadway pipe at sta 945+26 - Pipe staked wrong by Survey Party

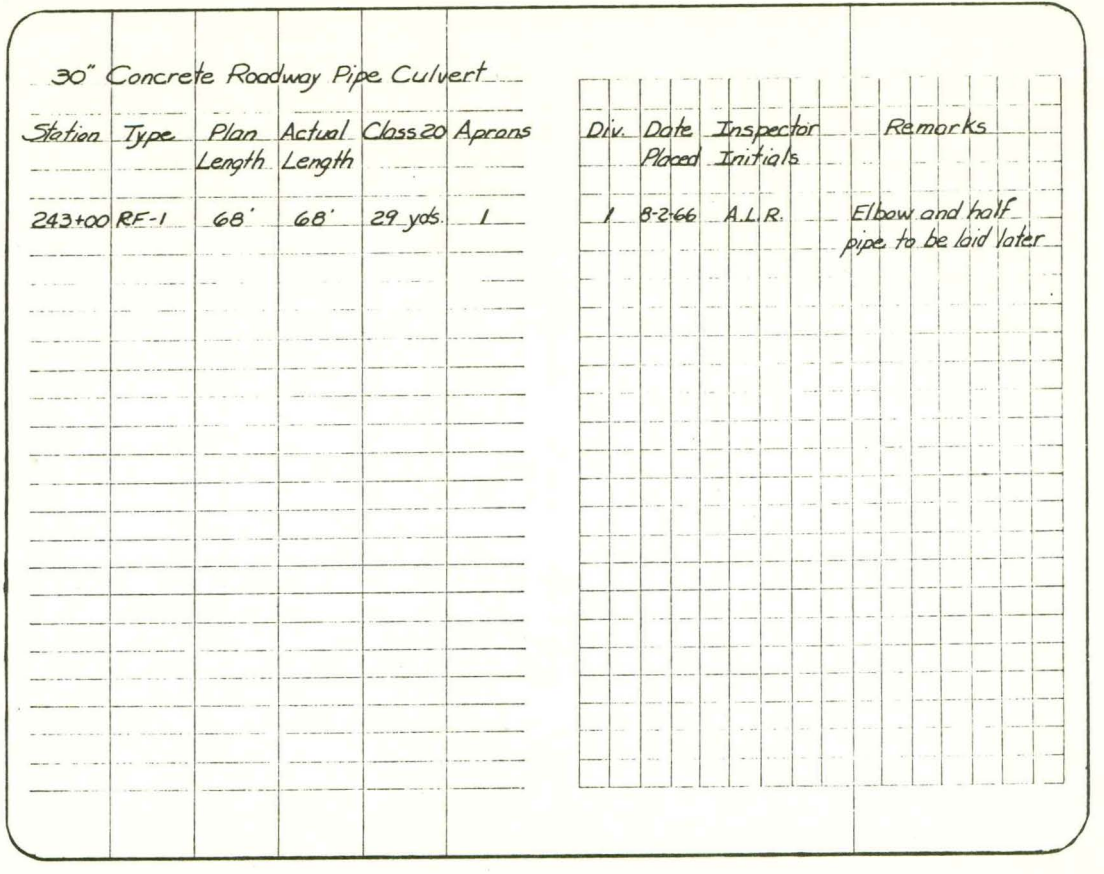
Mr. Jones — Talked to Mr Jones (Tenant) about removing Temp. Fence, so we can complete Co. Rd. sta 941+60 Finish work started today at sta 85+00 - 130

Accident Page 75 Book 6 Visitors — Car Accident with "C" pull today See details on page 75 Book 6 Dist. Engr. visited project today Discussed Depth of Trench sta 622-626 Said we should increase the depth to 3.0 instead of 2.0 as shown on the plans. Signature Distrct Engineer

NOTE: One page or more can be used for one days entry but start each day on a new page. Underline all important key words as shown in diary narrative.

(Insp.)

Figure 19 — Sample diary setup.



30" Concrete Roadway Pipe Culvert

Station	Type	Plan Length	Actual Length	Class 20	Aprons
243+00	RF-1	68'	68'	29 yds.	1

Div.	Date Placed	Inspector Initials	Remarks
1	8-2-66	A.L.R.	Elbow and half pipe to be laid later

Figure 20 — Sample diary setup.

NOTES