COMMONWEALTH OF KENTUCKY
DEPARTMENT OF HIGHWAYS
FRANKFORT

HENRY WARD
COMMISSIONER OF HIGHWAYS

March 23, 1961

ADDRESS REPLY TO
DEPARTMENT OF HIGHWAYS
MATERIALS RESEARCH LABORATORY
132 GRAHAM AVENUE
LEXINGTON 29, KENTUCKY

D.1.7.
D.2.4.

MEMO TO: A. O. Neiser
Assistant State Highway Engineer

SUBJECT: Performance Survey of Reinforced Concrete Pipe Culverts

Circular Memorandum 22-42 from Assistant Commissioner G. M. Williams, Bureau of Public Roads, dated November 12, 1959, requested that the Department of Highways select a group of reinforced concrete pipe installations designed and installed in accordance with Circular Memorandum 22-40, April 4, 1957, for continuing performance studies. The Department based the pipe culvert installation specification Amendment 15, 1956 Specifications, and the culvert pipe specification Amendment 16, 1956 Specifications, as well as Standard Drawings No. 11.22 and 11.23 on the proposed criteria in Circular Memorandum 22-40.

A group of RCP culverts were selected early last year and the inspections were begun. On April 1, 1960, Mr. J. C. Cobb was advised in a letter from Mr. D. H. Bray that 100 concrete pipe culverts had been selected for performance studies. This group has been increased to 113 RCP culverts. Additional culverts under construction in Scott County were included for observation of installation and performance.

Some rather serious failures were located and a detailed study was made of the distressed pipe. Some of these pipe culverts required a corrugated metal liner pipe for part of the length of the culverts.

The report on the initial performance survey of the pipe culverts has been delayed somewhat by the special investigations and repair work. Table 1 in the attached report lists all pipe requiring any type

of repairs. Only the culverts originally selected from the road plans for study have been reported in this performance survey (note asterisks in Table 1). A separate report on performance and repairs of the distressed pipe is being made.

Attached is the first performance survey of the pipe culvert. This survey has been prepared by R. C. Deen and R. D. Hughes of the Research Division staff, and is submitted for transmittal to the Division office of the Bureau of Public Roads.

Respectfully submitted,

W. B. Drake
Director of Research

WBD:dl
Att.: Performance Survey of RCPC
cc: Research Committee Members
Bureau of Public Roads (3)

Commonwealth of Kentucky
Department of Highways

PERFORMANCE SURVEY

of

REINFORCED CONCRETE PIPE CULVERTS

by

R. C. Deen
Research Engineer Senior

and

R. D. Hughes
Research Engineer Associate

Highway Materials Research Laboratory
Lexington, Kentucky

March, 1961

INTRODUCTION

Methods of installation and design criteria have tended to restrict the usefulness of rigid pipe culverts. With the increased mileage of highways which meet high standards, there has been an increase in the number of pipe culverts installed under high fills. This, of course, has accented the need for criteria for the proper design and installation of rigid pipe to obtain the maximum utilization of the pipe strength and to minimize the possible steelements that may occur in the road surface near the pipe installation or in the flow line of the pipe culvert.

In order to provide for an efficient utilization of rigid pipe, the Department of Highways issued Standard Drawings* and Amendments No. 15 and 16 to the 1956 Edition of Standard Specifications for Road and Bridge Construction specifying the bedding details and strength of pipe required for the various heights of fill. These standards were developed from the criteria set by the Bureau of Public Roads**. The BPR criteria had been developed in co-operation with the American Concrete Pipe Association and was an attempt to bring together and simplify the prevailing methods of computing the necessary pipe strengths

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* Standard Drawings No. 11.22 and 11.23, Kentucky Department of Highways.

** Bureau of Public Roads, Circular Memorandum 22-40, April 4, 1957.

for the various classes of bedding commonly in use. Included in the Kentucky Standards was a provision permitting the use of the imperfect trench type of construction. Kentucky is, thus, one of thirteen states which permits this type of bedding, or a modification thereof.

In order to evaluate the effectiveness of the design and construction criteria, the Bureau of Public Roads has requested that a number of reinforced concrete pipe installations be selected for periodic inspections. The data reported herein are a summary of the design and construction data for the pipes selected for study and a report of the condition of the pipes as observed during the first field inspection.

PERFORMANCE SURVEY

In compliance with the BPR request, a group of 113 reinforced concrete pipe installations on the Interstate System has been selected for study. The design and construction data for these pipe installations have been tabulated in the Appendix.

All of the 113 installations were visited during the summer and fall of 1960, and inspections made of the condition of the pipe. These condition surveys have been presented pictorially in the tables included in the Appendix. These tables bring together in one place much of the pertinent data pertaining to each pipe installation.

The pictorial plots of the pipe have all been made so that the inlet is to the left, and the sections of pipe are numbered from that end of the pipe. All signs of distress that were observed during the field inspection are indicated by the appropriate symbol in the section of pipe in which the distress was noted. If no distress was observed in a pipe, no special remark to this effect was made, but the sketch of the pipe was left free of any symbols.

A special notation is required with regard to the two Scott County projects, I 75-6(4)129 and I 75-6(5)123. The two pipes on I 75-6(4)129 and the pipe at Station 47+40, US 62 on I 75-6(5)123 have not yet been installed. The remaining pipe on I 75-6(5)123 have been laid but the fills over them are not as yet completed. Inspections have been made of the

pipes which have been laid and no distress has been noted except in the pipe at Station 37 + 50, US 460, SW Ramp. The conditions of installation and the performance of this particular pipe are under special study by the Research Division and will be reported separately.

During the course of the field inspections, a number of pipes were noted to be in serious distress. After an intensive study, certain pipes were recommended for repair by patching and/or lining with corrugated metal pipe. The pipes and the recommended repairs are listed in Table 1. Figures 1 through 6 illustrate some of the types of failures which were observed in the more distressed pipes.

Table 1. Recommended Repair for Pipe in Serious Distress

Project No.	County	Station No.	Patching*	Corrugated Metal Liner*
I 64-3(3)31	Shelby	1255 + 25		Sec. 10-13, 12 gauge, 42" min. dia.
I 64-3(5)45	Franklin	2225+50R**	Top & bottom - Sec. 8-15	
		2233+50R	Top & bottom - Sec. 13-32	
I 64-3(7)35	Shelby	1604+04R	Bottom - Sec. 12-16	
		1604+73L**	Bottom - Sec. 17-19	
			Top & bottom - Sec. 20-22	
		1619+45L		Sec. 11-32, 8 gauge, 48" min. dia.
		1633+30L		Sec. 10-41, 8 gauge, 48" min. dia.
		1635+69L**		Sec. 18-46, 10 gauge, 33" min. dia.
		1635+82R	Lift holes	
		1637+32L		Sec. 13-47, 8 gauge, 42" min. dia.
I 75-7(3)155	Grant	15+65FR 7a**	Lift holes	Sec. 8-22, 8 gauge, 60" min. dia.
I 75-7(5)160	Grant	978+12		Sec. 15-45, 10 gauge, 36" min. dia.
		1085+44	Joints, Sec. 67-73	
		1087+50	Joints, Sec. 19-21	Sec. 34-79, 8 gauge, 48" min. dia.
		27+32FR 9**		Sec. 5-19, 12 gauge, 33" min. dia.
		27+82FR 9a	Joints & lift holes	Sec. 5-12, 8 gauge, 60" min. dia.
I 75-7(11)151	Grant	538+88**	Sec. 40, Joints 102, 104, 108	Sec. 47-80, 8 gauge, 48" min. dia.
		24+43, Ky. 38**	Sec. 60 & 74	Sec. 44-51, 8 gauge, 54" min. dia.
I 75-8(6)181	Kenton	383+00**	Sec. 7, 12, 13, 16, 21-23, 29, 30	Sec. 46-50, 10 gauge, 36" min. dia.

* Sections numbered from inlet of culvert.

** Not included in the 113 pipe under study.

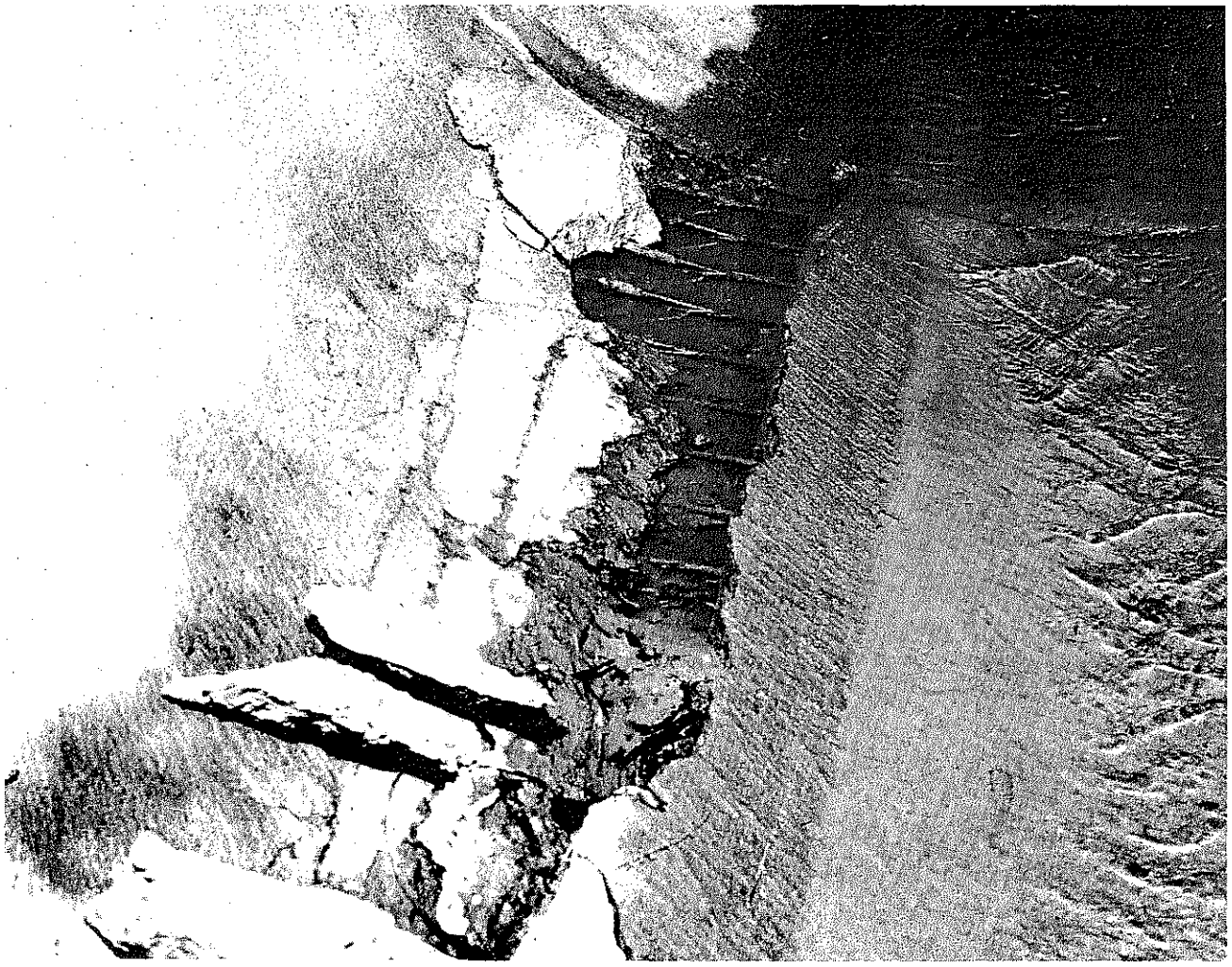


Fig. 1. Failure in Bottom of 60-inch Culvert Under a 28-foot Fill, Station 1619 + 45L, I 64-3(7)35, Shelby County.

Fig. 2. Failure in Top of 60-inch Culvert Under a 28-foot Fill, Station 1619 + 45L, I 64-3(7)35, Shelby County.

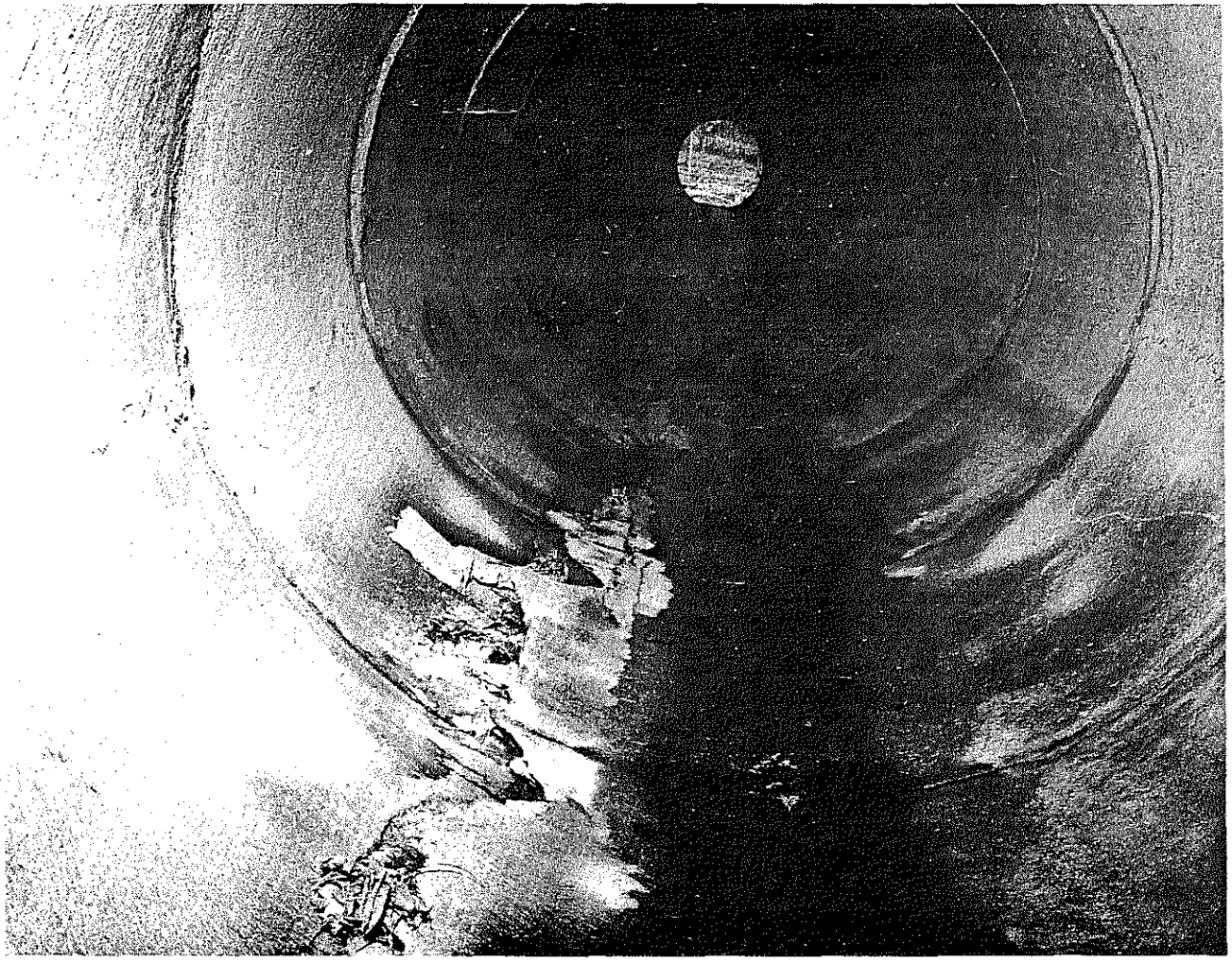


Fig. 3. Failure in Bottom of 54-inch Culvert Under a 32-foot Fill, Station 1633 + 30L, I 64-3(7)35, Shelby County.

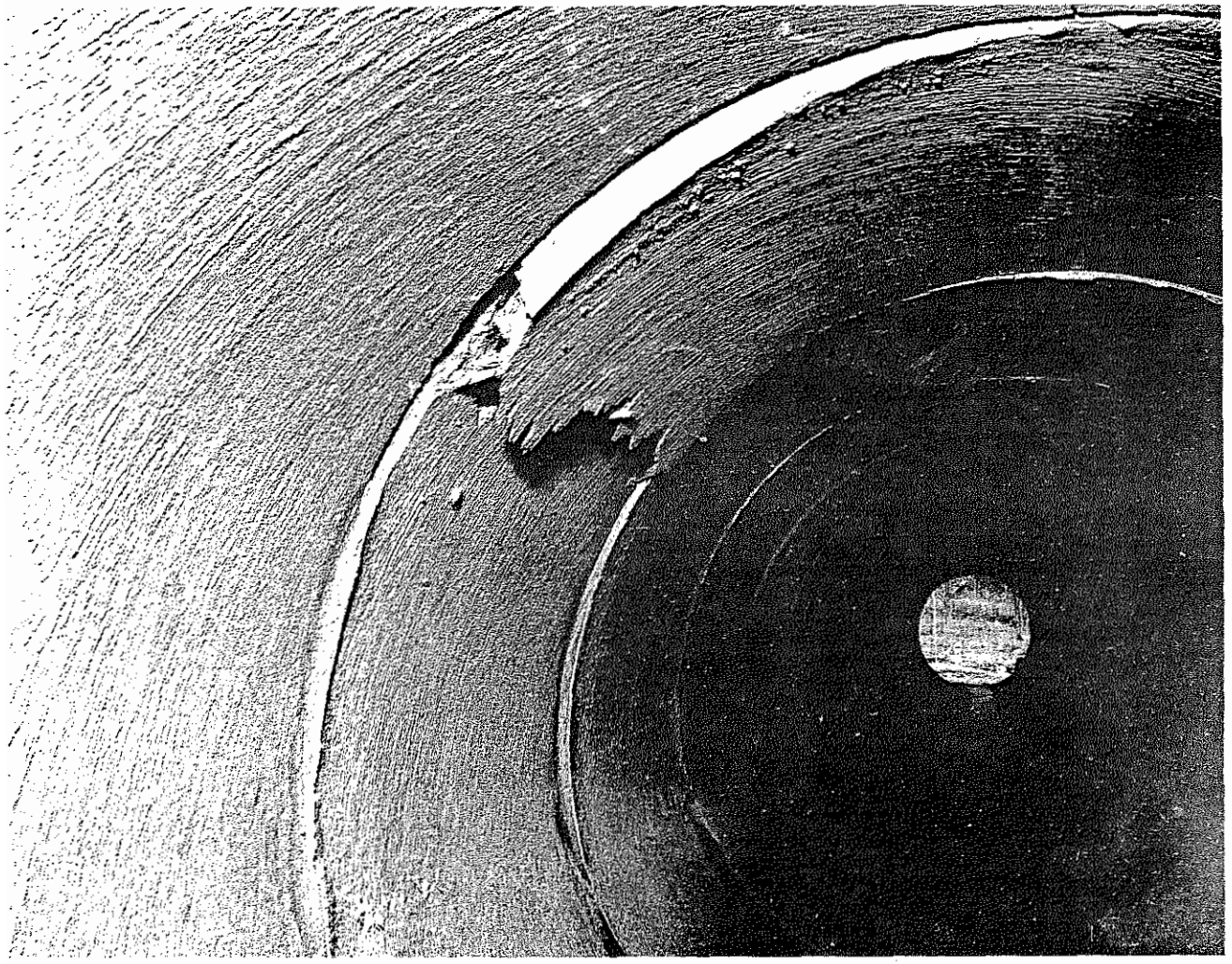


Fig. 4. Failure in Top of 54-inch Culvert Under a 32-foot Fill, Station 1633 + 30L, I 64-3(7)35, Shelby County.

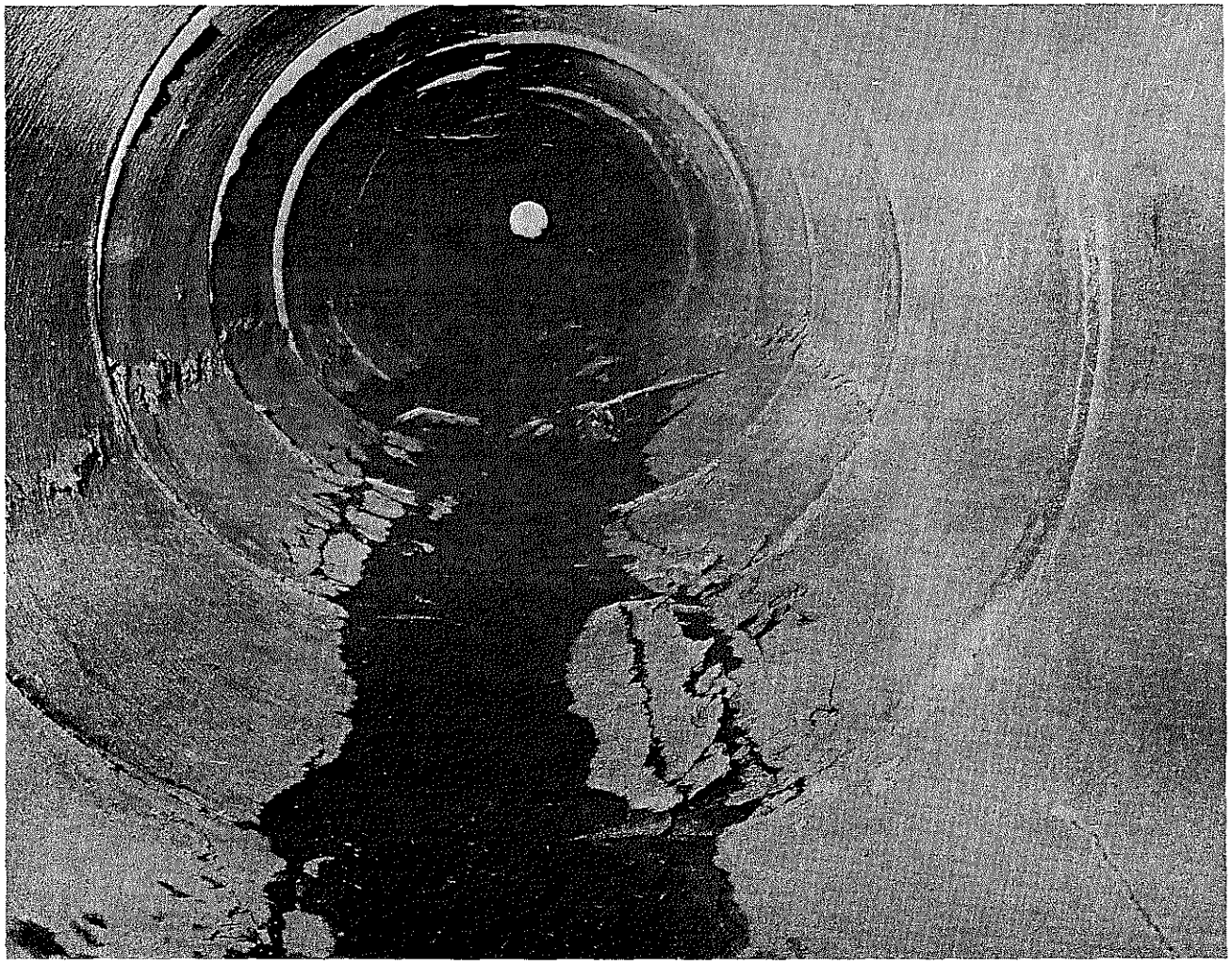


Fig. 5. Failure in Bottom of 54-inch Culvert Under a 53-foot Fill, Station 1087 + 50, I 75-7(5)160, Grant County.

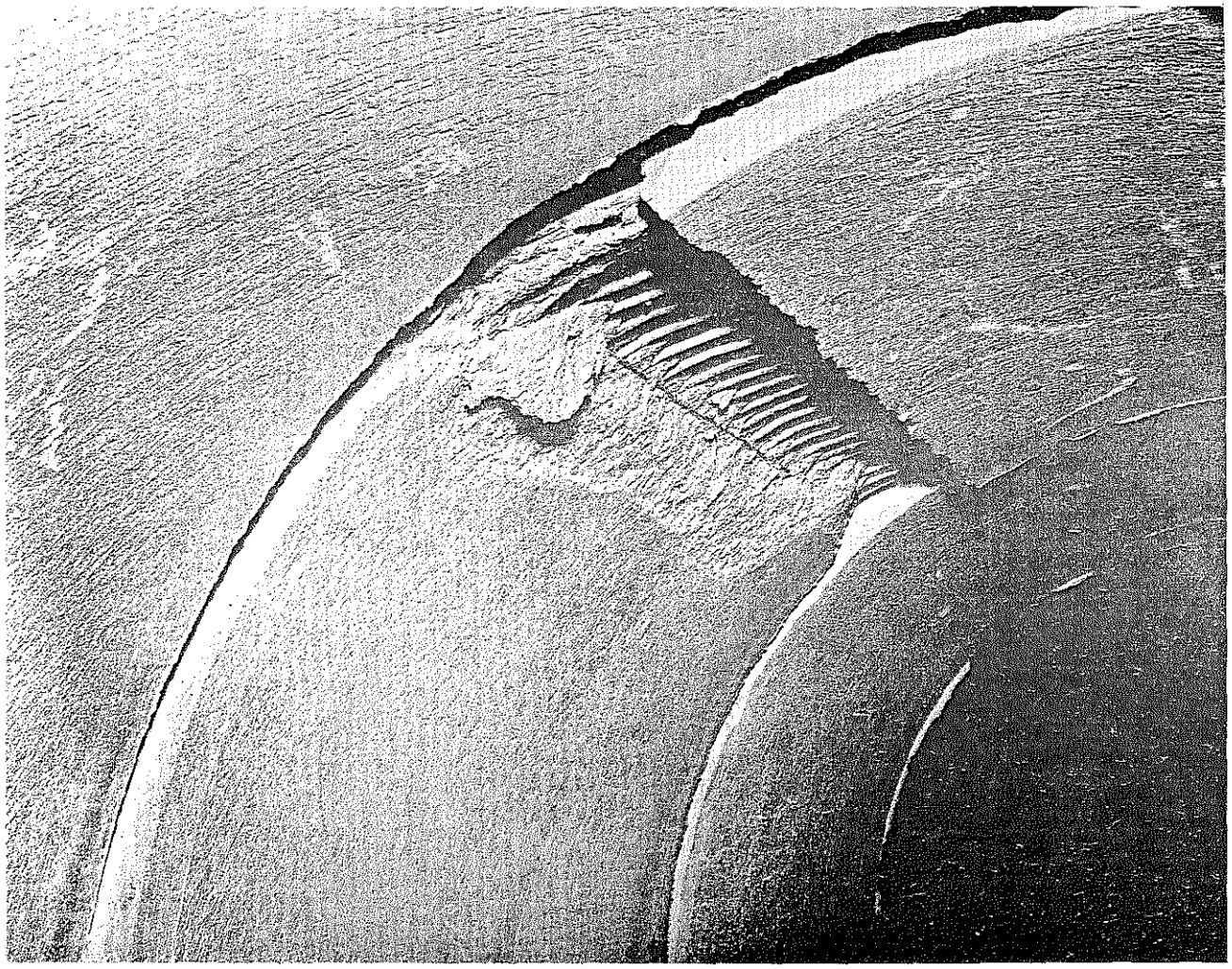


Fig. 6. Failure in Top of 54-inch Culvert Under a 53-foot Fill, Station 1087 + 50, I 75-7(5)160, Grant County.

APPENDIX

LEGEND

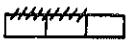
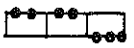
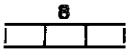
Hairline Crack	—	
Crock (.01 in. or above)	—	
Shear Failure	—	
Spalling	—	
Broken	—	
Mortar Missing	—	
Steel Exposed	—	
Faulted	—	
Section Settled	—	
Buckling	—	

TABLE OF DESIGN, CONSTRUCTION AND PERFORMANCE DATA

PROJECT NO. I 64-2(3) 22 SHELBY COUNTY

JEFFERSON COUNTY LINE TO JOYCE STATION ROAD

Station Number	Diameter (in.)	Design Length (ft.)	Actual Length (ft.)	Class	Bedding	Projection	Design Grade (%)	Actual Grade (%)	Embankment Height North (ft.)	Embankment Height South (ft.)	Skew (°)	Embankment Material	Factor of Safety as Constructed	Location of Inlet
900 + 15	48	156	156	III	Std.	Positive	0.32	0.32	4.5	4.5	0	Soil	1.00	North
968 + 25	42	172	172	III	Std.	Positive	2.00	2.00	8.0	9.5	0	Rock	2.50	North
983 + 90	18	228	228	III	Std.	Positive	1.89	1.89	24	22.5	0	Rock	1.00	South
988 + 75	24	212	212	III	Std.	Positive	1.98	1.98	17.0	15.0	0	Rock	1.38	South
1000 + 50	30	200	200	III	Std.	Out. to 58'-Pos. 58' to 200'-Neg.	1.90	1.90	13.5	12.0	0	Soil	1.32	South
1057 + 35	30	212	212	III	Std.	Positive	0.99	0.99	19.0	19.5	15 L	Rock	1.18	North
1133 + 10	36	168	168	III	Std.	Positive	1.01	1.01	4.5	6.0	0	Soil	4.45	North

TABLE OF DESIGN, CONSTRUCTION AND PERFORMANCE DATA

PROJECT NO. I 64-2(3) 22 SHELBY COUNTY

JEFFERSON COUNTY LINE TO JOYCE STATION ROAD

Station Number	Diameter (in.)	Design Length (ft.)	Actual Length (ft.)	Class	Bedding	Projection	Design Grade (%)	Actual Grade (%)	Embankment Height North (ft.)	Embankment Height South (ft.)	Skew (°)	Embankment Material	Factor of Safety as Constructed	Location of Inlet
Ramp 1 10 + 70	36	144	144	III	B_1	Positive	0.90	0.90	29.0		0	Soil & Rock	1.75	North
Ramp 5 9 + 50	18	100	100	III	Std.	31'-Pos. 69'-Neg.	2.50	2.50	12.0		0	Soil & Rock	1.85	South
Veechdale Rd. 70 + 00	18	148	148	III	B_1	In. to 30'-Neg. 30' to 148'-Pos.	4.39	4.39	28.0		0	Rock	1.89	South
Veechdale Rd. 74 + 00	24	168	168	III	B_1	Negative	0.60	0.60	32.5		0	Rock	1.60	South

TABLE OF DESIGN, CONSTRUCTION AND PERFORMANCE DATA

PROJECT NO. I 64-2(5) 17 JEFFERSON COUNTY

WEST OF ENGLISH STATION ROAD TO SHELBY COUNTY LINE

Station Number	Diameter (in.)	Design Length (ft.)	Actual Length (ft.)	Class	Bedding	Projection	Design Grade (%)	Actual Grade (%)	Embankment Height North (ft.)	Embankment Height South (ft.)	Skew (°)	Embankment Material	Factor of Safety as Constructed	Location of Inlet
577 + 65	36	260	260	III	Std.	Negative	3.19	3.19	16.0	14.0	45 R	Soil & Rock	1.48	South
588 + 50	36	312	312	III	B_1	Positive	3.48	3.48	36.0	33.5	30 R	Soil & Rock	1.47	South
597 + 00	48	260	260	III	B_1	Positive	3.30	3.30	34.0	31.0	0	Soil & Rock	1.53	South
608 + 75	42	268	268	III	B_1	Positive	2.00	2.00	27.0	26.0	30 R	Rock	1.89	North
652 + 68	42	228	228	III	B_1	Positive	3.50	3.50	22.0	25.0	15 R	Soil & Rock	2.02	North
668 + 00	30	296	296	III	Std.	Positive	3.45	3.23	16.0	19.5	45 R	Soil & Rock	1.27	North
698 + 00	24	224	224	III	Out.-100'-B_1 100'-224'-Std.	Out.to 52'-Pos. 52' to 140'-Neg. 140' to 224'-Pos.	4.69	4.69	20.0	24.0	0	Soil & Rock	2.25 1.03	North

TABLE OF DESIGN, CONSTRUCTION AND PERFORMANCE DATA

PROJECT NO. I 64-2(5) 17 JEFFERSON COUNTY

WEST OF ENGLISE STATION ROAD TO SHELBY COUNTY LINE

Station Number	Diameter (in.)	Design Length (ft.)	Actual Length (ft.)	Class	Bedding	Projection	Design Grade (%)	Actual Grade (%)	Embankment Height North (ft.)	Embankment Height South (ft.)	Skew (°)	Embankment Material	Factor of Safety as Constructed	Location of Inlet
744 + 30	30	260	260	III	B_1	Positive	2.08	2.08	23.5	25.0	30 R	Soil & Rock	2.00	North
776 + 50	30	260	260	III	B_1	Positive	3.15	3.15	32.0	30.0	15 L	Soil & Rock	1.57	South
720 + 35	24	208	208	III	Std.	Positive	3.89	3.89	11.0	15.0	30 L	Soil & Rock	1.74	North

TABLE OF DESIGN, CONSTRUCTION AND PERFORMANCE DATA

PROJECT NOS. I 64-2(7) 29 & I 64-3(3) 31 SHELBY COUNTY

JOYCE STATION ROAD TO KY. 55 (OLD) & KY. 55 (OLD) TO SEVEN MILE PIKE

Station Number	Diameter (in.)	Design Length (ft.)	Actual Length (ft.)	Class	Bedding	Projection	Design Grade (%)	Actual Grade (%)	Embankment Height North (ft.)	Embankment Height South (ft.)	Skew (°)	Embankment Material	Factor of Safety as Constructed	Location of Inlet
Joyce Station Road 78 + 50	30	108	108	III	B_1	Positive	1.02	1.02	24		30 L	Soil	2.11	North
Joyce Station Road 81 + 79	48	144	144	III	B_1	130'-Pos. 14'- Neg.	2.03	2.03	29.5		17.5 R	Soil	1.71	North
1168 + 37	42	204	204	III	Std.	Out. to 53'-Neg. 53' to 204'-Pos.	1.10	1.10	13.0	13.0	30 R	Soil & Rock	1.72	North
1255 + 25	48	208	208	III	Std.	Positive	2.74	2.74	19	21	0	Rock	1.13	North
1403 + 10	36	208	208	III	Std.	Positive	2.00	2.00	7.0	6.0	30 L	Rock	4.20	South

TABLE OF DESIGN, CONSTRUCTION AND PERFORMANCE DATA

PROJECT NO. I 64-3(5) 45 FRANKLIN COUNTY

SHELBY COUNTY LINE TO .3 MILES EAST OF NEW KY. 35

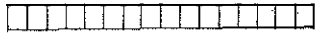
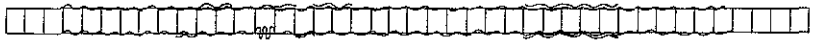
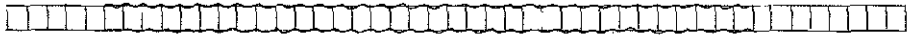
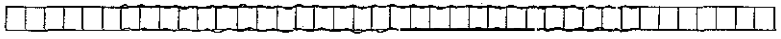
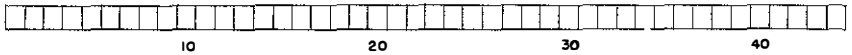
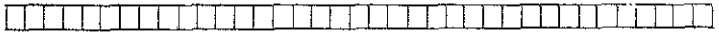
Station Number	Diameter (in.)	Design Length (ft.)	Actual Length (ft.)	Class	Bedding	Projection	Design Grade (%)	Actual Grade (%)	Embankment Height North (ft.)	Embankment Height South (ft.)	Skew (°)	Embankment Material	Factor of Safety as Constructed	Location of Inlet
2043 + 50 R	18	64	64	III	Std.	In. to 19'-Neg. 19' to 64'-Pos.	0.78	0.78		3.0	0		5.00	North
													
2054 + 75 R	30	168	168	III	Std.	Positive	3.39	3.39		19.5	45 L	Soil & Rock	1.19	North
													
2059 + 00 R	36	188	188	III	B_1	Positive	3.09	3.09		23.0	45 R	Rock	2.22	South
													
2060 + 85 L	42	160	160	III	Std.	Positive	1.69	1.50	18.0		45 R	Soil & Rock	1.27	South
													
2064 + 92 R	24	196	196	III	Std.	Positive	8.67	8.67		22.5	45 L	Soil & Rock	1.00	South
													
2129 + 50 R	18	176	176	III	Std.	Positive	5.40	4.66		20.0	45 L	Soil & Rock	1.12	North
													
2152 + 50 R	18	152	148	III	Std.	In. to 13'-Neg. 13' to 148'-Pos.	1.64	1.35		27.0	0	Soil & Rock		South
													

TABLE OF DESIGN, CONSTRUCTION AND PERFORMANCE DATA

PROJECT NO. I 64-3(5) 45 FRANKLIN COUNTY

SHELBY COUNTY LINE TO .3 MILES EAST OF NEW KY. 35

Station Number	Diameter (in.)	Design Length (ft.)	Actual Length (ft.)	Class	Bedding	Projection	Design Grade (%)	Actual Grade (%)	Embankment Height North (ft.)	Embankment Height South (ft.)	Skew (°)	Embankment Material	Factor of Safety as Constructed	Location of Inlet
2154 + 50 L	48	132	132	III	Std.	Positive	0.53	0.53	14.5		45 R	Soil & Rock	1.47	South
2233 + 50 R	36	144	144	III	B_1	Positive	2.57	2.57		25.0	0	Soil & Rock	1.92	North
2246 + 00 L	18	132	132	III	B_1	Positive	0.76	0.76	22.0		0	Soil & Rock	2.22	North
2343 + 00	18	200	176	III	Std.	Positive	1.30	0.74	10		0	Soil & Rock	2.20	North
9 + 50 Ramp "J"	30	232	220	III	B_1	In. to 69'-Pos. 69' to 220'-Neg.	9.22	9.73	28.5	38.5	0	Soil & Rock	1.33 1.80	South
38 + 00 Ky. 35	30	148	152	III	Std.	Negative	0.68	0.66	24.0		0	Soil & Rock	0.953	North

TABLE OF DESIGN, CONSTRUCTION AND PERFORMANCE DATA

PROJECT NO. I 64-3(7) 35 SHELBY COUNTY

SEVEN MILE PIKE TO 5000 ft. EAST OF KY. 714

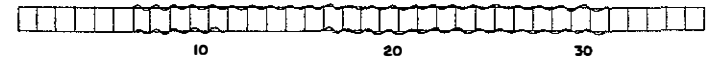
Station Number	Diameter (in.)	Design Length (ft.)	Actual Length (ft.)	Class	Bedding	Projection	Design Grade (%)	Actual Grade (%)	Embankment Height North (ft.)	Embankment Height South (ft.)	Skew (°)	Embankment Material	Factor of Safety as Constructed	Location of Inlet
1456 + 90 R	42	152	148	III	Std.	Out. to 26'-Pos. 26' to 148'-Neg.	6.15	6.32		14.0	45 R	8' Soil & Remain. Soil & Rock	1.60	South
1458 + 35 L	42	204	204	III	B_1	Positive	3.97	3.97	23.5		45 R	Soil & Rock	2.04	South
1471 + 00 R	18	64	64	III	Std.	Negative	0.47	0.47		3.0	30 R	Soil & Rock	5.00	South
1536 + 51 R	72	228	228	III	B_1	Out. to 129'-Pos. 129' to 228'-Neg.	2.50			28.5	45 R	12' Soil & Remain. Rock	1.69	North
1552 + 10 R	60	136	136	III	Std.	Positive	0.96	0.96		12.5	45 L	4.5' Soil & Remain. Rock	1.67	South
1595 + 91 R	36	220	220	IV	B_1	Positive	3.24	3.18		42.5	15 R	Soil & Rock	2.56	North
1596 + 71 L	36	184	184	III	B_1	Positive	3.24	3.34	34.0		15 R	12' Soil & Remain. Rock	1.53	North

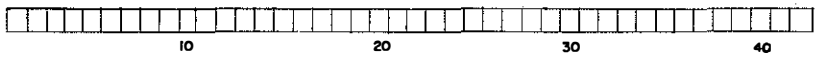
TABLE OF DESIGN, CONSTRUCTION AND PERFORMANCE DATA

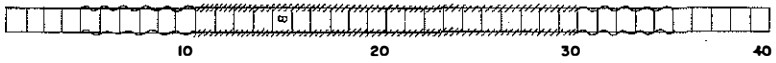
PROJECT NO. I 64-3(7) 35 SHELBY COUNTY

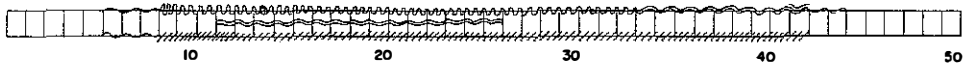
SEVEN MILE PIKE TO 5000 ft. EAST OF KY. 714

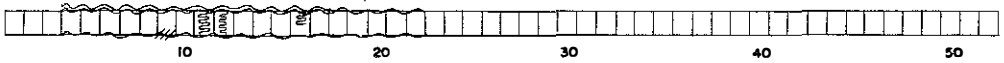
Station Number	Diameter (in.)	Design Length (ft.)	Actual Length (ft.)	Class	Bedding	Projection	Design Grade (%)	Actual Grade (%)	Embankment Height North (ft.)	Embankment Height South (ft.)	Skew (°)	Embankment Material	Factor of Safety as Constructed	Location of Inlet
1604 + 04 R	48	144	144	III	B_1	Positive	0.90	1.17		24.5	0	8' Soil & Remain. Rock	2.00	North
1619 + 44 R	60	168	168	III	B_1	Positive	2.80	2.18		24.0	30 L	10' Soil & Remain. Rock	1.90	North
1619 + 45 L	60	160	160	III	B_1	Positive	2.56	1.44	27.5		15 L	Rock	1.79	North
1633 + 30 L	54	200	200	III	B_1	Positive	2.75	3.16	32.0		30 L	Soil & Rock	1.57	North
1635 + 82 R	72	208	208	IV	B_1	Positive	2.64	2.60		40.5	0	14' Soil & Remain. Rock	1.90	North
1635 + 69 L	36	212	212	III	B_1	Inlet to 56'-Pos. 56' to 186' -Neg. 186' to 212'-Pos.	4.25	5.37	39.0		15 L	8' Soil & Remain. Rock	1.30	North
1637 + 32 L	48	236	236	III	B_1	Positive	4.11	4.38	39.0		30 R	Soil	1.31	North

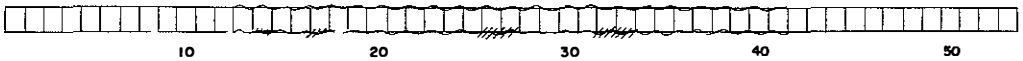












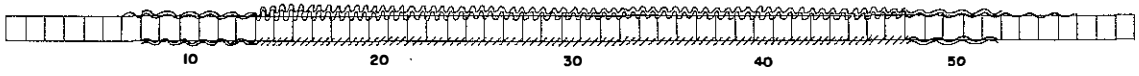


TABLE OF DESIGN, CONSTRUCTION AND PERFORMANCE DATA

PROJECT NO. I 64-3(7) 35 SHELBY COUNTY

SEVEN MILE PIKE TO 5000 ft. EAST OF KY. 714

Station Number	Diameter (in.)	Design Length (ft.)	Actual Length (ft.)	Class	Bedding	Projection	Design Grade (%)	Actual Grade (%)	Embankment Height North (ft.)	Embankment Height South (ft.)	Skew (°)	Embankment Material	Factor of Safety as Constructed	Location of Inlet
1653 + 30 L	54	120	120	III	Std.	Positive	2.56	2.58	18.0		15 L	Soil	1.26	North

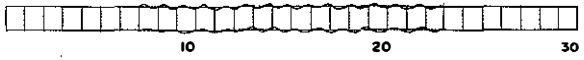


TABLE OF DESIGN, CONSTRUCTION AND PERFORMANCE DATA

PROJECT NO. I 64-5(5) 93 CLARK COUNTY

WINCHESTER TO MONTGOMERY COUNTY LINE

Station Number	Diameter (in.)	Design Length (ft.)	Actual Length (ft.)	Class	Bedding	*Projection	Design Grade (%)	Actual Grade (%)	Embankment Height North (ft.)	Embankment Height South (ft.)	Skew (°)	Embankment Material	Factor of Safety as Constructed	Location of Inlet
419 + 50	18	160	160	III	Std.	Positive	0.94	0.81	5.0	5.0	0	Soil	4.00	North
428 + 07	36	204	204	III	Std.	Positive	1.76	1.72	15.0	17.0	0	Soil & Rock	1.43	North
438 + 90	42	200	204	III	Std.	Positive	0.70	1.08	9.0	10.0	15 R	Soil & Rock	2.44	North
450 + 40	48	244	228	III	Std.	Positive	1.19	0.88	17.0	17.0	30 R	4' Soil & Remain. Rock	1.43	North
487 + 00	18	240	240	III	B_1	In. to 127'-Neg. 127' to 240'-Pos.	3.33	3.33	30.0	27.0	0	Soil & Rock	1.82	South
557 + 00	30	300	288	III	Std.	Positive	2.23	1.56	17.0	19.5	45 L	Soil & Rock	1.29	North
573 + 50	24	232	232	III	Std.	Positive	1.34	1.34	18.5	19.5	30 L	Rock	1.20	North

TABLE OF DESIGN, CONSTRUCTION AND PERFORMANCE DATA

PROJECT NO. I 64-5(5) 93 CLARK COUNTY

[redacted] COUNTY LINE

Station Number	Diameter (in.)	Design Length (ft.)	Actual Length (ft.)	Class	Bedding	*Projection	Design Grade (%)	Actual Grade (%)	Embankment Height North (ft.)	Embankment Height South (ft.)	Skew (°)	Embankment Material	Factor of Safety as Constructed	Location of Inlet
602 + 82	42	244	248	III	Std.	Positive	2.05	1.73	16.0	15.0	0	Rock	1.46	South
609 + 50	42	308	308	III	B_1	Positive	1.88	0.97	23.0	21.0	45 L	Rock	2.22	South
656 + 50	18	372	380	III	B_1	Positive	4.89	5.05	34.0 Ramp "0"-41.5	39.0	20 L	Soil & Rock	1.47	North
725 + 50	30	268	264	III	B_1	In. to 209'-Pos. 209 to 264'-Neg.	3.17	3.30	31.0	34.0	15 L	Rock	1.61	North
749 + 65	24	236	240	III	Std.	Positive	5.17	5.21	16.0	20.0	15 L	Rock	1.25	North

*All pipes laid with negative projection regardless of design projection values shown in table.

TABLE OF DESIGN, CONSTRUCTION AND PERFORMANCE DATA

PROJECT NO. I 64-5(6) 100 CLARK-MONTGOMERY COUNTY

WEST CLARK COUNTY LINE TO U.S. 60

Station Number	Diameter (in.)	Design Length (ft.)	Actual Length (ft.)	Class	Bedding	Projection	Design Grade (%)	Actual Grade (%)	Embankment Height North (ft.)	Embankment Height South (ft.)	Skew (°)	Embankment Material	Factor of Safety as Constructed	Location of Inlet
788 + 00	24	328	324	IV	B_1	Positive	2.35	4.02	47.0	45.5	15 R	10' Soil & Remain. Rock	1.71	South
804 + 80	24	308	296	IV	B_1	Positive	4.87	4.40	43.5	39.0	15 L	7' Soil & Remain. Rock	1.91	South
824 + 31	18	188	180	III	Std.	Positive	7.39	9.45	16.0	10.0	0	Soil	1.67	South
866 + 50	30	352	368	III	B_1	108'-Positive 260'-Negative	3.27	2.17	28.5	31.5	45 R	Soil	1.67	North
901 + 50	18	232	232	III	B_1	Positive	4.35	4.83	28.0	24.5	0	14' Soil & Remain. Rock	1.85	South
931 + 00	30	180	180	III	Std.	Positive	0.56	0.89	4.5	4.0	30 L	Soil	5.00	North
938 + 28	48	272	280	III	Std.	Positive	1.62	1.25	9.0	8.5	45 R	4' Soil & Remain. Rock	2.67	South

TABLE OF DESIGN, CONSTRUCTION AND PERFORMANCE DATA

PROJECT NO. I 64-5(6) 100 CLARK-MONTGOMERY COUNTY

WEST CLARK COUNTY LINE TO U.S. 60

Station Number	Diameter (in.)	Design Length (ft.)	Actual Length (ft.)	Class	Bedding	Projection	Design Grade (%)	Actual Grade (%)	Embankment Height North (ft.)	Embankment Height South (ft.)	Skew (°)	Embankment Material	Factor of Safety as Constructed	Location of Inlet
967 + 65	18	240	252	III	B_1	Positive	3.28	4.13	25.0	28.0	15 L	9' Soil & Remain. Rock	7.00	North
1043 + 90	24	228	204	III	Std.	Positive	3.29	4.61	15.0	11.5	15 R	10' Soil & Remain. Rock	1.67	South
1081 + 10	18	244	240	III	Std.	Positive	3.28	3.54	16.5	19.5	0	10' Soil & Remain. Rock	1.28	North
1197 + 50	60	320	320	III	B_1	Positive	1.09	7.82	24.0	25.5	45 R	5' Soil & Remain. Rock	1.89	North
1229 + 73	18	252	252	III	Std.	Positive	3.61	3.57	12.5	16.0	0	6' Soil & Remain. Rock	1.67	North

TABLE OF DESIGN, CONSTRUCTION AND PERFORMANCE DATA

PROJECT NO. I 75-6(4) 129 SCOTT COUNTY

Station Number	Diameter (in.)	Design Length (ft.)	Actual Length (ft.)	Class	Bedding	Projection	Design Grade (%)	Actual Grade (%)	Embankment Height West (ft.)	Embankment Height East (ft.)	Skew (°)	Embankment Material	Factor of Safety as Constructed	Location of Inlet
71 + 00	24	336		IV	B_1	Positive	3.57				25 R			East
97 + 50	30	132		III	B_1	Positive	0.97				30 R			East

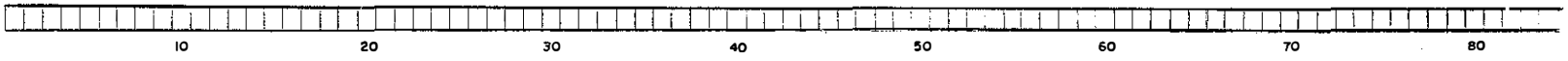


TABLE OF DESIGN, CONSTRUCTION AND PERFORMANCE DATA

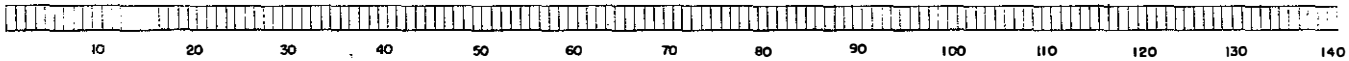
PROJECT NO. I 75-6(5) 123 SCOTT COUNTY

Station Number	Diameter (in.)	Design Length (ft.)	Actual Length (ft.)	Class	Bedding	Projection	Design Grade (%)	Actual Grade (%)	Embankment Height West (ft.)	Embankment Height East (ft.)	Skew (°)	Embankment Material	Factor of Safety as Constructed	Location of Inlet
65 + 30	48	208	212	III	B	Positive	0.77				30 R			East
110 + 50	36	212	212	III	B	Positive	1.98				15 L			East
153 + 25	42	204	204	III	B	Positive	1.86				15 L			East
166 + 25	36	296	296	III	B	Positive	2.03	2.03			30 L			East
212 + 30	30	220	220	III	B_1	Positive	1.86	1.86			0			East
322 + 00	54	284	284	III	B_1	Out. to 176'-Pos. 176' to Inlet-Neg.	1.13	1.13			30 R			West
36 + 50 SW Ramp	30	152	156	III	B_1	Out. to 56'-Pos. 56' to Inlet-Neg.	2.43				30 R			East

TABLE OF DESIGN, CONSTRUCTION AND PERFORMANCE DATA

PROJECT NO. I 75-6(5) 123 SCOTT COUNTY

Station Number	Diameter (in.)	Design Length (ft.)	Actual Length (ft.)	Class	Bedding	Projection	Design Grade (%)	Actual Grade (%)	Embankment Height West (ft.)	Embankment Height East (ft.)	Skew (°)	Embankment Material	Factor of Safety as Constructed	Location of Inlet
37 + 50 U.S. 460 SW Ramp	48	560	560	III	B	Positive	1.23				51 R			West
47 + 40 U.S. 62	30	132		III	B_1	Positive	5.15				0			East



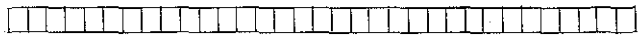


TABLE OF DESIGN, CONSTRUCTION AND PERFORMANCE DATA

PROJECT NO. I 75-7(5) 160 GRANT COUNTY

SOUTH OF SHERMAN-MT. ZION ROAD TO KENTON COUNTY LINE

Station Number	Diameter (in.)	Design Length (ft.)	Actual Length (ft.)	Class	Bedding	Projection	Design Grade (%)	Actual Grade (%)	Embankment Height West (ft.)	Embankment Height East (ft.)	Skew (°)	Embankment Material	Factor of Safety as Constructed	Location of Inlet
935 + 70	54	420	420	IV	B_1	Positive	1.05	1.05	44.0	43.0	45 L	20' Soil & Remain. Rock	1.71	East
963 + 26	60	352	342	IV	B_1	Negative	2.33	3.65	50.0	49.0	20 R	Soil & Rock	1.58	East
966 + 67	24	488	468	III	B_1	Negative	5.43	6.25	40.0	31.0	55 L	Soil & Rock	1.43	East
978 + 12	42	280	272	III	B_1	Positive	2.36	2.30	40.0	38.0	0	Rock	1.27	East
988 + 18	36	296	300	IV	B_1	Positive	2.03	2.00	42.0	43.0	15 L	Rock	1.79	East
1001 + 22	30	276	284	III	B_1	Positive	3.99	3.88	28.0	25.0	30 R	Soil & Rock	1.94	East
1004 + 33	36	292	292	III	B_1	Positive	3.42	3.42	29.0	26.0	35 L	Soil & Rock	1.90	East

TABLE OF DESIGN, CONSTRUCTION AND PERFORMANCE DATA

PROJECT NO. I 75-7(5) 160 GRANT COUNTY

SOUTH OF SHERMAN MT. ZION ROAD TO KENTON COUNTY LINE

Station Number	Diameter (in.)	Design Length (ft.)	Actual Length (ft.)	Class	Bedding	Projection	Design Grade (%)	Actual Grade (%)	Embankment Height West (ft.)	Embankment Height East (ft.)	Skew (°)	Embankment Material	Factor of Safety as Constructed	Location of Inlet
1028 + 05	30	240	244	III	Out. to 112' B_1 112'-244'-Std.	Positive	5.83	5.74	23.0	17.5	30 L	Soil	2.23 1.12	East
1085 + 44	54	412	412	IV	B_1	Positive	1.82	1.82	58.0	56.0	30 R	Rock	1.33	East
1087 + 50	54	388	388	IV	B_1	Out. to 21'-Pos. 21' to 326'-Neg. 326' to 388'-Pos.	2.86	2.67	55.5	53.0	26 L	Rock	1.43	East
1146 + 04	42	212	220	III	B_1	Positive	2.50	3.14	23.5	21.5	0	Soil	2.15	East
27 + 82 F.R. 9a	72	112	128	III	B_1	Negative	0.54	1.96	25.0		35 R	10' Soil & Remain. Rock	1.89	East

TABLE OF DESIGN, CONSTRUCTION AND PERFORMANCE DATA

PROJECT NO. I 75-7(11) 151 GRANT COUNTY

Station Number	Diameter (in.)	Design Length (ft.)	Actual Length (ft.)	Class	Bedding	Projection	Design Grade (%)	Actual Grade (%)	Embankment Height West (ft.)	Embankment Height East (ft.)	Skew (°)	Embankment Material	Factor of Safety as Constructed	Location of Inlet
566 + 65 NBL	42	264	264	IV	B_1	Negative	3.03	3.11	49.0		20 R	Soil & Rock	1.71	West
632 + 80 SBL	30	376	376	IV	B_1	Negative	4.52	4.55	45.0		50 L	Soil	1.88	West
7 + 34 FH 2	60	172	172	IV	B_1	Negative	2.33	2.38	44.0		20 L	Soil & Rock	1.83	East

TABLE OF DESIGN, CONSTRUCTION AND PERFORMANCE DATA

PROJECT NO. I 75-8(12) 181 KENTON COUNTY

BOONE COUNTY LINE TO SOUTH OF U.S. 25 INTERSECTION

Station Number	Dismeter (in.)	Design Length (ft.)	Actual Length (ft.)	Class	Bedding	Projection	Design Grade (%)	Actual Grade (%)	Embankment Height West (ft.)	Embankment Height East (ft.)	Skew (°)	Embankment Material	Factor of Safety as Constructed	Location of Inlet
194 + 21	18	296	288	III	Std.	Ito 128-Neg. 128 to 288-Pos.	I to 96+16.3 96'to Out-2.9	14.1 3.2	24.0	17.0	30 L	Soil	1.12	East
275 + 50	24	344	294	III	Std.	Positive	3.49	1.36	15		45 R	Soil	1.37	East
342 + 60	48	264	252	III	Std.	Inlet & Outlet-Pos. 50' in mid.-Neg.	1.44	4.84	26.0	24.0	21 L	10' Soil & Remain. Rock	0.91	East