HIGHWAY RESEARCH REPORT

EVALUATION OF THE NUCLEAR COMPACTION TEST METHOD

67-08

10

STATE OF CALIFORNIA

TRANSPORTATION AGENCY

DEPARTMENT OF PUBLIC WORKS

DIVISION OF HIGHWAYS

MATERIALS AND RESEARCH DEPARTMENT

RESEARCH REPORT

NO. M & R 632697-5

Prepared in Cooperation with the U.S. Department of Transportation, Bureau of Public Roads May, 1967

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State of California
Department of Public Works
Division of Highways
Materials and Research Department

June 15, 1967

Lab. Auth. 632697-5
HPR-1(2), F-04-03

Mr. J. C. Womack
State Highway Engineer
Division of Highways
Sacramento, California

Dear Sir:

Submitted for your consideration is:

INTERIM REPORT #5

on

EVALUATION OF THE

NUCLEAR COMPACTION TEST METHOD

District 10

Study made by ..... Foundation Section
Under general direction of ..... Travis Smith
Work supervised by ..... W. G. Weber, Jr.
Report prepared by ..... Bobby Lister

Very truly yours,

JOHN L. BEATON
Materials and Research Engineer

Attach.
cc:LR Gillis
AC Estep
JF Jorgensen
WL Welch
CG Beer
Research Files
C Roderick
KM Deboy

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Discussion of Project

This Materials and Research Department research study was financed with the Bureau of Public Roads 1-1/2 percent research funds under authorization HPR 1(2) F-04-03.

This is an abbreviated interim data report on a project in District 10 and is in compliance of Mr. D. J. Steele's letter stating it would not be necessary to present formal interim reports on each project. This report is patterned after the previous interim reports #1 in District 03, #3 in District 05, #3 in District 02, and #4 in District 06. A detailed explanation of the figures and tables of this report can be found in the first three interim reports.

The project is located on Route 5 in Stanislaus County between 0.4 mile north of Stuhr Road and 0.7 mile south of Del Puerto Canyon Road near Patterson about 9.3 miles in length. The location map in Figure 1 illustrates the general layout of the project. The contract is a four lane freeway constructed by grading and paving with portland cement concrete and asphalt concrete on cement treated base and aggregate base.

A Troxler moisture and density nuclear gage which obtains in-place densities by the transmission or the backscatter method was used for compaction control on this project. Several malfunctions of the Troxler gage made it necessary to either substitute a different manufactured nuclear gage or use the sand volume test for short periods. All embankment and finished subgrade was tested by the transmission method and the aggregate base material was tested by the backscatter method. The moisture portion of the nuclear gage was not utilized on this project because of the erratic correlation with the oven dried material. These erratic results were assumed to be caused by certain chemicals in the soil. This lack of confidence in the moisture correlation resulted in the use of the wet to wet method of obtaining percent relative compactions throughout the project.

The distribution charts for the area averages, Figures 8 and 9, show several tests passing with an average below minimum specifications. The test supervisor stated this was done only when the average was below specification by less than one percent relative compaction and with the requirement that the contractor must rework the material to the grade inspector's satisfaction.

The variation of materials coming from any one cut and mixed in the embankment by placement presented a problem in obtaining a maximum impact density value to use, by visual inspection, for a certain material. This resulted in taking a large number of maximum impact density cores and at times taking more than one in a six site area.

Although, more nuclear gage malfunctions occurred on this project than on any of the first four, all other problems encountered were very similar.

The opinions, findings and conclusions expressed in this publication are those of the authors and not necessarily those of the Bureau of Public Roads.

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TABLE I

Impact Compaction Maximum Densities

Date	Wet Density lbs. per ft^3	Type of Material
7-27-65	130.9	Emb.
7-28-65	115.6	OG
9-20-65	139.6	Emb. Sand, Clay, Rock
9-21-65	143.6	Emb. Sand, Clay, Rock
9-21-65	142.3	Emb. Sand, Clay, Rock
10-7-65	132.1	Emb. Clay
10-8-65	127.9	Emb. Silty Clay
10-11-65	128.7	Emb. Clay-Silt
10-13-65	142.6	Emb. Rock Clay
10-18-65	148.2	Emb. Rock Clay
10-21-65	144.5	Emb. Rock Clay
10-21-65	138.3	Emb. Silty Clay
10-21-65	142.3	Emb. Rock Clay
10-24-65	147.9	Emb. Rock Clay
10-25-65	135.7	Emb. " "
10-26-65	126.8	Emb. Clay
10-28-65	122.6	Emb. Silty Clay
10-28-65	141.8	Emb. Silt Clay
10-29-65	134.0	Emb. Sand, Silt,
10-29-65	140.6	Emb. Clay, Silt, Rock
10-29-65	140.4	Emb.
11-2-65	131.9	Emb. Clay Rock
11-4-65	118.4	Emb. Silt
11-5-65	117.3	Emb. Silt
11-5-65	141.2	Emb. Rock Clay
11-9-65	129.6	Emb. Silt Clay
11-9-65	138.8	Emb. Rock Clay
11-9-65	136.3	Emb. Clay
11-9-65	137.9	Emb. Sand-Clay
11-9-65	139.5	Emb. Clay Rock
11-10-65	132.7	Emb. Clay
11-10-65	129.1	Emb. Light Clay-Rock
12-2-65	137.9	Emb. Clay, Sand, Silty Clay
12-2-65	125.4	Emb.
12-2-65	129.1	Emb. Sandy
12-6-65	142.0	Clay
12-6-65	146.5	Emb.
12-6-65	127.5	Emb.
12-6-65	127.5	Emb.
12-6-65	132.1	Emb.
12-7-65	135.3	Emb.
12-7-65	140.9	Emb.
12-7-65	130.3	Emb.
12-8-65	121.4	Emb. Sandy Loam
12-8-65	130.6	Emb. Clay
12-13-65	125.4	Emb. Silty Clay
12-16-65	131.5	Emb. Clay
12-16-65	132.1	Emb. Clay

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TABLE I (contd)

Date	Wet Density lbs. per ft^3	Type of Material
12-21-65	130.9	Emb. clay
12-21-65	134.5	Emb. clay
12-22-65	134.0	Emb. clay
12-23-65	129.1	Emb. clay
1-4-66	139.2	Emb. clay
1-5-66	130.3	Emb. Silty Clay
1-6-66	137.9	Emb. clay
1-6-66	135.7	Emb. Silty Clay
1-7-66	123.5	Emb. Silty clay
1-10-66	135.7	Emb. Clay
1-10-66	128.7	Emb. Clay
1-11-66	122.6	Emb. Silty Clay
1-13-66	140.9	Emb. Clay
1-13-66	133.3	Emb. Silt &Rock
1-13-66	126.7	Emb. Clay & Sand
1-17-66	130.1	Emb. Clay
1-17-66	139.6	Emb. Silty Clay
1-17-66	136.3	Emb. Clay Rock
1-18-66	136.8	Emb. Clay Silt
1-18-66	135.3	Emb. Clay
1-18-66	132.7	Emb. Clay
1-18-66	137.0	Emb. Rock Clay
1-19-66	127.6	Clay
1-19-66	124.0	Clay
1-19-66	131.2	Clay & Light silt
1-21-66	140.9	Clay and Rock
1-26-66	127.5	Clay
1-28-66	134.5	Clay
2-9-66	121.4	Silty Clay
2-9-66	128.7	Emb. Clay Silt
2-9-66	135.3	Emb. Sand Rock
2-11-66	119.4	Emb. Silt
2-15-66	123.3	Emb. Silt
2-16-66	135.3	Str. Bkfl.
2-18-66	131.5	Emb. Clay
2-21-66	128.7	Emb. Clay
2-23-66	127.0	Emb.
2-23-66	129.8	Emb.
2-28-66	124.4	Emb.
3-3-66	135.7	Clay
3-9-66	143.6	Silty Clay
3-22-66	147.3	Emb.
3-22-66	133.3	Emb.
3-22-66	130.0	Emb. Clay
3-22-66	128.0	Emb. Clay, Chalk
3-23-66	130.0	Emb. Clay
3-24-66	130.0	Emb. Clay Silt
3-24-66	130.0	Emb. Gray Clay
3-28-66	145.0	Red Clay
3-29-66	133.3	Gravel Silt, Clay
3-30-66	119.4	Gray, Clay
3-31-66	129.1	Clay & Lime OG
4-22-66	140.9	Pea Gravel, Clay

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TABLE I (contd)

Date	Wet Density lbs. per ft^3	Type of Material
10-1-65	145.0	Str. Bkfl. Rock & Sand
10-12-65	149.9	Str. Bkfl. Rock & Sand
10-18-65	143.4	" " "
2-25-66	127.5	" " "
3-28-66	149.5	ASB Cl IV
4-12-66	130.0	Subg.
4-13-66	135.0	Subg.
5-11-66	140.9	Str. Bkfl.
5-11-66	137.9	SG
5-11-66	139.2	SG
5-11-66	134.0	Clay SG
5-11-66	134.0	SG Silt
5-11-66	139.2	SG Clay
5-12-66	134.0	SG (Emb)
5-12-66	129.5	SG Clay
5-13-66	132.1	SG
5-13-66	132.1	SG
5-13-66	133.3	SG
5-13-66	130.9	SG
5-13-66	124.4	SG Silt Sand Clay
5-13-66	132.1	SG Silt Sand Clay
5-13-66	133.3	SG Emb.
5-16-66	130.9	SG Clay
5-16-66	122.0	SG Sand
5-16-66	130.9	SG Emb.
5-16-66	125.0	SG Rock, Silt
5-17-66	133.3	SG Emb.
5-17-66	138.0	SG Emb.
5-17-66	121.4	SG Clay
5-17-66	128.7	SG Silt
5-17-66	145.8	Str. Bkfl.
5-17-66	128.7	SG Clay
5-17-66	128.7	Emb.
5-18-66	128.7	SG Emb.
5-18-66	133.1	SG Emb.
5-18-66	128.7	SG Clay
5-18-66	134.0	SG Clay
5-18-66	127.5	SG Emb.
5-18-66	133.3	SG Sand
5-18-66	132.1	SG Sand
5-18-66	135.7	SG, Silt Sand Clay
5-19-66	134.3	SG, Silt, Sand, Clay
5-19-66	133.3	SG, Silt Sand, Clay
5-19-66	133.3	SG " " "
5-19-66	142.3	SG
5-19-66	134.5	SG
5-19-66	138.3	SG
5-19-66	127.9	SG Silt
5-19-66	127.5	SG
5-19-66	128.7	SG Silt, Sand Clay
5-19-66	128.7	" " " "
5-19-66	134.0	" " " "

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TABLE I (contd)

Date	Wet Density lbs. per ft^3	Type of Material
5-19-66	130.3	SG Silt
5-20-66	139.6	SG,
5-20-66	129.8	SG
5-20-66	129.8	SG, Clay
5-20-66	129.8	SG, Clay
5-20-66	133.3	SG
5-20-66	125.4	SG
5-20-66	129.3	SG Silt
5-20-66	128.7	SG
5-23-66	134.0	SG Clay
5-23-66	132.7	SG
5-23-66	129.1	SG Clay
5-25-66	133.3	Sand Clay
5-25-66	130.9	Str. Bkfl.
5-31-66	138.3	Cl-4 SB
6-2-66	132.1	SG Sandy Rock
6-24-66	139.6	AS

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TABLE II

Calibration Data
Troxler 209

Wet Density lbs. per ft^3	Density Count Ratio	Transmission Depth (in.)	Moisture lbs per ft^3	Moisture Count Ratio	Type of Material
138.2	.45	10"	10.9	.65	OG
90.3	.98	"	2.4	.44	"
115.6	.66	"	17.0	.61	Emb.
119.3	.63	"	16.2	.61	OG
106.5	.74	"	4.5	.52	"
113.0	.63	"	18.8	.69	"
123.6	.48	"	6.1	.48	Emb.
130.4	.43	"	8.1	.49	"
130.9	.51	"	10.6	.65	"
130.9	1.60	6"	-	-	"
116.1	.62	10"	12.1	.72	"
116.1	1.66	6"	-	-	"
109.6	.69	10"	7.6	.48	Sandy Clay
109.6	1.78	6"	-	-	" "
110.8	.67	10"	8.5	.52	" "
110.8	1.72	6"	-	-	" "
130.4	.45	10"	7.4	.51	" "
130.4	1.42	6"	-	-	" "
142.0	.36	10"	6.7	.59	" "
142.0	1.13	6"	-	-	" "
127.2	.41	10"	5.4	.48	" "
127.2	1.30	6"	-	-	" "
131.6	.36	10"	7.0	.51	" "
131.6	1.21	6"	-	-	" "
136.1	.38	10"	5.6	.51	Silty Sand & Clay
136.1	1.27	6"	-	-	" " "
114.2	.63	10"	10.6	.60	Clay
114.2	1.63	6"	-	-	"
112.9	.63	10"	8.4	.50	"
112.9	1.71	6"	-	-	"
110.4	.66	10"	10.9	.56	Sand & Clay
110.4	1.80	6"	-	-	" "
111.5	.64	10"	9.2	.74	Clay
111.5	1.77	6"	-	-	"
122.9	.50	10"	13.8	.59	Sand & Clay
122.9	1.46	6"	-	-	" "
113.6	.66	10"	11.6	.58	" "
113.6	1.80	6"	-	-	" "
130.5	.41	10"	5.3	.46	Sand & Silt
130.5	1.31	6"	-	-	" "
125.6	.46	10"	4.4	.47	Sand & Clay
125.6	1.46	6"	-	-	" "
132.4	.41	10"	11.0	.53	Sandy-Silty Clay
132.4	1.27	6"	-	-	" " "
135.3	.43	10"	10.4	.51	Sandy Silty Clay
135.3	1.28	6"	-	-	" " "
128.3	.48	10"	8.5	.53	Sand-Clay-Rock
139.9	.43	"	9.9	.59	" " "
141.9	.41	"	11.5	.59	Clay-Rock
129.1	.56	"	-	-	Clay
113.9	.65	"	-	-	Silty Clay

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TABLE II (contd)

Wet Density lbs. per ft^3	Density Count Ratio	Transmission Depth(in.)	Moisture lbs per ft^3	Moisture Count Ratio	Type of Material
121.1	.65	10"	-	-	Silt & Clay
141.6	.44	"	-	-	Clay-Rock
141.6	.38	"	-	-	Rock-Sand
145.5	.36	"	-	-	Rock-Clay
107.4	.73	"	-	-	Silty Clay
128.0	.40	"	-	-	Rock Clay
134.1	.41	"	-	-	Clay
127.3	.46	"	-	-	Sand-Clay
121.7	.54	"	-	-	Clay-Rock
123.6	.51	"	-	-	Clay
114.2	.60	"	-	-	Light Clay-Rock
119.7	.51	"	18.9	.61	Clay
127.5	.50	"	18.2	.68	"
128.6	.45	"	19.0	.66	"
125.8	.51	"	14.3	.57	Silty Clay
133.3	.46	"	16.7	.66	Clay
132.1	.47	"	-	-	Silty Clay
115.6	.59	"	-	-	Clay-Silt
116.1	.57	"	-	-	" "
146.6	.35	"	10.8	.63	Rock & Sand Str. Bkfl.
151.5	1.09	6"	-	-	Rock & Sand Str. Bkfl.
143.0	1.07	6"	-	-	Clay Emb.
122.9	.57	10"	-	-	Silty Clay-Rocky Emb.
143.5	.70	Backscatter	-	-	C.T.B.
141.0	.71	"	-	-	"
153.0	.65	"	-	-	"
146.2	.64	"	-	-	"
141.3	.67	"	-	-	"
145.8	.66	"	-	-	"
140.1	.70	"	-	-	"
139.7	.70	"	-	-	"
143.3	.70	"	-	-	"
142.2	.73	"	-	-	"
144.6	.70	"	-	-	"
143.0	.64	"	-	-	"
146.5	.71	"	-	-	"

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TABLE III

Standard Deviation of Density Calibration Tests

Soil Type	Transmission Depth in inches	No. of Tests	Standard Deviation (Pcf) Calculated Regression Line
Embankment	6	20	4.2
Structure Backfill	6	1	*
C.T.B. & A.B.	Backscatter	13	3.8
Embankment	10	52	4.5
Structure Backfill	10	1	*

*Insufficient number of tests to properly determine a rational value for standard deviation.

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SUMMARY OF RELATIVE COMPACTION DATA

90% R. C. Required

TABLE IV

Rte. 5 Dist. 10

Cont. 10-080614

Date	Test No.	Relative Compaction, % #1	#2	#3	#4	#5	#6	Avg.	Accept	Reject	Remarks
9-20-65	5-1	99	92	93				95	X		
9-21	5-2	98	90	96	89	95	95	94	X		
9-21	5-3	97	100	97				98	X		
9-29	5-4	96	100	95	93	95	102	97	X		
10-7	5-5	92	86	91				90	X		
10-7	5-6	92	91	100				94	X		
10-8	5-8	88	89	99				92		X	
10-8	5-9	93	94	90				92	X		
10-11	5-10	88	87	95				90		X	
10-11	5-11	101	92	93				95	X		
10-11	5-12	98	98	99				98	X		
10-12	5-13	102	102	98	99	97	98	100	X		
10-12	5-14	99	102	91				97	X		
10-13	5-15	101	94	88	93	97	101	95	X		
10-13	5-16	101	96	96				98	X		
10-15	5-17	102/98	105	102/104	105	99	102	102	X		
10-18	5-18	96	100	96	99	85	96	96	X		
10-18	5-19	93	98	99				97	X		
10-19	5-20	96	96	96				96	X		
10-20	5-21	96	94	90				93	X		
10-20	5-22	99	96	92				96	X		
10-21	5-23	100	98	100				99	X		
10-21	5-24	101	100	97				99	X		
10-21	5-25	96	99	96				97	X		
10-21	5-26	98	92	98				96	X		
10-22	5-27	98	98	96				97	X		
10-22	5-27.1	96	94	94				95	X		
10-25	5-28	98	99	96	99	90	83	95	X		
10-25	5-29	100	100	100				100	X		
10-25	5-30	95	99	90				95	X		
10-26	5-31	95	96	108	97	99	98	100	X		
10-26	5-32	97	99	96	92	98	90	95	X		
10-27	5-33	101	95	96	88	90	92	94	X		
10-27	5-34	98	97	94	98	97	99	97	X		
10-28	5-35	85	93	98	95	93	94	93	X		
10-28	5-35A	90	94	94				93	X		

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SUMMARY OF RELATIVE COMPACTION DATA

90% R. C. Required
TABLE IV (contd)

Rte. 5 Dist. 10

Cont. 10-080614

Date	Test No.	Relative Compaction, % #1	#2	#3	#4	#5	#6	Avg.	Accept	Reject	Remarks
11-1-65	5-40	95	96	98	94	93	100	96	X		
11-1-65	5-41	89	95	98	99	93	99	96	X		
11-2-65	5-42	82	97	94	84	93	102	92	X		
11-2-65	5-43	100	97	94	88	96		95	X		
11-3-65	5-44	96	95	94	96	93	86	93	X		
11-3-65	5-45	93	95	87	96	90	92	92	X		
11-4	5-46	101	98	92	100	96	97	97	X		
11-4	5-47	90	93	96				93	X		
11-5	5-48	91	96	89				92	X		
11-5	5-49	98	92					96	X		
11-8	5-50	101	92					96	X		
11-9	5-51	101	101					101	X		
11-9	5-52	96	98	86				93	X		
11-9	5-53	88	95	89				91		X	
11-10	5-53A	92	97	95	89			93	X		
11-10	5-54	91	91	82				88		X	
11-10	5-54A	87	98	100				95	X		
11-11	5-10A	91	95	84				90	X		
11-11	5-55	96	90	95				94	X		
11-11	5-56	99	87	87				91		X	
11-1	5-57	94	88	91				90	X		
12-1	5-58	94	88	91	92	96	96	91	X		
12-1	5-59	99	96					97	X		
12-2	5-60	88	92	79				86		X	
12-2	5-60A	93	90	93				92	X		
12-2	5-61	87	85	97				90		X	
12-3	5-61A	92	106	98				98	X		Retest
12-2	5-62	91	88	90				90	X		
12-3	5-63	92	100	93				95	X		
12-3	5-64	101	103	101				102	X		
12-3	5-65	88	95	102				93	X		
12-3	5-66	103	94	89				95	X		
12-3	5-67	88	90	92				90	X		
12-6	5-68	104	85	95				95	X		

HMR T-2135(Orig. 12/66)

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SUMMARY OF RELATIVE COMPACTION DATA

Rte. 5 Dist. 10

90% R. C. Required
TABLE IV (contd)

Cont. 10-080614

Date	Test No.	Relative Compaction, % #1	#2	#3	#4	#5	#6	Avg.	Accept	Reject	Remarks
12-7	5-76	95	80	84	85	87		86		X	
12-7	5-76A	99	92	89	86	87		90		X	
12-7	5-76B	94	83					88		X	
12-7	5-76C	89	89					89		X	
12-8	5-76D	83	87	90				87		X	
12-8	5-76E	93	90	95				93	X		
12-7	5-77	93	91	96				93	X		
12-8	5-78	99	95	92				95	X		
12-8	5-79	93	94	98				95	X		
12-8	5-80	95	95	91				94	X		
12-8	5-81	83	88	100	95	96		92	X		
12-9	5-82	101	110	93				101	X		
12-9	5-83	92	90	93				92	X		
12-9	5-84	84	98	97				93	X		
12-9	5-85	97	92	93				94	X		
12-9	5-86	94	102	97				98	X		
12-9	5-87	94	96	92	96	92		94	X		
12-9	5-88	91	93	88	92	88	91	91	X		
12-10	5-89	82	94	93				90	X		
12-10	5-90	95	96	97	93	95	93	95	X		
12-10	5-91	100	97	100				99	X		
12-10	5-92	91	90	91				91	X		
12-10	5-93	85	91	92				89	X		
12-10	5-94	88	88	82	81			85		X	
12-10	5-94A	83	82					83		X	Retest
12-10	5-94B	89	88					89		X	Retest
12-13	5-94C	102	94	92				96	X		Retest
12-13	5-95	84	82	81				82		X	
12-13	5-95A	90	89	98				92	X		Retest
12-13	5-96	98	96	95				96	X		
12-13	5-97	88	92	94				91	X		
12-13	5-98	94	85	94				91	X		
12-13	5-99	100	87	97				94	X		
12-14	5-100	90	92	96				93	X		
12-14	5-101	93	93	95				94	X		

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SUMMARY OF RELATIVE COMPACTION DATA

90% R.C. Required
TABLE IV (contd)

Rte. 5 Dist. 10

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Date	Test No.	Relative Compaction, % #1	#2	#3	#4	#5	#6	Avg.	Accept	Reject	Remarks
12-14	5-102	94	93					94	X		
12-14	5-103	100	96	91				96	X		
12-14	5-104	92	98	90				93	X		
12-15	5-105	93	93	90	100	96	98	95	X		
12-15	5-106	94	97	92				94	X		
12-15	5-107	96	95	102				97	X		
12-15	5-108	97	96	97				97	X		
12-15	5-109	93	101	101				98	X		
12-15	5-110	98	98	98				98	X		
12-16	5-111	94	97	104				98	X		
12-16	5-112	93	97	96	92	97	95	95	X		
12-16	5-113	88	95	96				93	X		
12-16	5-114	92	86	81				86		X	
12-16	5-114A	96	90	87				91	X		Retest
12-16	5-115	90	90	85				88		X	
12-16	5-115A	88	93	100				94	X		Retest
12-16	5-116	99	94	99				97	X		
12-16	5-117	91	92	86				90	X		
12-17	5-118	99	95	93				94	X		
12-17	5-119	94	89	98				94	X		
12-17	5-120	93	91	91				92	X		
12-17	5-121	100	96	91				96	X		
12-17	5-122	94	101	95				97	X		
12-20	5-123	91	93		92			92	X		
12-20	5-124	96	94	91				94	X		
12-20	5-125	94						94	X		
12-20	5-126	92	97	95				95	X		
12-21	5-127	92	94	90				92	X		
12-21	5-128	91	92	94				92	X		
12-21	5-129	93	99	96				96	X		
12-21	5-130	97	96	95				96	X		
12-21	5-131	95	93	93				94	X		
12-22	5-132	94	95	90	93	97	91	94	X		
12-22	5-133	92	86	93				90	X		
12-22	5-134	99	97	99				98	X		

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Rte. 5 Dist. 10

SUMMARY OF RELATIVE COMPACTION DATA
90% R. C. Required
TABLE IV (contd)

Cont. 10-080614

Date	Test No.	Relative Compaction, % #1	#2	#3	#4	#5	#6	Avg.	Accept	Reject	Remarks
12-22	5-135	91	93	96				93	X		
12-22	5-136	89	91	90				90	X		
12-23	5-137	92	93	90	99	97	93	95	X		
12-23	5-138	89	92	89				90		X	
12-23	5-139	88	89	89				89		X	
12-23	5-140	94	96	98				96	X		
12-23	5-141	93	92	94				93	X		
12-24	5-142	97	98	92	100	95	91	95	X		
12-24	5-143	95	94	95	93	89	94	94	X		
12-24	5-144	92	92	87				90	X		
12-27	5-145	93	94	92	95	95	99	95	X		
12-27	5-146	99	100	99	95	105	98	99	X		
12-27	5-147	95	88	92				92	X		
12-28	5-148	96	92	97				95	X		
12-28	5-149	93	95					94	X		
12-28	5-150	94	95	98	91	94	99	95	X		
12-28	5-151	94	93					94	X		
1-4-66	5-152	93	98	86				92	X		
1-5	5-153	95	96	92				94	X		
1-6	5-154	89	89	93				90		X	
1-6	5-154A	91	100	93				98	X		
1-6	5-155	93	94	90	90			93	X		
1-7	5-156	86	90	87				88		X	
1-7	5-156A	94	90	94				93	X		
1-7	5-157	96	94	94				95	X		
1-7	5-158	92	91	101	96			95	X		
1-10	5-159	92	84	94				90	X		
1-10	5-160	92	90	93				93	X		
1-10	5-161	87	91	94				91	X		
1-10	5-162	100	96	96				98	X		
1-11	5-163	96	94	88	88	92		92	X		
1-11	5-164	92	96	92				93	X		
1-11	5-165	99	94	97				97	X		
1-11	5-166	90	92	92				91	X		
1-11	5-167	93	92	89				91	X		

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SUMMARY OF RELATIVE COMPACTION DATA

90% R. C. Required

TABLE IV (contd)

Rte. 5 Dist. 10

Cont. 10-080614

Date	Test No.	Relative Compaction, % #1	#2	#3	#4	#5	#6	Avg.	Accept	Reject	Remarks
1-12	5-168	98	97	100				98	X		
1-12	5-169	90	92	94				92	X		
1-12	5-170	87	93	92				91	X		
1-13	5-171	94	92	96				94	X		
1-13	5-172	97	91	95				94	X		
1-13	5-173	95	93	94				94	X		
1-13	5-174	100	100	91				97	X		
1-13	5-175	87	87	93				89		X	
1-13	5-175A	87	90	80				84		X	
1-13	5-175-B	89	88					89		X	
1-13	5-175C	97	90	95				94	X		
1-13	5-176	99	98	98				98	X		
1-13	5-177	94	97	94	89	100	94	95	X		
1-13	5-178	94	97	91				94	X		
1-14	5-179	93	94	90				92	X		
1-14	5-180	97	91	97				95	X		
1-14	5-181	96	98	97				97	X		
1-14	5-182	92	98	91				94	X		
1-17	5-183	92	97	96				95	X		
1-17	5-184	94	92	96				94	X		
1-17	5-185	92	94	93				93	X		
1-17	5-186	95	90	87				91	X		
1-18	5-187	90	89	90				90	X		
1-18	5-192	89	92	95				92	X		
1-19	5-193A	99	93	94				95	X		
1-19	5-194	93	88	93				91	X		
1-19	5-195	91	91	90	92	96	90	91	X		
1-19	5-196	92	105	92	90			95	X		
1-19	5-197	79	98	93				90	X		
1-19	5-198	94	99	95	98	101		97	X		
1-20	5-199	94	96	96	97	94	89	94	X		
1-20	5-200	92	97	97				95	X		
1-20	5-201	89	85	85				86		X	
1-20	5-202	88	91	96				92	X		
1-20	5-203	99	100	90	87	96	100	94	X		

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SUMMARY OF RELATIVE COMPACTION DATA

Rte. 5 Dist. 10

90% R.C. Required
TABLE IV (contd)

Cont. 10-080614

Date	Test No.	Relative Compaction, % #1	#2	#3	#4	#5	#6	Avg.	Accept	Reject	Remarks
1-20-66	5-204	89	99	94				94	X		
1-20	5-205	96	93	92				94	X		
1-21	5-197A	90	99	92				94	X		Retest
1-21	5-201A	96	91	96				94	X		Retest
1-21	5-206	92	95	92				93	X		
1-21	5-207	94	93	99				95	X		
1-21	5-208	93	89	91	91	93	88	91	X		
1-21	5-209	97	95	96				96	X		
1-21	5-210	99	96	95				97	X		
1-24	5-211	93	98	91				94	X		
1-24	5-212	89	91	93	93	98	93	93	X		
1-24	5-213	93	91	88	98	94	95	93	X		
1-24	5-214	92	93	98	95	94	94	94	X		
1-24	5-215	94	94	95	88	89	89	92		X	
1-25	5-189A	91	98	93				94	X		Retest
1-25	5-215A	95	89	93				92	X		Retest
1-25	5-216	90	94	90				91	X		
1-25	5-217	96	92	91	86	91	89	91	X		
1-25	5-218	101	91	95	92	96	92	94	X		
1-26	5-219	100	94	89				94	X		
1-26	5-220	99	89	97	95	95	92	95	X		
1-26	5-221	92	91	92				92	X		
1-26	5-222	101	95	89				95	X		
1-26	5-223	98	96	90	101	92	96	95	X		
1-26	5-224	96	99	96				97	X		
1-27	5-225	96	90	91				92	X		
1-27	5-226	95	93	93				94	X		
1-27	5-227	94	90	93	87	100	100	94	X		
1-27	5-228	94	96	94				95	X		
1-27	5-229	92	91	91				91	X		
1-27	5-230	96	89	96				94	X		
1-28	5-231	95	89	97				94	X		
1-28	5-232	86	91	88				88		X	
1-28	5-232A	97	94	92				94	X		Retest
1-28	5-233	97	100	92				96	X		
1-28	5-234	86	100	97	99	91	99	95	X		

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SUMMARY OF RELATIVE COMPACTION DATA

90% R.C. Required

TABLE IV (contd)

Rte. 5 Dist. 10

Cont. 10-080614

Date	Test No.	Relative Compaction, % #1	#2	#3	#4	#5	#6	Avg.	Accept	Reject	Remarks
1-28-66	5-235	99	102	98				99	X		
1-31	5-236	98	95	90	89	93	87	92	X		
1-31	5-237	95	94	90	93	93	100	94	X		
1-31	5-238	94	93	90				92	X		
1-31	5-239	91	98	93	91	91	92	93	X		
1-31	5-240	95	96	98				96	X		
2-1	5-241	97	95	89				94	X		
2-1	5-242	91	100	98				96	X		
2-1	5-243	95	97	92				95	X		
2-3	5-244	95	89	91				92	X		
2-3	5-245	92	89	92	94	90	88	91	X		
2-3	5-246	97	93	96				95	X		
2-4	5-247	92	90	91	90			91	X		
2-4	5-248	91	95	90	89	95	92	92	X		
2-4	5-249	98	96	100				98	X		
2-4	5-250	95	91	96				94	X		
2-4	5-251	88	93	97	97	99	100	96	X		
2-7	5-297	94	91	95				93	X		
2-9	5-252	95	91	92	93	92	90	92	X		
2-9	5-253	97	95	91				94	X		
2-9	5-254	94	99	98	93			96	X		
2-9	5-255	98	95	92				95	X		
2-9	5-256	92	94	87	96			92	X		
2-9	5-257	90	93	89				91	X		
2-9	5-258	86	96	94	93	96	95	93	X		
2-9	5-259	97	96	93	92	90	91	94	X		
2-10	5-260	97	100	91	88	97	89	93	X		
2-10	5-261	96	100	98				98	X		
2-10	5-262	88	93	89	91	92	90	90	X		
2-10	5-263	86	92	94				91	X		
2-10	5-264	97	86	90				91	X		
2-10	5-265	92	94	92				93	X		
2-10	5-266	97	96	95				96	X		
2-10	5-267	93	96	95				95	X		
2-10	5-268	91	94	98				94	X		

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SUMMARY OF RELATIVE COMPACTION DATA

90% R. C. Required

TABLE IV (contd)

Rte. 5 Dist. 10

Cont. 10-080614

Date	Test No.	Relative Compaction, % #1	#2	#3	#4	#5	#6	Avg.	Accept	Reject	Remarks
2-10-66	9Y-8	82	83	79				81		X	
2-10	9Y-8A	92	95	97				95	X		Retest
2-11	5-269	93	94	93				93	X		
2-11	5-270	90	92	101				94	X		
2-11	5-271	93	101	91				95	X		
2-11	5-272	89	88	92	97	97	97	93	X		
2-11	2-273	93	92	88	99	90	92	93	X		
2-11	5-274	90	91	102				94	X		
2-11	5-275	97	87	95				94	X		
2-14	5-276	87	86					87		X	
2-14	5-276A	92	90	94				92	X		
2-14	5-277	90	90	102	95	91	91	93	X		
2-14	5-278	94	93	98	92			95	X		
2-14	5-279	95	85	98	94	95	95	93	X		
2-14	5-280	96	101	94				97	X		
2-15	5-281	92	89	85	85			88		X	
2-15	5-281A	102	98	91				97	X		Retest
2-15	5-282	93	94	94	90	88	95	92	X		
2-15	5-283	92	91	89				91	X		
2-15	5-284	91	92	91				91	X		
2-15	5-285	89	89	93				90	X		
2-15	5-286	89	91	90	98	93	89	92	X		
2-15	5-287	96	89	96				93	X		
2-15	5-288	99	91	94				95	X		
2-16	5-289	87	93	90				90	X		
2-16	5-290	91	88	89	95	91	91	91	X		
2-16	5-291	92	96	89				92	X		
2-16	5-292	91	95	95				94	X		
2-16	5-293	95	96	93	96	86	87	92	X		
2-17	5-294	100	94	95	94	88	90	93	X		
2-17	5-295	99	99	96	100	94	97	97	X		
2-17	5-296	94	95	89				93	X		
2-17	5-298	95	94	100	102	92	91	96	X		
2-17	5-299	92	91	94				92	X		
2-18	5-300	92	87	93	87	91	90	90	X		
2-18	5-301	93	85	96	90	91	103	93	X		

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SUMMARY OF RELATIVE COMPACTION DATA

90% R.C. Required

TABLE IV (contd)

Rte. 5 Dist. 10

Cont. 10-080614

Date	Test No.	Relative Compaction, % #1	#2	#3	#4	#5	#6	Avg.	Accept	Reject	Remarks
2-18-66	5-302	96	97	95				96	X		
2-18	5-303	90	90	90				90	X		
2-18	5-304	98	100	99				99	X		
2-18	5-305	95	89	96				93	X		
2-18	5-306	95	95	95				95	X		
2-19	5-307	96	95	97				96	X		
2-19	5-308	94	94	92				93	X		
"	5-309	96	98	96				97	X		
"	5-310	95	92	95				94	X		
2-21	5-312	90	94	94	85	91	90	91	X		
"	5-313	95	86	100	85	91	90	92	X		
"	5-314	91	94	94				93	X		
"	5-315	92	91	94				92	X		
"	5-316	97	94	94				95	X		
"	5-317	86	92	89				89		X	
"	5-318	99	97	98				98	X		
2-23	5-319	85	86	87				86		X	
"	5-320	92	93	91				92	X		
"	5-319A	85	87	90				87		X	Retest
2-24	5-317A	100	89	99				96	X		
"	5-319B	86	93	97				92	X		
"	5-321	98	95	95				96	X		
"	5-322	98	99	98				98	X		
"	5-323	101	101	97				100	X		
"	5-324	97	95	93				95	X		
"	5-325	92	92	91				92	X		
"	5-326	98	97	97				97	X		
"	5-327	95	96	99				97	X		
"	5-328	95	102	94				97	X		
"	5-329	97	97	95				96	X		
2-25	5-330	92	93	93				93	X		
"	5-331	97	87	90				91	X		
"	5-332	92	97	95				95	X		
"	5-333	85	89					87		X	
2-28	5-333A	84	83					84		X	

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90% R.C. Required

Rte. 5 Dist. 10 Cont. 10-080614

TABLE IV (contd)

Date	Test No.	Relative Compaction, % #1	#2	#3	#4	#5	#6	Avg.	Accept	Reject	Remarks
2-28-66	5-333B	87	91	96				91	X		Retest
"	5-334	99	100	89				96	X		
"	5-335	86	98	86				90		X	
"	5-335A	98	93	95				95	X		Retest
"	5-336	88	92	94				91	X		
"	5-337	93	96	94				94	X		
"	5-338	97	93	93				94	X		
"	5-339	94	94	101				96	X		
3-1-66	5-340	92	92	90				91	X		
"	5-341	85						85		X	
"	5-341A	92	89	93				91	X		Retest
"	5-342	92	96	93				93	X		
"	5-343	91	93	86				90	X		
"	5-344	91	87	92				90	X		
"	5-345	97	90	95				94	X		
3-2	5-346	97	95	94				95	X		
"	5-347	93	86	92				90	X		
"	5-348	101	97	92				96	X		
"	5-349	86	93	85				88		X	
"	5-349A	91	90	88				90	X		Retest
"	5-350	79	92	94				88		X	
"	5-350A	94	92	92				93	X		
"	5-351	93	91	93				92	X		
"	5-352	95	91	88				91	X		
3-3	5-353	86	100	94				93	X		
"	5-354	85	85					85		X	
3-3	5-355	92	92	92				92	X		
"	5-356	95	97	95				96	X		
"	5-357	93	95	100				96			
"	5-358	94	95	99				96	X		
"	5-359	94	96	94				95	X		
"	5-360	95	89	94				93	X		
"	5-354A	88	90	92				90	X		Retest
3-4	10Y-1	91	94	95				93	X		
3-4	5-362	92	94	87				91	X		

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SUMMARY OF RELATIVE COMPACTION DATA

90% R. C. Required

TABLE IV (contd)

Rte. 5 Dist. 10

Cont. 10-080614

Date	Test No.	Relative Compaction, % #1	#2	#3	#4	#5	#6	Avg.	Accept	Reject	Remarks
3-4	5-363	89	92	100				94	X		
"	5-364	95	96	92				94	X		
"	5-365	96	95	97				96	X		
"	5-366	95	95	88				92	X		
3-7	5-367	96	97	100				98	X		
"	5-368	92	93	87				91	X		
"	5-369	91	90	95				92	X		
"	5-370	100	97	96				98	X		
"	5-371	98	93	98				96	X		
"	5-372	90	89	90				90	X		
"	5-373	97	101	87				95	X		
"	5-374	94	97	94				95	X		
3-8	5-375	90	93	97				93	X		
"	5-376	98	94	96				96	X		
"	5-377	96	103	102				99	X		
"	5-378	93	94	102	98	96	96	96	X		
"	5-379	88	93	94				92	X		
"	5-380	97	95	98	94	97	94	96	X		
"	5-381	93	94	95				94	X		
"	5-382	90	96	91				92	X		
3-9	5-383	91	94	95	94	96	95	94	X		
"	5-384	91	86	97				91	X		
3-10	5-385	100	89	94				94	X		
"	5-387	97	98	93	99	93	90	95	X		
"	5-388	95	94	87				92	X		
3-11	5-389	98	93	93	97	90	98	95	X		
"	5-390	90	93	92				92	X		
"	5-391	84	81					83		X	
"	5-392	98	95	87	96	91	93	93	X		
3-14	5-394	87	90	93				90	X		
"	5-395	84	86					85		X	
"	5-396	90	98	91				93	X		
3-15	5-391A	86	82	90				86		X	Retest
"	5-391B	100	96	101				99	X		Retest
"	5-395A	94	85	90				90	X		Retest
"	5-397	92	88	90				90	X		

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SUMMARY OF RELATIVE COMPACTION DATA

90% R. C. Required

TABLE IV (contd)

Rte. 5 Dist. 10

Cont. 10-080614

Date	Test No.	Relative Compaction, % #1	#2	#3	#4	#5	#6	Avg.	Accept	Reject	Remarks
4-5-66	5-436	95	88	88				90		X	
"	5-435	100	97	96	97	100+	88	96	X		
4-6	10Y-7	96	92	99				96	X		
4-7	5-436A	96	94	98				96	X		
4-20	5-437	95	97	94				95	X		
4-21	5-438	101	92	98				97	X		
"	5-439	95	93	82	100			93	X		
"	5-440	100	94	97				97	X		
4-22	5-441	98	99	89				95	X		
4-25	5-442	96	92	87				92	X		
4-26	5-443	103	88	99	96	96	90	95	X		
4-27	5-443A	96						96	X		
"	5-444	90	95	87	94			91	X		
"	5-445	90	89	100				93	X		
5-9	5-446	97	99	92				96	X		
5-24	5-447	85	92	100	95	96	82	92	X		
6-1	5-449	96	90	92	93			92	X		
6-10	5-450	93						93	X		
6-14	5-451	94	90	97	92			93	X		
7-8	10Y-24	92						92	X		
7-16	10Y-25	94						94	X		
8-8	16Y-3	89	91					90		X	
8-10	19Y-5	90	89	98				92	X		
8-11	16Y-5	99	100					100	X		
8-16	19Y-6	90	94	98				94	X		
8-17	19Y-7	99	96					98	X		
8-18	19Y-8	83	100	101	97			95	X		
8-22	19Y-10	92	94					93	X		
8-23	19Y-11	90	93	98				94	X		
8-26	16Y-19	100	98	95				98	X		
"	19Y-13	96		100				98	X		
"	19Y-12	91	87	98				92	X		
9-2	19Y-14	98	90	93	88	92	83	91	X		
9-5	20Y-1	97	87	89				91		X	
9-7	20Y-1A	96	96					96	X		

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SUMMARY OF RELATIVE COMPACTION DATA

90% R.C. Required

TABLE IV (contd)

Rte. 5 Dist. 10 Cont. 10-080614

Date	Test No.	Relative Compaction, % #1	#2	#3	#4	#5	#6	Avg.	Accept	Reject	Remarks
3-15-66	5-398	93	96	97				96	X		
"	5-399	82	103	87	85			89		X	
"	5-399A	95	92	89	94	95	91	93	X		Retest
"	5-400	84	87	94	92			89		X	
"	5-401	93	94	95				94	X		
3-16	5-402	87	93	92				91	X		
"	5-403	91	92	97	96	96	98	95	X		
"	5-404	92	98	96	102	88	88	94	X		
3-17	5-405	95	92	90	88	86	100	93	X		
"	5-406	96	94	95	94	91	92	94	X		
3-18	5-407	91						91	X		
3-24	5-418	101	93	94	90	86	92	93	X		
3-25	5-419	92	90	96				93	X		
3-28	5-420	91	94	95				94	X		
"	5-421	100	93	94				95	X		
"	10Y-4	99	94	98				97	X		
3-29	5-410A	102	89	91				94	X		Retest
"	5-422	90	90	90				90	X		
"	5-423	93	90	88	92	99		92	X		
"	5-424	91	84	88				88		X	
"	5-424A	95	97	100				97	X		Retest
"	5-425	84	85	86				85		X	
3-30	5-426	90	87	92				90	X		
"	5-427	91	92	90				91	X		
"	5-428	100	98	91				96	X		
3-31	5-425A	97	94	91				94	X		Retest
"	--	90	99	99				96	X		
"	--	95	98	95	91			95	X		
4-1	5-429	100	92	93	84	93	100	94	X		
"	5-431	95	97	90				94	X		
4-4	5-432	99	89	98				95	X		
"	5-433	98	100++	98				99+	X		
"	5-434	89	90	91				90	X		
"	10Y-5	94	95					95	X		
"	10Y-5	94	97					96	X		

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SUMMARY OF RELATIVE COMPACTION DATA

90% R. C. Required

TABLE IV (contd)

Rte. 5 Dist. 10

Cont. 10-080614

Date	Test No.	Relative Compaction, %							Accept	Reject	Remarks
		#1	#2	#3	#4	#5	#6	Avg.			
9-8-66	20Y-2	96	97	93				95	X		
9-13-66	10Y-29	91	93					92	X		

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SUMMARY OF RELATIVE COMPACTION DATA

95% R. C. Required

TABLE V

Rte. 5 Dist. 10

Cont. 10-080614

Date	Test No.	Relative Compaction, % #1	#2	#3	#4	#5	#6	Avg.	Accept	Reject	Remarks
10-1-65	9Y-1	97	99	94				97	X		
10-8	9Y-2	100	96	96				97	X		
10-12	9Y-3	99	97	98				98	X		
10-18	9Y-4	99	100	98				99	X		
10-19	9Y-5	98	97	98				98	X		
11-2	9Y-6	101	96					98	X		
11-3	9Y-7	97	95					96	X		
12-27	11Y-2	101	97	92				97	X		
2-16-66	9Y-9	88	87	89				88		X	
2-16	9Y-9A	99	101	98				99	X		
2-17	9Y-10	99	98	97				98	X		
2-17	9Y-11	96	92	96				95	X		
2-17	9Y-12	79	78	76				77		X	
2-18	9Y-13	92	90					91		X	
2-21	9Y-12A	94	82	82				86		X	
"	9Y-12B	89	87					88		X	
"	9Y-13A	95	95	95				95	X		
"	9Y-14	96	93	95				95	X		
2-23	9Y-12C	98	93	96				96	X		
2-23	9Y-15	92	95	97				95	X		
"	9Y-16	96	94	95				95	X		
"	9Y-17	94	93	90				93		X	
2-24	5-317A	100	89	99				96	X		
"	9Y-18	90	97	97				95	X		
2-25	9Y-17A	96	95	99				97	X		Retest
"	9Y-18	95	95	100				97	X		
2-28	9Y-20	99	98	100				99	X		
3-1	9Y-21	90	88					89		X	
3-3	S-1	99	96	101	102	98	101	99	X		
3-4	S-2	98	94	95	95	99	98	97	X		
"	9Y-21A	94	97	93				95		X	Retest
"	9Y-22	96	96	96				96	X		
"	9Y-23	95	92	97				95	X		
"	9Y-24	91	89					90		X	
3-8	9Y-24A	93	95	95				94		X	Retest
"	9Y-25	99	97	100				99	X		

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SUMMARY OF RELATIVE COMPACTION DATA

95% R. C. Required

TABLE V (contd)

Rte. 5 Dist. 10

Cont. 10-080614

Date	Test No.	Relative Compaction, % #1	#2	#3	#4	#5	#6	Avg.	Accept	Reject	Remarks
3-9-66	9Y-26	94	94	93				94		X	
"	9Y-27	100	94	93				96	X		Retest
"	9Y-27A	98	100					99	X		Retest
"	9Y-28	100	101	100				100	X		
3-10-66	9Y-29	103	102	103	102	99	106	102	X		
3-16	20Y-1	97	100	97	98			98	X		
"	10Y-2	95	96	98				96	X		
"	S-3	86	94	84	101	96	96	93		X	
"	S-4			96				96	X		
"	S-5	102	93	96	101			98	X		
3-17	S-5A	93						93		X	
3-18	S-5B	91	91					91		X	
"	20Y-2	97	100	101				99	X		
"	S-6	99	98	97				98	X		
3-24	10Y-1A	101	103	101				102	X		
"	10Y-3	102	100	98				100	X		
"	S-11	98	86	93	95	94	84	93		X	
3-25	19Y-1	98	98	97	98	99	100	98	X		
"	19Y-2	97	94	97	96	98	93	96	X		
3-28	19Y-3	98	94	95				96	X		
"	S-11A	93	94	93	81		93	90		X	
"	S-11A	100	96	89	81	82	95	90		X	
"	S-11A	83	87	90		106	93	92		X	
3-29	9Y-30	95	95	95				95	X		
3-30	9Y-31	97	97	94				97	X		
"	S-12	88	89	97	97	96	99	94		X	
"	S-12A	93	92					93		X	
"	S-13	88	99	94	97	97	91	94		X	
"	S-14	100	93	96	96	97	94	96	X		
3-31	S-15	93	94	94				94		X	
"	S-15A	93	98	100				97	X		
"	S-16	95	97	93	94	98	95	95	X		
"	S-17	98	95	95	95			96	X		
"	S-12A	98	101	99	96	94	95	97	X		Retest
4-1	S-18	101	94	99	101			99	X		

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SUMMARY OF RELATIVE COMPACTION DATA

95% R. C. Required

TABLE V (contd)

Rte. 5 Dist. 10

Cont. 10-080614

Date	Test No.	Relative Compaction, % #1	#2	#3	#4	#5	#6	Avg.	Accept	Reject	Remarks
4-1-66	S-19	100	100					100	X		
4-4	S-20	100	90					95		X	
4-6	S-21	99	97	98				98	X		
"	S-20A	95	95	98	98	98		97	X		
4-7	19Y-6	99	102	97				99	X		
4-8	10Y-8	96	93	96	100			96	X		
"	10Y-9	100	100	98	100			100	X		
"	19Y-5	97	100	94	94	96	94	96	X		
"	19Y-4	90	95					93		X	
4-11	10Y-10	96	92	101	97			97	X		
4-18	10Y-11	97	96	93				95	X		
4-19	10Y-12	100	98	100				99	X		
4-20	10Y-11A	99	96					98	X		
4-25	9Y-32	95	95	99				96	X		
4-27	S-25	91	93	92	98	95	96	94		X	
4-28	S-25A	98	90	95	95	96		95	X		
"	S-25B	96						96	X		
4-29	S-26	100		96		100		99	X		
"	S-26	100		100		98		99	X		
5-2-	10Y-13	98	95					97	X		
"	S-28	99	100	98				99	X		
"	S-27	93	93	93				93		X	
5-3-	10Y-14	96	95					96	X		
5-3	S-27A	99	97	95	96			97	X		
5-4	S-29	98	92	96	95	100	101	97	X		
5-5	S-29A	94						94		X	
"	S-30	96	92	93	98	98		95	X		
"	10Y-15	97	96					97	X		
"	S-31	97	99	95	97	95		97	X		
"	S-32	80	95	93	90	92		90		X	
5-6	S-32A	95	93					94		X	
"	S-33	100	90	100	96	96		97	X		
"	S-34	97	95	84				92		X	
5-9	S-33A	95						95	X		
"	9Y-33	98	97	97	97			97	X		

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SUMMARY OF RELATIVE COMPACTION DATA

95% R. C. Required

TABLE V (contd)

Rte. 5 Dist. 10

Cont. 10-080614

Date	Test No.	Relative Compaction, % #1	#2	#3	#4	#5	#6	Avg.	Accept	Reject	Remarks
5-9-66	S-54B	100	91	92				94		X	
5-22	80Y-4	97	97	90	96	101	98	96	X		
"	S-74	94	97	97	88	93	91	93		X	
5-24	S-75	99	95	97	95			97	X		
"	S-54A	93	92	95	97			94		X	
5-25-	S-448	90	85	92				89		X	
"	10Y-17	90	91					91		X	
"	10Y-16	94	89	84				89		X	
5-26	10Y-18	103	97	98	95	98	90	97	X		
5-27	-	94	95					95	X		
"	10Y-18A	98	96					97	X		
5-24	20Y-4B	97	93	94				95		X	
"	20Y-4	87	88	93	94			90		X	
5-25	20Y-4A	91	93	100	95	91	99	95		X	
5-26	20Y-4E	95	97					96	X		
"	20Y-5	99	99	101	99	95	95	97	X		
"	20Y-6	99	94					96	X		
"	S-54C	99	96	99				98	X		
" -	S-61A	89	96	93	96			94		X	
5-26	S-77	98	96	99	96			97	X		
5-27	S-78	97	93	99				96	X		
"	20Y-7	94	94	98				95	X		
"	20Y-8	96	95	93	93	98	100	98	X		
5-31	10Y-19	99	100	97				98	X		
"	10Y-16A	86	98	101				95	X		
"	9Y-37	85	87					86		X	
"	9Y-36A	98	98					98	X		
"	9Y-36	92	90					91		X	
"	S-80	97	94	97	96	100	95	97	X		
"	S-79	100	97	93	96			97	X		
6-1	S-74A	94	98	95	94			95	X		
"	10Y-17A	100	100					100	X		
"	9Y-37A	99	96					98	X		
6-2	9Y-38	101	100					101	X		
"	S-81	100	98	102				100	X		

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SUMMARY OF RELATIVE COMPACTION DATA

95% R.C. Required

TABLE V (contd)

Rte. 5 Dist. 10

Cont. 10-080614

Date	Test No.	Relative Compaction, % #1	#2	#3	#4	#5	#6	Avg.	Accept	Reject	Remarks
6-2-66	S-82	94	91					93		X	
6-3	S-82A	97	100					99	X		
"	S-83	99	100	95	96	94	95	97	X		
6-7	10Y-20	95	99					97	X		
"	S-84	99	104	95				99	X		
6-8	S-85	94	98	100				97	X		
"	S-86	97	100	97				98	X		
6-10	S-87	96	96	97				96	X		
"	S-88	96	97	97				97	X		
"	S-89	95	89					92		X	
6-13	S-89A	97	95					96	X		
6-14	S-90	96	93	93	95	91	91	93		X	
6-15	S-90A	97	95	95	99			97	X		
-	S-91	94	92	92				93		X	
6-15	S-91A	94	92	95	100	98	97	96	X		
"	S-92	86	90					88		X	
6-16	20Y-9	92	95	101	97			96	X		
"	S-91-B	99	97					98	X		
"	S-92-A	94	95	97	95			95	X		
6-17	S-93	97	99	98				98	X		
"	S-94	99	98					99	X		
6-20	S-95	101	99	95				98	X		
"	19Y-7	100	96	95	98	95	96	97	X		
6-21	19Y-8	98	98	96	95	98		98	X		
"	S-96	97	98	87				94		X	
"	19Y-9	94	94	98	95	96		95	X		
6-22	S-97	96	92	95	96			95	X		
"	19Y-10	103	94	96	96	92		96	X		
"	19Y-11	94	97	96	99	97		96	X		
"	19Y-12	97	96	95	93			95	X		
6-23	19Y-12A	95	99					97	X		
"	19Y-13	92	95	99	95			95	X		
"	19Y-14	95	97	96	94	97	95	96	X		
"	19Y-15	98	96	85	93			93		X	
"	20Y-10	97						97	X		

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SUMMARY OF RELATIVE COMPACTION DATA

95% R.C. Required

TABLE V (contd)

Rte. 5 Dist. 10

Cont. 10-080614

Date	Test No.	Relative Compaction, % #1	#2	#3	#4	#5	#6	Avg.	Accept	Reject	Remarks
6-23-66	20Y-12	96	96	98	97			97	X		
6-24	19Y-17	92	96	92				93		X	
"	19Y-17A	92	92					92		X	
"	19Y-17B	95	100					98	X		
"	19Y-18	102	102	96	100	95	91	98	X		
"	19Y-19	95	96	92	95	97		95	X		
"	S-97A	96	96					96	X		
"	19Y-16	96	98	98	96	99	100	98	X		
"	10Y-21	96	101	101	100			100	X		
6-25	19Y-18	102	99					101	X		
"	19Y-19A	97						97	X		
"	19Y-20	95	98	95	97			96	X		
"	19Y-21	94	97	95	95	96	97	95	X		
6-27	19Y-25	93	92	95	96	95		94	X		
"	19Y-24	93	94	97	100			96		X	
"	10Y-22	100	92	101	93	98	97	97	X		
"	S-98	95	94	93				94		X	
"	19Y-22	97	95	96	95	94	95	95	X		
"	19Y-23	93	93					93		X	
6-28	19Y-26	97	98	95	97	98	93	96	X		
"	19Y-23A	96	98					97	X		
"	S-98A	100	95	95	96	97	94	96	X		
"	S-99	97	96	94				96	X		
6-29	S-100	94	94	97	100			96	X		
"	19Y-24A	100	97					99	X		Retest
"	10Y-23	99	96	97	93			96	X		
--	10Y-23A	97	97					97	X		Retest
6-30	19Y-25A	95	95					95	X		Retest
"	19Y-27	97	97	96				96	X		
"	19Y-28	96	93	95	94	96		95	X		
"	19Y-29	99	96	94	100			97	X		
"	19Y-16B	99	97					98	X		Retest
7-1	20Y-13	96	97					97	X		
"	S-101	98	92	100				97	X		
"	S-401	95	92	94	97	100		96	X		

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SUMMARY OF RELATIVE COMPACTION DATA

95% R.C. Required

TABLE V (contd)

Rte. 5 Dist. 10

Cont. 10-080614

Date	Test No.	Relative Compaction, % #1	#2	#3	#4	#5	#6	Avg.	Accept	Reject	Remarks
7-6-66	19-26A	91	97					94		X	
"	"	94	93					94		X	
"	19Y-31	92	93	90	94	95		93		X	
"	S-102	93	94	97	98	99		96	X		
7-7	19Y-31A	95	92	96	97	98	98	96	X		
"	19Y-30	97	98					98	X		
"	19Y-34	97	95	99	103	94		98	X		
"	14Y-33	93	97	96				95	X		
"	19Y-32	102	97	95	103	99	98	99	X		
"	S-103	96	95	95				95	X		
7-11	19Y-36	100	99	101	102	85	91	97			
"	19Y-35	98	98	94	98	98	100	97	X		
"	19Y-37	99	104	94	95	97	97	98	X		
7-12	19Y-38	95	96	95	98	96	95	96	X		
"	19Y-39	96	95	93				95	X		
7-13	19Y-40	95	100	97	97			98	X		
"	19Y-41	97	100	100	96			98	X		
"	S-96A	103	103	101				102	X		
7-14	S-104	98	101	101	98	97		97	X		
"	19Y-42	96	100	96	97	94	93	96	X		
"	19Y-43	97	93	101	97	96	97	97	X		
"	19Y-44	98	96	95				96	X		
"-15	20Y-14	97	98	96	96	100	101	97	X		
"	19Y-45	97	98	95	96	99	101	98	X		
"	19Y-46	95	99	90			96	97	X		
"	19Y-48	96	92	94	98	97		95	X		
"	19Y-47	100	92	99	98	100	100	98	X		
7-16	20Y-15	99	99	90	95			96	X		
"	19Y-49	97	96	95	92	98		96	X		
7-18	19Y-50	94	103	98	99	99	95	98	X		
"	20Y-16	98	98	96				97	X		
"	19Y-51	93	98	95				95	X		
7-19	S-105	96	100	97				98	X		
"	10Y-26	97	96					97	X		
7-20	19Y-52	94	95	94				94	X		

HMR T-2135(Orig. 12/66)

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SUMMARY OF RELATIVE COMPACTION DATA

95% R. C. Required

TABLE V (contd)

Rte. 5 Dist. 10

Cont. 10-080614

Date	Test No.	Relative Compaction, % #1	#2	#3	#4	#5	#6	Avg.	Accept	Reject	Remarks
7-20-66	19Y-53	100	96	96	94	97	95	98	X		
7-21	S-106A	96	97					97	X		
"	S-106	91	95					93		X	
"	20Y-17	100	95					98	X		
"	10Y-27	100	100	98	99			99	X		
7-22	10Y-28	100	100					100	X		
"	S-107	99	98					98	X		
"	20Y-18	100	97					99	X		
"	S-108	94	100	95				96	X		
7-25	19Y-54	98	92	96	96	98		96	X		
"	19Y-55	94	94	96				95	X		
7-26	19Y-56	96	93	98				95	X		
"	22Y-2	94	96	103	97	98	102	99	X		
"	22Y-1	94	98	94				96	X		
"	22Y-3	101	97	94	93			97	X		
7-27	19Y-57	94	95	95				95	X		
"	22Y-5	94	98	98	95	99	96	97	X		
"	22Y-4	97	95	98				97	X		
"	22Y-6	96	97					98	X		
7-28	22Y-7	96	102	101	100			100	X		
"	22Y-8	96	96	94	96	94		95	X		
"	22Y-9	93	95	98	94	93	99	95	X		
"	19Y-58	94	99	100				98	X		
"	19Y-59	99	99					99	X		
"	19Y-60	94	98	100				98	X		
7-29	19Y-61	95	98	97				97	X		
"	19Y-62	99	98					99	X		
"	S-109	96	99	97	97			97	X		
7-30	19Y-64	97	99	100				98	X		
"	19Y-63	98	96	94				96	X		
8-1	19Y-66	100	95	98				98	X		
"	19Y-65	98	98	96		94		96	X		
"	22Y-10	96	98	96	94	94		96	X		
8-2	22Y-11	94	95	96				95	X		
8-3	22Y-12	94	98	91				94		X	

HMR T-2135(Orig. 12/66)

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SUMMARY OF RELATIVE COMPACTION DATA

95% R.C. Required

TABLE V (contd)

Rte. 5 Dist. 10

Cont. 10-080614

Date	Test No.	Relative Compaction, % #1	#2	#3	#4	#5	#6	Avg.	Accept	Reject	Remarks
8-9-66	26Y-5	82	98	97	90	94		92		X	
"	26Y-5A	100	93	98				97	X		
"	26Y-6	98	97	100	95			98	X		
8-10	26Y-7	94	99					97	X		
"	16Y-4	94	92					93		X	
8-11	16Y-7	94						94	X		
"	16Y-6	98						98	X		
"	16Y-4A	95	100					97	X		
8-12	16Y-9	97						97	X		
"	16Y-8	94	97	98				96	X		
8-15	27Y-1	98	95					97	X		
"	16Y-10	94	90					92		X	
8-16	S-110	94	97	99				97	X		
"	16Y-10A	93	101	101				98	X		
"	26Y-8	94	96	95				95	X		
"	16Y-11	95	95					95	X		
8-17	16Y-13	96	95					96	X		
"	16Y-12	97	94					96	X		
8-18	S-111	92	95	100				96	X		
8-19	26Y-9	96	98	100				98	X		
"	27Y-2	101	96	101				99	X		
"	16Y-14	97	98	98				98	X		
"	19Y-9	95	95					95	X		
8-22	27Y-3	98	100	93				96	X		
"	16Y-15	92	91					92		X	
"	16Y-15A	96	96					96	X		
"	27Y-4	94	96	98				96	X		
8-23	27Y-5	98	95	96				96	X		
"	16Y-16	100	94	96				97	X		
"	16Y-17	97	98					98	X		
8-24	26Y-10	100	88	92	92	96		94		X	
"	16Y-18	96	92					94	X		
8-25	S-112	100	97	97				98	X		
8-26	19Y-13	96		100				98	X		
8-30	16Y-20	100	93	99				97	X		

HMR T-2135(Orig. 12/66)

Rte. 5 Dist. 10

SUMMARY OF RELATIVE COMPACTION DATA

95% R. C. Required

TABLE V (contd)

Cont. 10-080614

Date	Test No.	Relative Compaction, % #1	#2	#3	#4	#5	#6	Avg.	Accept	Reject	Remarks
8-30-66	17Y-2	91	97	100				96	X		
8-31	26Y-12	98	93	97	98			97	X		
"	26Y-11	100	103	102				102	X		
"	S-	96	94	101	97			97	X		
9-1		96	97					97	X		
9-6	27Y-6	103	98	103				101	X		
9-7	26Y-14	100	97	98	95	97		96	X		
9-7	26Y-13	93	97	101	92			95	X		
9-8	20Y-3	94	93	94				94	X		
"	26Y-15	97	100	103	93	96		98	X		
9-12	S-118	93	93					93		X	
9-13	S-118A	97	99	98				98	X		Retest
"	S-119	95	96	97				96	X		
9-14	S-120	102	100	95				99	X		
9-15	S-121	93	96	100				96	X		
"	S-122	97	95	97				96	X		
9-20	S-123	95	94	100	99			97	X		
"	S-124	95	98	98	98	96	98	97	X		
9-21	S-125	99	97	99	98	100	94	98	X		
"	S-126	91	96	98	95			95	X		
9-22	S-127	97	93	96				95	X		
9-23	S-128	100	103	101	93			99	X		
"	S-129	94	95	94	100			96	X		
9-26	19Y-67	91	98	95	96	95		95	X		
"	S-130	94	95	95				95	X		
"	S-131	93	97	98	98			97	X		
"	S-132	99	98	96	97			98	X		
9-28	S-133	92	98	100	96	96	96	96	X		
"	S-134	97	95	96				96	X		
9-29	S-135	99	97	96	97	93	96	96	X		
"	S-136	99	95	101	98			98	X		
9-30	S-137	96	93	94	100	95	96	96	X		
"	S-138	96	97	98	96	99	93	97	X		
"	21Y-1	94	95	96				95	X		
10-3	19Y-68	92	95	92	94	100	96	95	X		
10-4	21Y-2	102	96	101	97	95	98	98	X		

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SUMMARY OF RELATIVE COMPACTION DATA

95% R.C. Required

TABLE V (contd)

Rte. 5 Dist. 10

Cont. 10-080614

Date	Test No.	Relative Compaction, % #1	#2	#3	#4	#5	#6	Avg.	Accept	Reject	Remarks
10-4-66	19Y-30	97	97					97	X		
"	19Y-68A	99	99	95				98	X		
"	S-139	94	99	99	94	100		97	X		
10-5	19Y-69	98	100	94	101	99	97	98	X		
"	19Y-70	94	96	95	95	96		95	X		
"	S-140	97	96	94	99	97		97	X		
10-6	21Y-3	99	95	100				98	X		
"	21Y-4	79	94	93				89		X	
"	S-141	98	94	96	100	96		97	X		
10-7	21Y-4A	95	96	96	97	94	95	96	X		Retest
"	21Y-5	95	93	93	95	95	96	95	X		
"	21Y-6	97	94	95	92	94		95		X	
"	S-142	90	95	97	98			95	X		
"	S-143	95	100	98	100	99	96	98	X		
10-10	21Y-7	100	94	93	95			94		X	
"	21Y-7A	99	97	97				98	X		Retest
"	21Y-8	97	98	95	92	99	96	96	X		
"	21Y-9	96	97	95	94	101	95	97	X		
"	21Y-10	97	94	95				95	X		
"	S-144	95	96					96	X		
10-12	19Y-71	99	95	94	98			97	X		
"	21Y-11	101	100	94	99			99	X		
"	21Y-12	99	95	93	84	87		92		X	
"	21Y-13	95	97	97				96	X		
10-13	21Y-12A	94	95	96	94	96	95	95	X		Retest
10-14	21Y-14	94	96	98	97	96	97	96	X		
"	21Y-14	96	95					95	X		
10-17	21Y-15	95	95	94				95	X		
10-20	21Y-16	97	100	97				98	X		
"	21Y-17	97	96	100	96	96	97	97	X		
"	21Y-18	97	96	97	95			96	X		
10-24	19Y-72	96	95	101	95			98	X		
"	21Y-19	101	101	100	99	102	101	101	X		
"	21Y-20		93	96		93	100	96		X	
"	21Y-21	95	92	96	95			95	X		
10-25	21Y-23	91	88	85	91	84	95	87		X	

HMR T-2135(Orig. 12/66)

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SUMMARY OF RELATIVE COMPACTION DATA

95% R.C. Required

TABLE V (contd)

Rte. 5 Dist. 10

Cont. 10-080614

Date	Test No.	Relative Compaction, % #1	#2	#3	#4	#5	#6	Avg.	Accept	Reject	Remarks
10-25-66	21Y-23A	95	95	94	92	95	91	95		X	
"	21Y-24	100						100	X		
10-26	21Y-25	106	86	97	94			96		X	
"	21Y-25A	96	98					97	X		
"	21Y-26	96	97	96	94	94	96	96	X		
"	21Y-27	103	100	97	93	96	98	98	X		
10-27	21Y-28	100	94	100	100	100	94	98	X		
10-28	21Y-29	99	97	99				98	X		
"	21Y-30	97	99	100	96			98	X		
"	21Y-31	98	98	98	98			98	X		
10-31	21Y-33	100	95	103				99	X		
"	21Y-32	100	96	96	95	94		96	X		
11-1	21Y-34	99	100	99	101			100	X		
11-2	21Y-35	95	96	98	98	98		100	X		
11-2	21Y-36	99	95	97				97	X		
11-3	21Y-37	95	101	93	98			97	X		
"	21Y-38	100	97	93	98	98	93	96	X		
11-9	21Y-39	100	95	96				97	X		
"	21Y-40	97	95	96	95	95		96	X		

HMR T-2135(Orig. 12/66)

TABLE VI

Percentage of Total Tests that Failed to Meet the Minimum Requirements by the 2/3 Areas Passing, Average Passing, and Both

	No. of Tests	Percentage of Total Tests
Number of test areas which failed due to the 2/3 requirement and the average was at or above the minimum specification	21	17
Number of test areas which failed due to minimum average RC requirement and less than 1/3 failed	7	6
Number of failing test areas which do not satisfy both the 2/3 and minimum average RC requirements	96	77

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TABLE VII
Record of Nuclear Gage Malfunctions

Description of Malfunction	Date Gage Out	Date Back on Job	Downtime Working Days
Timer stopped functioning (Used stop watch for 2 days)	7-23-65	7-30-65	4
A density standard count or a plateau could not be obtained. Replaced preamp and geiger mueller tube replaced.	8-5-65	8-30-65	18
Timer stopped functioning	9-3-65	9-10-65	6
Transmission rod stuck with nuclear source exposed	9-22-65	9-22-65	1/4
Density count stopped functioning. Replaced transistor in preamp.	9-24-65	9-29-65	4
Timer stopped functioning	10-12-65	10-13-65	2
Timer stopped functioning Replaced timer.	10-21-65	10-21-65	1/2
Insulation broken from interconnecting cable.	12-6-65	12-6-65	None
Transmission rod starting to bind. Cleaned dirt from rod.	12-15-65	12-15-65	None
Transmission rod binding. Cleaned dirt from rod	1-4-65	1-5-65	1
The scaler starts and stops intermittently. Interconnecting cable had broken wire.	1-17-66	1-21-66	5
Transmission rod stuck with the source exposed.	2-2-66	2-2-66	1/4

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TABLE VII (contd)

Description of Malfunction	Date Gage out	Date Back on Job	Downtime Working Days
Density high voltage reading dropped from 950 to 425. Density will not count. Dirt was cleaned from the probe preamp.	3-18-66	3-19-66	1
Density and moisture high voltage dropped to 500. Scaler will not count at all. PS 400 module replaced.	3-21-66	3-24-66	4
The 10-thousand dec. tube will not count. Replaced.	4-1-66	4-1-66	None
The interconnecting cable has a broken wire.	4-11-66	4-14-66	4
Scaler will not stop counting. Replace DS 400 module.	5-10-66	5-23-66	10
Unit digit dec tube goes to two and stops. Replaced.	6-13-66	6-14-66	1
The interconnecting cable has a broken wire.	9-19-66	9-19-66	1/2

$$\frac{\text{Downtime}}{\text{Working Days}} \quad \frac{61\text{-}1/2}{260} = 23.6\% \text{ Downtime}$$

Total 61-1/2 days

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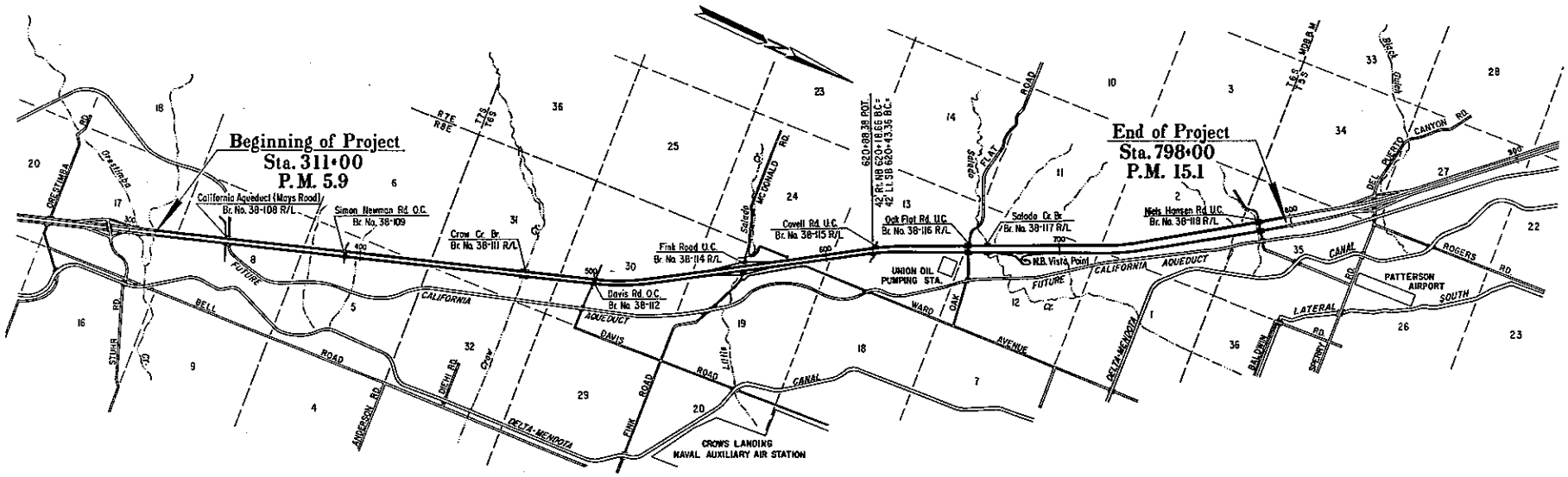
In Stanislaus County between 0.4 mile north of Stuhr Road and 0.7 mile south of Del Puerto Canyon Road

FREEWAY
and by resolution of the California Highway Commission
June 25, 1958



Scale in Feet
2000 0 2000 4000 6000

Length of Project = 9.2 miles

Figure 1

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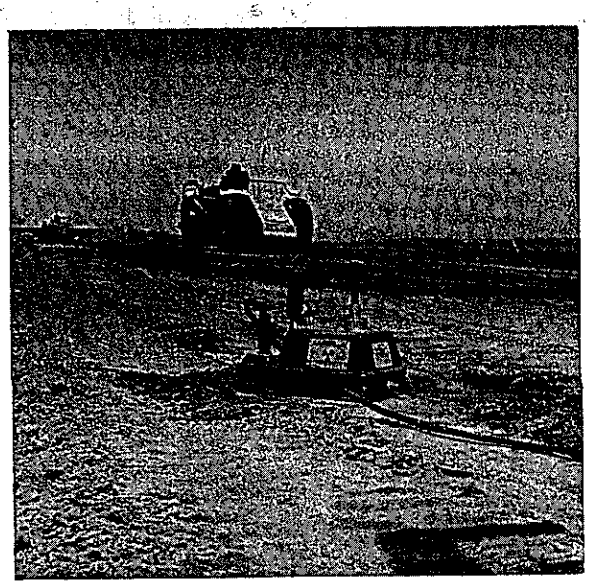

Figure 2. Illustration of Nuclear Test Equipment

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DENSITY CALIBRATION CURVES
TROXLER SN. 209

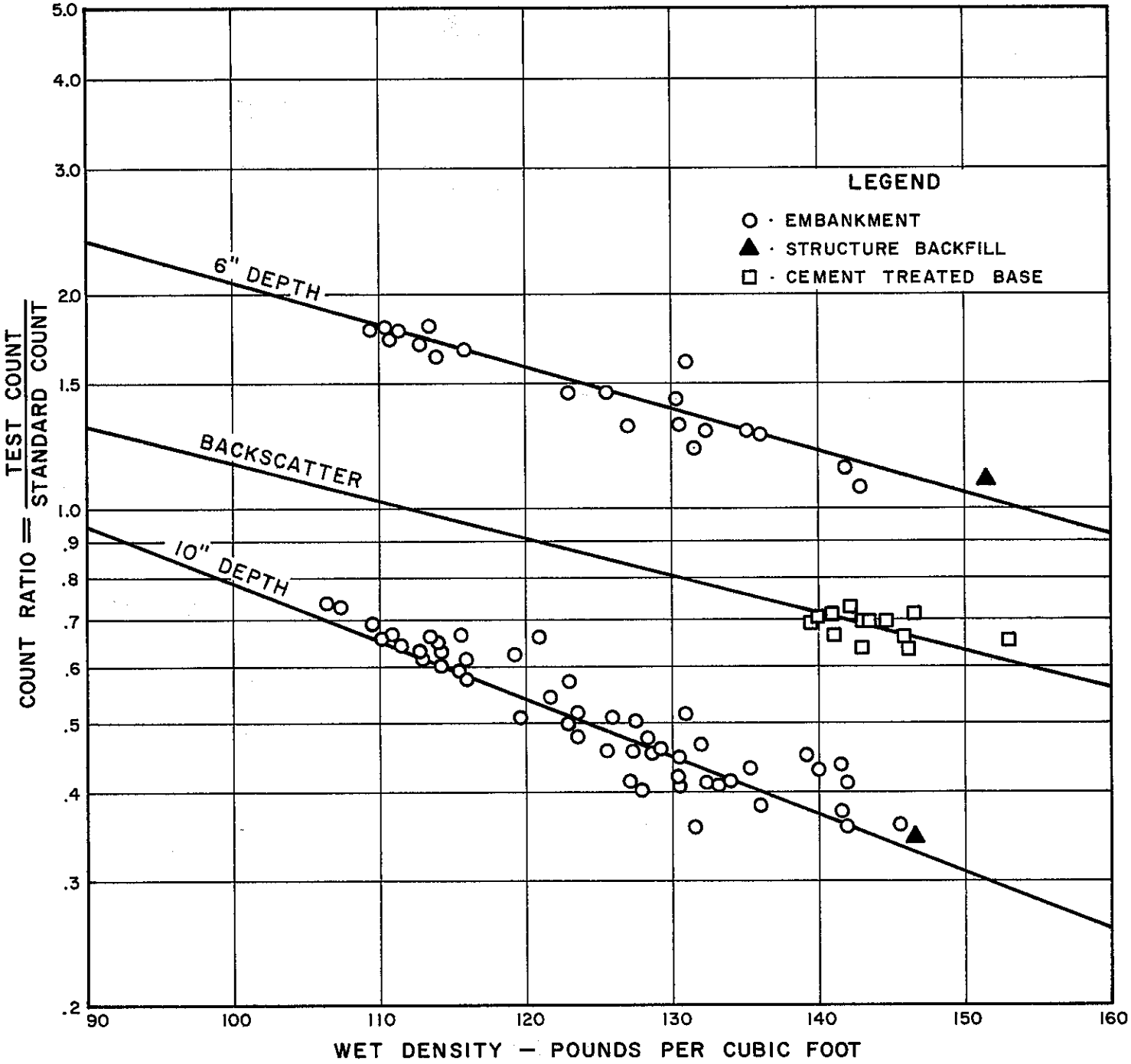

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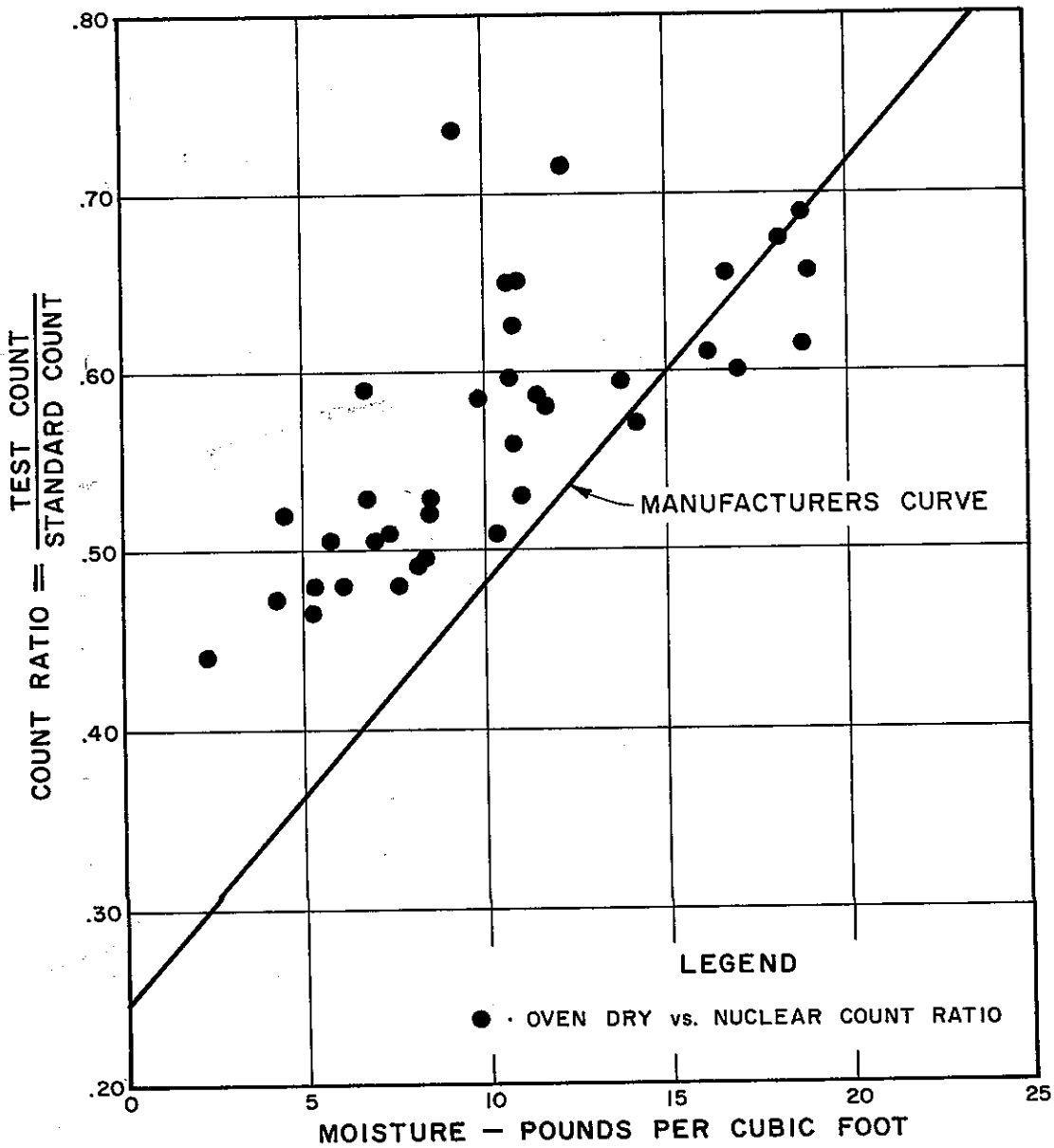
Figure 4

MOISTURE CALIBRATION CURVE
TROXLER SN. 209



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FREQUENCY DISTRIBUTION OF IMPACT COMPACTION MAXIMUM WET DENSITIES

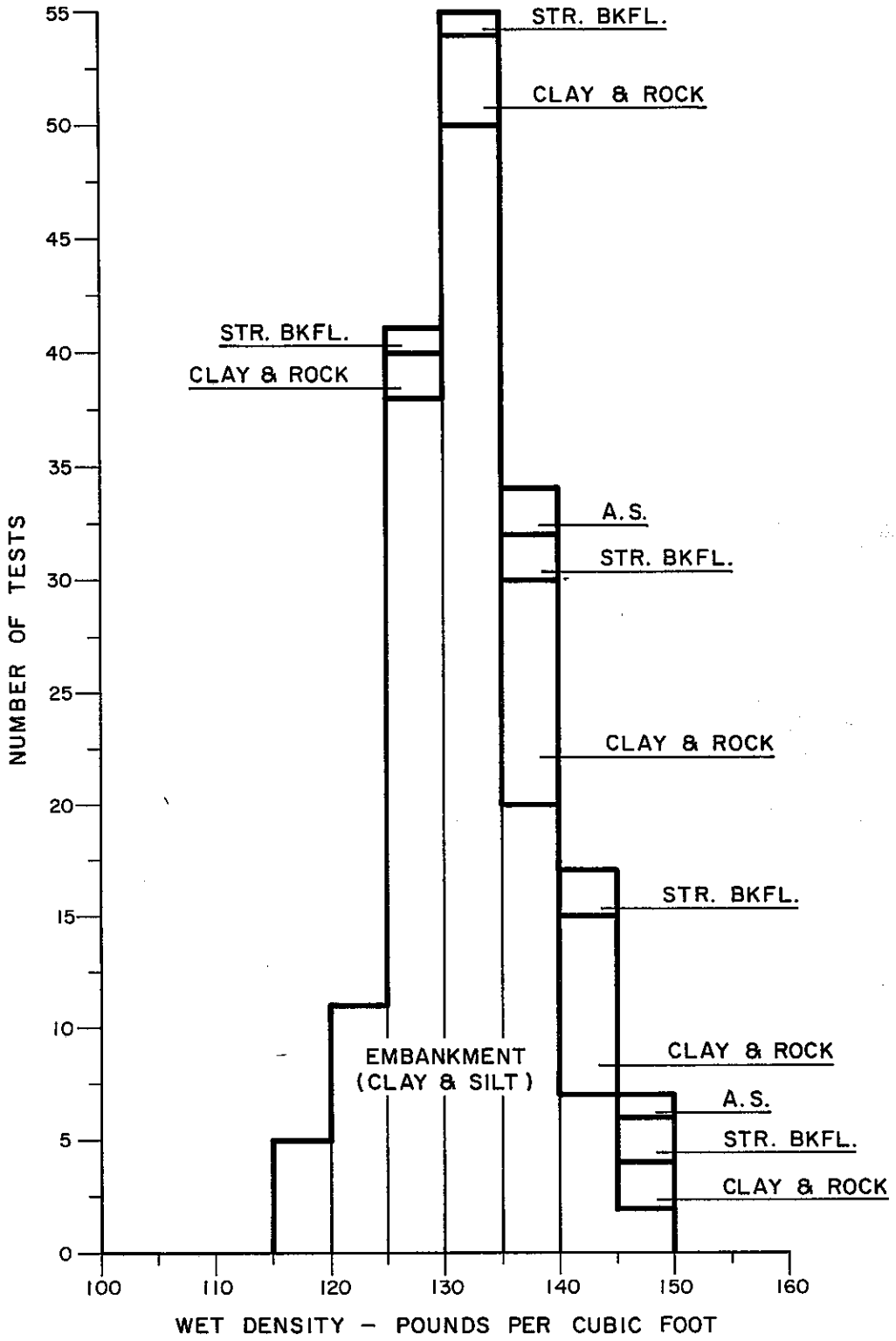

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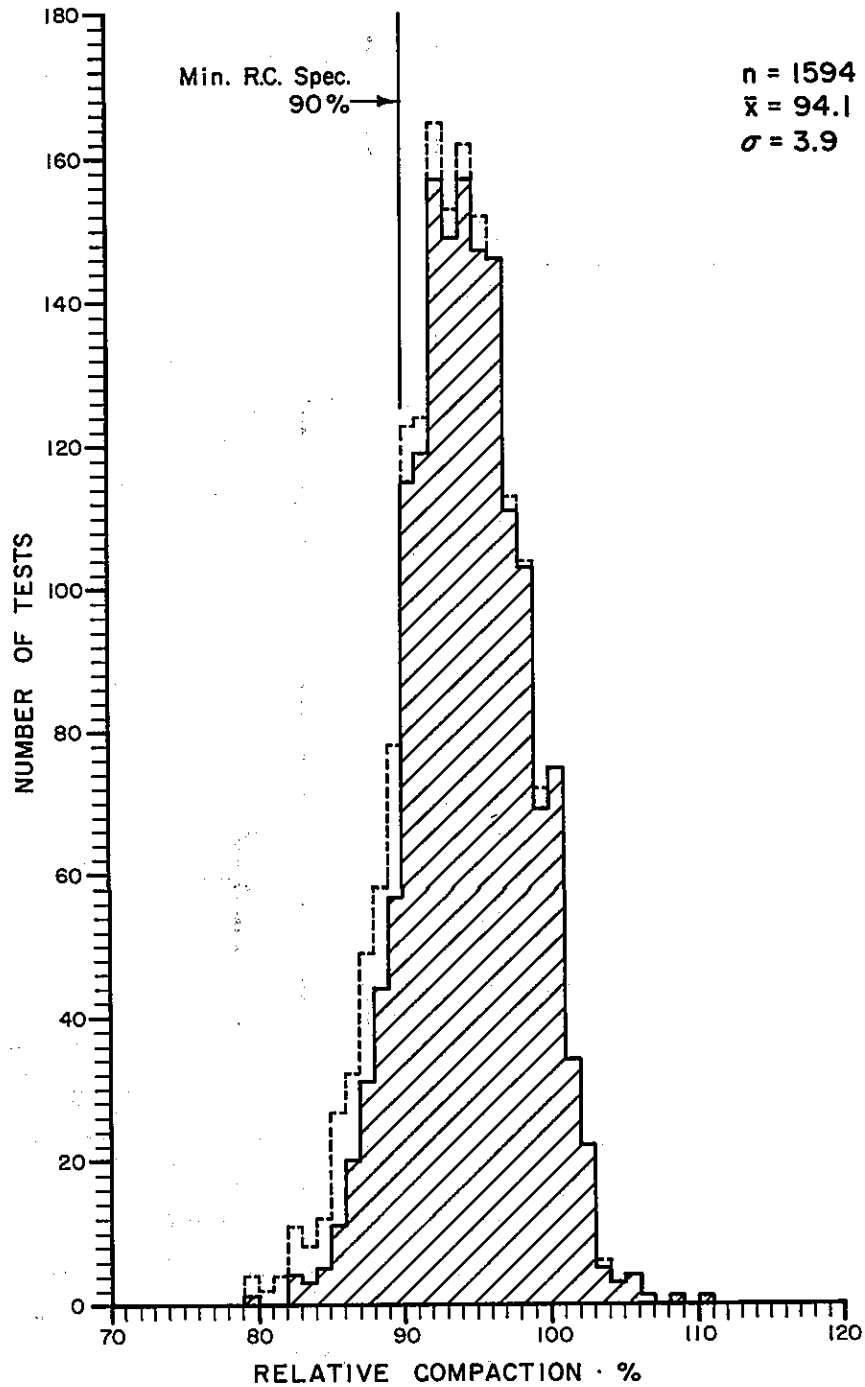
Figure 6

FREQUENCY DISTRIBUTION OF RELATIVE COMPACTIONS AT INDIVIDUAL TEST SITES

EMBANKMENT



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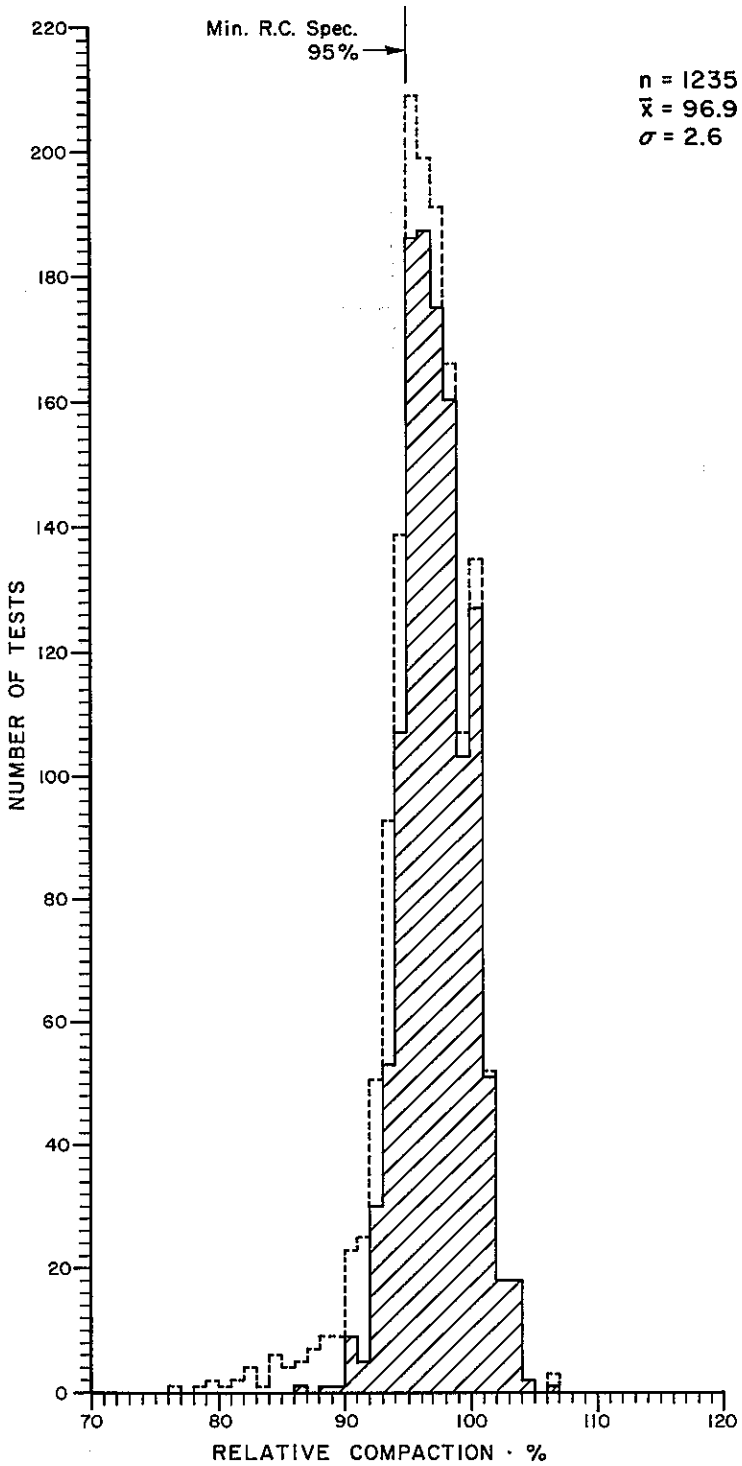
FREQUENCY DISTRIBUTION OF RELATIVE COMPACTIONS AT INDIVIDUAL TEST SITES

STRUCTURE BACKFILL OG, AS, & AB

1235 TESTS FROM PASSING AREAS
248 TESTS FROM FAILING AREAS
1483 TOTAL



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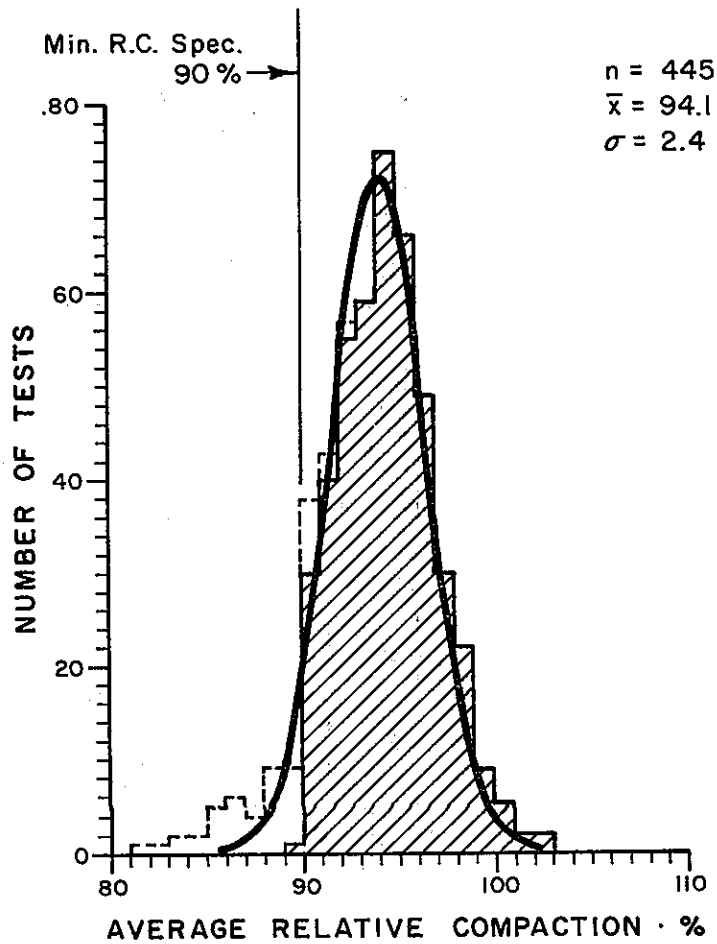
FREQUENCY DISTRIBUTION OF AVERAGE RELATIVE COMPACTIONS FOR AREAS

EMBANKMENT

▨ 445 AREAS – AVERAGE VALUES, PASSING AREAS
[ ] 51 AREAS – AVERAGE VALUES, FAILING AREAS



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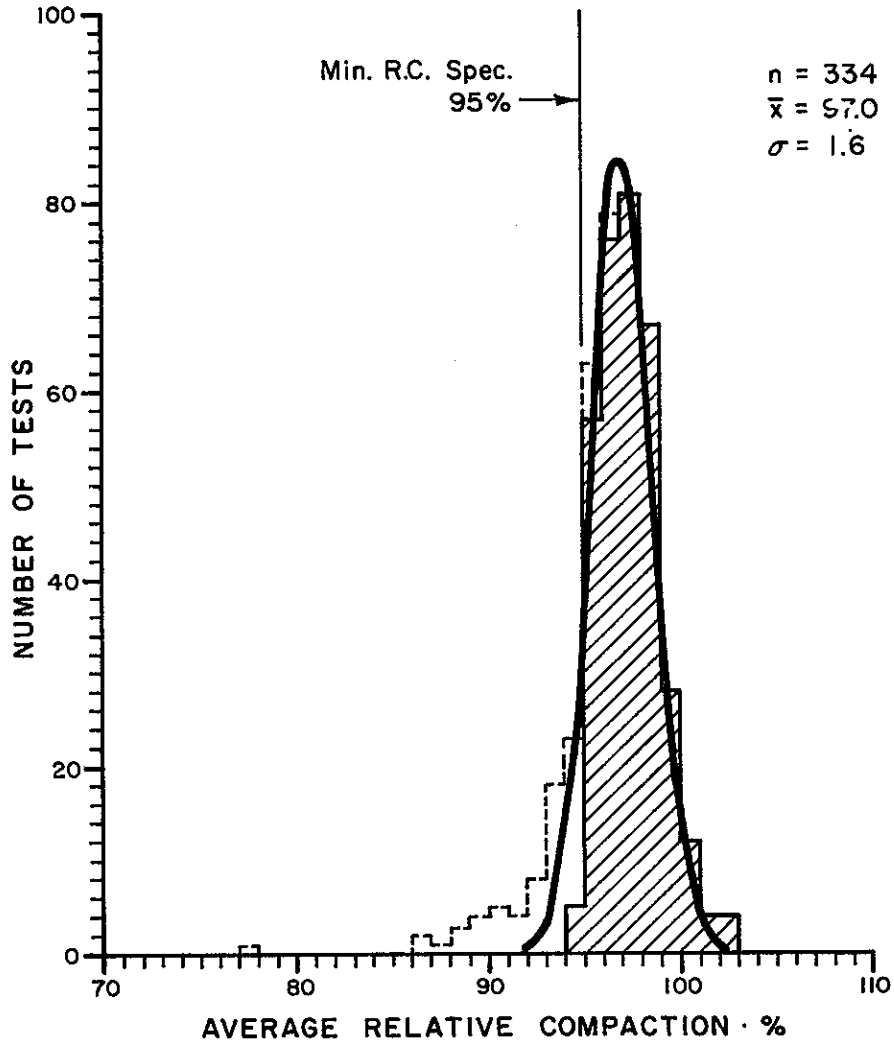
FREQUENCY DISTRIBUTION OF AVERAGE RELATIVE COMPACTIONS FOR AREAS

STRUCTURE BACKFILL, OG, AS, & AB

▨ 334 AREAS – AVERAGE VALUES, PASSING AREAS
⬚ 73 AREAS – AVERAGE VALUES, FAILING AREAS



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EMBANKMENT

AREAS WHICH FAILED TO MEET 90% MINIMUM REQUIRMENTS

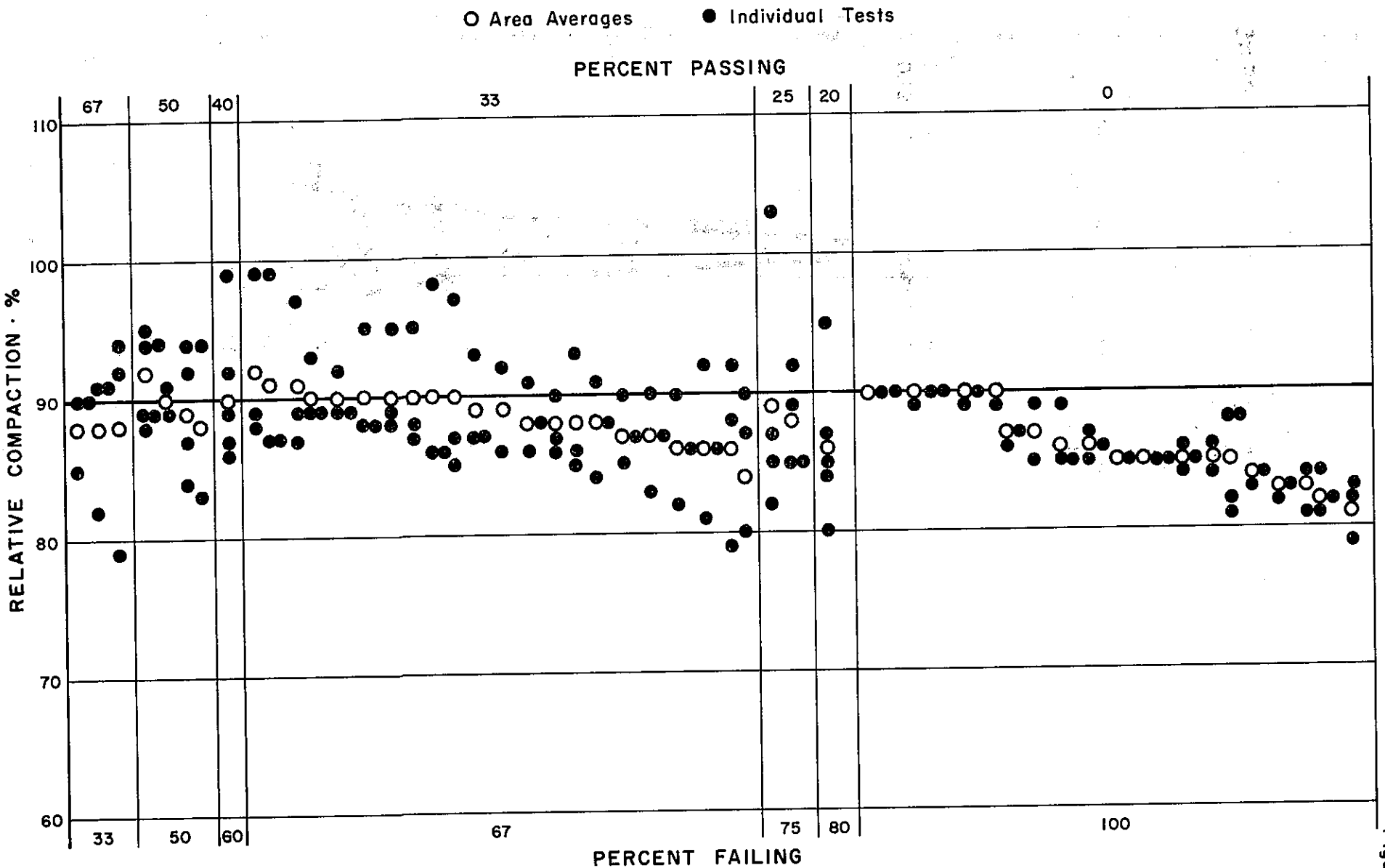

Figure 10

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STRUCTURE BACKFILL OG, SB, AB, & CTB

AREAS WHICH FAILED TO MEET 95% MINIMUM REQUIREMENTS

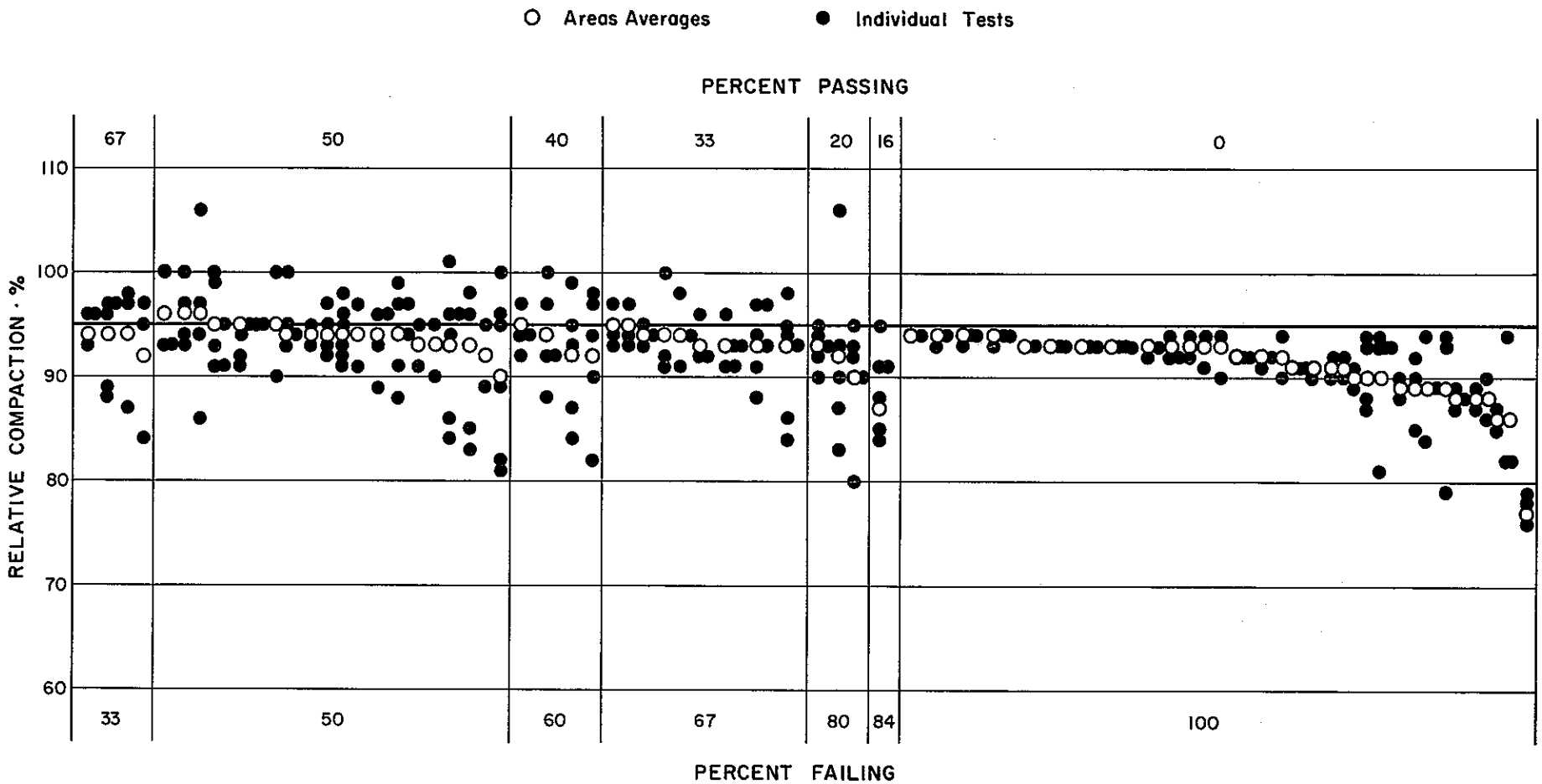

Figure 11

APPENDIX A

Assistant Resident Engineer's Final Report
Nuclear Compaction Testing
10-Sta-5 5.9/15.1
10-080614
I-005-5(21)424

Personnel

At the beginning of the project, we had two trained operators. Due to a back injury to one operator and the fact that the Contractor used two shifts per day on the grading operations, it was necessary to have more men trained to operate the nuclear gauge. Three additional personnel received training and were used to operate the gauge at various times throughout the project. I operated the gauge myself during the times no one else was available.

Materials

The soils on the project varied from light silty sands, through sandy gravel, to red clay and black adobe. Consequently, there was a large variation in the maximum density of the various materials. Most of the cuts contained several of the above mentioned different types of soil, and there was no consistent pattern in the way the material was situated in the cuts or the amount of any one material in a cut.

Compaction Methods

The Contractor used a sheepsfoot compactor behind a D-8 Cat. tractor and a Waggoner compactor on the fill areas. A Bros rubber-tired roller and a steel roller were also used to make finished subgrade and to compact the aggregate subbase and aggregate base.

Equipment

The nuclear gauge assigned to this project was a Troxler Nuclear Soil Gage, Model 276 C. Testing with this equipment can be done either by the direct transmission method, or by the backscatter method. Both systems were utilized on this project. Compaction test readings on embankment material and finished subgrade were obtained by direct transmission. Compaction tests on the aggregate base material were performed by the back-scatter method.

Both a Nuclear-Chicago Density Probe and a Hidrodensimeter Nuclear Gage were used on the project for brief periods while the Troxler Nuclear Soil Gage was broken down. These gauges were loaned to us by Materials & Research.

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An International Carryall was used to transport the equipment, including the generator needed to provide power necessary for drilling holes in the embankment material for the probe rod. This generator was connected to the carryall's battery and fuel tank, and was equipped with a self starter. The carryall was very satisfactory for housing and transporting the equipment. The only difficulty with it was that it became stuck several times even though it was equipped with "positraction" drive. A four-wheel drive vehicle would probable be better for the conditions under which it is necessary to operate the vehicle.

Breakdowns

1. Automatic Timer - The automatic timer in the scaler stopped functioning four different times (7-23-65, 9-3-65, 10-12-65, & 10-21-65) within the first 3 months the scaler was in use. On the first two occasions, the manufacturer's representative sent a loan scaler for our use while he repaired the timer. On the third occasion Materials and Research personnel repaired the timer; and Materials and Research personnel replaced the entire automatic timing unit when it malfunctioned the fourth time. After this replacement, we had no further trouble with the timer. Although the problem with the timer was annoying, it wasn't necessary to halt testing operations because a stop watch can be used to time the test count with only a small loss in accuracy.

2. Preamp and Pickup Tube - While running a standard density count with the nuclear gauge approximately three weeks after it had arrived at the project site, the operator found that the standard count kept varying. He then tried to run a plateau curve, and could not get consistent readings. Materials and Research was notified, and made arrangements with the Troxler Co. in North Carolina to have the gauge shipped there for checking and repair. The Troxler Co. finally decided that the Preamp and Pickup Tube were faulty, and these were replaced. However, it took them three weeks (8-5-65 to 8-30-65) to discover the trouble, repair it, and return the equipment to the project. Fortunately the Contractor had not yet started his construction operations at this time, and the gauge was only being used to obtain density curves for the materials present at the project site.

3. Transistor in Preamp Tube - The scaler stopped functioning during compaction tests on 9-23-65. Arrangements were made with the manufacturer's representative in Los Angeles to ship the equipment there for repair. It was determined that there was a defective transistor in the preamp. Repairs were made, and the nuclear gauge was returned to the project on 9-29-65. M & R loaned us a Nuclear-Chicago gauge to use while the Troxler gauge was being repaired.

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4. PS 400 Module - On 3-18-66 (Friday), the operator reported that the scaler voltage wouldn't go above 425, and that the scaler wouldn't record count. The gauge was taken to M & R in Sacramento where M & R personnel cleaned it out and checked it. After blowing the dust out of the scaler, the gauge appeared to be operating normally, so it was returned to Patterson. When the operator tried to use it on Monday (3-21-66) morning, the scaler again wouldn't record count and the voltage wouldn't go above 500. The gauge was returned to M & R and at this time it was determined that the PS 400 Module was bad. It took 4 days to obtain a replacement part and return the equipment to the project site.

5. DS 400 Tube - When the operator started to use the gauge on 5-10-66, he discovered that the scaler was recording counts 3 to 4 times faster than normal. Also, the scaler wouldn't stop recording count at the end of the 1 minute timed period, and the reset button wouldn't set the counter tubes back to zero. The equipment was taken to M & R in Sacramento for repair. M & R personnel checked the scaler and found that the DS 400 tube was bad. As they had no replacement tube on hand, it was necessary to order this part from the Troxler Laboratories in North Carolina. It was 6-1-66 before the tube was obtained and the gauge returned to Patterson. From 5-10-66 to 5-23-66, compaction tests on the project were taken by the sand volume method. On 5-23-66, M & R brought a Hidrodensimeter nuclear gauge to the project which we used until the Troxler gauge was reapired and returned.

6. Unit Count Tube - During afternoon of 6-13-66, the unit digit counter on the scaler quit operating. It would record to the number 2 and then stop, along with all other count tubes. The equipment was taken to M & R in Sacramento for checking. It was discovered that the Unit Digit Counter (CK6909) was burned out. They had another one on hand, so the replacement was made, and the equipment was back on the job site ready for use on the morning of 6-14-66.

7. Cable - A small wire in the cable that connects the scaler to the gauge broke on 4 different occasions. M & R had a spare cable that they loaned us whenever the regular cable had to be repaired, so down time due to the wire breaking was confined to the time it took to get the "loaner" cable from Sacramento -- usually about 1/2 day.

8. Probe Rod Stuck - The probe rod became stuck several times with the source end of the rod outside the gauge. On one occasion it became stuck due to a burr on the rod that developed when the rod was rotated in the test hole and rubbed against a rock. The other occasions were caused by fine material being drawn into the gauge by the rod and binding it up.

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Problems

In embankment areas where the different soil type were mixed in varying proportions due to the blending action of the earth moving equipment in loading and unloading, it was practically impossible to identify the maximum density of the material with any accuracy without pounding out a maximum density curve. Also, if the test area consisted of six individual sites, there could very well be six different maximum densities that might not even be particularly close to each other. It was therefore necessary to run a large number of maximum density cores in order to determine the relative compaction.

We could get no correlation between moisture readings obtained by the nuclear gauge and the results calculated from oven dried samples. Sometimes the nuclear results would be higher than those obtained by Test Method 226-C, sometimes the same, and sometimes lower. Some of the differences were quite large. This problem was discussed with M & R, and it was their opinion that the erratic results obtained with the nuclear gauge were due to the gypsum content of the soil in the project locality. They said there was no known correction that would alleviate this situation. It was therefore necessary to run all compaction tests on a wet-to-wet basis because we had no accurate way to determine the moisture content at the test site without oven drying the material. The time involved to oven dry would have cancelled any time advantage inherent in the nuclear test method.

Another problem was the frequent breakdown of the nuclear equipment (detailed previously), and the resultant necessity of having to take compaction tests by sand volume until our gauge was repaired or a loaner could be obtained from M & R in Sacramento. The "loaner" gauges presented some problem themselves in that it was necessary to check out the density curves and sometimes plot new ones due to the difference in gauges before these "loaner" gauges could be used.

Weaknesses in Test Method

1. Area Size

In testing structure backfill, most locations aren't large enough to justify six sites for one test. I don't believe it is a good idea to take six individual locations, such as six different C.M.P.'s, call each one a site, and average the six as suggested at the M & R class. The average of the six could be above minimum due to a couple of high in-place-densities, and two-thirds of the sites could be above minimum, but one or two of the sites might still be failures by over a couple of percentage points due to insufficient effort, a different method of compaction, low moisture content, or a

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difference in material. If the areas aren't continuous, and compacted at the same time with the same effort at approximately the same moisture content, I don't think it is valid to average them together. Each individual structure location should be tested by itself, and one or two test sites at each location, depending on the area involved, should be sufficient to pass or fail it.

I also think that on short fill areas, a three site test should be adequate to accept or reject the embankment area.

2. Wet-to-Wet Method

It was decided that our compaction testing would be performed on a wet-to-wet basis because of the failure of the nuclear gauge to give accurate moisture contents, as described previously. When a wet-to-wet basis is used with the nuclear gauge, the operator is assuming that all test sites are at the same moisture content as the maximum density test core. If the maximum density core is obtained while the material is at optimum moisture content, and if the embankment material on which the in-place wet density is taken is at or within 1% of optimum, the resulting relative compaction result will be accurate. However, if the embankment material is not at the same moisture content as the optimum test core, the relative compaction could be in error. As it is unlikely that all test sites will be at the same moisture content as an optimum test core that was run on the material at some other time, I feel that this method introduces errors into the resulting relative compaction results. To obtain maximum accuracy the test should be run by the dry method -- that is, the weight of the water should be subtracted from the in-place density and the maximum density test core, and the relative compaction be calculated from the dry densities.

3. One Maximum Density for Each Six Site Test Location

According to the test procedure, a maximum density core is to be run with material from the nuclear test site which has the in-place density just below the average in-place density of all six sites combined. This maximum density is then used to compute the relative compaction of all six sites. While this one maximum density would probably give accurate relative compactions for all sites if the material is uniform and has only a small range in its maximum density, I don't believe it is accurate enough where the materials vary considerably as they did on this project. The alternative is to take a maximum density core at each site. If this were done, the increase in time would be such that it would be much faster to run a sand volume test instead of a six site nuclear test.

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4. Relative Compaction of C.T.B.

The maximum density value used to calculate the relative compaction of Classes A and B C.T.B. is the density obtained from the test specimen fabricated for compressive strength analysis of the C.T.B. The in-place density test is performed at the location where the test specimen sample was obtained to insure that the material being tested was placed at the same moisture content as the test specimen sample. Under the nuclear compaction testing method an in-place density is obtained not only at the original test specimen site, but also at five or more other sites in order to meet the "area concept" requirement of the nuclear test method. When these additional sites are also at the same moisture content as the test specimen sample, the resulting relative compaction results would be accurate. If, however, the moisture contents of these other sites vary appreciably and this fact isn't determined due to calculating relative compactions on a wet-to-wet basis, the relative compaction result could be in error. When the C.T.B. material is a plant mixed material, the control of the product is probably good enough that the moisture content variation wouldn't be sufficient to affect the relative compaction results. However, when the C.T.B. is road mixed as it was on this project, the moisture content varies quite a bit from one location to another. This variation could affect the relative compaction results of the sites that are being compared with a maximum test specimen density obtained at a different moisture content.

Contractor's Opinion of Nuclear Compaction Control Testing

The Contractor was very favorable to the taking of compaction tests with the nuclear soil gauge. I discussed the test procedure with several of the Contractor's personnel -- Project Superintendent, Grading Superintendent, Grading Foremen, etc., and all preferred the nuclear method over the sand volume method. The feature they like best was that in most cases an answer could be given right away if a new maximum density didn't need to be pounded out. They also like the fact that equipment could be worked relatively close to the test site while the testing was in progress, and that it wasn't necessary to stop the equipment at any time during the test procedure. They felt that there was a lot less interference with their operations under the nuclear testing, and that in most cases they got the results faster.

General Comments

1. Comparison of Nuclear Method & Sand Volume Method

Compaction testing by both the nuclear method and the sand volume method involve two distinct operations -- the determination of the in-place density of the material being tested, and the determination of the maximum density of the material.

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In determining the in-place density of an area, we found that a six site test can be run by the nuclear method in approximately the same length of time that a sand volume test can be run. Thus, there is six times the coverage of an area on one nuclear test than there is on the sand volume test, with the same amount of time expended.

There is no difference in the length of time needed to pound out a maximum density core for the two test methods because the same procedure is used in each case. However, M & R suggested that if the material from test to test was uniform and the maximum density only varied over a small range, it wouldn't be necessary to pound out a maximum density core for each test. An average value of the maximum density could be used on a series of tests as long as the material didn't change. While this certainly saves time, I don't believe that it should be considered as a savings of time for the nuclear method over the sand volume method. If it is legitimate to use the same maximum density for a series of nuclear compaction tests because the material is uniform, it ought to be permissible to apply the same criteria to the sand volume test. Thus the savings in time in each case would be the same.

2. Breakdown of Nuclear Gage

As detailed previously, we had a number of breakdowns with the nuclear gauge assigned to our project. Because of this, I think the following steps should be taken:

A. Have a sufficient number of gauges available so that a replacement can be obtained within ½ day. All of these gauges should be the same so that it isn't necessary to run a calibration curve each time a different gauge is used.

B. Have qualified repairmen and spare parts available in the District so that repairs can be made as soon as possible.

C. Have the special provisions for the project state that compaction tests can be taken by either the nuclear method or the sand volume method. This would prevent any delay in compaction testing and possible arguments with the Contractor if the nuclear gauge broke down and couldn't be repaired immediately.

3. Testing Method - Direct Transmission Versus Backscatter

I prefer the direct transmission method for testing embankment. By using the probe at a depth of from 8 to 10 inches the nuclear count reflects the density of the entire lift of material. Also, the site preparation and seating of the gauge for the test count isn't so critical with this method. Preparing a satisfactory test site for the backscatter method on the average roadway embankment can be quite time consuming.

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On compaction tests of the subbase and base layers of the structural section, I think the backscatter method is better. The structural layers are relatively thin, so the backscatter reading reflects the density of the layer adequately. Using the backscatter method on the layers of the structural section prevents the operator from sticking the probe rod past the bottom of the material being tested. The site preparation on a rolled subbase or base isn't the problem that it is on embankment material, because the base surface is rolled with steel rollers and is smooth. Therefore, the backscatter method in this case is faster.

Conclusion

I think that the nuclear method of taking compaction tests is generally faster than the sand volume method, especially when the materials are uniform. The test coverage is also greater.

However, I think that some discretion must be used in applying the method and interpreting the results. Types of material should be watched closely for changes so that an in-place density isn't compared with a maximum density core of a different material. Unless the operator is sure that the test site material is at the same moisture content as the maximum density core, the in-place density and maximum density should be converted to dry densities to insure that differences in moisture content don't affect the relative compaction result. Above all, this test shouldn't be interpreted by the operator as a "quick" compaction testing method that is infallible. He must be aware of why the test is run like it is, how changes of material and moisture can affect the validity of the compaction results, and what steps should be taken to correct errors that are caused by changed conditions.

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