HIGHWAY RESEARCH REPORT

COMPACTION OF THICK LIFT ASPHALT CONCRETE PAVEMENTS

INTERIM REPORT

68-30

STATE OF CALIFORNIA

TRANSPORTATION AGENCY

DEPARTMENT OF PUBLIC WORKS

DIVISION OF HIGHWAYS

MATERIALS AND RESEARCH DEPARTMENT

RESEARCH REPORT

NO. M & R 633294

Prepared in Cooperation with the U.S. Department of Transportation, Bureau of Public Roads December, 1968

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STATE OF CALIFORNIA—TRANSPORTATION AGENCY

RONALD REAGAN, *Governor*

DEPARTMENT OF PUBLIC WORKS
DIVISION OF HIGHWAYS
MATERIALS AND RESEARCH DEPARTMENT
5900 FOLSOM BLVD., SACRAMENTO 95819

December 1968
Interim Report
M & R No. 633294

Mr. J. A. Legarra
State Highway Engineer

Dear Sir:

Submitted herewith is a research report entitled:

COMPACTION OF THICK LIFT

ASPHALT CONCRETE PAVEMENTS

ERNEST ZUBE
Principal Investigator

JOHN SKOG AND JAMES CECHETINI
Co-Investigators

Very truly yours,

JOHN L. BEATON
Materials and Research Engineer

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REFERENCE: Zube, E., Skog, J. B. and Cechetini, J. A., "Compaction of Thick Lift Asphalt Concrete Pavements", State of California, Department of Public Works, Division of Highways, Materials and Research Department, Research Report 633294, December 1968.

ABSTRACT: Various methods of compaction were analyzed on eight different asphalt concrete projects in which experimental thick lift compaction was used. The compacted thicknesses of the AC experimental sections ranged from 0.25 to 0.40 foot and were spread and compacted in one lift. The compaction equipment consisted of 9 to 16 ton pneumatic rollers, 8 to 16 ton steel wheeled rollers with either two or three axles, an eight ton tandem vibratory roller, a self-propelled vibratory plate compactor and a 4.5 ton vibratory plate which was attached to the paver.

The main conclusions were: (1) California AC mixes can be readily compacted in single compacted thicknesses of up to 0.40 foot with conventional compaction equipment. (2) It is necessary to use a conventional thinner surface course over the thick lift bases in order to provide a riding surface of satisfactory smoothness. (3) Contrary to the findings of others, we found no particular advantage in using a heavy pneumatic compactor for breakdown rolling. (4) A 4.5 ton vibratory plate attached to a paving machine was quite effective in producing initial compaction of the mix and made it much easier to achieve adequate compaction with subsequent rolling. (5) An eight ton tandem vibratory roller was more effective than any of the pneumatic or steel wheeled rollers in compacting the AC to the specified density.

KEY WORDS: Asphalt concrete, asphalt pavement, compaction, pneumatic rollers, vibratory roller, vibratory compaction, rolling equipment, compactors, lift thickness, nuclear applications, density, pavement smoothness.

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ACKNOWLEDGMENTS

The authors wish to express their appreciation to the construction personnel of the various Districts of the State of California for their cooperation in obtaining the data for this investigation.

This is an interim report of a research project to study the effect of "thick lift" compaction on the density of asphalt concrete pavements. This work was done in cooperation with the U. S. Department of Transportation, Federal Highway Administration, Bureau of Public Roads (Federal Program No. HPR-1(5), D-05-26). 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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INTRODUCTION

During the past few years, several papers[1,2&3*] have been presented on the use of "thick lifts" in the construction of asphalt concrete (AC) pavements. The results of this work have indicated that compaction is more easily performed on thicker lifts since the mix remains at a higher temperature for a longer period of time when greater thicknesses are used. Therefore, a greater amount of compactive effort can be applied before the mix cools to the point at which additional compaction provides little benefit. Although these reports indicate the riding quality of a conventionally placed surface course placed over a thick lift base course is adequate, very little is said about the riding quality of the thick lift surface itself. These reports also indicated that heavy pneumatic rollers were quite effective in the "breakdown rolling" position.

This study was initiated to see if these findings are applicable to the types of AC mixes used in California and to gain more information on the surface roughness of AC compacted in a single thick lift.

Various rolling patterns have been studied on eight different projects located throughout the State. The compactors used on these projects consisted of 9 to 16 ton pneumatics, 8 to 16 ton steel wheeled rollers with either two or three axles, an eight ton tandem vibratory compactor and, on one project, a self-propelled vibratory plate compactor was used. Also, a 4.5 ton vibratory plate attachment to the paver was used for preliminary compaction on one of the projects. Single compacted thicknesses of 0.25 to 0.40 foot were analyzed. Density measurements were made after each application of compactive effort with a back-scatter nuclear gage.[4] Thermocouples were imbedded in the AC pavement and the temperature of the AC was continuously recorded throughout the entire rolling operation. A record of the air temperature was also kept throughout the rolling operation. A street sample of each mix was compacted in the California kneading compactor in accordance with Test Method No. Calif. 304-E. The density obtained from these laboratory compacted samples was used to calculate relative compaction values. Water permeability tests were performed at 25 foot intervals on most of the test sections

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*Superscripts refer to references at the end of this report.

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in accordance with Test Method No. Calif. 341-A. After each test section was completed, the profile of each thick lift base course was measured with the California profilograph and the profile index was calculated in accordance with Test Method No. Calif. 526-D. To provide a reference scale for this value, it might be well to mention a profile index of seven inches per mile is the maximum allowed for a new PCC pavement built in California.

CONCLUSIONS

From results compiled to date on thick life construction of AC pavements, it is concluded that:

Thick Lifts

1. Thick lift pavement can be constructed without sacrificing density.

2. We have not found any construction procedure that will alleviate the problem of roughness in thick lift pavements. It appears necessary to use a thin surface course to smooth out the irregularities of the thick lift pavements.

3. We did not find any advantage in using a pneumatic roller in the breakdown position. The disadvantage of using the pneumatic for breakdown rolling is that it cannot compact within 10 inches of the edge of pavement.

Pavers

1. A paving machine using a 4.5 ton experimental vibratory plate attachment produced an initial density of about 10 PCF more than a paver without the attachment.

2. The average relative compaction obtained by the vibratory plate attachment was 86%.

3. The vibratory plate attachment reduced the water permeability of the AC pavement.

Breakdown Rolling

1. In order for the completed pavement to have a relative compaction of 95% or more, it is necessary to attain a relative compaction of 90% or more immediately after the completion of breakdown rolling.

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Intermediate Rolling

1. The number of passes made by a nine ton pneumatic roller had little or no significant effect on the maximum density, but did decrease the permeability.

2. If the pavement was not sufficiently compacted prior to rolling with the pneumatic roller, the pneumatic tended to slightly decompact the top portion of the pavement.

3. Pneumatic rollers can be used for the intermediate rolling without "pick-up" providing the mat is over 200°F, and the tires are hot.

Vibratory Rolling

1. A higher pavement density was generally obtained on both thick lift and normal AC construction after two or three passes of an eight ton vibratory roller than is generally obtained by our normal rolling procedure.

2. Vibratory compaction appears to make the pavement less pervious to water in a manner similar to that of a pneumatic roller.

RECOMMENDATIONS

1. More projects should be designed for the base and/or level courses to be compacted as a single lift. A maximum compacted thickness of 0.40 foot should be maintained until more experience is gained with this method of construction.

2. Greater use of vibratory compaction should be encouraged. This recommendation stands for both vibratory plates and vibratory rollers.

DISCUSSION

The basic data from all eight projects is shown in Table 1. Although there are a number of cases in which our minimum relative compaction requirement of 95 percent was not reached, it is apparent from this data that this requirement can be met with a reasonable amount of compactive effort on single compacted thicknesses of as much as 0.40 foot.

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For this report, a pass in coverage of a compactor is defined as a forward and backward movement, both of which are in the same path.

The profile index values shown in Table 1 are all well above the seven inches per mile which is presently specified for new PCC construction in California. This indicates that none of the rolling patterns used on these thick lifts could produce an adequately smooth riding surface. It appears, therefore, to be necessary to use a thin surface course to iron out the surface irregularities inherent in thick lift compaction.

Contrary to the findings of other researchers[1,2&3], the data presented in Table 1 indicates there is no particular advantage to using pneumatic compaction for breakdown rolling of compacted thicknesses of up to 0.40 foot. Figures 1 and 2 show the effect of 16 ton "air-on-the-run" pneumatic rollers used in the breakdown position. Very little improvement in density is shown after the first pass of the pneumatic compactor. A very significant increase in density is obtained by a single finish pass of an eight ton tandem steel wheeled roller, however. The compaction of the test section shown in Figure 2 was to have been accomplished with only the 16 ton pneumatic roller, but the spray bar broke on its second pass and a nine ton pneumatic was substituted for three passes while the 16 ton roller was repaired. A final pass with the eight ton tandem roller was necessary to iron out the wheel tracks left by the pneumatic roller.

One major objection to the use of a pneumatic roller for breakdown rolling is that it cannot come any closer than 10 inches from the edge of the mat without breaking it down and a steel roller will have to be used for the edge compaction.

Figure 3 shows the results of our normal rolling sequence and is typical of the results of most other tests using the same roller sequence, in that the pneumatic roller shows only a minor improvement in density. This data was obtained after a 4.5 ton vibratory plate, which was attached to the paver (Figure 4), had supplied considerable initial compaction and that is why the breakdown rolling by the 12 ton tandem roller caused only a minor increase in density. The vibratory plate attachment appears to provide considerable initial compaction and allows a final relative compaction of 95 percent or more to be more easily obtained. It also appears to lower the water permeability of the mix (see the fourth project listed in Table I).

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Table 2 shows the effect of the number of breakdown passes of the various types of compactors on the final relative compaction achieved. This data is from projects compacted in both thick and normal lifts and shows:

1. Those pavements receiving one breakdown pass had an average final relative compaction of 91.3 percent with a range of 88.0 to 96.0 percent.

2. Those receiving two breakdown passes had an average final relative compaction of 92.9 percent with a range of 87.7 to 97.0 percent.

3. Those receiving three or more breakdown passes had an average final relative compaction of 94.4 percent with a range of 91.0 to 98.9 percent.

It is interesting to note that this relation developed in spite of any compactive effort which was applied subsequent to the breakdown rolling.

On the first test section on Road 07-LA-5-R65.5/70.9, a self-propelled vibratory plate compactor was used for the first time on a State contract (see Figure 5). It was used immediately behind the paver, but its use had to be discontinued before it had traveled 100 feet because the mix was sticking to the plates and this caused it to leave grooves about one inch deep in the surface of the mat. After an intermediate pass with a 12 ton tandem roller, the self-propelled vibratory plate compactor was again tried, but the mix continued to stick to the plates and its use had to be discontinued. The mix stuck to the vibratory plates because the unit had no means for heating the plates. The vibratory plate paver attachment which was previously mentioned, had a means of heating the plate, and consequently, the mix did not stick to it.

An eight ton tandem vibratory roller was a very effective means of compacting AC. In every case shown in Tables 1 and 2, in which the vibratory roller was used, a minimum final relative compaction of 92 percent was achieved and in eight of thirteen test sections, it produced 95 percent or greater final relative compaction. Compared to the other rollers studied, this appears to be exceptionally good compaction.

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TABLE 1

COMPACTION STUDY RESULTS

Project District County Route No. Post Miles	Test Section Number	Rolling Sequence	Type of Compactor	Number of Passes	Temp(°F) AC	Temp(°F) Air	Density PCF	% Rel. Comp.	Permeability 1 Hr.	Permeability 4 Day	Compacted Thickness Feet	Profile Index In./Mi.
07	1	Breakdown	12 T. Tandem	2	275	80	133	88				
		Intermediate	9 T. Pneumatic	2	260	to	133	88				
Ora		Finish	12 T. Tandem	1	250	90	137	91	136	81	0.33	37
405	2	Breakdown	12 T. Tandem	3	260	80	134	89				
		Intermediate	16 T., 3 Axle Tandem	3	255	to	141	94				
11.2/14.4		Finish	12 T. Tandem	1	250	90	139	93	312	110	0.33	14.5
	3	Breakdown	16 T. Pneumatic	1	265	80	120	80				
			9 T. Pneumatic	3	265	to	121	80				
			16 T. Pneumatic	5	260	90	128	85				
		Intermediate	None	0	---	--	---	--				
		Finish	8 T. Tandem	1	200		138	92	137	83	0.33	
									24 Hr.			
10	1	Breakdown	12 T. Tandem	1	290	84	132	92				
		Intermediate	9 T. Pneumatic	1	285	to	132	92				
Mer		Finish	8 T. Tandem	1/2	275	87	139	97	91	0	0.40	27±
152	2	Breakdown	12 T. Tandem	1	275	77	128	88				
		Intermediate	9 T. Pneumatic	4	270	to	125	87				
15.4/19.4		Finish	8 T. Tandem	1/2	245	83	131	91	80		0.40	27±
	3	Breakdown	12 T. Tandem	1	265	72	133	92				
		Intermediate	9 T. Pneumatic	6	245	to	134	93				
		Final	8 T. Tandem	1/2	215	81	137	95	133		0.40	27±

TABLE 1 (CON'T)

Project District County Route No. Post Miles	Test Section Number	Rolling Sequence	Type of Compactor	Number of Passes	Temp(°F) AC	Temp(°F) Air	Density PCF	% Rel. Comp.	Permeability ML/Min. 24 Hrs.	Compacted Thickness Feet	Profile Index In./Mi.
07	1	Breakdown	Plate Vibrator	1/2	250	77	119	82			
		Intermediate	12 T. Tandem	1	220	to	128	88			
LA		Finish	Plate Vibrator	1/2	160	86	127	88	220	0.30	
5	2	Breakdown	8 T. Vibratory	3	260	86	132	91			
		Intermediate	None	0	---	to	---	--			
R65.5/		Finish	None	0	---	94	---	--	309	0.30	
R70.9	3	Breakdown	12 T. Tandem	1/2	---	94+	---	--			
		Intermediate	9 T. Pneumatic	1-1/2	---	--	127	88			
		Finish	None	0	---	--	---	--	496	0.15	
	4	Breakdown	12 T. Tandem	3	230	--	134	91			
		Intermediate	9 T. Pneumatic	3	110	?	132	90			
		Finish	8 T. Tandem	1	105	--	130	88	307	0.15	
07	1	Behind Paver	None	0	---	--	118	80			
		Breakdown	12 T. Tandem	1	290	72	130	88			
LA		Intermediate	9 T. Pneumatic	3	290	to	120	81			
		Finish	8 T. Tandem	1	285	74	133	90	377	0.33	17
170	2	Behind Paver	Vibratory Plate	1/2	---	--	132	89			
R18.0/		Breakdown	12 T. Tandem	1	320	52	133	90			
		Intermediate	9 T. Pneumatic	3	310	to	134	91			
R20.6		Finish	8 T. Tandem	1	270	54	141	95	55	0.33	35
	3	Behind Paver	Vibratory Plate	1/2	---	--	125	84			
		Breakdown	16 T. 3 Axle Tandem	2	270	70	130	88			
		Intermediate	None	0	---	to	---	--			
		Finish	8 T. Tandem	1	260	72	135	92	162	0.33	36
	4	Behind Paver	Vibratory Plate	1/2	---	--	127	86			
		Breakdown	8 T. Tandem Vibration	2	290	58	144	97			
		Intermediate	None	0	---	to	---	--			
		Finish	None	0	---	60	---	--	124	0.33	24

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TABLE 1 (CON'T)

Project District County Route No. Post Miles	Test Section Number	Rolling Sequence	Type of Compactor	Number of Passes	Temp(°F) AC	Temp(°F) Air	Density PCF	% Rel. Comp.	Permeability ML/Min. 24 Hrs.	Compacted Thickness Feet	Profile Index In./Mi.
07-LA 170 R18.0/ R20.6	5	Behind Paver	None	0	---	--	115	78			
		Breakdown	8 T. Tandem Vibratory	3	330	76	133	93			
		Intermediate	None	0	---	--	---	--			
		Finish	None	0	---	--	---	--	245	0.33	15
01-Men 101 77.7/ 78.1	1	Breakdown	16 T. Pneumatic	3	310	76	124	86			
		Intermediate	None	0	---	--	---	--			
		Finish	8 T. Tandem	1	300	85	132	93	637	0.40	
	2	Breakdown	8 T. Tandem	4	300	67	137	96			
		Intermediate	16 T. Pneumatic	3	290	to	133	93			
		Finish	8 T. Tandem	3	280	72	142	99	388	0.40	
11 Imp 8 R36.6/ R41.4	1	Breakdown	12 T. Tandem	1	250	69	132	88			
		Intermediate	9 T. Pneumatic	3	240	to	134	90			
		Finish	8 T. Tandem	1	195	70	138	92		0.25	
	2	Breakdown	12 T. Tandem	2	255	78	139	93			
		Intermediate	9 T. Pneumatic	3	215	to	139	93			
		Finish	8 T. Tandem	1	180	86	136	91		0.25	
	3	Breakdown	12 T. Tandem	3	255	77	139	93			
		Intermediate	9 T. Pneumatic	3	220	to	144	96			
		Finish	8 T. Vibratory	1	205	82	145	97		0.25	
	4	Breakdown	8 T. Tandem	1	250	68	135	90			
		Intermediate	8 T. Vibratory	3	220	to	143	96			
		Finish	None	0	---	70	---	--		0.25	
	5	Breakdown	8 T. Vibratory	2	265	69	140	94			
		Intermediate	9 T. Pneumatic	3	220	to	140	94			
		Finish	12 T. Tandem	1	190	75	142	95		0.25	
	6	Breakdown	8 T. Vibratory	3	240	63	140	94			
		Intermediate	9 T. Pneumatic	3	185	to	139	93			
		Finish	8 T. Vibratory	1	120	67	142	95		0.25	

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TABLE 1 (CON'T)

Project District County Route No. Post Miles	Test Section Number	Rolling Sequence	Type of Compactor	Number of Passes	Temp (°F) AC	Temp (°F) Air	Density PCF	% Rel. Comp.	Permeability ML/Min. 24 Hrs.	Compacted Thickness Feet	Profile Index In./Mi.
11-Imp 8 R36.6/ R41.4	7	Breakdown	8 T. Tandem	2	240	74	139	93			
		Intermediate	9 T. Pneumatic	3	225	to	141	94			
		Finish	8 T. Vibratory	1	190	84	140	94		0.25	
11 SD, Ora 5 R62.5/ 0.2	1	Behind Paver	None	0	---	--	118	80			
		Breakdown	12 T. Tandem	3	215	63	130	88			
		Intermediate	9 T. Pneumatic	2	190	to	133	90			
		Finish	8 T. Tandem	2	170	64	135	91	162	0.33	43
	2	Behind Paver	Vibratory Plate	1/2	---	--	127	86			
		Breakdown	12 T. Tandem	4	255	55	135	91			
		Intermediate	None	0	---	to	---	--			
		Finish	None	0	215	57	---	--	110	0.33	26
	3	Behind Paver	Vibratory Plate	1/2	---	--	129	87			
		Breakdown	12 T. Tandem	4	250	59	140	95			
		Intermediate	None	0	---	to	---	--			
		Finish	None	0	210	62	---	--	177	0.33	43
	4	Behind Paver	Vibratory Plate	1/2	---	--	124	84			
		Breakdown	12 T. Tandem	4	225	60	136	92			
		Intermediate	None	0	---	to	---	--			
		Finish	None	0	175	62	---	--	118	0.33	62
03 But 99 29.7/ 38.3	1	Breakdown	12 T. Tandem	1	---	--	---	--			
		Intermediate	12 T. Pneumatic	3	---	--	---	--			
		Finish	8 T. Tandem	1	---	--	140	93	352	0.125	
	2	Breakdown	12 T. Pneumatic	4	260	--	132	87			
		Intermediate	12 T. Tandem	2	200	--	139	92			
		Finish	8 T. Tandem	1	175	--	139	92	490	0.25	

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TABLE 2

COMPACTION STUDY RESULTS

Type Compaction	Field Max. Density(PCF)	Lab. Max. Density(PCF)	Rel. Comp.(%)	Temperature (°F) Start	End	Dist-Co-Rte
1b[×]-5p[××]-1f[×××]	137.1	151.6	90.4	200	140	03-Gle-5
1b-4p-1f	142	156	91.1	255	135	04-CC-4
1b-3p-1f	127	139.8	91	243	162	05-SB-1
1b-3p-1f	134.7	150.5	89.5	240	165	07-Ora-405
1b-2p-1f	137.2	150.5	91.3	268	238	07-Ora-405
1b-3p-1f	127	145	88	230	105	07-LA-05
1b-3p-1f	133	147.3	90	300	185	08-Riv-10
1b-3p-1f	132.8	148.5	89.5	200	165	11-Riv-10
1b-3p-1f	133.4	145.4	92	231	195	11-Imp-8
1b(8T.Tandem)-3p-1f	137	146.6	93	275	150	11-SD-8
1b(8T.Tandem)-3p-1f	137	146.6	93	290	167	11-SD-8
1b-3p-1f	140	146.6	96	286	227	11-SD-8
1b-3p-1f(8T.Vib.)	138	149.8	92	250	188	11-Imp-111
1b-1p-1/2f	139	144	97	280	260	10-Mer-152
1b-4p-1/2f	131	144	91	275	240	10-Mer-152
1b-6p-1/2f	137	144	95	265	185	10-Mer-152
2b-5p-1f	138.5	151.6	91.4	190	140	03-Gle-5

× "b" Breakdown pass by 12 T. Tandem, unless stated otherwise
×× "p" Pneumatic, 9 Ton
××× "f" Final pass by 8 T. Tandem

TABLE 2 (CON'T)

Type Compaction	Field Max. Density(PCF)	Lab. Max. Density(PCF)	Rel. Comp.(%)	Temperature (°F) Start	End	Dist-Co-Rte
2b-5p-1f	133	151.6	87.7	230	150	03-Gle-5
2b-3p-1f	139	147.3	94.4	275	150	04-Sol-680/21
2b-5p-1f	137.5	147.3	93.3	240	135	04-Sol-680/21
1b-5p-1f	137.1	151.6	90.4	200	140	03-Gle-5
1b-4p-1f	142	156	91.1	255	135	04-CC-4
1b-3p-1f	127	139.8	91	243	162	05-SB-1
1b-3p-1f	134.7	150.5	89.5	240	165	07-Ora-405
1b-2p-1f	137.2	150.5	91.3	268	238	07-Ora-405
1b-3p-1f	127	145	88	230	105	07-LA-05
1b-3p-1f	133	147.3	90	300	185	08-Riv-10
1b-3p-1f	132.8	148.5	89.5	200	165	11-Riv-10
1b-3p-1f	133.4	145.4	92	231	195	11-Imp-8
1b(8T.Tandem)-3p-1f	137	146.6	93	275	150	11-SD-8
1b(8T.Tandem)-3p-1f	137	146.6	93	290	167	11-SD-8
1b-3p-1f	140	146.6	96	286	227	11-SD-8
1b-3p-1f(8T.Vib.)	138	149.8	92	250	188	11-Imp-111
1b-1p-1/2f	139	144	97	280	260	10-Mer-152
1b-4p-1/2f	131	144	91	275	240	10-Mer-152
1b-6p-1/2f	137	144	95	265	185	10-Mer-152

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TABLE 2 (CON'T)

Type Compaction	Field Max. Density(PCF)	Lab. Max. Density(PCF)	Rel. Comp.(%)	Temperature (°F) Start	End	Dist-Co-Rte
2b-5p-1f	138.5	151.6	91.4	190	140	03-Gle-5
2b-5p-1f	133	151.6	87.7	230	150	03-Gle-5
2b-3p-1f	139	147.3	94.4	275	150	04-Sol-680/21
2b-5p-1f	137.5	147.3	93.3	240	135	04-Sol-680/21
2b-6p-2f	139	147.3	94.4	250	175	04-Sol-680/21
2b-2p-1f	129.3	142.3	91	230	140	05-SB-1
2b-3p	138	156.6	88	230	165	05-SBt-156
2b(16T. 3Leg.)-4p-1f	148	154	97	280	210	05-Mon-68
2b-3p-1f	137.5	148	93	225	125	06-Mad-99
2b-1f	132	137.3	96	235	152	08-SBd-40
2b-2p-2f	138.5	154.1	89.9	232	150	10-Sac,Ama-16
2b-2p-1f	138.5	145.4	95	250	230	11-Imp-8
2b(8T.Tandem)-3f(8T.Vib.)	143	149.8	96	252	145	11-Imp-8
3b-7p-2f	142.5	144.1	98.9	275	160	04-Sol-680/21
3b-2p-4f	148.8	156.0	95.4	200	140	04-CC-4
3b(8T.Vib.)-3p-1f	144.4	156.0	93.5	255	172	04-CC-4
3b(8T.Vib.)-4p-1f(8T.Vib.)	148.3	156	95.1	270	225	04-CC-4
3b-3p-1f	148.7	156.6	95	240	136	05-SBt-156

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TABLE 2 (CON'T)

Type Compaction	Field Max. Density(PCF)	Lab. Max. Density(PCF)	Rel. Comp.(%)	Temperature (°F) Start	End	Dist-Co-Rte
3b-3p-1f	127	139.8	91	180	142	05-SB-1
3b-1f	132	137.3	95	268	150	05-SBd-40
3b-3p(16T)-1f	140.5	150.5	93.4	262	235	07-Ora-405
3b-4p-1f	137	147.3	93	300	120	08-Riv-10
3b-3p-1f	139	146.6	94.8	275	200	11-SD-8
3b(8T.Tandem)-3p-2f	141	146.6	96	270	209	11-SD-8
3b(8T.Vib.)-1p-2f	142	149.8	95	239	183	11-Imp-111
3b-3p-1f	145	149.8	97	255	199	11-Imp-111
4p-2b-1f	139	151	92.1	260	200	03-But-99
4b-4p-1f	145	147.3	98.4	260	165	04-Sol-680/21
4b-4p-1f	151.5	156	97.1	260	175	04-CC-4
4b-2p-2f	142.8	154.1	92.6	260	145	10-Sac,Ama-16
4b-2p-1f	137.5	148.5	92.6	225	160	11-Riv-10
4b-3p-1f	138.1	145.4	95	230	175	11-Imp-8
4b(8T.Tandem)-6p-2f(12T.Tandem)	142	149.8	95	263	185	11-Imp-111
4b(8T.Tandem)-6p-2f	140	149.8	94	239	143	11-Imp-111
4b-6p-2f (12T. Tandem)	139	149.8	93	256	138	11-Imp-111

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TABLE 2 (CON'T)

Type Compaction	Field Max. Density(PCF)	Lab. Max. Density(PCF)	Rel. Comp.(%)	Temperature (°F) Start	End	Dist-Co-Rte
4b-(all Vib.)	142	149.8	95	240	173	11-Imp-111
4b-2p	142	149.8	95	258	136	11-Imp-111
5b-1p-1f	139.3	150.5	92.7	285	245	07-Ora-405
6b-6p-1f	134	145	92	230	107	07-LA-5
6b-(8T.Vib.)	134	145	92	265	165	07-LA-5
9p-1f	139.5	150.5	92.7	265	190	07-Ora-405

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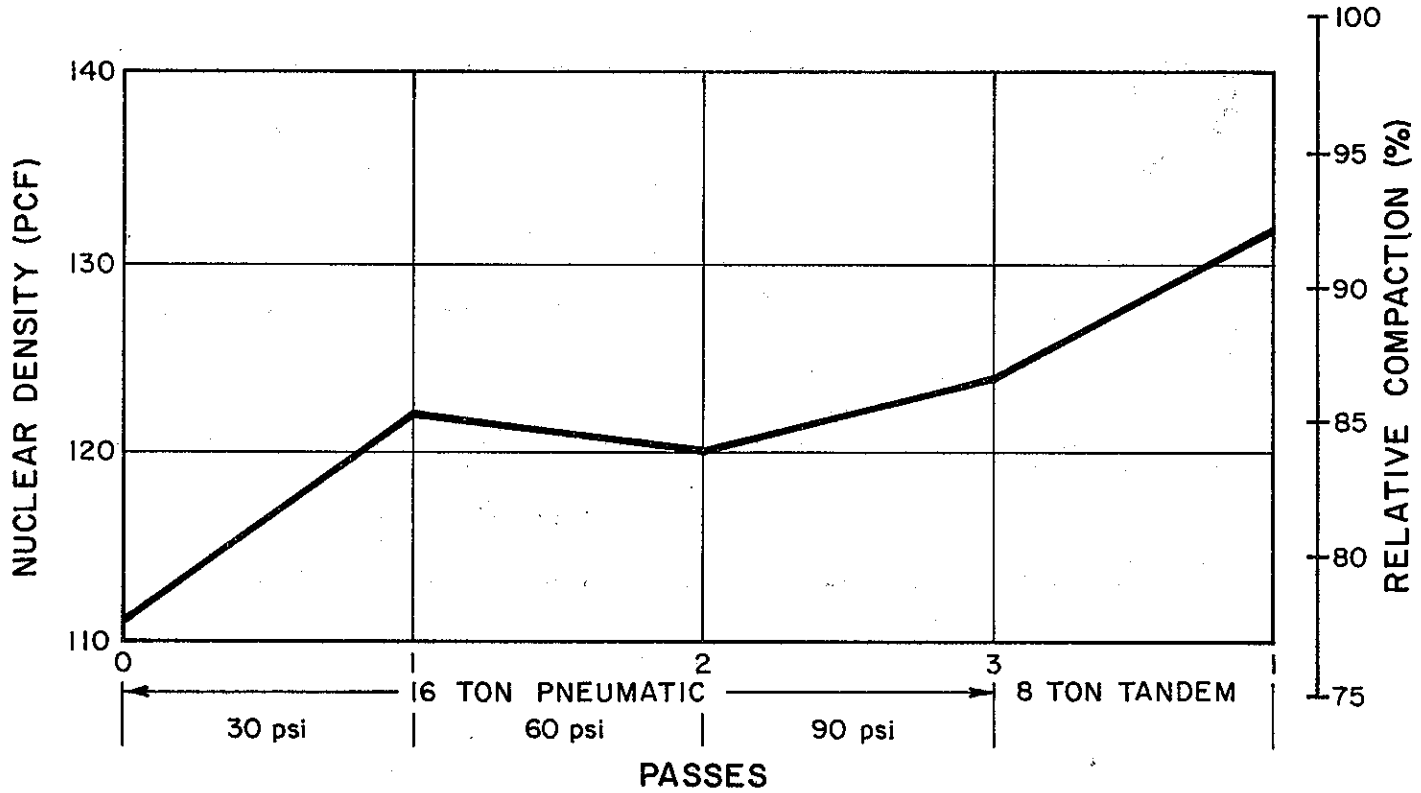
Figure 1

ASPHALT CONCRETE COMPACTION STUDIES

CONTRACT 01-092404
ROAD 01-Men-101-77.7/78.1
0.4' BASE COURSE-ONE LIFT



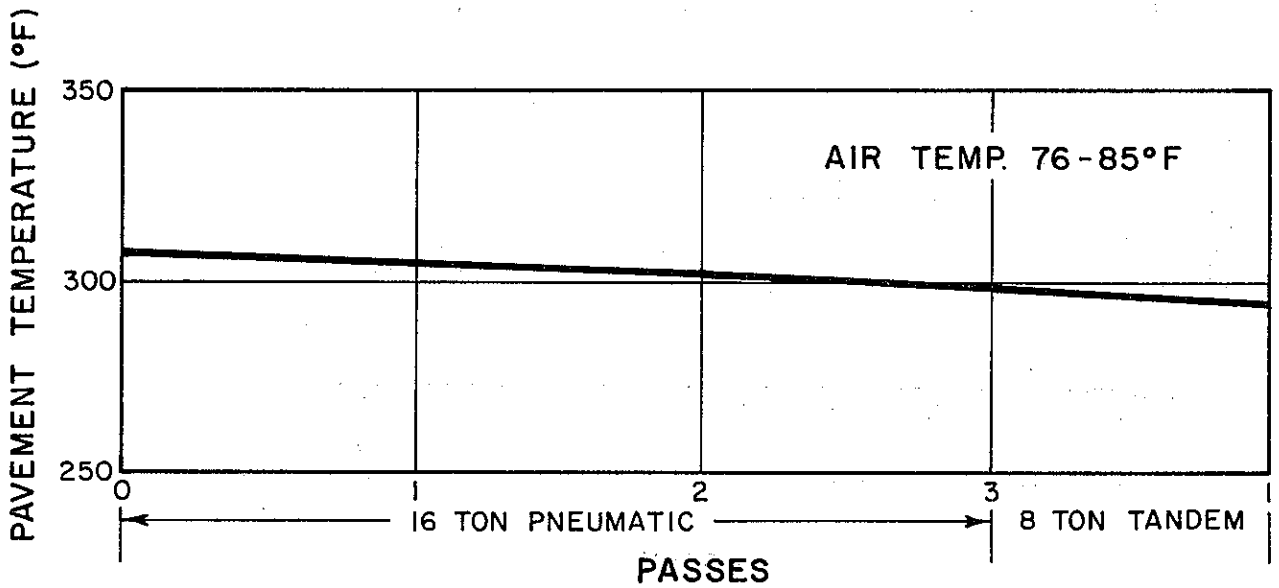


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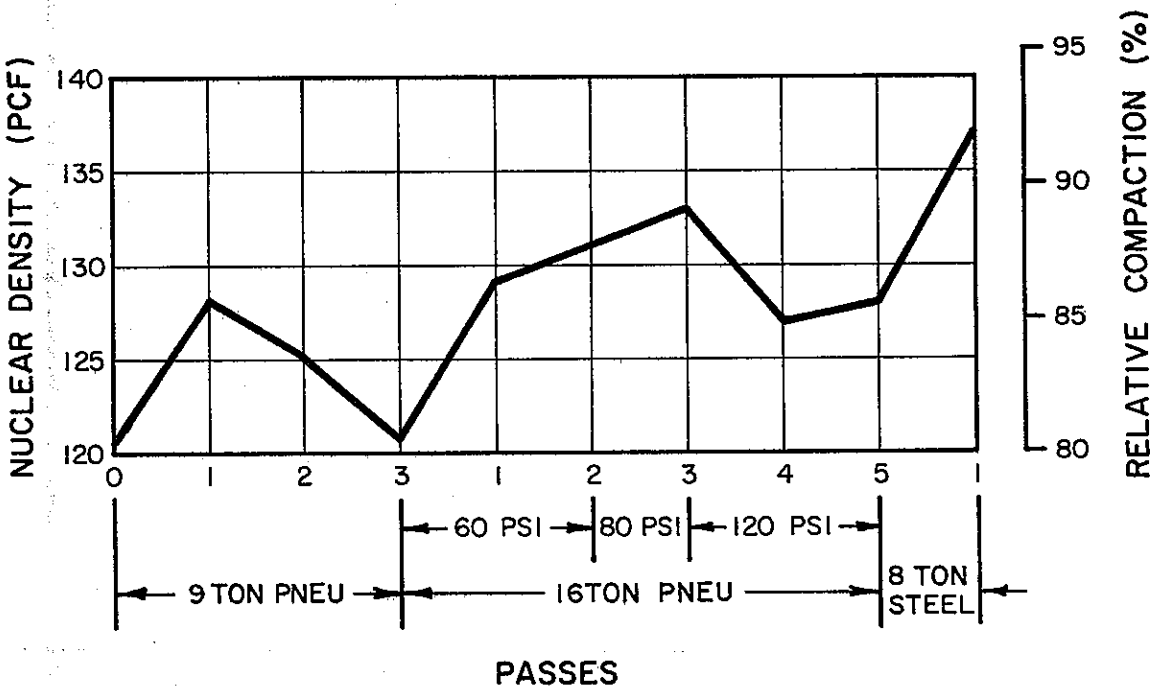
Figure 2

ASPHALT CONCRETE COMPACTION STUDIES

CONTRACT 07-031634
ROAD 07-Ora-405-11.2/14.4
0.33' BASE COURSE-ONE LIFT



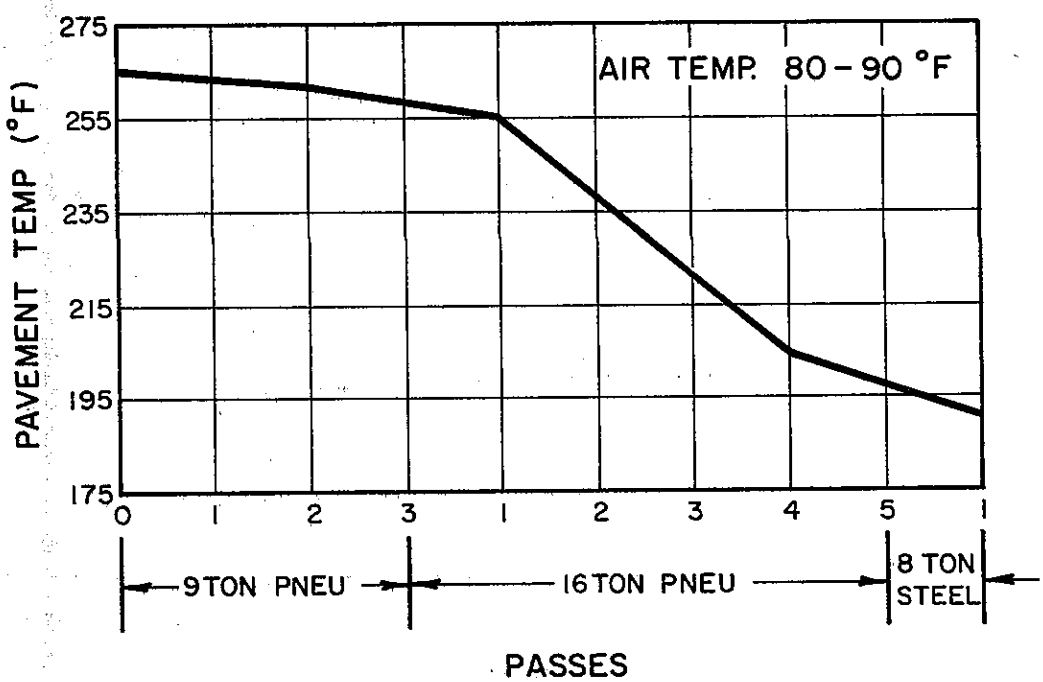


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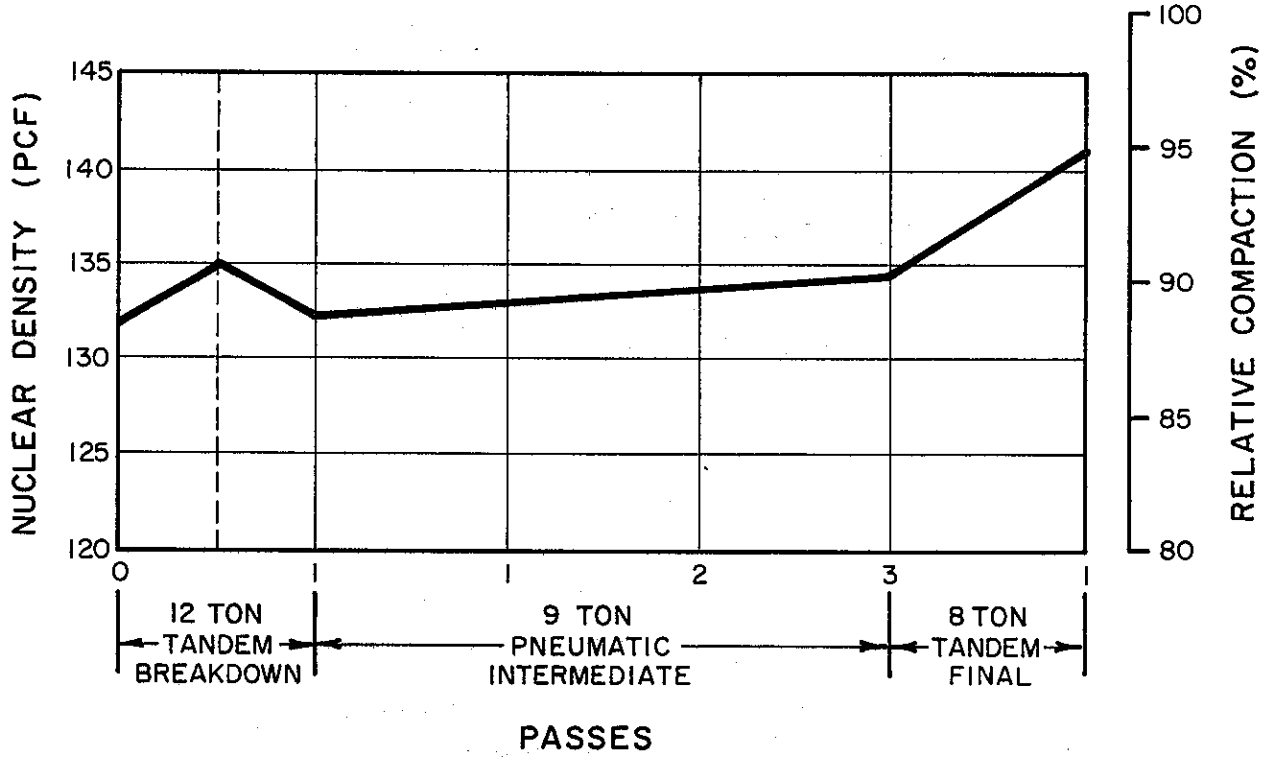
Figure 3

ASPHALT CONCRETE COMPACTION STUDIES

CONTRACT 07-031334
ROAD 07-L.A-170-13.0/20.6
0.33 LEVEL COURSE-ONE LIFT



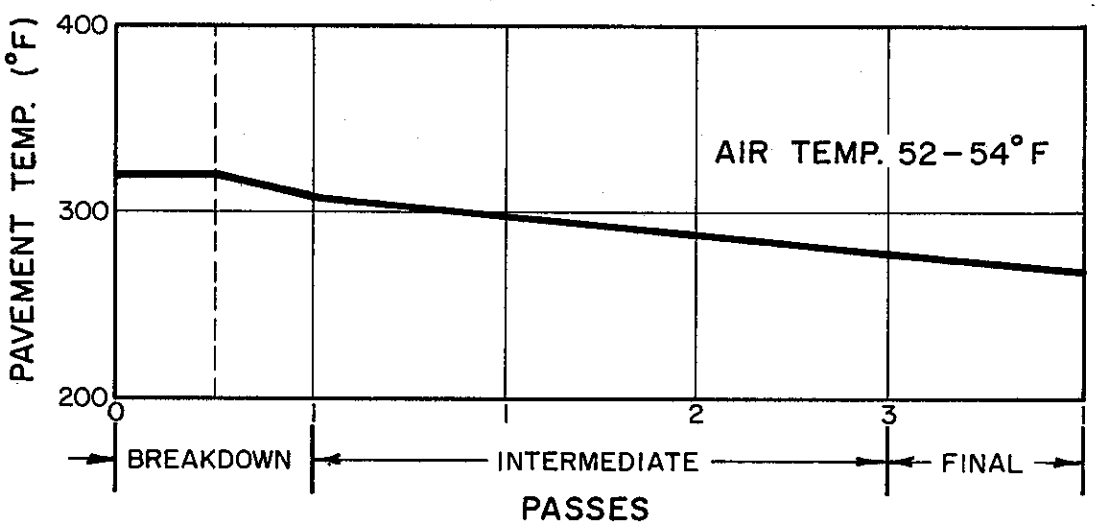


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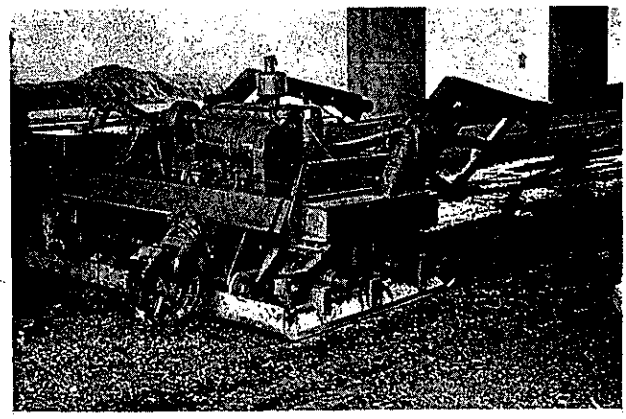
Figure 4.



Paving Machine Vibratory Plate Attachment

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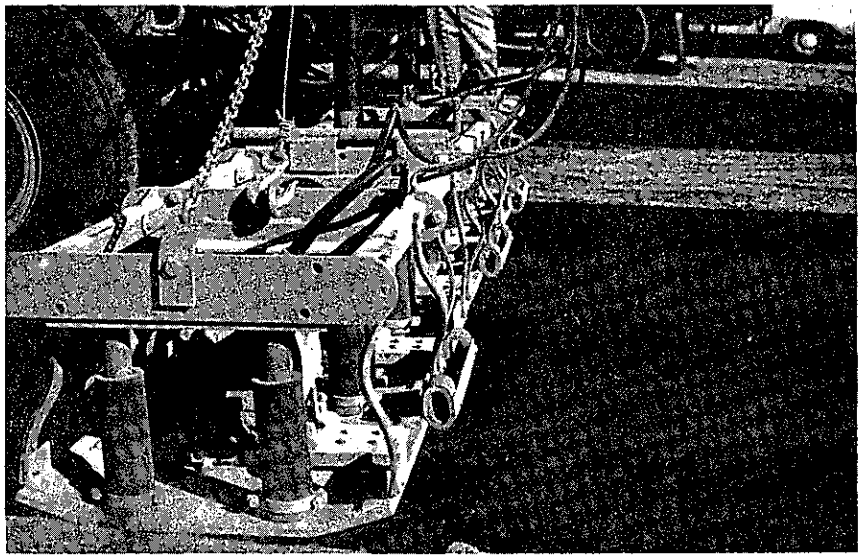
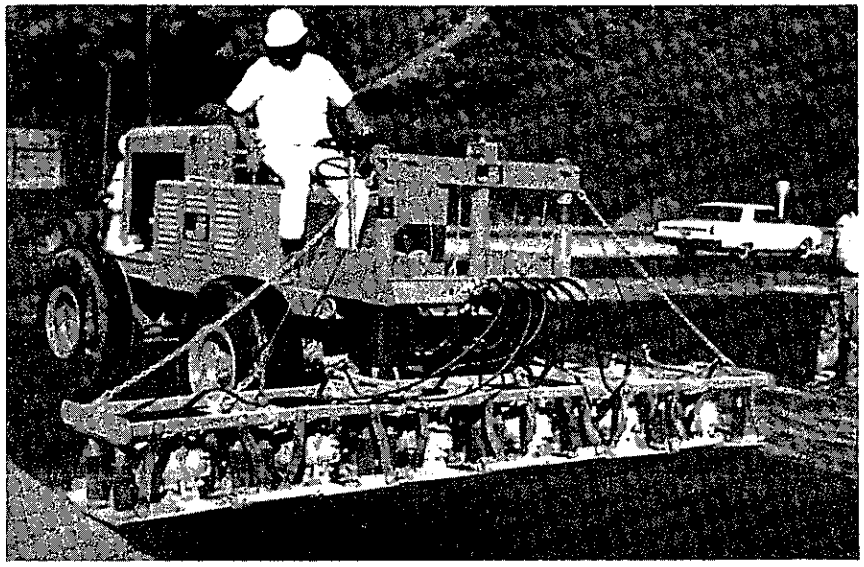
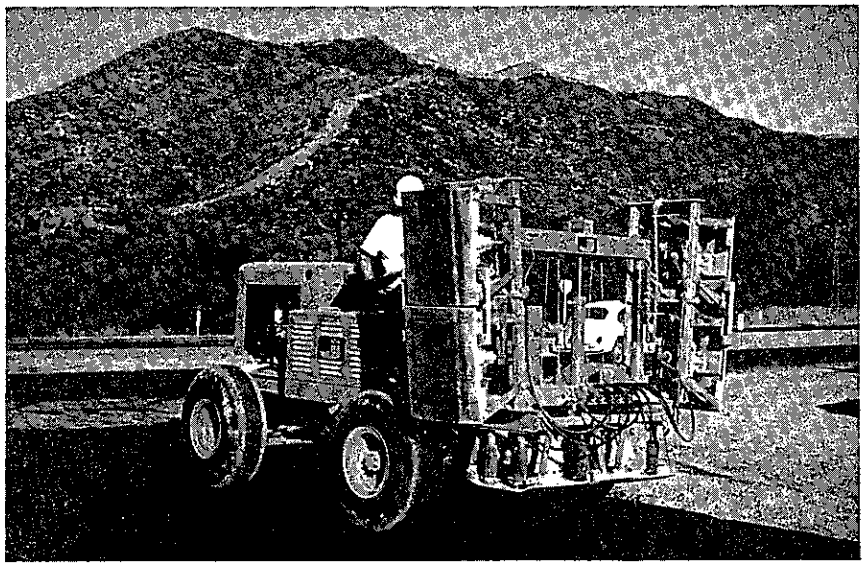
Figure 5







Self Propelled Vibratory Plate Compactor

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