COMMONWEALTH OF KENTUCKY
DEPARTMENT OF HIGHWAYS
FRANKFORT

HENRY WARD
COMMISSIONER OF HIGHWAYS

February 13, 1961

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

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D.1.7.

MEMO TO: D. V. Terrell
Director of Research

The attached report, "Evaluation of a Vibratory Roller for use in Compacting Bituminous Concrete Mixes," by R. C. Deen, covers the construction and initial density measurements on Project FFG 13(8), reconstruction of US 60 in and around Olive Hill. After the project had been let and was under grade and drain construction, discussions were held in the State Highway Engineer's Office as to its suitability for bituminous concrete-mix density studies.

The Plant Mix Asphalt Industry of Kentucky, and the paving sub-contractor, East Kentucky Paving Company, Grayson, Kentucky, were most co-operative and agreed to perform any extra work required by the research at no extra cost to the Highway Department. The project was constructed with a minimum of delay to the contractor.

Mr. Deen shows in his Figs. 3, 4, 5 and 6 the effect of roller coverages on bulk density of the base and binder courses. One passage of the tandem-vibratory combination has been plotted versus one passage of the tandem only. It is interesting to note in Fig. 3 that three coverages of the combination produced 131 lbs/cu.ft., while eight coverages of the tandem produced about 130 lbs/cu.ft. on the first course of Class I modified base.

The data collected on the Class I modified base indicates that density increases with number of passes up to ten and might have gone higher if more passes had been tried. These courses were approximately 2-1/2-in. compacted thickness and the mix is compactable.

The Class I, Type B surface in 1-1/4-in. compacted thickness layers does not appear subject to additional compaction after minimum break down and finishing.

We expect some of the sections to densify under traffic and plan to take density cores later this year.

Respectfully submitted,

W. B. Drake
Associate Director of Research

WBD:dl
Encs.
cc: Research Committee Members
Bureau of Public Roads (3)

Commonwealth of Kentucky
Department of Highways

EVALUATION OF A VIBRATORY ROLLER FOR USE IN COMPACTING BITUMINOUS CONCRETE MIXES

by

R. C. Deen
Research Engineer Senior

Highway Materials Research Laboratory
Lexington, Kentucky
February, 1961

INTRODUCTION

According to Article 4.3.5-D-1 of the 1956 Edition of Kentucky's Standard Specifications for Road and Bridge Construction, a minimum of two rollers, one 3-wheeled roller and one tandem roller, shall be required on each state project involving bituminous concrete paving operations. A further requirement of the specifications is that additional rollers will be provided so that there is available "...at least one roller for each 30 tons of the bituminous mixture per hour..." that is laid. This, of course, means that for paving operations involving the laying of the bituminous mixture at rapid rates, the contractor must have available and make use of an increased number of rollers.

With the widespread use in Kentucky of dense graded aggregate as a base course material, there is also an increased use of vibratory rollers to obtain the desired densities of the base. Very often then, the paving contractor will have available on the job site such vibratory compacting equipment. Current practice does not permit the use of this equipment for compacting the bituminous mixture and thus the vibratory roller usually stands idle during the laying of the bituminous mixture. From the contractor's point of view, it would be highly desirable if this equipment could be used to satisfy the specification requirements for the additional rollers as stated by Article 4.3.5-D-1 and thus reduce the contractor's investment in compacting equipment.

Widespread interest and concern in the application of vibratory compactors to bituminous mixes shown by The Plantmix Asphalt Industry of Kentucky and by highway personnel indicated a need for more information concerning the effect of such rollers on densities. The work reported in this paper is an attempt to evaluate the effectiveness of a vibratory roller in compacting bituminous concrete mixes.

PROCEDURE

Location of Test Section

Since it was not practical for the Department to set up a test road for the purpose of evaluating the vibratory roller, it was decided to make the study on a project that was under contract and already under construction. The project selected was the reconstruction of US 60 at Olive Hill, Kentucky, FFG 13(8), under contract to the East Kentucky Paving Company. The designed pavement structure for this project consisted of 9 inches of dense-graded aggregate base, 5 inches of modified Class I base, 1-1/2 inches of Class I binder, and 1-1/4 inches of Class I, Type B surface. The test strip was situated on a slight grade and also on a slight curve.

A section of the project 600 feet long (Sta. 129 + 99 to Sta. 135 + 99) near the west city limits of Olive Hill was selected for study. The pavement was 36 feet wide at this point, and the center 18 feet were selected for purposes of this investigation (See Fig. 1). Four control

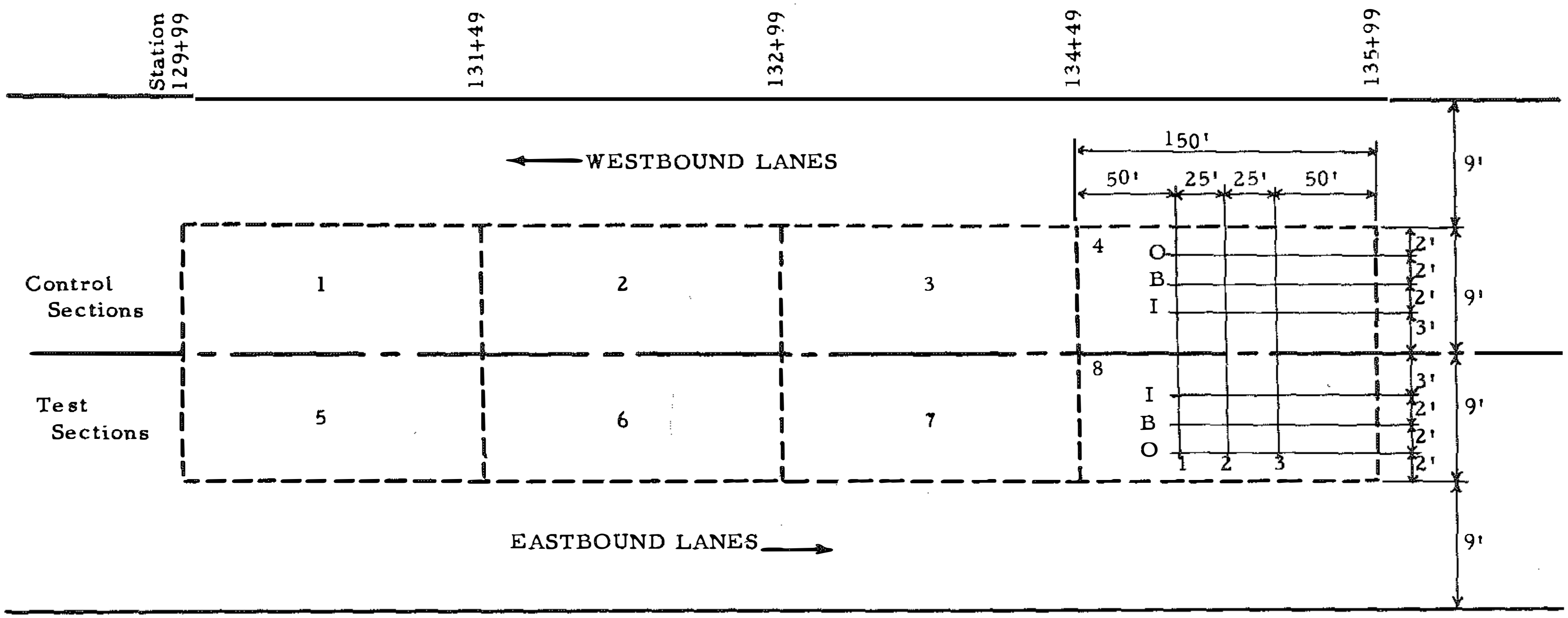


Fig. 1. Layout of Control and Test Sections.

sections (Sections 1, 2, 3, and 4) were used, each 150 feet long, and located in the westbound lanes. Similarly, four test sections (Sections 5, 6, 7, and 8) were located in the eastbound lanes.

Compaction Equipment

The standard compaction equipment used on this project consisted of one 10-ton, 3-wheel roller and two 8-ton tandem rollers. The vibratory roller that was available for evaluation was an Essick vibrating roller, VR-54-T. This roller weighs approximately 3200 pounds and applies the compactive effort at a rate of 3600 vibrations per minute. The roller dimensions were 30 inches diameter by 54 inches wide. Since the vibrating roller was not self-propelling, it was necessary that arrangements be made to tow it with the tandem roller (See Fig. 2). A rigid attachment was made between the tandem and vibrating rollers so that the Essick roller could be either pushed or pulled.

Test Procedure

Eight sections 150 feet long by nine feet wide were selected for study. Sections 1 through 4 were used as control sections and were located in the inside westbound lane. Sections 5 through 8 were selected as test sections and were located in the inside eastbound lane (See Fig. 1).

During the paving operation, samples of the mix were taken at the paver. These samples were returned to the laboratory where

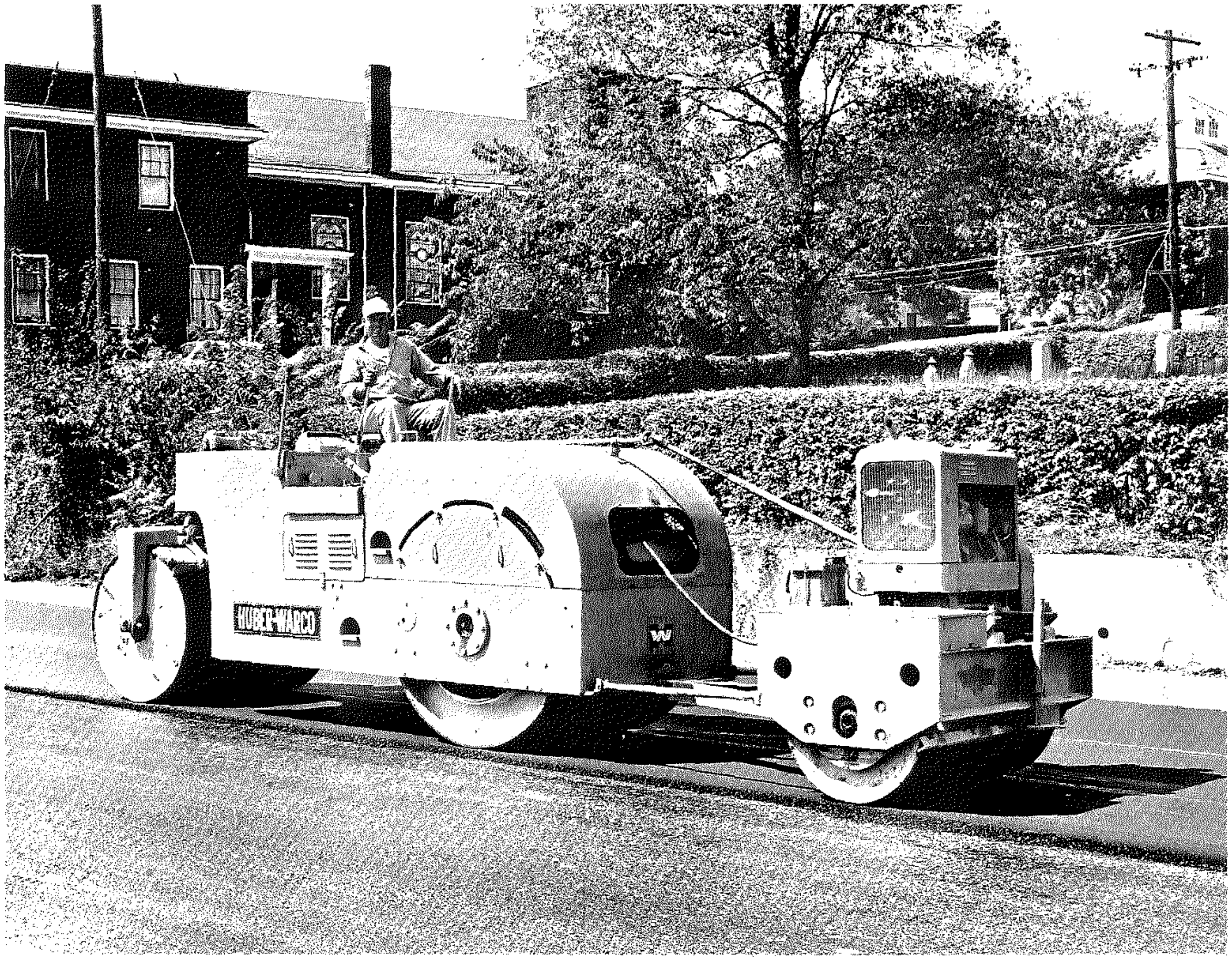


Fig. 2. Vibrating Roller Towed by Tandem Roller.

stability, gradation, and extraction data were obtained. Temperatures of the bituminous mixture as it was being laid were also obtained, as well as temperatures at the beginning of rolling operations. The laboratory data and the field temperatures are summarized in table form in the Appendix.

Breakdown rolling of the two base courses and the binder course was accomplished by using the 8-ton tandem roller in both the control sections and the test sections. For the surface course only, one to three coverages of the 3-wheel roller were used for breakdown rolling. Intermediate and final rolling of the control sections were done exclusively with the tandem roller. The test sections were compacted with the vibrating roller towed by the tandem roller, except that the surface course of the test sections received some final compaction with the tandem roller.

It was also desirable to determine the effect of various amounts of compactive effort on densities and thus each control section and its companion test section were rolled with different compactive efforts. The compactive effort was varied by changing the number of coverages of the roller on each section. The speed of operating the vibrating roller was only slightly reduced from that of normal tandem rolling operations.

Within two to 18 hours after the bituminous mixture had been placed and compacted, 4-inch diameter core specimens were obtained.

It was necessary to obtain these specimens within such a short time in order to get specimens from the bituminous pavement before traffic had passed over it. Coring in such fresh bituminous pavement presented no particular difficulties. However, it was noted that after several days of summer storage some of these specimens tended to slump and disintegrate.

There were nine locations within each sections which were designated as areas from which core specimens were to be taken (See Fig. 1).

The three longitudinal locations were designated by numbers: "1" indicated a transverse line 25 feet west of the center of each section, "2" designated the transverse line at the center, and "3" the line 25 feet east of the center of each section. Three transverse positions were designated by the letters; I, B and O: "I" for inside wheel track, "B" for between wheel tracks, and "O" for outside wheel track. As a result, each location number contained three characters, for example: 4B1. The first number indicated the section, the second letter indicated the location in a transverse direction, and the last number designated the longitudinal position.

Nine cores -- three from each of three locations -- were obtained from each section for every lift of bituminous mixture that was placed. To permit the coring of only the last layer to be placed, sheets of Kraft paper approximately 2 feet x 2 feet were placed at the desired location immediately in advance of the paver. This prevented the adhesion of the bituminous material to the previous layer and allowed easy removal of the cores.

The cores were returned to the laboratory where bulk density determinations were made by a rather simple method. The bulk volume of the core was determined by averaging several measurements of height and diameter and making the necessary computations. Knowing this volume and the weight of the core, the bulk density could be calculated.

After these densities had been obtained, arbitrarily selected specimens from each section of the two courses of the modified Class I base were sawed in half so that the density could be determined for the bottom portions and top portions. No such determinations were made on cores obtained from the binder and surface courses because the specimens were too thin for sawing and tended to slump and disintegrate.

To investigate the degradation effects of the two types of rolling used in this study, two to four core specimens from each section for every lift of bituminous mixture were combined. Extraction and gradation data were obtained for the combination. In a similar manner extraction and gradation data were obtained for the top and bottom portions of selected cores.

RESULTS

Densities

A summary of core densities is presented in Tables 2, 3, 4, and 5. These data have been presented graphically in Figs. 3, 4, 5, and 6. It is noted from the curves that higher densities are obtained when the vibrating roller was used. It should be pointed out, however, that oneshould exercise caution in making these comparison. For example, two coverages by the tandem-vibrating roller train actually subjects the bituminous mixture to two coverages of the tandem roller as well as two coverages of the vibrating roller. Thus it may be desirable to compare the density obtained with two coverages of the tandem vibrating train with that obtained with four coverages of the tandem roller only.

Figures 3, 4, and 5 show that, under the conditions of this investigation, there was an increase in densities of the base course mixture when the vibrating roller was used. In the case of the binder course (Fig. 6) there was no significant difference between the densities obtained with the two types of rolling until there were six or more coverages of the compaction equipment. In all cases except one, the curves indicate that there is a tendency for the densities to approach a maximum value for the compaction equipment and mixture under study. This would be even more apparent if the number of coverages were plotted on an arithmetic scale rather than on a logarithmic scale. The only exception to this general statement is noted in Fig. 6, where the densities of the binder course are observed to be rapidly increasing even after eight coverages of the compaction equipment.

LEGEND

for

BULK DENSITY CURVES

Solid Lines - Tandem Roller

Dashed Lines - Vibrating Roller Towed by Tandem Roller

Red Lines - Tops of Cores

Green Lines - Bottoms of Cores

Black Lines - Entire Core

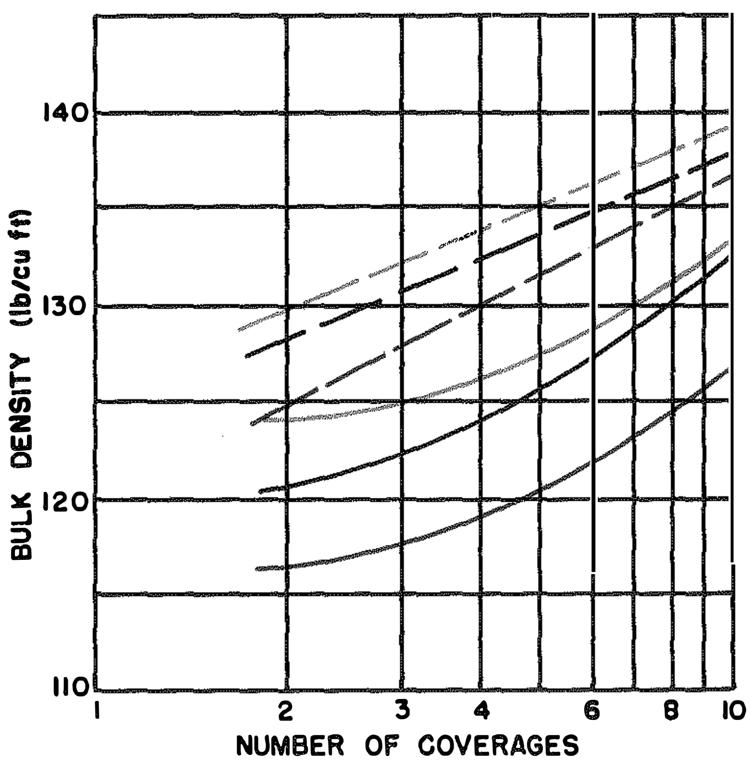


Fig. 3. Density Curves for First Course of Class I, Modified Base.

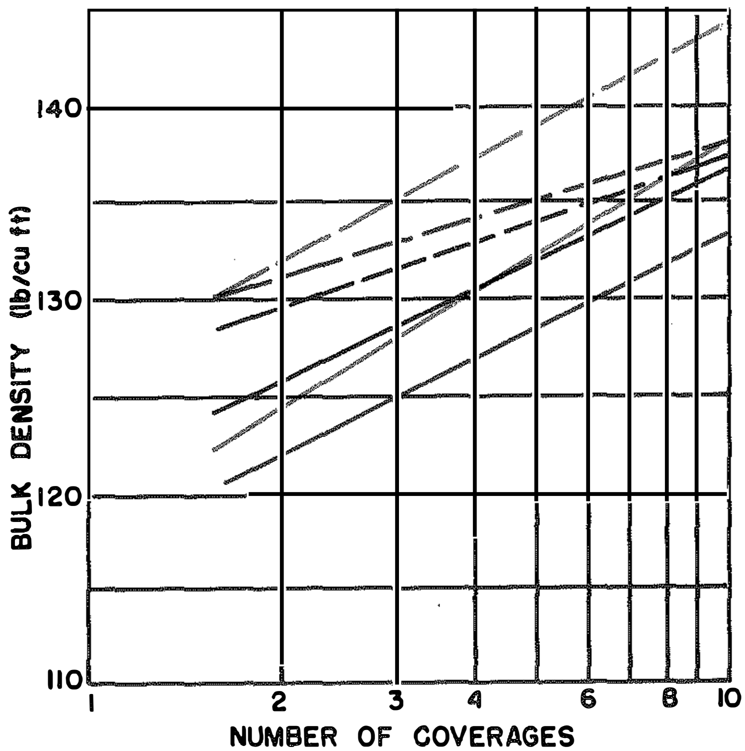


Fig. 4. Density Curves for Second Course of Class I, Modified Base.

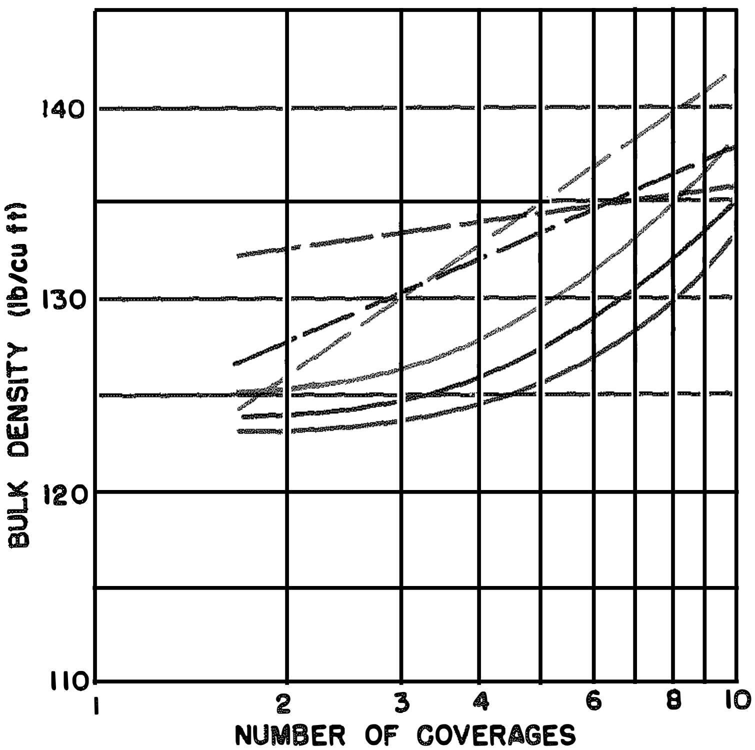


Fig. 5. Density Curves for Entire Class I, Modified Base.

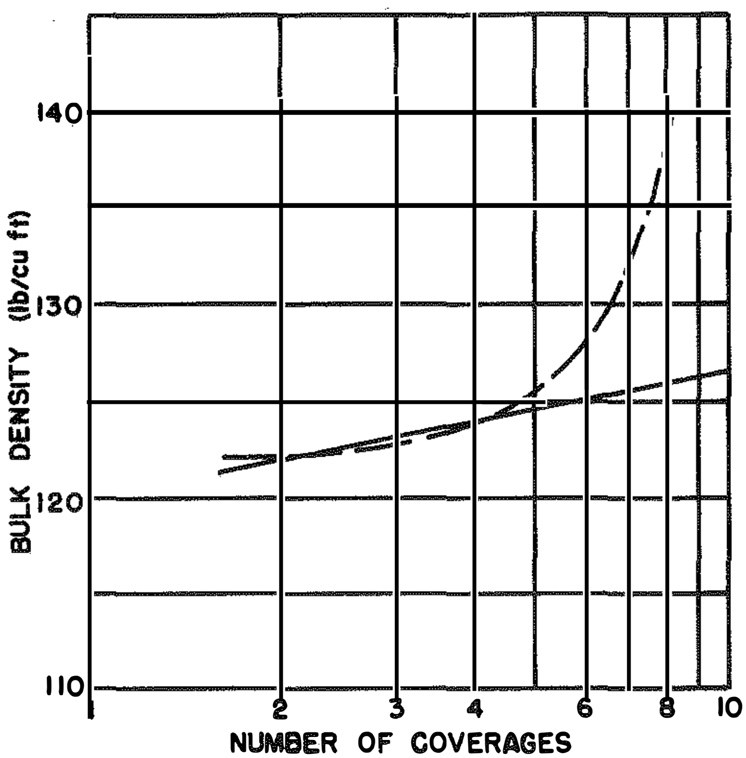


Fig. 6. Density Curves for Class I Binder.

An analysis of the density data for the surface course (Table 5) indicates that the surface mixture is rather insensitive to compaction. The densities obtained for the material ranged between 127 to 135 lbs./cu.ft., averaging approximately 131 lbs./cu.ft., regardless of the compactive effort used or the compaction equipment used. This, of course, is not unreasonable since the surface mix is a predominantly sand mixture which would not be expected to respond differently to various compactive efforts or techniques.

The standard 50-blow Marshall Compaction Test was performed on samples of the bituminous mixtures taken from the pavement at the paver. These test data are recorded in Table 1. Comparing the laboratory test densities with those obtained in the field suggests that densification under traffic might be expected since the field densities, even with eight to ten coverages of the compaction equipment, were lower than those obtained in the laboratory.

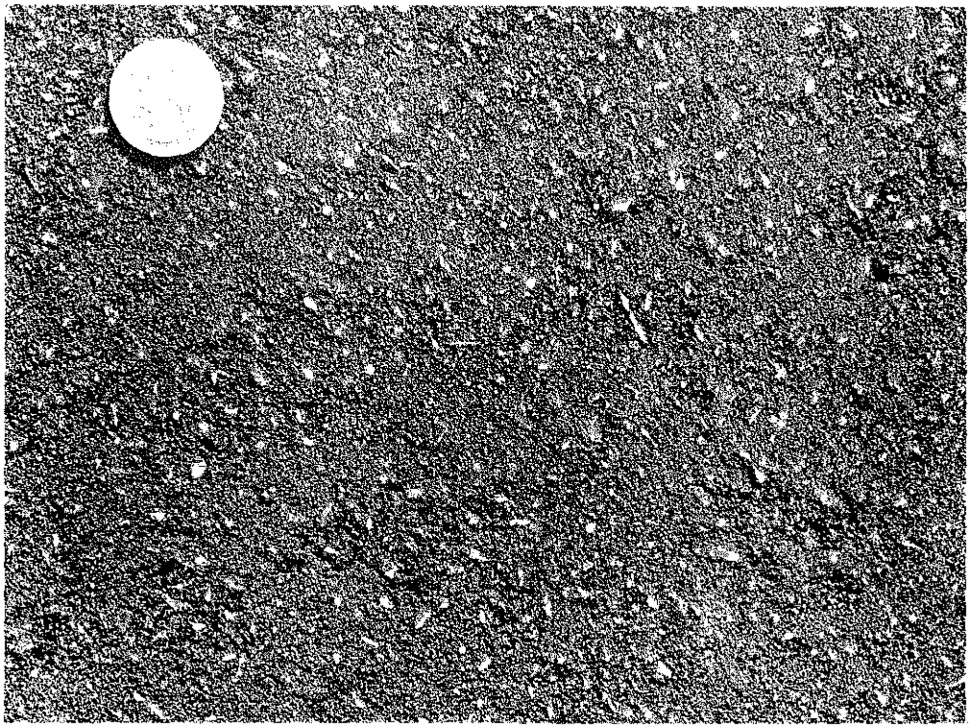
In general, density determinations on the top portions and on the bottom portions of cores taken from the modified Class I base courses indicate that the bottom of the courses reach higher densities than the upper portions.

During the rolling operations several interesting observations were made. First, for both the tandem roller and for the tandem-vibrating roller train, there was a very definite and discernable wave that preceded the roller wheels by a distance of 1.5 to 2 feet. After approximately two to four coverages of either type of compaction equipment, this wave had decreased to such a small amount that it was just detectable by the human eye. This small wave preceded the roller wheel by only a matter of two to three inches.

The temperatures of the bituminous mixtures at the time of laying ranged between 200°F. and 295°F., averaging 261°F. At the beginning of the rolling operations, the temperature range was 155°F. to 265°F. with an average of 197°F.

In laying the first 2-1/2-inch course of the Class I modified base, the test sections were placed and compacted first. It was noted that this material shoved three to six inches in a lateral direction under the vibrating roller and to a much greater extent than under the tandem roller. The material was placed in a 9-foot width which had increased to 9-1/4-9-1/2 feet at the completion of rolling. For the remaining three courses, the two outside lanes were placed and compacted by standard techniques. Then the test and control lanes were laid. In this manner the material was confined and showed very little tendency to shove laterally under the vibrating roller.

At times it was felt that the use of the vibrating roller tended to mark the surface of the bituminous mixture more than the tandem roller did. However, after a very close and careful study, it was decided that marking by the rollers was not to be more expected with one type of rolling than with the other. In Fig. 7 are two photographs



a. After Rolling with Vibrating Roller

b. After Rolling with Tandem Roller

Fig. 7. Photographs Showing Surface Texture of Class I, Type B Surface.

showing the surface texutre of the Class I, Type B surface course. Figure 7a was taken in Section 8 after being rolled with six coverages of the tandem-vibrating roller train. Figure 7b was taken in Section 4 after rolling with six coverages of the tandem roller. No significant difference is noted between the appearance of the two surfaces.

Degradation

The core specimens that were returned to the laboratory for density determinations provided an excellent opportunity to investigate the degradation of the aggregate as a result of the two types of compaction equipment that were used.

The gradation data are summarized in Table 6 and presented graphically in Figs. 8, 9, 10 and 11. It is noted that the gradations of the core specimens have definitely shifted to a finer grading than that for the specimens taken from the pavement before rolling. The tops of the cores exhibit slightly more degradation of the aggregate than the bottoms.

The data in Table 6 indicate that approximately the same degree of degradation of the aggregate can be expected for the modified Class I base mixture for both types of compaction equipment used in this investigation. It is also noted that the breakdown occurs during the first two coverages of the roller. No increase in degradation is observed for those sections which were rolled with larger compactive efforts, by

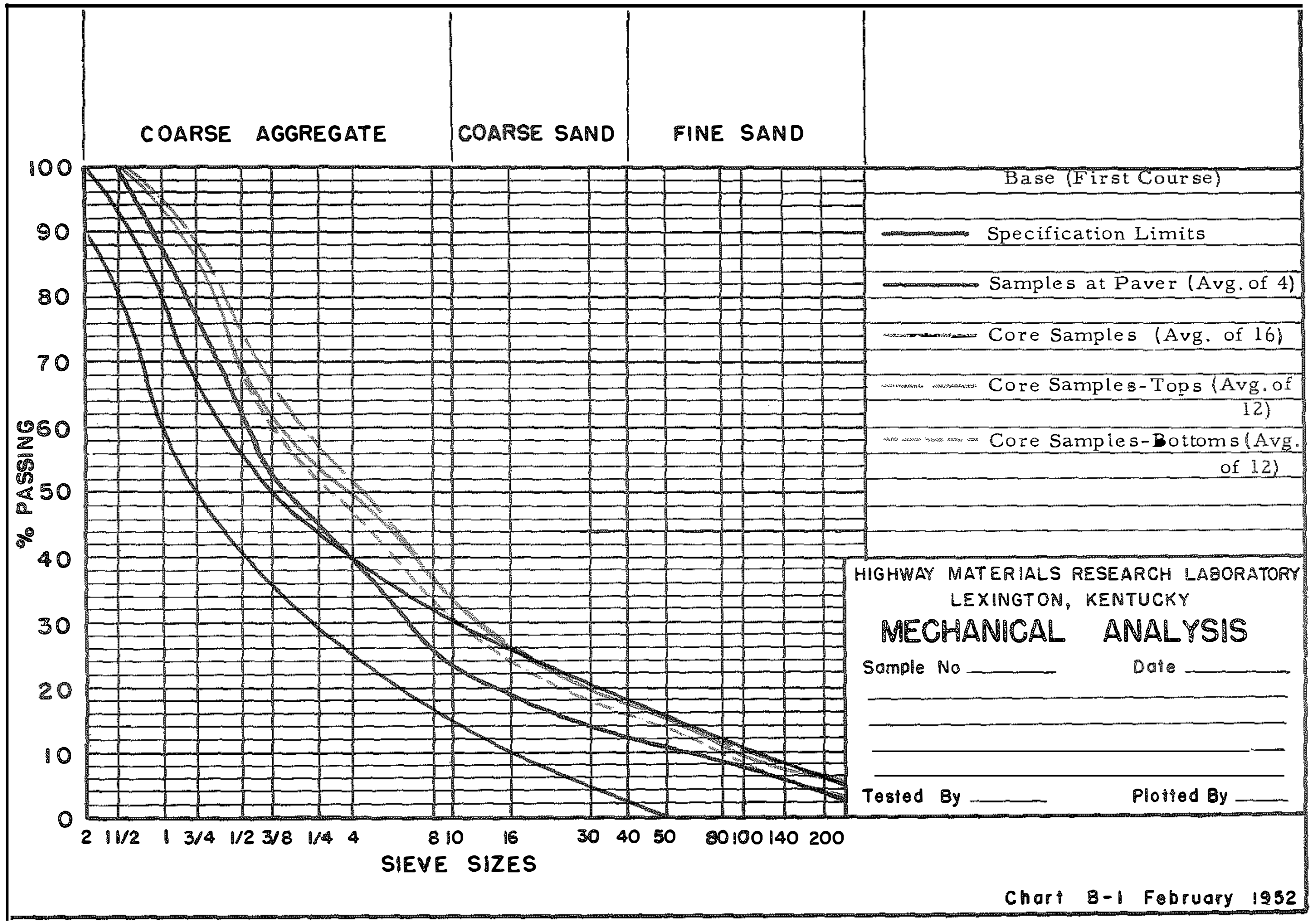


Fig. 8. Gradation Curves for the First Course of Class I Modified Base.

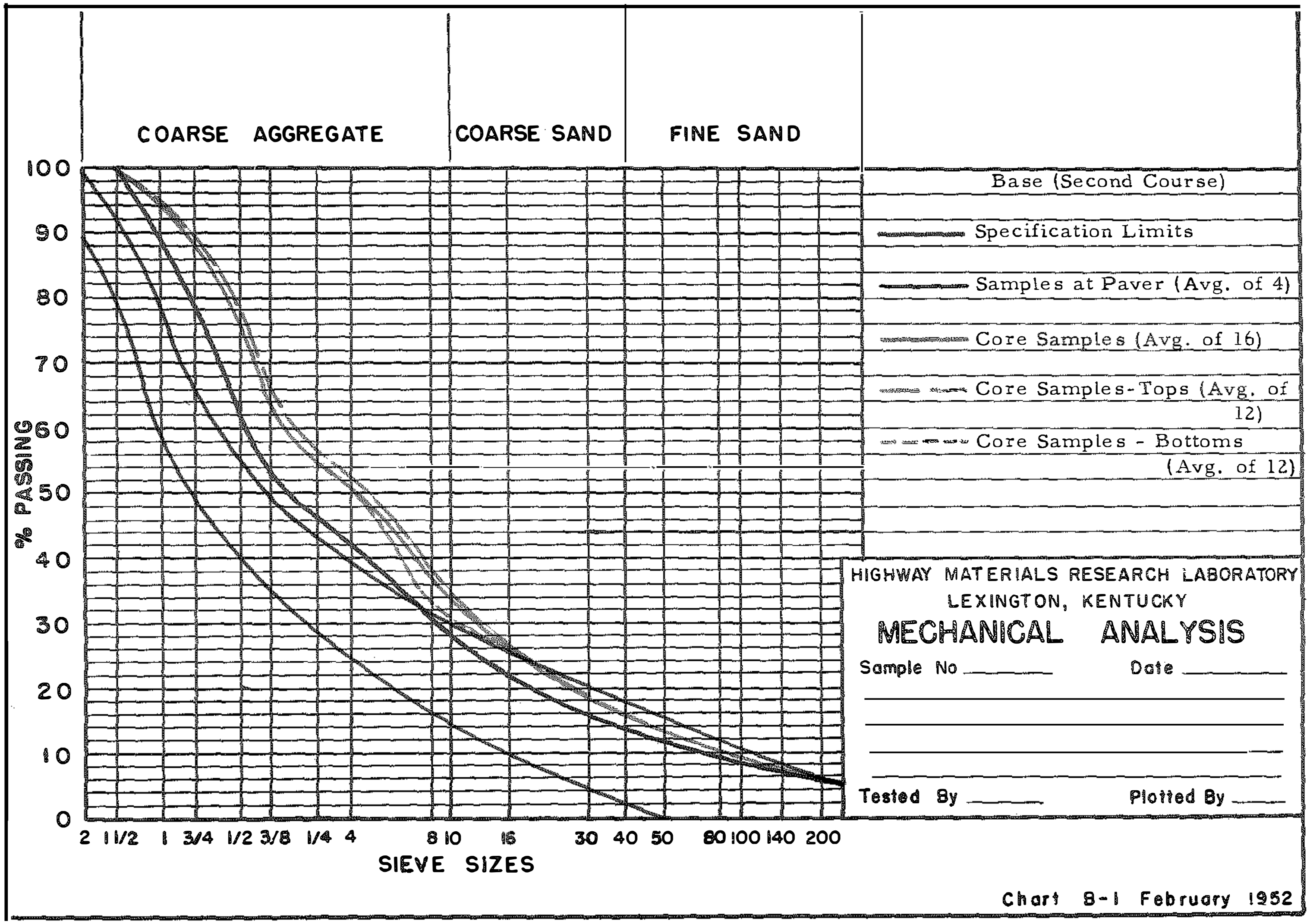


Fig. 9. Gradation Curves for the Second Course of Class I Modified Base.

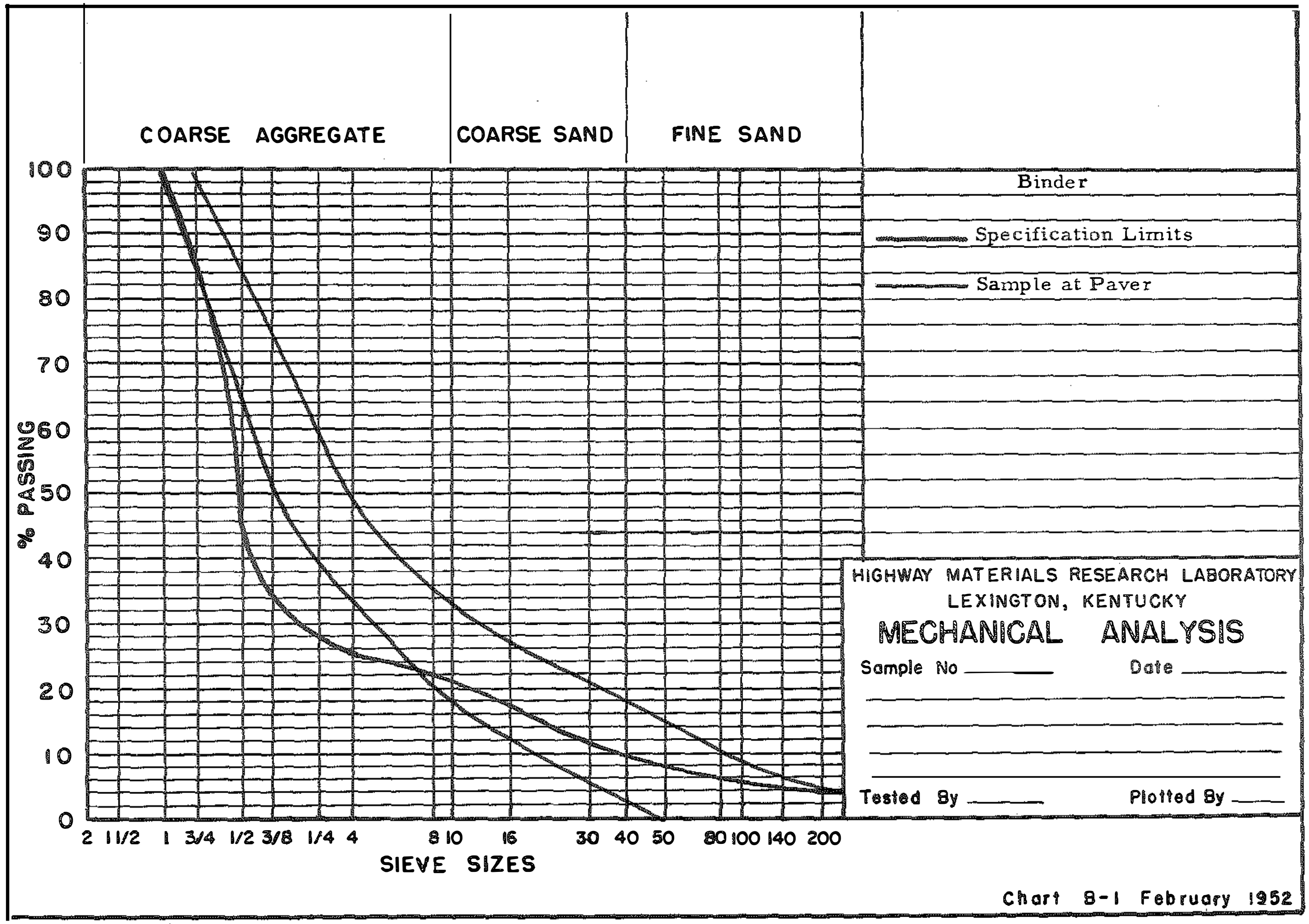


Fig. 10. Gradation Curves for the Class I Binder

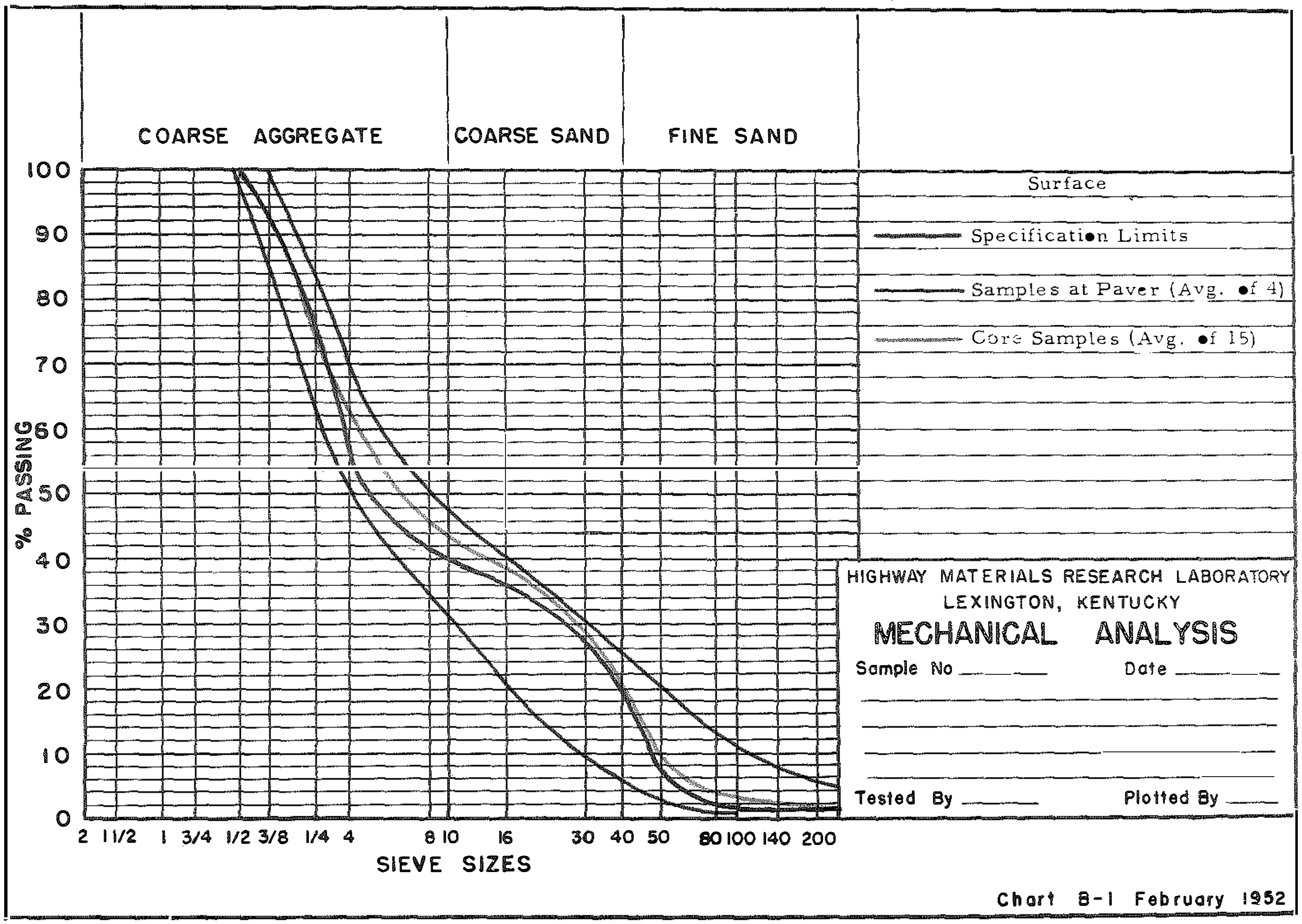


Fig. 11. Gradation Curves for the Class I, Type B Surface

increasing the number of coverages. This same behavior was also noted for the Class I, Type B surface mixture. Data for the binder course are not available since these core specimens were destroyed before gradation data were obtained.

FURTHER CONSIDERATIONS

The study reported herein has attempted to determine the effectiveness of a vibrating roller in compacting bituminous mixtures. There are numerous aspects of the problem that need further investigation, some of which are briefly mentioned below:

1. Self-propelled Vibrating Roller - Because of the equipment available on this particular project, it was necessary to investigate the compaction obtained with a tandem-vibrating roller train. It would be desirable to investigate compaction techniques and results obtained with self-propelled, vibrating rollers only.

2. Speed of Rolling - The experience of some users of vibrating rollers indicate that it is necessary to reduce the speed of operation of the roller in order to obtain the desired densities. A study of the effects of roller speed on densities is thus needed.

3. Size of Roller Wheel.

4. Temperature at Time of Rolling - Some investigators suggest that there is an optimum temperature for compacting bituminous concrete mixes. The timing of the rolling operation depends upon the temperatures of the supporting base, the atmosphere, and the mixture itself. The initial compaction of the mix is properly done at the optimum temperature with subsequent rolling being timed so that this operation is completed before the mix has cooled to a point where the compaction equipment is no longer

effective. It would then be desirable to define the temperature range in which the bituminous mixtures could be compacted to obtain the optimum results.

5. Densification of Bituminous Mixture Under Traffic - The density data obtained from the core specimens indicate that some densification under traffic can be expected. It is hoped that this densification, if any, can be followed by obtaining cores from this project at various times in the future.

6. Gradation Specifications - There has been a recent tendency to remove specimens of bituminous mixtures from the finished pavement and to compare the gradations of these samples with specification requirements. The degradation data reported herein indicate that care should be exercised in making these comparisons and that certain tolerance limits on the specification limits may be needed if gradation data from such specimens of the finished pavement are to be used as acceptance criteria.

   In sawing or coring a specimen from a bituminous pavement, there is, of necessity, a "splitting" of aggregate particles which are situated around the periphery of the specimen. This will be reflected in the mechanical analysis by a shift in the gradation to the finer sizes. It may be that certain fractions are more affected by this splitting than other sizes. This might account for the tendency towards gaps that occur in the gradations (See Figs. 8 and 9). The gradation curves presented in this report have not been corrected for this type of degradation. There, of course, is a need for the development of a method by which this correction could be made.

APPENDIX

Table 1. Summary of Marshall Test Results for Mixture Samples Obtained at the Paver.

Course	Date and Time of Sampling	Percent Bitumen	Stability (lb.)	Flow (0.01 in.)	Unit Weight (lb./cu. ft.)	Voids-aggregate only (%)	Voids-total mix (%)	Voids filled with asphalt (%)
Base	10:30 AM, 18 Aug 1960	4.83	2221	12	138.1	22.1	11.4	48.4
Base	11:00 AM, 18 Aug 1960	4.76	1974	13	140.6	20.6	9.9	51.7
Base	10:00 AM, 19 Aug 1960	4.73	1635	18	139.5	21.9	10.7	49.8
Base	12 noon, 19 Aug 1960	5.21	1980	13	134.9	24.2	12.7	46.6
Mean		4.88	1953	14	138.3	22.2	11.2	49.1
Binder	1:45 PM 26 Aug 1960	4.98	2068	13	145.3	18.6	7.0	62.6
Binder	3:40 PM 26 Aug 1960	3.88	1876	13	145.5	17.9	8.5	52.8
Mean		4.43	1972	13	145.4	18.3	7.8	57.7
Surface	12:00 noon 15 Sept 1960	5.12	532	7	140.4	20.9	9.4	55.3
Surface	4:00 PM 15 Sept 1960	5.25	747	6	142.2	20.1	8.1	59.7
Mean		5.19	639	7	141.3	20.5	8.8	57.5

Table 2. Summary of Density Data for the First Course of Class I, Modified Base.

Type of Compaction	No. of Coverages	Location No.	Average Height (inches)	Bulk Unit Wt. (lb./cu. ft.)	Temperature (°F) At Paver	Temperature (°F) Beginning of Rolling
Tandem roller	2	1I1	2.79	120	285	200
		1B2	2.61	121		
		103	2.66	127		
		Average	2.69	123		
	4	2I1	2.29	126	285	210
		2B2	2.59	116		
		203	2.44	122		
		Average	2.44	121		
	6	3I1	2.89	120	285	215
		3B2	2.25	123		
		303	2.38	132		
		Average	2.51	125		
	10	4I1	2.30	133	285	190
		4B2	2.00	133		
		403	2.33	135		
		Average	2.21	134		
Vibratory Roller towed by tandem roller	2	501	2.37	134	200	185
		5B2	2.40	126		
		5I3	2.24	128		
		Average	2.34	127		
	4	601	2.33	136	230	215
		6B2	2.26	128		
		6I3	2.41	134		
		Average	2.33	133		
	8	701	2.42	136	250	205
		7B2	2.35	140		
		7I3	2.41	138		
		Average	2.39	138		
	11	801	2.40	136	270	170
		8B2	2.59	138		
		8I3	2.38	135		
		Average	2.46	136		

Table 3. Summary of Density Data for the Second Course of Class I, Modified Base.

Type of Compaction	No. of Coverages	Location No.	Average Height (inches)	Bulk Unit Wt. (lb./cu. ft.)	Temperature (°F)	
					At paver	Beginning of rolling
Tandem roller	2	1B1	2.71	128	240	175
		102	2.70	126		
		1I3	2.62	123		
		Average	2.68	126		
	4	2B1	2.46	131	260	185
		202	2.74	132		
		2I3	2.64	129		
		Average	2.61	131		
	6	3B1	2.65	128	265	175
		302	2.57	138		
		3I3	2.37	134		
		Average	2.53	133		
	10	4B1	2.50	139	295	175
		402	2.72	136		
		4I3	2.70	135		
		Average	2.64	137		
Vibratory roller towed by tandem roller	2	5B1	2.54	131	270	230
		5I2	2.81	128		
		503	2.31	132		
		Average	2.55	130		
	4	6B1	2.16	125	285	220
		6I2	2.33	137		
		603	2.30	132		
		Average	2.26	131		
	6	7B1	2.71	135	295	210
		7I2	2.62	139		
		703	2.77	124		
		Average	2.70	133		
	10	8B1	2.32	139	260	210
		8I2	2.34	136		
		803	2.50	138		
		Average	2.39	138		

Table 4. Summary of Density Data for the Class I Binder.

Type of Compaction	No. of Coverages	Location No.	Average Height (inches)	Bulk Unit Wt. (lb./cu. ft.)	Temperature (°F)	
					At paver	Beginning of rolling
Tandem roller	2	101	1.55	124	250	160
		1I2	1.60	128		
		1B3	1.50	122		
		Average	1.55	125		
	4	201	1.64	125	255	155
		2I2	1.55	121		
		2B3	1.60	126		
		Average	1.60	124		
	6	301	2.01	124	255	170
		3I2	1.46	122		
		3B3	2.09	120		
		Average	1.85	122		
	8	401	1.90	127	235	185
		4I2	1.99	123		
		4B3	1.79	128		
		Average	1.89	126		
Vibratory roller towed by tandem roller	2	5I1	1.70	118	250	195
		502	1.75	128		
		5B3	1.87	121		
		Average	1.77	122		
	4	6I1	1.68	124	255	200
		602	1.66	128		
		6B3	1.80	121		
		Average	1.71	124		
	6	7I1	2.02	125	270	265
		702	1.35	132		
		7B3	1.73	128		
		Average	1.70	128		
	8	8I1	1.94	138	265	230
		802	1.65	138		
		8B3	1.88	138		
		Average	1.82	138		

Table 5. Summary of Density Data for the Class I, Type B Surface.

Type of Compaction	No. of Coverages	Location No.	Average Height (inches)	Bulk Unit Wt. (lb./cu. ft.)
Three-wheel roller	1	1I1	1.76	132
Tandem roller	4	1B2	1.72	127
		103	1.28	133
		Average	1.59	131
Three-wheel roller	1	2I1	1.95	132
Tandem roller	6	2B2	1.90	133
		203	1.68	132
		Average	1.84	132
Three-wheel roller	1	4I1	1.84	132
Tandem roller	8	4B2	1.96	133
		403	1.57	133
		Average	1.79	133
Three-wheel roller	3	601	1.77	131
Tandem roller	4	6B2	1.80	130
		6I3	1.71	130
		Average	1.76	130
Three-wheel roller	3	701	1.91	130
Tandem + vibratory roller	4	7B2	1.95	134
Tandem roller	3	7I3	1.53	130
		Average	1.79	131
Three-wheel roller	3	801	1.90	135
Tandem + vibratory roller	6	8B2	1.82	132
Tandem roller	3	8I3	1.68	130
		Average	1.80	132

Table 6. Summary of Gradation Data.

Course	Specimen	Date and Time of Sampling	Gradation (Percent Passing) (Sieves) 1½"	3/4"	3/8"	4	8	16	30	50	100	200	Percent Bitumen
Base, First Course	Paver Sample No. 1	10:30 A.M., 18 Aug. 1960	100.0	80.7	53.1	40.2	26.9	18.5	14.1	10.8	6.9	3.9	4.72
	" " No. 2	" "	100.0	79.8	54.1	41.7	28.9	20.0	15.0	11.4	7.3	4.0	4.94
	Mean (Test Sections)		100.0	80.2	53.6	40.9	27.8	19.3	14.5	11.1	7.1	4.0	4.83
	Paver Sample No. 3	11:30 A.M., 18 Aug. 1960	100.0	68.4	46.9	37.1	25.4	16.8	12.4	9.1	5.6	3.0	4.30
	" " No. 4	" "	100.0	79.9	53.2	39.5	27.1	18.2	13.4	9.9	6.0	3.3	4.79
	" " No. 5	" "											5.19
	Mean (Control Sections)		100.0	74.1	50.1	38.3	26.2	17.5	12.9	9.5	5.8	3.2	4.76
	Mean (First Course)		100.0	77.1	51.8	39.6	27.0	18.4	13.7	10.3	6.4	3.6	4.80
	Cores 1B2-1 & 103-2	18 Aug. 1960	100.0	89.9	62.1	49.8	35.6	24.6	18.6	14.2	8.9	5.0	5.2
	" 2I1-3 & 2B2-1	"	100.0	89.4	62.3	47.8	34.7	23.8	18.1	13.8	8.7	4.9	5.6
	" 2I1-2 & 303-2	"	100.0	84.8	57.3	45.5	34.0	23.5	17.5	12.9	7.8	4.2	5.1
	" 4I1-2 & 403-1	"	100.0	84.9	59.7	55.3	40.4	27.9	21.2	15.9	9.7	5.4	5.3
	Mean (Control Sections)		100.0	87.3	60.4	49.6	36.2	25.0	18.9	14.2	8.8	4.9	5.3
	Cores 501-2 & 501-3	18 Aug. 1960	100.0	85.6	61.4	52.1	39.6	28.0	21.4	16.4	10.7	5.7	5.4
	" 6I3-2 & 6I3-3	"	100.0	86.3	61.6	50.0	37.2	25.6	18.8	14.2	9.1	5.0	5.4
	" 701-2 & 7I3-3	"	100.0	82.0	61.5	50.0	35.4	24.5	18.4	14.1	9.0	4.9	5.2
	" 8B2-2 & 8I3-2	"	100.0	87.2	60.7	48.8	35.4	24.1	17.8	13.5	8.8	5.0	5.5
	Mean (Test Sections)		100.0	85.3	61.3	50.2	36.9	25.6	19.1	14.6	9.4	5.2	5.4
	Mean (First Course Cores)		100.0	86.3	60.8	49.9	36.5	25.3	19.0	14.4	9.1	5.1	5.3
Base, Second Course	Paver Sample No. 1	10:00 A.M., 19 Aug. 1960	100.0	74.8	49.3	37.5	27.4	19.4	14.4	10.9	7.8	5.2	4.80
	" " No. 2	" "	100.0	74.3	45.9	36.3	26.3	18.5	13.5	10.1	6.8	4.3	4.34
	" " No. 3	" "											5.05
	Mean (Control Sections)		100.0	74.6	47.6	36.9	26.8	19.0	13.9	10.5	7.3	4.8	4.73
	Paver Sample No. 4	12:00 Noon, 19 Aug. 1960	100.0	82.5	59.8	48.8	35.3	24.3	17.5	12.5	8.0	4.9	5.12
	" " No. 5	" "	100.0	81.0	57.2	46.5	33.2	23.0	16.4	11.7	7.4	4.5	5.30
	Mean (Test Sections)	" "	100.0	81.7	58.5	47.6	34.2	23.7	17.0	12.1	7.7	4.7	5.21
	Mean (Second Course)		100.0	78.0	53.0	42.3	30.5	21.4	15.4	11.3	7.5	4.8	4.97
	Cores 102-1 & 1I3-3	19 Aug. 1960	100.0	88.0	60.1	47.8	34.0	22.6	16.2	12.2	8.5	5.7	6.0
	" 202-2 & 2I3-1	"	100.0	91.4	64.1	48.9	33.8	22.4	16.0	12.2	9.0	6.4	5.4
	" 302-2 & 3I3-1	"	100.0	87.6	66.1	54.3	40.2	28.6	20.7	14.9	9.2	6.6	5.6
	" 4B1-1 & 4I3-2	"	100.0	91.0	63.4	53.2	39.2	27.7	20.1	14.6	9.2	5.9	5.2
	Mean (Control Sections)		100.0	89.5	63.4	51.1	36.8	25.3	18.3	13.5	9.0	6.2	5.6
	Cores 5B1-1 & 503-3	19 Aug. 1960	100.0	83.9	62.2	49.3	34.3	23.5	16.9	12.6	8.4	5.5	5.9
	" 6I2-2 & 603-1	"	100.0	84.4	55.5	44.7	33.2	22.9	16.2	11.5	6.9	4.1	4.9
	" 7I2-2 & 7I2-3	"	100.0	93.5	68.5	55.5	41.1	28.7	20.3	14.8	9.5	6.2	5.5
	" 8I2-3 & 803-1	"	100.0	91.1	64.8	52.6	38.1	26.3	18.3	12.9	8.4	5.7	5.6
	Mean (Test Sections)		100.0	88.2	62.8	50.5	36.7	25.4	17.9	13.0	8.3	5.4	5.5
	Mean (Second Course Cores)		100.0	88.8	63.1	50.8	36.8	25.3	18.1	13.3	8.6	5.8	5.5
Binder	Paver Sample No. 1	1:45 P.M., 26 Aug. 1960											4.83
	" " No. 2	" "											5.12
	Mean (Control Sections)												4.98
	Paver Sample No. 3	3:40 P.M., 26 Aug. 1960	00.0	85.1	33.9	24.6	21.9	16.8	11.9	8.4	5.3	3.5	3.62
	" " No. 4	" "											4.13
	Mean (Test Sections)		100.0	85.1	33.9	24.6	21.9	16.8	11.9	8.4	5.3	3.5	3.88
	Mean (Binder Course)		100.0	85.1	33.9	24.6	21.9	16.8	11.9	8.4	5.3	3.5	4.43
Surface	Paver Sample No. 1	12:00 Noon, 15 Sep. 1960		100.0	91.7	57.7	42.8	37.1	28.0	7.3	1.5	1.0	5.14
	" " No. 2	" "		100.0	92.2	57.4	42.1	36.7	27.8	7.3	1.4	0.9	5.11
	Mean (Control Sections)			100.0	91.6	57.5	42.4	36.9	27.9	7.3	1.5	1.0	5.12
	Paver Sample No. 3	4:00 P.M., 15 Sep. 1960		100.0	92.6	55.7	39.8	33.9	25.3	6.7	1.7	1.3	5.24
	" " No. 4	" "		100.0	92.3	58.6	41.1	34.6	26.0	6.8	1.8	1.3	5.26
	Mean (Test Sections)			100.0	92.4	57.1	40.4	34.3	25.7	6.7	1.7	1.3	5.25
	Mean (Surface Course)			100.0	92.0	57.3	41.4	35.6	26.8	7.0	1.6	1.2	5.18
	Cores 1I1-1, 1B2-1, 103-1 & 103-3	16 Sep. 1960		100.0	94.1	63.1	47.1	40.8	30.8	8.8	2.5	1.6	5.8
	" 2I1-2, 2B2-1 & 2B2-3	"		100.0	90.8	59.3	44.6	38.8	29.8	8.3	2.3	1.6	6.0
	" 4I1-2 & 4B2-2	"		100.0	91.8	61.2	46.6	40.6	31.3	8.7	2.5	1.7	5.6
	" 601-2 & 6B2-2	"		100.0	94.0	62.8	44.8	38.2	28.4	7.8	2.4	1.7	6.1
	Mean			100.0	92.7	61.6	45.8	39.6	30.1	8.4	2.4	1.7	5.9
	Cores 701-3 & 7I3-3	16 Sep. 1960		100.0	95.0	61.1	43.2	36.7	27.2	7.8	2.5	1.8	5.6
	" 801-2 & 8B2-2	"		100.0	94.4	65.5	46.9	39.5	29.3	8.4	2.8	2.0	5.8
	Mean			100.0	94.7	63.3	45.0	38.1	28.3	8.1	2.7	1.9	5.7
	Mean (Surface Course Cores)			100.0	93.7	62.4	45.4	38.8	29.2	8.2	2.5	1.8	5.8