PUBLIC ROADS

A JOURNAL OF HIGHWAY RESEARCH

UNITED STATES DEPARTMENT OF AGRICULTURE
BUREAU OF PUBLIC ROADS

VOL. 18, NO. 3 ▽ MAY 1937

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PUBLIC ROADS ▸ ▸ ▸ *A Journal of Highway Research*

Issued by the

UNITED STATES DEPARTMENT OF AGRICULTURE

BUREAU OF PUBLIC ROADS

Volume 18, No. 3 — May 1937

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THE EFFECT OF CURING CONDITIONS ON STRENGTH OF CONCRETE TEST SPECIMENS CONTAINING BURNT CLAY AGGREGATES

BY THE DIVISION OF TESTS, BUREAU OF PUBLIC ROADS

Reported by W. F. KELLERMANN, Associate Materials Engineer

THE TREND toward increased span lengths on highway bridges has stimulated efforts to decrease the dead load caused by the weight of the bridge floor. Results of a study of the relative strengths of test specimens of concrete bridge floor slabs made of several materials and placed by each of several methods have been published.[1]

Included among the concrete aggregates used was the artificial, lightweight aggregate known as "Haydite." The tests showed that there was a progressive retrogression in flexural strength for the Haydite concrete specimens for ages exceeding 90 days, whereas concrete made with siliceous gravel, crushed limestone, and quartz sand aggregates, cured under presumably the same conditions, continued to gain in strength. In view of the probability that this behavior of the Haydite specimens might be related to the moisture-retaining qualities of the aggregate, it was decided to conduct further studies of Haydite concrete specimens. A supplementary series of laboratory tests under controlled curing conditions is discussed in this report.

Two series of concrete specimens, one containing fine and coarse Haydite as total aggregate and the other a natural sand and crushed limestone, were made and tested at various ages up to and including 1 year. In addition, a limited number of specimens made with Haydite aggregates were tested at an age of 428 days, and corresponding specimens made with natural aggregates were tested at 409 days. The mix used with the natural aggregates was 1 : 2.1 : 3.9 by dry loose volume (1 : 2 : 3.5 by dry-rodded volume). The mix used with the Haydite aggregates was 1 : 1.5 : 3 by dry loose volume, with 3 pounds of "Celite" added per sack of cement.

The latter mix was the same as that used in the bridge slab tests where the retrogression in flexural strength was noted. However, the Haydite used in the previous tests came from Jackson County, Missouri, while that used in these tests came from Erie County, New York. Though the materials were from different sources, both were manufactured by the same process and were submitted by the manufacturer as being representative of the type. The natural sand came from the Potomac River at Washington, the limestone from Martinsburg, W. Va. Physical characteristics of the aggregates are given in table 1, and the mix data are shown in table 2.

MIXING AND TESTING PROCEDURES DESCRIBED

Because dried Haydite aggregate absorbs water rapidly, it was decided to presaturate all aggregates and use them in this condition. The procedure followed was to dry the materials in an oven, weigh out the fine and coarse aggregates required for each batch in a watertight container, and immerse them for 48 hours in a measured quantity of water before mixing. By this procedure the total water used was accurately determined, yet thorough presaturation of the aggregates was accomplished. However, the net water-cement ratio reported for the Haydite concrete is only approximate, because of the difficulty of determining accurately the amount of water absorbed by the aggregates.

TABLE 1.—*Grading and physical properties of aggregates*

	Haydite fine aggregate	Potomac River sand	Haydite coarse aggregate	Martinsburg limestone
Retained on:	*Percent*	*Percent*	*Percent*	*Percent*
1½-inch sieve	----------	----------	----------	----------
1-inch sieve	----------	----------	----------	20
¾-inch sieve	----------	----------	----------	49
½-inch sieve	----------	----------	17	74
⅜-inch sieve	----------	----------	60	87
4-mesh sieve	----------	5	98	100
8-mesh sieve	14	24	100	100
16-mesh sieve	48	41	100	100
30-mesh sieve	67	59	100	100
50-mesh sieve	78	86	100	100
100-mesh sieve	84	97	100	100
Fineness modulus	2.91	3.12	6.58	7.36
Physical properties:				
Specific gravity [1]	1.63	2.53	1.42	2.71
Absorption [2] ... percent	11.4	2.1	7.8	0.13
Weight (dry loose) per cubic foot ... pounds	57	101	45	90
Voids ... percent	44	36	49	47

[1] Bulk specific gravity, A. S. T. M. definition E 12—27.
[2] 70° cone method of Bureau of Public Roads.

TABLE 2.—*Data on mixes used in making concrete specimens*

Aggregates		Proportion by dry loose volume	Celite per sack of cement	Water content per sack of cement		Consistency flow [1]	Weight	Cement factor
Coarse	Fine			Total	Net			
			Lb.	*Gal.*	*Gal.*		*Lb. per cu. ft.*	*Sacks per cu. yd.*
Haydite	Haydite	1:1.5:3.0	3	8.4	5.9	140	104	7.2
Limestone	Potomac River sand.	[2] 1:2.1:3.9	--------	6.4	5.8	165	151	5.7

[1] Fifteen ½-inch drops in 10 seconds.
[2] Proportions by dry-rodded volume 1:2:3.5.

The concrete was mixed with shovels in watertight pans, each batch being of sufficient size to make one flexure specimen (6- by 6- by 21-inch beam) or two 6- by 12- inch cylinders. After 1 day in the molds and 6 days in the moist room, the flexural specimens were subjected to the curing conditions indicated in table 3, and the compression specimens to the curing conditions shown in table 4. Moist curing was accomplished by storing the

[1] The Effect of Materials and Methods of Placing on the Strength and Other Properties of Concrete Bridge Floor Slabs, by L. W. Teller and G. W. Davis. PUBLIC ROADS, vol. 12, no. 10, December 1931.

specimens in the moist room under standard conditions of humidity and temperature. The final wet curing consisted of immersion in water at laboratory temperatures prior to test.

TABLE 3.—*Curing conditions for concrete beam specimens*

Group no.	Period of curing				Age at test
	Initial moist curing	Air	Oven at 170° F.	Water at 70° F. prior to test	
	Days	*Days*	*Days*	*Days*	*Days*
1	7	-----	-----	-----	7
2	7	21	-----	-----	28
3	28	-----	-----	-----	28
4	7	173	-----	-----	180
5	7	166	-----	7	180
6	7	169	-----	4	180
7	7	170	-----	3	180
8	7	171	-----	2	180
9	7	172	-----	1	180
10	173	7	-----	-----	180
11	172	1	7	-----	[1] 180
12	180	-----	-----	-----	180
13	7	353	-----	-----	360
14	7	346	-----	7	360
15	28	332	-----	-----	360
16	180	180	-----	-----	360
17	270	90	-----	-----	360
18	28	325	-----	7	360
19	180	173	-----	7	360
20	270	83	-----	7	360
21	353	7	-----	-----	360
22	352	1	7	-----	[1] 360
23	359	1	-----	-----	360
24	358	1	1	-----	[1] 360
25	360	-----	-----	-----	360
26	[2] 360	1	[3] 67	-----	[1] 428
	[4] 360	1	[3] 48	-----	[1] 409
27	[2] 428	-----	-----	-----	428
	[4] 409	-----	-----	-----	409
28	[2] 7	421	-----	-----	428
	[4] 7	402	-----	-----	409

[1] Oven-dried specimens cooled in air of laboratory for 1 day prior to test.
[2] Data for beams having Haydite aggregates.
[3] Dried in oven to constant weight prior to test.
[4] Data for beams having natural sand and crushed limestone aggregates.

TABLE 4.—*Curing conditions and crushing strengths of cylinders*

Group no.	Age at test	Curing		Coarse aggregate				Strength ratio, Haydite concrete to limestone concrete
				Haydite		Limestone		
		Moist room	Air	Crushing strength[1]	Coefficient of variation	Crushing strength[1]	Coefficient of variation	
	Days	*Days*	*Days*	*Lb. per sq. in.*	*Percent*	*Lb. per sq. in.*	*Percent*	*Percent*
1	7	7	------	2,300	3.5	2,280	3.8	101
2	28	7	21	3,460	6.2	3,510	2.1	99
3	28	28	------	3,970	4.6	4,040	5.4	98
4	180	7	173	5,180	1.4	4,470	3.7	116
12	180	180	------	6,490	5.6	5,270	1.8	123
13	360	7	353	5,230	4.4	4,250	4.4	123
25	360	360	------	6,850	1.9	5,410	3.2	127
Average	------	------	------	4,780	3.9	4,180	3.5	114

[1] Each value represents the average of tests on 5 specimens.

Air curing was accomplished by storing the specimens in air in a frame structure which was heated only enough to keep the specimens from freezing. Twenty-four hours before test the air-cured specimens were moved to the laboratory in order to attain laboratory temperatures, and the final day was counted as part of the curing period. Oven-dried specimens were heated in an electric oven maintained at a temperature of 170° F. ± 5° F. and were brought to the laboratory 24 hours before test in order to cool. Each value given in tables represents the average of tests on five specimens in practically all cases.

The compression specimens were standard 6- by 12-inch cylinders; the flexural specimens were 6- by 6- by 21-inch beams. Flexure specimens were weighed at the time they were fabricated, when they were removed from the molds, at each time the curing conditions were changed, and at the time of test. Thus it was possible to calculate the percentage of water remaining in each specimen at each change of curing condition and at test.

The flexure specimens were tested as simple beams on an 18-inch span with a side as molded, in tension. They were loaded at the third points with the apparatus described in PUBLIC ROADS (vol. 13, no. 11), January 1933. The compression specimens were tested in accordance with standard methods.

The percentage of original mixing water remaining in the flexural specimens at the periods indicated is shown in table 5. Similar data are not available for the cylinders, because it was necessary to cap them, thereby changing the weight as well as the composition of the individual specimens. The average flexural strength for each group tested is given in table 6; table 4 gives similar data as regards crushing strength.

HAYDITE CONCRETE RELATIVELY SLOW IN ABSORBING AND LOSING MOISTURE

Table 5 shows the amounts of water remaining in the beam specimens at various periods, expressed as percentages of the original mixing water. The results show that the Haydite concrete lost approximately 7 percent of its mixing water during the first 24 hours. After 6 days curing in the moist room the specimens had reabsorbed moisture until the water content averaged about 95 percent of the original amount. After 28 days the percentage had increased to about 97 percent, and complete saturation was reached at 180 days. For the limestone concrete the percentage of original mixing water at 24 hours averaged about 91 percent. After curing in the moist room for 6 days the water content was about 95 percent, and complete saturation was attained at 28 days. Complete saturation is considered to have been reached when the water content of the specimen was 100 percent of the original amount of water used.

The amounts of moisture lost by specimens cured in the moist room for 6 days, followed by curing in air for varying periods, are shown for groups 2, 4 to 9 inclusive, 13, 14, and 28 in table 5. It will be observed that for both aggregates the moisture loss reached a maximum after about 6 months' curing in air. Increasing the curing period beyond 6 months (groups 13, 14, and 28) appeared to have negligible effect insofar as drying was concerned.

Data for groups 5 to 9, inclusive, show the effect of immersing the specimens from 1 to 7 days in water after approximately 6 months curing in air. The initial curing period was 6 days in the moist room in each case. It will be observed that after 7 days of immersion (group 5) the limestone concrete had reabsorbed a considerably larger proportion of its original mixing water than had the Haydite concrete. Moreover, the rate of gain in weight after the first 24 hours in water appeared to be considerably less for the Haydite concrete.

Comparing groups 5 and 14 we find that for the limestone concrete, 7 days' curing in water was sufficient time for the specimens to regain all the moisture lost during the 6-month or 1-year curing in air. This was not true of the Haydite concrete, the amount of water reabsorbed after 7 days curing in water being substantially less than the amount present at the time the specimens were subjected to air curing.

TABLE 5.—*Percentages of original mixing water remaining in concrete specimens after curing*

CONCRETE BEAM SPECIMENS CONTAINING HAYDITE AGGREGATES

Group no.	Molds for 24 hours	Moist room: Period	Moist room: Water content	Air: Period	Air: Water content	Oven: Period	Oven: Water content	Water: Period	Water: Water content	Laboratory air: Period	Laboratory air: Water content	At test
	Percent	*Days*	*Percent*	*Days*	*Percent*	*Days*	*Percent*	*Days*	*Percent*	*Days*	*Percent*	*Percent*
1	93	6	94									94
2	93	6	96	20	73					1	71	71
3	92	27	96									96
4	94	6	96	172	62					1	62	62
5	93	6	96	166	62			7	82			82
6	92	6	94	169	60			4	81			81
7	93	6	95	170	62			3	81			81
8	92	6	94	171	59			2	80			80
9	94	6	97	172	62			1	81			81
10	93	172	100	6	95					1	95	95
11	94	171	100			7	63			1	64	64
12	93	179	100									100
13	93	6	96	352	61					1	61	61
14	93	6	94	346	60			7	84			84
15	94	27	98	331	70					1	70	70
16	93	179	100	179	83					1	84	84
17	93	269	100	89	88					1	88	88
18	93	27	96	325	69			7	87			87
19	93	179	98	173	83			7	92			92
20	93	269	99	83	88			7	95			95
21	94	352	101	6	97					1	96	96
22	96	351	101			7	74			1	75	75
23	93	358	100							1	97	97
24	94	357	101			1	90			1	90	90
25	94	359	100									100
26	94	359	101			67	29			1	30	30
27	95	427	100									100
28	93	6	96	352	60					69	58	58

CONCRETE BEAM SPECIMENS CONTAINING NATURAL SAND AND CRUSHED LIMESTONE

Group no.	Molds for 24 hours	Moist room: Period	Moist room: Water content	Air: Period	Air: Water content	Oven: Period	Oven: Water content	Water: Period	Water: Water content	Laboratory air: Period	Laboratory air: Water content	At test
1	92	6	96									96
2	90	6	93	20	76					1	75	75
3	93	27	100									100
4	92	6	96	172	66					1	66	66
5	91	6	96	166	67			7	95			95
6	92	6	95	169	65			4	95			95
7	90	6	94	170	66			3	92			92
8	91	6	96	171	65			2	91			91
9	89	6	93	172	64			1	88			88
10	94	172	103	6	97					1	96	96
11	92	171	101			7	52			1	53	53
12	90	179	101									101
13	92	6	96	352	67					1	67	67
14	92	6	96	346	67			7	97			97
15	92	27	100	331	70					1	70	70
16	92	179	100	179	80					1	79	79
17	91	269	101	89	86					1	85	85
18	92	27	99	325	70			7	95			95
19	90	179	99	173	80			7	94			94
20	90	269	98	83	84			7	94			94
21	92	352	102	6	98					1	97	97
22	91	351	102			7	63			1	63	63
23	90	358	101							1	97	97
24	91	357	101			1	88			1	88	88
25	90	359	101									101
26	92	359	103			48	32			1	34	34
27	91	408	101									101
28	92	6	95	352	66					50	63	63

Data for groups 13, 15, 16, and 17 show the moisture content at 1 year, after the specimens had been subjected to moist curing followed by air curing for periods of various length. As might be expected, the percentage of water remaining at the end of the drying period decreased as the period of air curing increased. This was true also for groups 14, 18, 19, and 20 insofar as the amount of moisture remaining at the end of the air curing period was concerned. However, these specimens were subjected to 7 days of water curing following the air curing period. For the limestone concrete, this final immersion in water resulted in final moisture contents approximately the same as before air curing began. However, the final moisture content of the Haydite concrete specimens varied with the length of the air curing period—the shorter this period the greater the water content at the end of the final 7 days of water curing.

TABLE 6.—*Curing conditions and flexural strengths of concrete beams*

Group no.	Age at test	Curing: Initial moist	Curing: Oven	Curing: Air	Curing: Water	Haydite: Modulus of rupture	Haydite: Coefficient of variation	Limestone: Modulus of rupture	Limestone: Coefficient of variation	Strength ratio, Haydite concrete to limestone concrete
	Days	*Days*	*Days*	*Days*	*Days*	*Lb. per sq. in.*	*Pct.*	*Lb. per sq. in.*	*Pct.*	*Pct.*
1	7	7				386	6.6	445	6.2	87
2	28	7		21		357	8.3	442	4.5	81
3	28	28				533	1.6	591	12.8	90
4	180	7		173		556	4.3	643	11.2	86
5	180	7		166	7	550	11.0	586	3.2	94
6	180	7		169	4	544	7.1	573	10.1	95
7	180	7		170	3	[1] 572	[1] 4.8	589	12.9	97
8	180	7		171	2	590	8.8	600	4.2	98
9	180	7		172	1	[1] 607	[1] 4.4	675	4.5	90
10	180	173		7		391	13.2	[1] 534	[1] 9.0	73
11	180	172	7	1		372	15.4	[1] 560	[1] 6.2	66
12	180	180				629	6.5	770	5.9	82
13	360	7		353		512	4.2	623	13.2	82
14	360	7		346	7	483	10.9	535	4.5	90
15	360	28		332		468	16.6	656	8.0	71
16	360	180		180		246	2.9	657	6.5	37
17	360	270		90		296	11.7	652	8.1	45
18	360	28		325	7	660	3.2	627	11.5	105
19	360	180		173	7	585	4.4	809	8.6	72
20	360	270		83	7	540	8.7	800	5.4	68
21	360	353		7		422	7.6	589	7.1	72
22	360	352	7	1		305	6.4	612	5.0	50
23	360	359		1		476	3.4	577	8.4	82
24	360	358	1	1		376	6.6	[1] 631	[1] 7.4	60
25	360	360				679	8.2	736	5.6	92
26	[2] 428	360	67	1		452	10.4			76
	[3] 409	360	48	1				591	14.9	
27	[2] 428	428				675	8.2			97
	[3] 409	409						695	7.8	
28	[2] 428	7		421		534	10.7			80
	[3] 409	7		402				668	5.8	
Average						493	7.7	624	7.8	79

[1] Values represent average of tests on 4 specimens, all other values represent average of tests on 5 specimens.
[2] Data for beams having Haydite aggregates.
[3] Data for beams having natural sand and crushed limestone aggregates.

Data for groups 10 and 21 show for both types of concrete that the moisture loss after 7 days in air curing was approximately the same for specimens that were cured initially for 1 year in the moist room as it was for specimens cured for 6 months. On the other hand, 7 days of oven curing at 170° F. for specimens previously cured for 6 months in the moist room reduced their water contents by 43 percent, as compared with a reduction of only 33 percent for specimens cured for 1 year (groups 11 and 22, respectively). Data for groups 23 and 24 show that for specimens cured initially 1 year in the moist room, drying in the oven for 1 day drove off three or four times as much water as drying for 1 day in air.

In order to determine how much water could be driven off at a temperature of 170° F., a group of both Haydite and limestone specimens were kept in the oven until they had reached constant weight. The results show (group 26) that a slightly greater percentage of

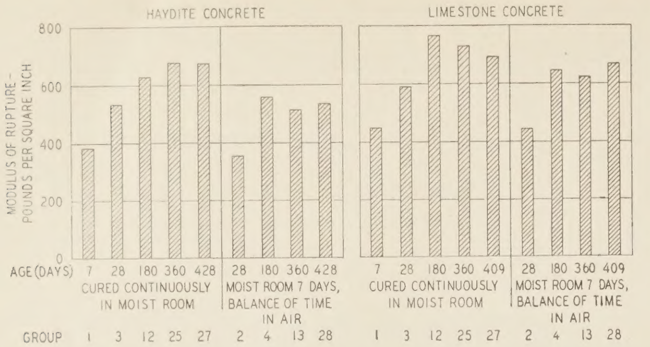

FIGURE 1.—RELATIONS BETWEEN AGE AND FLEXURAL STRENGTH OF HAYDITE AND LIMESTONE CONCRETE SPECIMENS.

water was lost by the Haydite concrete than by the limestone concrete, the percentages of water retained being 29 and 32, respectively. However, 67 days were required for the Haydite concrete to reach constant weight, as compared with 48 days for the limestone concrete.

Results of the absorption tests are of interest principally as indicating the effect of type of aggregate on rate of change in moisture content resulting from drying or absorption. In general, Haydite concrete both lost and gained moisture at a slower rate than did limestone concrete. In this connection it should be remembered that the concrete made with Haydite aggregates contained 7.2 sacks of cement per cubic yard, while concrete made with natural aggregates contained but 5.7 sacks per cubic yard.

NONUNIFORM MOISTURE DISTRIBUTION FOUND TO AFFECT FLEXURAL STRENGTH

The results of tests for flexural strength at various ages and for the several conditions of curing investigated are given in table 6 and are shown graphically in figures 1 to 6, inclusive. The relations between flexural strength and age under continuous moist and continuous air curing conditions for both types of aggregate are shown in figure 1. It will be observed that under moist curing the Haydite concrete increased in strength up to 360 days, and specimens tested at the age of 428 days gave practically the same results as those tested at 1 year.

For limestone concrete under moist curing there was a distinct decrease in strength at 360 days as compared with strength at 180 days, with still further retrogression at 409 days. The retrogression in strength after 6 months for the limestone concrete is quite surprising in view of the fact that standard moist curing conditions obtained throughout the curing period.

In the case of specimens cured in air after 7 days of initial moist curing, we find little change in strength after 180 days for both types of aggregate. The maximum strength attained by the Haydite concrete specimens cured in air was about the same as the 28-day strength after moist curing. For the limestone concrete specimens cured in air the maximum strength was slightly higher than the 28-day strength after moist curing. Also, the 28-day strengths (after curing in air for 21 days) were about the same as the strengths of the 7-day, moist-cured specimens. In this case the normal gain in strength between 7 and 28 days was probably neutralized by the fact that specimens air dried for 21 days were only partially dry when tested; that is, while the outer shell of the specimen was fairly dry the core

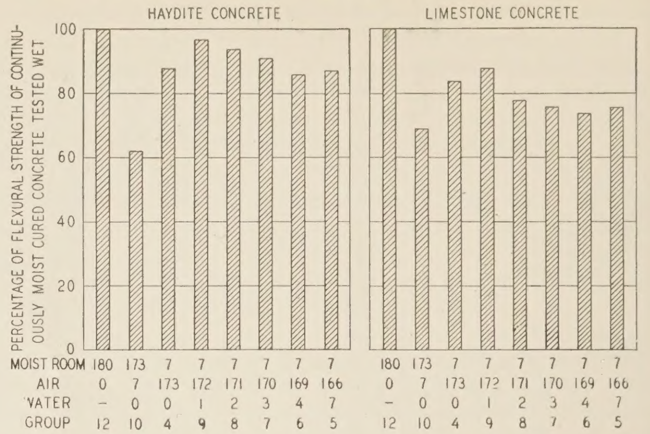

FIGURE 2.—EFFECT OF VARIATIONS IN PERIOD OF RESATURATION ON FLEXURAL STRENGTH OF CONCRETE SPECIMENS AFTER CURING 180 DAYS AS INDICATED.

was still wet. The drying shell produced tensile stresses in the extreme fibers of the beam.

These initial stresses of course tended to reduce the load required to produce failure in bending, resulting in an observed modulus of rupture considerably lower than would have been obtained if the moisture content of the specimens when tested had been the same throughout. The fact that the strengths after 180 days in air curing increased materially probably resulted from the fact that during this period the specimens had an opportunity to dry uniformly, thus relieving these moisture stresses. That this so-called "shell" effect is of great importance in influencing the observed modulus of rupture will be evident from consideration of the results for specimens cured for 6 months and for 1 year, a discussion of which follows.

The results of flexure tests on specimens cured for 180 days under various curing and moisture conditions are shown in figure 2. Values in all cases have been expressed as percentages of the strength developed under continuous moist curing. It will be noted that specimens taken from the moist room at 173 days and cured in air for 7 days before testing attained only about two-thirds of the strength of specimens tested immediately upon removal from the moist room (groups 12 and 10). This decrease no doubt resulted from the partial drying of the specimens during the final 7-day period, as explained above. The effect was somewhat more marked in the Haydite concrete, the decrease in strength being 38 percent as compared with 31 percent for the limestone concrete.

The effect of partial drying is further illustrated by comparing the strengths of specimens cured in the moist room for 173 days, followed by 7 days in air, with those cured for 7 days in the moist room, followed by 173 days in air (groups 10 and 4). The air-cured specimens had much higher strengths, probably as a result of the absence of internal shrinkage stress in the concrete.

The effect of curing in water from 1 to 7 days just prior to testing the air-cured specimens is also shown in figure 2 (groups 5 to 9, inclusive). It will be observed that immersing the specimens for 1 day increased the strength, but that further immersion tended to lower the strength. This applied to both the Haydite and the limestone concretes. Here we have a condition where the dry specimen was absorbing water from the outside, resulting in an effect just the reverse of that previously described in which the wet specimen was

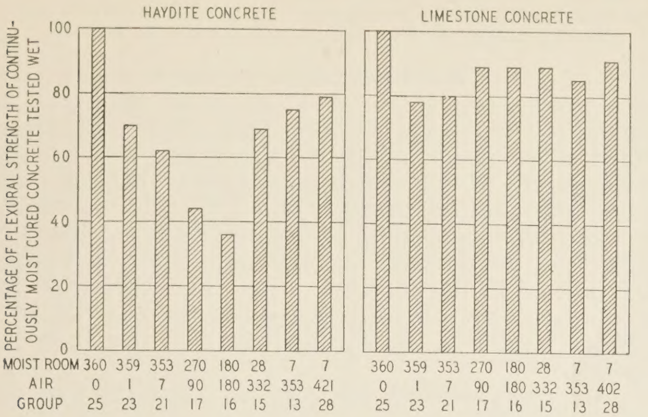

Figure 3.—Effect of Variations in Periods of Moist Room and Air Curing on Flexural Strength of Concrete Specimens After Curing 1 Year as Indicated.

drying. In this case the effect of moisture in the outer shell was to produce compressive stresses in the extreme fibers of the beam, thereby raising, instead of lowering, the observed modulus of rupture. That this is true is evidenced by the fact that specimens immersed for only 1 day in water had higher strengths than the specimens tested dry, but the strengths decreased as the period of immersion increased.

The strength of Haydite concrete after 4 days of immersion was practically the same as that of the air-dry specimens, indicating that moisture equilibrium had been established. For limestone concrete, the strengths after 2 days of immersion and longer were all somewhat lower than those of the air-dried specimens. For immersion periods of 3 days and longer there was little difference in strength. The results indicate that when curing has been in air, a 24-hour water immersion period prior to testing may not give true results because of incomplete moisture penetration.

EFFECT OF PERIOD AND TYPE OF CURING ON FLEXURAL STRENGTH STUDIED

The effect of variations in the relative amounts of moist and air curing on the flexural strength of specimens tested at the age of 1 year is shown in figure 3. It will be observed that, for Haydite concrete, increasing the period of air curing prior to test caused a progressive reduction in flexural strength up to and including 180 days of air curing. For this condition, the specimens developed only 36 percent of the strength of the continuously moist-cured concrete. However, further increasing the period of air curing up to 353 days resulted in increasing the strength progressively. An increase in the drying period up to 421 days still further increased the strength. It is believed, however, that the increase was caused more by the change in moisture condition than by the additional curing that the specimens received between 360 and 428 days.

The very peculiar behavior of the Haydite concrete here indicated is believed also to be caused by internal moisture stresses, as discussed above. There seems to be no other explanation that will cover the facts. In this connection it is interesting to note that, although the limestone concrete exhibited the same tendency, the maximum decrease in strength was not as great, and also that it occurred after only 1 day of drying. The moisture distribution appeared to be equalized, at least insofar as effect on internal stress was concerned, somewhere between 7 and 90 days of air curing, whereas in the Haydite concrete it did not occur until certainly well beyond the 180-day period.

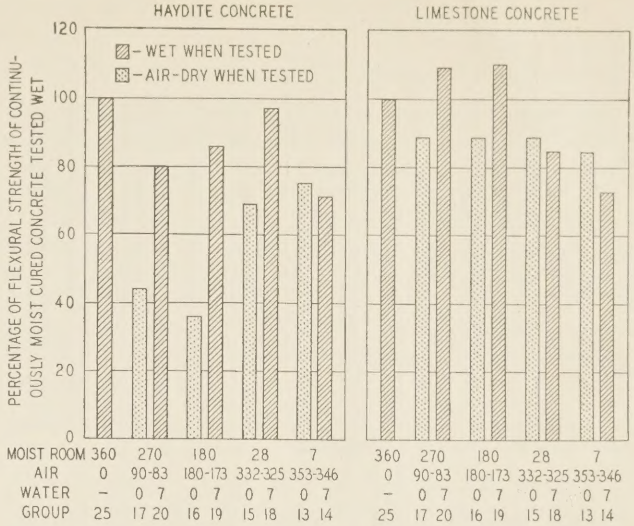

Figure 4.—Effect on Flexural Strength of Resaturation for 7 Days Prior to Testing for Concrete Specimens After Curing 360 Days as Indicated.

By comparing the results of the strength tests with the corresponding moisture losses at the time of test as shown in table 5 it will be noted also that the measured moisture loss appeared to bear no relation to variation in strength caused by moisture. For instance, groups 13, 15, 16, and 17 for limestone concrete showed practically the same strength although the percentage of total moisture retained varied from 67 to 85.

In order to study the effect of resaturation on the strength of the concrete cured for various periods in air, certain of the specimens cured as indicated in figure 3 were removed from air curing and immersed in water for 7 days prior to testing. The results are shown in figure 4, together with values for the corresponding air-dried specimens. In studying these results it should be noted that, insofar as curing is concerned, each pair of values (for instance, groups 16 and 19) represent tests on specimens subjected, except for the final 7-day period, to identical curing conditions. Therefore, the variations noted must have been caused by some other factor, presumably the shell effect previously discussed.

FLEXURAL STRENGTH OF HAYDITE CONCRETE FOUND MOST SUSCEPTIBLE TO MOISTURE CHANGE

It is difficult to explain satisfactorily all of the trends observed in figure 4. This applies particularly to the results obtained on the specimens immersed in water for 7 days prior to test. This period would certainly seem sufficient to eliminate the shell effect. However, if we assume this to be true, then variations in strength of the resaturated specimens must be caused by variations in curing only. This would not explain the relative strengths shown by the Haydite concrete in groups 18, 19, and 20. It would certainly be reasonable to expect the strength to decrease with decrease in the length of the initial moist curing period, whereas, with the single exception of the specimens cured for 7 days in the moist room (group 14), just the reverse is true.

In the limestone concrete the relative values are as would be expected, except for the high strengths shown for groups 19 and 20. It is possible that in these groups the reabsorption of water actually produced compression

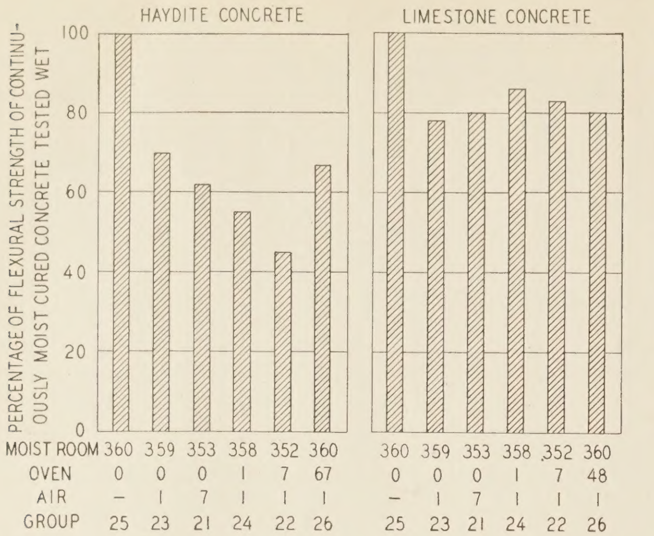

Figure 5.—Effect of Drying Prior to Test on Flexural Strength of Concrete Specimens After Curing Approximately 1 Year in Moist Room.

in the extreme fibers which, combined with the relatively long inital period of moist air curing, produced the exceptionally high strengths observed. In any event, it is obvious that, in the determination of the flexural strength of concrete, great care should be exercised to insure that the specimens are truly in equilibrium, insofar as internal moisture stresses are concerned, when they are tested.

In the discussion so far presented the specimens cured in air were partially dried by storing in an unheated room adjacent to the laboratory. When the outside temperature went below freezing, a window leading to the laboratory was opened so that with the exception of short periods the temperature in the curing room was kept above freezing.

Tests were made to determine the effect of rapid drying and also to determine what effect drying to constant weight would have on the flexural strength. A number of specimens were dried in an electric oven at a temperature of approximately 170° F. for periods of 1 and 7 days. Others were dried to constant weight, the time required varying for the individual specimens in each group. The 48 days noted for the limestone concrete and the 67 days noted for the Haydite concrete represent the average of five separate tests in each case. After removal from the oven the specimens were allowed to cool for 1 day in the laboratory before being tested. The results are shown in figure 5.

Referring first to the results for Haydite concrete, it will be observed that the strengths progressively decreased as the amount of drying increased up to 7 days of oven curing. Haydite specimens subjected to this treatment developed only 45 percent of the strength of moist-cured specimens of the same age, as compared with 83 percent for the limestone specimens. It will be noted also that, with the limestone concrete, the greatest decrease in strength occurred after 1 day of air drying, as against 7 days of oven and 1 day of air drying for the Haydite concrete. These results again point to the greater susceptibility of the Haydite concrete to moisture change and show also the effect of the slower drying action in concrete containing Haydite.

RECOMMENDATION MADE THAT FLEXURE SPECIMENS BE IMMERSED IN WATER FOR 48 HOURS BEFORE TESTING

Comparison of the flexural strengths of the Haydite and the limestone concrete specimens subjected to similar curing conditions shows that the average for all Haydite specimens tested wet was about 90 percent of the strength of the limestone concrete. On the other hand, the average strength of all Haydite specimens tested in various degrees of dryness was only about 70 percent of the strength of the limestone concrete cured and tested in like manner. This indicates that the strength of the Haydite concrete was affected to a greater degree by air curing than was the limestone concrete.

The degree to which the Haydite specimens were adversely affected varied over a wide range. For instance, the strength of Haydite specimens cured for 173 days in air after 7 days of moist curing was 86 percent of that of limestone specimens, or nearly equal to the 90 percent for the continuously moist-cured specimens. On the other hand, the Haydite specimens cured for 180 days in air after 180 days of moist curing had but 37 percent of the strength of limestone concrete similarly cured. It is apparent, therefore, that the time at which dry curing began had a marked effect on the ratio of the strength of the Haydite to the strength of the limestone concrete.

The previous discussion has been confined to the effect of the several variables on the flexural strength of the concrete tested. Additional tests were made to determine the effect on crushing strength of air curing as compared with moist curing. Tests were made at 7, 28, 180, and 360 days, on specimens cured the entire time in the moist room and on specimens cured in air after an initial moist curing of 7 days. No tests were made on specimens cured dry and tested wet or on specimens cured wet and tested dry as was done with the beam specimens. In other words, all of the compression specimens were probably in a stabilized moisture condition when tested.

The results for the Haydite concrete (fig. 6) indicate a progressive increase in strength for moist curing up to 180 days, with a small increase over the 180-day strength at 360 days. The same general trend is found for the specimens cured in air; that is, the strength at 360 days was approximately the same as that at 180 days. At each curing period the air-cured specimens had lower strengths than the moist-cured specimens, the difference becoming greater as the age at test increased. The results are in agreement with those found in the flexure tests; that is, the specimens cured in air and tested dry had lower strengths than those cured in moist air and tested wet.

The right-hand panel of figure 6 gives similar results for the limestone concrete. The results obtained are in general agreement with those found for the Haydite concrete; therefore they will not be discussed in detail. They are also in agreement with the flexure test results where the specimens were subjected to like curing treatments.

These tests indicate that the flexural strength of concrete containing aggregates of the type represented by Haydite is affected considerably more by variations in curing and moisture content at time of test than is concrete containing naturally occurring aggregates of average quality.

(Continued on p. 61)

THE OLIENSIS SPOT TEST IMPROVED

Reported by R. H. LEWIS, Associate Chemist, and J. Y. WELBORN, Junior Highway Engineer, Division of Tests, Bureau of Public Roads

SINCE the publication in 1933 of Mr. Oliensis' paper "A Qualitative Test for Determining the Degree of Heterogeneity of Asphalts",[1] the Bureau of Public Roads has devoted considerable time to the study of this test, which has proven to be a very useful one. The results of these studies corroborate the author's conclusions with respect to the scope and limitations of the test.

In tests by the Bureau on a large number of asphaltic materials from all producing centers, heterogeneity is found to be far more prevalent among the more fluid materials than among the refined, semisolid, paving asphalts, and the quantitative method recently developed by Mr. Oliensis should be of great value in comparing the degree of heterogeneity of various asphaltic materials. The paper[2] describing this new method of test has been studied and the data obtained are presented in this report.

Clifford Richardson has stated: [3]

> In residual pitches, at times some of the bitumen is found which is insoluble in cold carbon tetrachloride, and this is evidently due to the severe treatment which the material has suffered in the course of its production at very high temperatures. A determination of the amount is only valuable as an indication of the care which has been used in the preparation of such pitches.

For years, therefore, asphalt specifications, have required a high solubility in carbon tetrachloride as a protection against overheating in the refining process.

However, examination of fluid and semisolid asphalts from numerous sources has shown that many of the products that have been subjected to temperatures much higher than those used in normal steam refining have relatively high solubility in carbon tetrachloride. Many materials that are definitely cracking-coil residues produce a positive stain with both naphtha and xylene, while the majority of those that apparently have been inadvertently overheated in a steam or vacuum process, and some blends of cracked and uncracked residuals, give a positive stain with naphtha and a negative stain with xylene. In spite of their high solubility in carbon tetrachloride, these asphaltic materials are heterogeneous. It is apparent, therefore, as has been pointed out by Mr. Oliensis, that a high solubility in carbon tetrachloride does not indicate definitely that the material has not been overheated in the refining process.

The Bureau is now engaged in a detailed investigation of commercial grades of semisolid asphalts from the refineries of the major producers. This study involves among other things the exposure of the asphalts in films one-eighth inch thick to the action of sun and light for 15 weeks (approximately 900 sunlight hours).

Thirty-nine samples of 85–100 penetration asphalt have been studied, of which 16 samples gave negative stains both before and after exposure. Nine gave negative stains before exposure and showed varying degrees of heterogeneity after exposure. Twelve gave positive stains before and after exposure; and two materials that showed slight heterogeneity before exposure produced negative stains after 15 weeks of exposure. Perhaps these two are examples of the fugitive type which has been observed by Mr. Oliensis.

For the 23 samples that gave positive stains either before or after exposure, table 1 gives the base petroleum and the refining process as reported by the manufacturers. Results of the Oliensis spot test before and after exposure, the gilsonite and xylene equivalents before exposure, and the xylene equivalent after exposure are also listed.

METHOD OF DETERMINING GILSONITE AND XYLENE EQUIVALENTS DESCRIBED

In considering the data in table 1, and later in table 2, the heterogeneity of the materials is expressed quantitatively by limits representing the highest percentage of gilsonite or xylene that would produce a positive stain and the lowest percentage of gilsonite or xylene that would produce a negative stain. The true xylene or gilsonite equivalent (the exact percentage of homogeniser necessary to produce a negative stain) is within these limits. Thus, a xylene equivalent of 12–16 means that with 12 percent or less of xylene in the standard naphtha the material developed a positive stain and that with 16 percent or more of xylene, a negative stain was obtained. A gilsonite equivalent of 50–60 means that when 50 percent of gilsonite was blended with the material under test and the blend tested with standard naphtha a positive stain was produced; when the blend of gilsonite and asphaltic material contained 60 percent of gilsonite a negative stain was obtained. The term "xylene insoluble" indicates that a positive stain was obtained with 100 percent of xylene and the material is beyond the range of the test, i. e., the heterogeneity of the material is indeterminable with this solvent.

Table 1 shows that only 2 of the 39 materials produced a positive stain with xylene, either before or after exposure. Eight of the 14 original materials that were heterogeneous had xylene equivalents of 8 or less, and gilsonite equivalents of 10 or less. Of the heterogeneous exposure residues of the nine materials that were originally homogeneous, seven had xylene equivalents of eight or less. For those materials that were heterogeneous originally, the increase in xylene equivalent in the exposed residues was quite variable.

Samples 7 and 8 are of special interest. Both were produced from the same Venezuelan crude, the first by the continuous vacuum steam distillation and the latter by batch steam distillation. After exposure sample 8, which gave a positive stain initially, had a higher xylene equivalent than sample 7, which gave a negative stain initially.

In table 1 of Mr. Oliensis' report,[2] he shows that the xylene equivalent for sample 13, representing a wax-bearing residual, crude K, was greater than the gilsonite equivalent. Sample 23 of the materials tested by the Bureau was a wax-bearing residual, produced from a crude that tested positive in the spot test. Tests made on other semisolid products from this same refinery and on residues reduced in the laboratory with a high

[1] Proceedings, American Society for Testing Materials, vol. 33, pt. II.
[2] A Further Study of the Heterogeneity of Asphalt—A Quantitative Method, by G. L. Oliensis. Proceedings, American Society for Testing Materials, vol. 36, pt. II.
[3] The Modern Asphalt Pavement, by Clifford Richardson. John Wiley & Sons, New York, 1905, 1 ed., p. 120.

TABLE 1.—*Oliensis spot test results and gilsonite and xylene equivalents for samples of 85–100 penetration asphalt*

Sample no.	Base petroleum	Refining process	Tests before exposure			Tests after exposure for 15 weeks in 1/8-inch film	
			Standard naphtha stain	Gilsonite equivalent	Xylene equivalent	Standard naphtha stain	Xylene equivalent
1	California	Steam distillation	Negative			Positive	0–2
2	do	Vacuum distillation	do			do	0–2
3	do	Steam distillation	do			do	12–16
4	do	Vacuum distillation	Positive	0–1	0–2	do	12–16
5	Mexican		do	50–60	24–28	do	28–32
6	Venezuelan	Steam distillation	do	5–8	2–4	do	12–16
7	do	Continuous vacuum steam distillation	Negative			do	12–16
8	do	Batch steam distillation	Positive	5–10	2–4	do	20–24
9	do	Steam distillation	do	5–10	2–4	do	12–16
10	do	Vacuum distillation	Negative			do	0–2
11	do	Steam distillation	do			do	0–2
12	Smackover	Vacuum distillation	Positive	0–1	0–2	Negative	
13	Oklahoma		do	30–35	44–48	Positive	72–76
14	do		do	2–4	2–4	do	4–8
15	do		do	5–10	4–8	do	8–12
16	do		do	60–80	(1)	do	(1)
17	Blend of Mexican and Oklahoma	Steam distillation	Negative			do	4–8
18	Kansas	Winkler-Kock shell still	Positive	80–90	(1)	do	(1)
19		Steam distillation	do	15–25	12–16	do	32–36
20		do	do	0–2	0–2	Negative	
21	Blend of Mexican and domestic Gulf coast crudes.		Negative			Positive	0–2
22	do		do			do	2–4
23	Texas		Positive	35–40	16–20	do	36–40

[1] Xylene insoluble.

steam ratio from the crude oils used as base petroleum by this refinery, showed that they required approximately 35 percent of gilsonite to produce a negative stain. Although the other samples from this source were not tested for xylene equivalent, it is noted that the xylene equivalent for sample 23 was considerably lower than the gilsonite equivalent. This is not in agreement with the conclusion by Mr. Oliensis that gilsonite is more efficient than xylene in correcting heterogeneity caused by waxy bodies.

The spot test results for these representative asphalts show that 23 out of 39 samples, or about 60 percent, were homogeneous, and that 16, or about 40 percent, remained homogeneous after 15 weeks of exposure. All of the homogeneous materials that became heterogeneous upon exposure had xylene equivalents of 16 or less. Under the climatic conditions existing during the winter months at Madison, Ill., it is possible that heterogeneity might not have developed in these samples.

NEW METHOD USEFUL IN TESTING BOTH ORIGINAL MATERIALS AND RESIDUES FROM EXPOSURE

Under the same summer conditions to which the 85–100 penetration asphalts were subjected, all fluid materials that were studied in this investigation developed heterogeneous residues within 5 weeks. In a previous report covering a study of the spot test on liquid asphalts, mentioned in Mr Oliensis' paper, the following statement was made: [4]

> Since the results of the tests were based upon the appearance of the stain as interpreted by the observer, it is difficult if not impossible to distinguish between border-line materials or to express clearly the apparent degree of heterogeneity that may be indicated by the varying degrees of nonuniformity in the stain. The classification given should be understood to mean that, in the judgment of the observers, the materials and their residues gave stains that appeared either entirely uniform throughout or were only slightly nonuniform, having a slightly darker, more pronounced center, or else they had a definite dark to black center surrounded by a uniformly lighter colored stain, and were consequently classified as homogeneous, slightly heterogeneous, and heterogeneous respectively.

The use of the xylene equivalent gives promise of overcoming past difficulties in the proper interpretation of the spot test results and appears to offer a ready means of determining the comparative degree of heterogeneity and the rate of its development in materials exposed to weathering.

In a report presented at the January 1936 meeting of the Association of Asphalt Paving Technologists [5] the behavior of five materials—three steam-distilled residuals (Mexican, midcontinent, and California), and two cracking coil residuals under exposure conditions—was described. The results of the spot tests, determined on these materials after exposure in films 1/8, 1/16, and 1/32 inch thick for 5, 10, and 15 weeks, may help to show the possibilities of the quantitative method of determining heterogeneity suggested by Mr. Oliensis.

The two cracking coil residues gave positive spots with xylene, and the development of heterogeneity in these materials under exposure could only be detected by the steady development of organic matter insoluble in CS_2 and CCl_4. The other three materials and their distillation residues gave negative stains. The xylene equivalents of the residues after various periods of exposure are shown in table 2.

It will be seen that, at each test period, the thinner the film thickness the greater the xylene equivalent. For each thickness of film, except the 1/8- and 1/16-inch films of the Mexican residual, the xylene equivalent increased with the time of exposure. The reason that the 1/8- and 1/16-inch films of the Mexican residual after 10 weeks of exposure had lower xylene equivalents than the corresponding films after 5 weeks of exposure is not known.

Data on the solubilities of some of these residues are of interest (table 3). It will be seen that the 1/32-inch film of sample 2 after 15 weeks of exposure had more matter insoluble in CS_2 than two of the other residues, and more matter insoluble in CCl_4 than three of the other residues. However, it was readily dispersed in 68–72 percent xylene-naphtha solution, while the other samples all contained material insoluble in 100 percent xylene. This would seem to indicate a difference in the

[4] Further Studies of Liquid Asphaltic Road Materials, by R. H. Lewis and W. O'B. Hillman. PUBLIC ROADS, vol. 16, no. 6, August 1935, p. 108.

[5] A Report on the Weather-Resistant Properties of Certain Slow-Curing Liquid Asphaltic Materials. Proceedings of the Association of Asphalt Paving Technologists, Jan. 23, 1936.

TABLE 2.—*Xylene equivalents of residues of slow-curing liquid asphaltic materials (grade SC—2) after exposure*

Samples tested after exposure for—	Xylene equivalent of residues of—								
	Sample 1, Mexican residual. Film thickness of—			Sample 2, midcontinent residual. Film thickness of—			Sample 3, California residual. Film thickness of—		
	1/8-inch	1/16-inch	1/32-inch	1/8-inch	1/16-inch	1/32-inch	1/8-inch	1/16-inch	1/32-inch
5 weeks	4–8	8–12	12–16	0–2	28–32	48–52	24–28	36–40	48–52
10 weeks	0–2	4–8	([1])	16–20	36–40	60–64	32–36	44–48	64–68
15 weeks	8–16	([1])	([1])	36–40	56–60	68–72	36–40	48–52	([1])

[1] Xylene insoluble.

character of the insoluble materials in the several residues that affects their dispersion in the solvents used for determining heterogeneity.

The stain obtained in the original Oliensis spot test indicates only that the material is homogeneous or heterogeneous. The degree of heterogeneity is not determinable by this test and, as indicated in table 1, it automatically classes materials that have been only slightly overheated with products that have been subjected to excessive heat. This quantitative method, therefore, should prove extremely valuable in future studies of asphaltic materials.

TABLE 3.—*Comparison of solubilities of exposed samples with xylene equivalents*

Sample no.	Time of exposure	Film thickness	Total organic matter insoluble in CS_2	Total organic matter insoluble in CCl_4	Xylene equivalent
	Weeks	*Inch*	*Percent*	*Percent*	
1	10	1/32	1.88	1.98	Insoluble.
1	15	1/16	1.42	1.67	Do.
1	15	1/32	2.88	3.22	Do.
2	15	1/32	1.65	2.06	68–72.
3	15	1/32	1.21	1.40	Insoluble.

(Continued from p. 58)

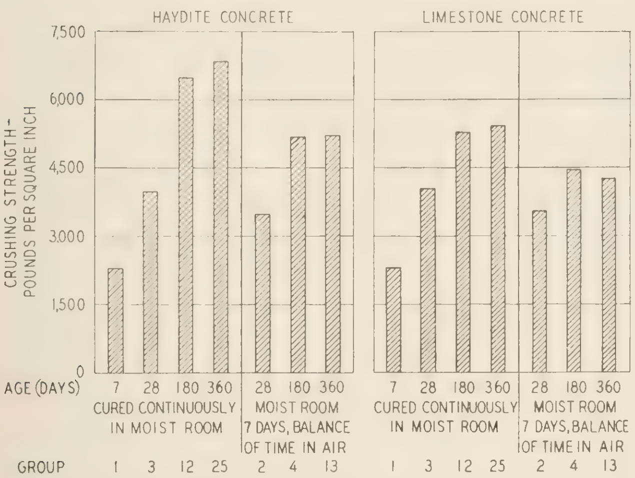

FIGURE 6.—RELATIONS BETWEEN AGE AND CRUSHING STRENGTH OF CONCRETE SPECIMENS CURED IN VARIOUS WAYS.

The wide variations in flexural strength of the Haydite concrete appear to result primarily from its tendency to absorb and to give off moisture at a slower rate than concrete containing normal aggregates, thus delaying the even distribution of moisture which is necessary in order to eliminate internal stresses.

The results emphasize the importance of controlling testing procedure so as to insure that specimens under test are free from stresses induced by an uneven distribution of moisture. They indicate that, where curing has been in air, immersion in water prior to test for more than the customary 24 hours may be necessary and that, when the specimens have been subjected to continuous moist curing until test, care should be exercised to prevent any drying prior to test.

Drying to constant weight in order to eliminate moisture stresses is not practicable because of the length of time required. For this reason it is recommended that all flexure testing be performed on saturated specimens, and that in cases where specimens have been subjected to drying prior to test they be immersed in water for at least 48 hours immediately before testing.

SLIPPERINESS OF ROAD SURFACES STUDIED BY ENGLISH INVESTIGATORS

Apparatus for accurately measuring the slipperiness of various road surfaces has been developed at the Road Research Laboratory of the Department of Scientific and Industrial Research in England. The machine used consists of a motorcycle and sidecar in which the sidecar wheel can be set at an angle to the direction of travel.

The horizontal reaction of the road, developed by the wheel because of its position, and the load on the wheel, are measured. From data obtained with instruments carried in the sidecar, the ratio of these forces is obtained and expressed as a coefficient which is high for nonskid surfaces and low for slippery ones. The construction and operation of the motorcycle and sidecar and of the measuring apparatus are described in a bulletin [1] recently issued jointly by the Department of Scientific and Industrial Research and the Ministry of Transport. The apparatus, which has been in regular use for several years, is estimated to cost £475 (approximately $2,350).

A bulletin [2] reporting results of the first of a series of studies of road friction has also been published recently. This bulletin summarizes the results of numerous measurements made on various types of road surfaces under different climatic conditions and at different speeds. Deductions and conclusions are drawn from the results obtained.

The skidding coefficient was found to be high for dry road surfaces free from loose material, and such surfaces can be considered as nonskid. On wet surfaces, the coefficient decreases as the speed increases. A value of 0.5 at 30 miles per hour may be regarded as reasonably safe; a value of 0.2 indicates that the surface affords insufficient resistance to skidding. Values of 0.2 or less are found most frequently on city streets.

The most slippery condition of a road is probably during a silver thaw, when the coefficient is as low as 0.1 at all speeds. Measurements taken on a snow-covered road showed values ranging from 0.5 to 0.2, the latter being found after the snow had become packed. The values for snow-covered roads were no lower than those found on some smooth, wet surfaces, but on snow-covered roads the lower values may persist down to speeds of 5 miles per hour.

On concrete surfaces the coefficient varied but little at different seasons of the year. Practically all other surfaces, when wet, were more slippery in summer than in winter. Tests made on wood- and rubber-block pavements showed them to have low coefficients.

The apparatus is now being improved to enable tests to be made at speeds higher than 30 miles per hour.

[1] Road Research Bulletin No. 1. Measurement of the Non-Skid Properties of Road Surfaces, H. M. Stationery Office, 9d net.

[2] Road Research Technical Paper No. 1. Studies in Road Friction. 1. Road Surface Resistance to Skidding. Published by H. M. Stationery Office, 1s. 6d. net.

MOTOR-FUEL CONSUMPTION, 1936

[Compiled for calendar year from reports of State authorities]

State	Tax rate per gallon— On Jan. 1	Tax rate per gallon— On Dec. 31	Date of rate change	Net total consumption in State [1]	Amounts exempted from payment of tax [2]: Federal and other public use [3]	Amounts exempted: Nonhighway use [4]	Amounts exempted: Allowance for evaporation and other losses	Amounts exempted: Total	Gross amount assessed for taxation	Amount subject to refund of entire tax	Net amount taxed	Amount taxed at full rate	Amount taxed at reduced rates: Rate per gallon	Amount taxed at reduced rates: Amount	Approximate amount taxed for highway use [5]: 1936	Approximate amount taxed for highway use [5]: 1935	Percentage change
	Cents	Cents		1,000 gallons	1,000 gallons	1,000 gallons	1,000 gallons	1,000 gallons	1,000 gallons	1,000 gallons	1,000 gallons	1,000 gallons	Cents	1,000 gallons	1,000 gallons	1,000 gallons	
Alabama	6	6		199, 040					199, 040		199, 040	199, 040			*199, 040	*172, 474	15. 4
Arizona	5	5		96, 543	5, 475			5, 475	91, 068	11, 559	79, 509	79, 509			79, 509	67, 323	18. 1
Arkansas	6½	6½		154, 208	4, 472		1, 460	5, 932	148, 276		148, 276	133, 884	([6])	14, 392	*148, 276	*131, 784	12. 5
California	3	3		1, 651, 837	27, 824		16, 240	44, 064	1, 607, 773	147, 780	1, 459, 993	1, 459, 993			1, 459, 993	1, 340, 137	8. 9
Colorado	4	4		208, 897	[7] 9, 188	615	4, 145	13, 948	194, 949	22, 288	172, 661	172, 661			172, 661	152, 324	13. 3
Connecticut	3	3		299, 405	3, 024		2, 957	5, 981	293, 424	6, 206	287, 218	287, 218			287, 218	263, 781	8. 9
Delaware	4	4		50, 766	[8] 1, 024			1, 024	49, 742	2, 675	47, 067	47, 067			47, 067	42, 948	9. 6
Florida	7	7		300, 192	7, 642	1, 993	2, 478	12, 113	288, 079		288, 079	288, 079			*288, 079	*256, 609	12. 3
Georgia	6	6		303, 968	3, 809		1, 486	5, 295	298, 673		298, 673	298, 673			*298, 673	*264, 617	12. 9
Idaho	5	5		87, 848	4, 331	478		4, 809	83, 039	8, 135	74, 904	74, 701	2½	[9] 203	74, 701	63, 743	17. 2
Illinois	3	3		1, 191, 915					1, 191, 915	68, 583	1, 123, 332	1, 123, 332			1, 123, 332	1, 015, 019	10. 7
Indiana	4	4		564, 073	2, 364			2, 364	561, 709	35, 800	525, 909	525, 909			525, 909	472, 010	11. 4
Iowa	3	3		460, 298					460, 298	48, 754	411, 544	411, 544			411, 544	386, 489	6. 5
Kansas	3	3		450, 331		[10] 124, 886	9, 007	133, 893	316, 438		316, 438	316, 438			316, 438	295, 308	7. 2
Kentucky	5	5		228, 333					228, 333		228, 333	228, 333			*228, 333	*201, 324	13. 4
Louisiana	5	7	July 28	223, 093	3, 853		6, 693	10, 546	212, 547		212, 547	[11] 212, 547			*212, 547	*186, 201	14. 1
Maine	4	4		134, 521	1, 412			1, 412	133, 109		133, 109	127, 513	1	[12] 5, 596	127, 513	114, 532	11. 3
Maryland	4	4		245, 231	3, 731			3, 731	241, 500	14, 964	226, 536	224, 319	3	[13] 2, 217	226, 536	204, 850	10. 6
Massachusetts	3	3		654, 309					654, 309	29, 379	624, 930	624, 930			624, 930	584, 233	7. 0
Michigan	3	3		995, 581	4, 971	49, 925	28, 027	82, 923	912, 658	39, 682	872, 976	872, 976		([14])	[15] 871, 512	767, 987	13. 5
Minnesota	3	3		483, 844	3, 768	1, 881	15, 510	21, 159	462, 685	58, 259	404, 426	404, 426			404, 426	374, 701	7. 9
Mississippi	6	6		169, 945	4, 496		3, 305	7, 801	162, 144		162, 144	151, 880	1	[16] 10, 264	151, 880	123, 291	23. 2
Missouri	2	2		567, 750					567, 750	19, 539	548, 211	548, 211			548, 211	498, 350	10. 0
Montana	5	5		111, 743	3, 813		2, 116	5, 929	105, 814	15, 367	90, 447	90, 447			90, 447	77, 393	16. 9
Nebraska	5	5		231, 581	1, 274		7, 085	8, 359	223, 222		223, 222	223, 222			*223, 222	*219, 165	1. 8
Nevada	4	4		32, 839	1, 633	1, 189	601	3, 423	29, 416	1, 996	27, 420	27, 420			27, 420	24, 046	14. 0
New Hampshire	4	4		80, 898					80, 898	2, 150	78, 748	78, 748			78, 748	71, 992	9. 4
New Jersey	3	3		723, 024	[17] 12, 193			12, 193	710, 831	52, 977	657, 854	657, 854			657, 854	594, 432	10. 7
New Mexico	5	5		81, 858	4, 622		1, 165	5, 787	76, 071	6, 525	69, 546	69, 546			69, 546	57, 987	19. 9
New York	4	3	July 1	1, 721, 830	[18] 59, 681	4, 010		63, 691	1, 658, 139	39, 017	1, 619, 122	[19] 1, 619, 122			1, 619, 122	1, 495, 863	8. 2
North Carolina	6	6		350, 380	3, 750	638	2, 315	6, 703	343, 677		343, 677	335, 097	1	[16] 8, 580	335, 097	305, 579	9. 7
North Dakota	3	3		103, 697	877			877	102, 820	25, 799	77, 021	77, 021			77, 021	78, 877	−2. 4
Ohio	4	4		[20] 1, 201, 445	4, 216	29, 893	33, 985	68, 094	1, 133, 351	9, 998	1, 123, 353	1, 078, 255	1	[20] 45, 098	1, 078, 255	965, 240	11. 7
Oklahoma	4	4		365, 737	3, 666		7, 222	10, 888	354, 849	22, 606	332, 243	322, 243			332, 243	299, 593	10. 9
Oregon	5	5		216, 578	4, 663			4, 663	211, 915	25, 050	186, 865	186, 092	1	[21] 773	186, 092	160, 434	16. 0
Pennsylvania	4	4		1, 283, 280	6, 055			6, 055	1, 277, 225		1, 277, 225	1, 277, 225			*1, 277, 225	*1, 171, 439	9. 0
Rhode Island	2	2		123, 298	1, 009			1, 009	122, 289	7, 889	114, 400	114, 400			114, 400	106, 133	7. 8
South Carolina	6	6		163, 474	2, 341			2, 341	161, 133		161, 133	161, 133			[22] *160, 810	*143, 014	12. 4
South Dakota	4	4		116, 043	1, 970		4, 563	6, 533	109, 510		109, 510	98, 447	2	[23] 11, 063	98, 447	[24] 96, 531	2. 0
Tennessee	7	7		266, 315	[25] 11, 122		2, 528	13, 650	252, 665		252, 665	252, 665			*252, 665	*216, 386	16. 8
Texas	4	4		1, 108, 063	12, 453		10, 956	23, 409	1, 084, 654	125, 697	958, 957	958, 957			958, 957	835, 942	14. 7
Utah	4	4		83, 358	2, 758		2, 417	5, 175	78, 183		78, 183	78, 183			[26] *77, 912	*69, 396	12. 3
Vermont	4	4		60, 026	2, 329			2, 329	57, 697		57, 697	57, 697			*57, 697	*51, 388	12. 3
Virginia	5	5		316, 556					316, 556	17, 454	299, 102	299, 102			299, 102	272, 169	9. 9
Washington	5	5		319, 302	5, 563			5, 563	313, 739	25, 518	288, 221	288, 221			288, 221	252, 601	14. 1
West Virginia	4	4		181, 039	[27] 457			457	180, 582	5, 952	174, 630	174, 630			174, 630	153, 105	14. 1
Wisconsin	4	4		503, 969	3, 161		12, 521	15, 682	488, 287	35, 778	452, 509	452, 509			452, 509	405, 909	11. 5
Wyoming	4	4		58, 044	1, 748			1, 748	56, 296		56, 296	56, 296			[28] *55, 482	*47, 445	16. 9
Dist. Columbia	2	2		126, 837	[29] 4, 299		293	4, 592	122, 245	620	121, 625	121, 625			121, 625	111, 983	8. 6
Total	Weighted average rate 3.85 cents.			19, 653, 142	247, 037	215, 508	179, 075	641, 620	19, 011, 522	933, 996	18, 077, 526	17, 979, 340		98, 186	17, 993, 077	16, 264, 077	10. 6

[1] Export sales and other amounts not representing consumption in State have been eliminated as far as possible. Exemptions and refunds in a few States include small amounts of such deductible items not reported separately. In cases where States failed to report amounts exempted from taxation the gross amount taxed is shown in this column.

[2] In cases where refunds were made for Federal and other public uses, or for losses, the amounts have been included with the exemptions listed below, rather than with the refund gallonage.

[3] Federal use except as otherwise noted.

[4] In Kansas exemptions rather than refunds are made for all nonhighway uses. Other States, as shown, make both exemptions and refunds. Florida exempts motor fuel used in aviation but not other nonhighway uses.

[5] 13 States do not provide for exemptions or refunds for nonhighway use. The amounts entered for these States, indicated by stars, include both highway and nonhighway uses.

[6] Within 300 feet of border tax rate is reduced to that of adjacent State. Gallons taxed at 2 cents, 2,739,000; at 4 cents, 11,534,000; at 5 cents, 119,000.

[7] Federal use, 5,415,000 gallons; State, county, and municipal use, 3,773,000 gallons.

[8] Federal use, 414,000 gallons; State use, 610,000 gallons.

[9] Motor fuel used in aviation.

[10] Includes Federal use.

[11] Includes 113,859,000 gallons taxed at 5 cents per gallon and 98,688,000 gallons taxed at 7 cents per gallon.

[12] 3 cents per gallon refunded on nonhighway uses.

[13] 1 cent per gallon refunded on motor fuel used in vehicles licensed to operate exclusively in cities.

[14] 1½ cents per gallon refunded on motor fuel used in interstate aviation. Amount not reported.

[15] Excludes 1,464,000 gallons of aviation fuel taxed at 3 cents per gallon.

[16] 5 cents per gallon refunded on nonhighway uses.

[17] Federal use, 3,335,000 gallons; State, county, and municipal use, 8,858,000 gallons.

[18] Federal use, 11,880,000 gallons; State, county, and municipal use, 47,801,000 gallons.

[19] Includes 705,520,000 gallons taxed at 4 cents per gallon and 913,602,000 gallons taxed at 3 cents per gallon.

[20] Does not include 69,610,000 gallons of liquid fuel (kerosene, fuel oil, etc.) taxed at 1 cent per gallon but not subject to the 3-cent tax on motor-vehicle fuel.

[21] 4 cents per gallon refunded on motor fuel used in aviation.

[22] Excludes 323,000 gallons of aviation fuel.

[23] 2 cents per gallon refunded on nonhighway uses.

[24] Revised figure.

[25] Federal use, 7,634,000 gallons; county and municipal use, 3,488,000 gallons.

[26] Excludes 271,000 gallons of aviation fuel.

[27] Public use not reported in full; amount includes 32,000 gallons Federal use and 425,000 gallons, State, county, and municipal use, on which refunds were paid.

[28] Excludes 814,000 gallons of aviation fuel.

[29] Includes both Federal and District Government use.

STATE MOTOR-FUEL TAX RECEIPTS, 1936

[Compiled for calendar year from reports of State authorities]

State	Tax rate per gallon—		Date of rate change	Receipts from taxation of motor fuel			Other receipts in connection with motor-fuel tax [1]					Net total receipts
	On Jan. 1	On Dec. 31		Gross receipts	Refunds paid	Net receipts	Distributors' and dealers' licenses	Inspection fees [2]	Fines and penalties	Miscellaneous receipts [3]	Total	
	Cents	*Cents*		*1,000 dollars*	*1,000 dollars*	*1,000 dollars*	*1,000 dollars*	*1,000 dollars*	*1,000 dollars*	*1,000 dollars*	*1,000 dollars*	*1,000 dollars*
Alabama	6	6		11, 754		11, 754	*	49			49	11, 803
Arizona	5	5		4, 483	642	3, 841	*		2		2	3, 843
Arkansas	6½	6½		9, 155		9, 155		80			80	9, 235
California	3	3		47, 429	4, 433	42, 996	12				12	43, 008
Colorado	4	4		7, 855	1, 022	6, 833						6, 833
Connecticut	3	3		8, 967	185	8, 782	53				53	8, 835
Delaware	4	4		1, 962	109	1, 853	3		*		3	1, 856
Florida	7	7		19, 925		19, 925	33	359			392	20, 317
Georgia	6	6		17, 493		17, 493						17, 493
Idaho	5	5		4, 094	402	3, 692	1		*	3	4	3, 696
Illinois	3	3		35, 398	1, 940	33, 458		359	2		361	33, 819
Indiana	4	4		22, 127	1, 432	20, 695	*	458		1	459	21, 154
Iowa	3	3		13, 585	1, 389	12, 196						12, 196
Kansas	3	3		9. 372		9, 372	6	100		42	148	9, 520
Kentucky	5	5		11, 273		11, 273			3	1	4	11, 277
Louisiana	5	7	July 28	12, 121		12, 121		86	*		86	12, 207
Maine	4	4		5, 370	168	5, 202	*					5, 202
Maryland	4	4		9, 542	621	8, 921						8, 921
Massachusetts	3	3		19, 348	900	18, 448						18, 448
Michigan	3	3		26, 925	1, 190	25, 735	3		1		4	25, 739
Minnesota	3	3		13, 994	1, 861	12, 133	1	194	1	*	196	12, 329
Mississippi	6	6		9. 577	515	9, 062	*			(4)		9, 062
Missouri	2	2		11, 360	288	11, 072		116			116	11, 18
Montana	5	5		5, 249	794	4, 455						4, 455
Nebraska	5	5		11, 443	225	11, 218		102			102	11, 320
Nevada	4	4		1, 166	86	1, 080	*					1, 080
New Hampshire	4	4		3, 266	86	3, 180				1	1	3, 181
New Jersey	3	3		21, 304	2, 217	19, 087	16		*	3	19	19, 106
New Mexico	5	5		3, 715	326	3, 389	21				21	3, 410
New York	4	3	July 1	57, 221	1, 587	55, 634	59			16	75	55, 709
North Carolina	6	6		20, 423	429	19, 994		962		5	967	20, 961
North Dakota	3	3		3, 088	843	2, 245	*	56			56	2, 301
Ohio	4	4		[5] 45, 198	1, 748	43, 450	*					43, 450
Oklahoma	4	4		14, 094	883	13, 211			5		5	13, 216
Oregon	5	5		10, 492	1, 284	9, 208			1	9	10	9, 218
Pennsylvania	4	4		49, 364		49, 364			12	7	19	49, 383
Rhode Island	2	2		2, 396	170	2, 226	4				4	2, 230
South Carolina	6	6		9, 650	155	9, 495		200			200	9, 695
South Dakota	4	4		4, 320	252	4, 068		118			118	4, 186
Tennessee	7	7		17, 177		17, 177		981			981	18, 158
Texas	4	4		43. 495	5, 028	38, 467				4	4	38, 471
Utah	4	4		3, 087		3, 087	1			*	1	3, 088
Vermont	4	4		2, 277		2, 277						2, 277
Virginia	5	5		15, 576	873	14, 703	*		11		11	14, 714
Washington	5	5		15, 612	1, 276	14, 336	*			9	9	14, 345
West Virginia	4	4		7, 067	264	6, 803	7				7	6, 810
Wisconsin	4	4		19, 299	1, 468	17, 831		197			197	18, 028
Wyoming	4	4		2, 252		2, 252	2				2	2, 254
District of Columbia	2	2		2, 395	13	2, 382	11				11	2, 393
Total	Weighted average rate 3.85 cents.			723, 735	37, 104	686, 631	233	4, 417	38	101	4, 789	691, 420

[1] Stars indicate amounts less than $500.

[2] Fees for inspection of motor-vehicle fuel. Wherever possible fees for inspection of kerosene and other non-motor-vehicle fuels have been eliminated.

[3] Includes fees for motor-fuel carrier permits, refund or exemption permits, interest on deposits, and miscellaneous unclassified receipts.

[4] A special tax of 3 cents per gallon in Hancock County and 2 cents per gallon in Harrison County is imposed for sea-wall protection. The receipts from these taxes were $130,000 in 1936. These receipts are distributed back to the respective counties.

[5] Ohio imposes a 3-cent tax on motor-vehicle fuel and a 1-cent tax on all liquid fuels. The receipts from the 1-cent tax applicable to non-motor-vehicle fuels (kerosene, fuel oil, etc.) were $689,000. These receipts have been eliminated from the total given, which represents a 4-cent tax on motor-vehicle fuel.

STATUS OF FEDERAL-AID HIGHWAY PROJECTS

AS OF APRIL 30, 1937

STATE	APPORTIONMENT 1/	COMPLETED			UNDER CONSTRUCTION			APPROVED FOR CONSTRUCTION			BALANCE OF FUNDS AVAILABLE FOR NEW PROJECTS
		Estimated Total Cost	Federal Aid	Miles	Estimated Total Cost	Federal Aid	Miles	Estimated Total Cost	Federal Aid	Miles	
Alabama	$ 7,872,980	$ 51,600	$ 25,800	9.0	$ 1,381,601	$ 690,800	58.5	$ 345,500	$ 172,750	12.1	$ 6,983,630
Arizona	5,394,661	2,220,645	1,717,594	124.3	1,434,196	1,084,980	52.5	404,531	279,269	7.5	2,312,818
Arkansas	6,463,681				2,424,142	2,421,562	148.1	1,310,022	1,309,353	81.5	2,732,766
California	14,366,891	6,264,184	3,560,738	162.2	9,318,237	5,172,708	228.3	1,298,097	729,549	21.8	4,903,896
Colorado	6,911,198	3,972,008	2,109,120	160.1	3,581,611	1,995,118	129.3	443,032	247,012	16.8	2,559,948
Connecticut	2,388,339	771,224	385,224	14.2	745,158	370,176	8.7				1,632,939
Delaware	1,843,750	591,091	286,931	29.3	512,798	256,220	12.3	231,196	115,594	10.4	1,185,005
Florida	5,020,323	1,015,726	501,796	31.5	1,697,855	848,923	57.9	609,970	304,985	7.4	3,364,619
Georgia	9,569,722	1,856,155	886,717	117.7	2,183,984	1,091,977	127.4	1,199,040	599,520	51.0	6,991,508
Idaho	4,635,991	2,645,269	1,534,328	256.6	1,675,377	997,350	102.0	49,381	29,554	7.0	2,074,759
Illinois	15,564,720	8,553,819	4,259,908	136.7	6,816,788	3,353,628	181.4	5,232,697	2,618,487	143.6	5,332,696
Indiana	9,333,269	5,660,722	2,800,122	184.4	4,889,761	2,444,693	115.8	2,370,020	1,185,010	82.2	2,903,445
Iowa	9,757,950	7,219,533	3,513,360	493.8	4,434,057	2,030,570	138.4	1,997,466	871,299	56.9	3,342,721
Kansas	10,005,211	3,798,047	1,896,656	752.2	5,730,694	2,838,900	298.4	3,690,910	1,845,444	176.3	3,424,212
Kentucky	6,961,271	2,151,753	1,038,281	150.6	1,701,912	850,961	41.0	2,046,443	1,023,221	67.6	4,048,808
Louisiana	5,387,420	2,021,801	1,008,034	72.1	1,085,777	542,584	32.3	9,246,580	1,135,750	32.4	2,701,051
Maine	3,299,867	1,911,238	929,566	58.9	1,015,958	507,979	27.0	1,094,759	547,379	31.4	1,314,943
Maryland	3,094,808				1,302,126	651,029	19.9	519,651	259,826	8.1	2,183,954
Massachusetts	5,255,300	333,935	166,968	3.1	4,335,990	2,167,995	20.3	511,780	255,890	2.3	2,664,447
Michigan	11,562,296	9,270,093	4,559,604	332.2	5,972,169	2,985,181	150.9	2,388,450	1,193,550	64.2	2,823,961
Minnesota	10,344,485	8,191,155	3,851,133	532.8	2,621,794	1,308,163	141.7	1,969,147	967,618	90.6	4,217,571
Mississippi	6,635,344	4,640	2,320		1,400,500	700,100	84.5	3,373,670	1,686,040	148.3	4,246,884
Missouri	11,479,090	4,724,554	2,345,944	470.6	7,913,139	3,943,290	269.0	3,658,864	1,774,035	178.8	3,415,820
Montana	7,744,061	4,131,050	2,312,045	409.3	2,869,856	1,607,635	185.4	1,109,912	584,946	74.6	3,239,436
Nebraska	7,809,353	3,253,004	1,623,692	190.8	2,343,573	1,191,149	261.5	2,007,072	1,003,517	251.7	3,990,995
Nevada	4,821,864	1,641,393	1,394,331	272.2	1,673,167	1,445,353	54.4	9,600	8,300	.5	1,973,880
New Hampshire	1,843,750	841,608	406,036	24.8	192,933	96,014	2.3				1,341,700
New Jersey	5,054,295	2,466,551	1,230,502	34.7	2,276,352	1,060,881	24.9	20,880	10,440		2,752,472
New Mexico	6,030,708	3,832,624	2,351,638	309.5	1,673,162	1,017,929	98.3	1,705,313	1,010,055	148.5	1,651,086
New York	18,565,567	8,060,857	3,965,173	167.7	17,536,184	8,141,842	271.1	1,085,400	521,200	22.0	5,937,352
North Carolina	8,877,837	2,494,670	1,243,481	312.9	4,918,404	2,336,652	309.3	2,043,920	932,330	89.2	4,365,375
North Dakota	5,914,683	197,000	105,473	.3	214,800	124,266	2.0	1,135,190	1,135,190	171.8	4,549,754
Ohio	13,771,548	2,473,583	1,231,087	44.3	7,695,049	3,723,521	80.0	2,434,910	1,212,689	27.0	7,604,250
Oklahoma	8,880,547	3,374,231	1,756,840	116.8	2,556,806	1,341,329	90.1	2,215,616	1,164,284	88.9	4,618,094
Oregon	6,182,079	3,002,674	1,794,866	112.8	3,745,458	2,245,576	145.5	1,021,690	557,118	17.6	1,584,518
Pennsylvania	16,129,804	6,673,839	3,308,562	111.2	10,148,433	5,061,176	148.5	2,486,323	1,189,404	27.6	6,570,662
Rhode Island	1,843,750	217,017	106,747	3.4	790,556	395,278	6.6	77,857	36,754	1.1	1,304,972
South Carolina	5,103,525	626,395	262,900	51.7	4,416,239	1,832,523	277.4	777,410	301,702	75.6	2,706,400
South Dakota	6,162,747	1,381,557	775,874	188.6	334,467	194,131	51.7	971,581	536,292	80.7	4,656,451
Tennessee	7,949,380	2,494,552	1,245,146	107.1	1,368,594	684,292	46.0	1,011,028	505,519	40.1	5,514,423
Texas	23,506,431	13,290,909	6,622,202	721.9	10,948,324	5,410,037	736.6	3,624,734	1,783,920	220.7	9,690,272
Utah	4,274,740	2,084,182	1,453,580	138.1	1,131,773	815,447	82.9	125,560	89,533	12.5	1,916,180
Vermont	1,843,750	1,301,001	641,439	62.9	888,145	417,110	26.4	155,340	77,670	5.9	707,531
Virginia	6,887,569	3,158,260	1,575,817	133.3	3,241,793	1,581,803	129.6	1,104,555	552,277	30.0	3,177,671
Washington	5,907,615	4,324,629	2,270,026	164.6	1,744,634	914,371	71.3	1,156,564	557,124	16.5	2,166,093
West Virginia	4,107,201	863,017	431,486	42.3	891,956	445,966	23.9	677,991	335,146	11.6	2,894,604
Wisconsin	9,197,557	3,829,205	1,831,756	160.6	4,250,178	2,070,628	134.0	3,217,170	1,295,675	76.7	3,999,498
Wyoming	4,722,322	3,161,808	1,946,187	392.8	2,150,986	1,320,619	181.7	1,226,440	745,094	161.2	710,421
Puerto Rico	625,000										625,000
Hawaii	1,843,750	29,953	14,542	.8	858,512	424,300	17.2				1,404,908
TOTALS	368,750,000	152,434,761	79,281,572	8,367.7	165,035,958	85,154,715	5,904.2	75,393,262	35,297,314	2,950.2	169,016,399

1/ Apportionments for fiscal years 1936 to 1938 inclusive.

CURRENT STATUS OF UNITED STATES WORKS PROGRAM HIGHWAY PROJECTS

(AS PROVIDED BY THE EMERGENCY RELIEF APPROPRIATION ACT OF 1935)

AS OF APRIL 30, 1937

STATE	APPORTIONMENT	COMPLETED			UNDER CONSTRUCTION			APPROVED FOR CONSTRUCTION			BALANCE OF FUNDS AVAILABLE FOR NEW PROJECTS
		Estimated Total Cost	Works Program Funds	Miles	Estimated Total Cost	Works Program Funds	Miles	Estimated Total Cost	Works Program Funds	Miles	
Alabama	$ 4,151,115	$ 3,314,570	$ 3,299,584	109.2	$ 771,036	$ 771,036	29.1				$ 80,495
Arizona	2,569,841	2,817,718	2,256,486	178.5	354,525	239,795	17.4				73,560
Arkansas	3,352,061	2,721,113	2,702,059	294.7	595,560	594,386	64.5				55,616
California	7,747,928	5,960,206	5,772,207	230.4	2,109,674	1,868,531	29.3	$ 63,950	$ 61,700	4.6	45,490
Colorado	3,395,263	1,819,885	1,763,469	98.1	153,511	153,494	7.0				1,478,300
Connecticut	1,418,709	425,783	406,771	4.3	683,475	656,946	13.2	106,543	88,960	2.8	266,032
Delaware	900,310	497,551	476,418	47.0	355,632	276,827	19.6	19,870	11,076		135,989
Florida	2,597,144	1,905,233	1,871,739	77.7	676,031	676,031	21.4				49,374
Georgia	4,988,967	501,931	491,984	29.4	1,061,480	1,061,480	75.7	857,322	857,322	43.5	2,578,181
Idaho	2,222,747	2,223,133	2,132,180	182.9	56,927	56,927	2.7	7,396	7,396		26,244
Illinois	8,694,009	7,519,354	7,431,432	429.9	1,239,320	1,239,242	41.3				23,335
Indiana	4,941,255	2,959,595	2,802,643	122.8	2,099,308	2,099,308	105.7	37,924	37,924	6.3	1,379
Iowa	4,991,664	3,732,818	3,503,036	424.6	1,492,689	1,432,139	101.2	60,176	44,075	2.4	12,413
Kansas	4,994,975	3,440,405	3,421,727	319.2	1,557,217	1,545,720	59.5	27,528	27,528	9.5	
Kentucky	3,726,271	2,706,939	2,638,223	315.3	689,216	689,216	27.6	314,901	314,892	11.5	83,939
Louisiana	2,890,429	1,406,224	1,251,066	110.2	1,612,242	1,468,068	55.9	171,682	157,053	10.0	14,242
Maine	1,676,799	1,294,221	1,280,861	57.7	317,194	317,194	14.3	62,100	62,100	2.1	16,644
Maryland	1,750,738	478,755	473,816	17.7	465,489	465,489	10.8	475,216	441,384	13.0	370,049
Massachusetts	3,262,885	216,783	216,783	2.5	2,687,114	2,333,754	15.9	812,060	439,338	.4	273,010
Michigan	6,301,414	6,233,848	5,968,828	287.9	336,871	291,871	4.8	5,766	4,650		36,065
Minnesota	5,277,145	5,162,242	4,397,312	815.4	1,147,311	743,326	85.5	137,137	120,248	2.3	16,259
Mississippi	3,457,552	2,173,987	2,169,455	159.6	1,207,208	1,206,169	75.1	8,900	8,900	.6	73,028
Missouri	6,012,652	4,372,992	4,332,974	743.8	1,732,190	1,547,473	32.8	38,755	36,658	1.1	95,547
Montana	3,676,416	3,339,802	3,334,379	185.1	254,250	254,250	10.2	100,210	60,987	.2	26,800
Nebraska	3,870,739	2,591,622	2,517,334	283.8	1,036,387	1,036,383	80.3	67,729	67,729	5.8	249,293
Nevada	2,243,074	1,957,802	1,900,723	89.1	352,584	337,584	13.7	4,767	4,767	5.2	
New Hampshire	945,225	614,516	587,925	26.7	208,060	205,762	8.1	77,464	76,704	2.8	74,834
New Jersey	3,129,805	719,597	716,597	14.5	2,291,862	2,278,707	16.4	105,542	96,573	6.2	37,928
New Mexico	2,871,397	2,253,708	2,249,140	179.2	398,230	398,230	17.0	83,314	83,314	5.2	140,713
New York	11,046,377	9,466,047	9,037,819	134.5	1,657,560	1,657,560	33.4	305,778	305,778	2.4	45,221
North Carolina	4,720,173	2,807,785	2,775,072	208.3	1,872,245	1,834,445	81.0	33,878	27,700	2.3	82,956
North Dakota	2,867,245	1,560,107	1,551,437	231.4	878,804	875,313	90.1	86,471	86,471	16.1	354,024
Ohio	7,670,815	3,305,823	3,241,513	139.8	4,162,047	4,114,612	140.0	193,060	190,540	22.8	124,150
Oklahoma	4,580,670	3,254,994	3,204,702	324.1	1,126,782	1,114,123	69.5	90,798	90,738	2.8	171,107
Oregon	3,038,642	2,046,351	2,025,483	149.3	1,291,232	929,798	12.8	25,003	25,003	5.7	58,358
Pennsylvania	9,347,797	1,831,538	1,741,190	91.1	2,893,643	2,835,918	81.3	3,615,290	3,277,909	93.0	1,492,780
Rhode Island	989,208	1,063,950	973,538	18.8	9,520	9,520		6,520	3,837		2,312
South Carolina	2,702,012	1,451,458	1,377,378	138.7	946,605	921,756	87.4	324,807	277,801	17.6	125,078
South Dakota	2,976,454	1,955,626	1,953,796	383.5	749,357	749,357	80.7	181,040	181,040	29.1	92,261
Tennessee	4,192,460	2,200,158	2,193,276	92.0	1,375,681	1,375,681	43.6	492,461	492,461	13.4	131,042
Texas	11,989,350	12,064,251	11,054,928	1,078.9	896,406	792,468	28.0	76,061	60,475	6.0	81,480
Utah	2,067,154	1,678,191	1,523,294	169.5	385,607	354,243	23.3	76,141	76,141	3.5	113,476
Vermont	924,306	831,474	734,053	20.6	220,948	162,427	1.6	18,212	18,090	.9	9,736
Virginia	3,652,667	2,862,164	2,799,244	927.8	594,789	582,608	103.8	45,533	45,533	4.8	225,282
Washington	3,026,161	3,100,004	2,802,045	162.6	294,845	223,272	1.8				844
West Virginia	2,231,412	645,820	642,324	30.7	1,677,410	1,541,511	64.1	52,460	45,080	2.6	2,497
Wisconsin	4,823,884	4,912,675	4,344,446	328.1	509,195	368,403	15.1	2,999	2,999		108,037
Wyoming	2,219,155	1,656,909	1,654,661	124.2	549,869	546,972	28.4				17,522
District of Columbia	949,496	949,496	949,496	8.8							
Hawaii	926,033	642,788	621,909	8.9	322,161	298,335	8.5				5,789
TOTALS	195,000,000	135,650,042	129,568,755	10,608.8	50,357,299	47,533,660	2,050.4	9,272,764	8,318,874	358.5	9,578,711

CURRENT STATUS OF UNITED STATES WORKS PROGRAM GRADE CROSSING PROJECTS

(AS PROVIDED BY THE EMERGENCY RELIEF APPROPRIATION ACT OF 1935)

AS OF APRIL 30, 1937

STATE	APPORTIONMENT	COMPLETED					UNDER CONSTRUCTION					APPROVED FOR CONSTRUCTION					BALANCE OF FUNDS AVAILABLE FOR NEW PROJECTS
		Estimated Total Cost	Works Program Funds	NUMBER: Grade Crossings Eliminated by Separation or Relocation	NUMBER: Grade Crossing Structures Reconstructed	NUMBER: Grade Crossings Protected by Signals or Otherwise	Estimated Total Cost	Works Program Funds	NUMBER: Grade Crossings Eliminated by Separation or Relocation	NUMBER: Grade Crossing Structures Reconstructed	NUMBER: Grade Crossings Protected by Signals or Otherwise	Estimated Total Cost	Works Program Funds	NUMBER: Grade Crossings Eliminated by Separation or Relocation	NUMBER: Grade Crossing Structures Reconstructed	NUMBER: Grade Crossings Protected by Signals or Otherwise	
Alabama	$ 4,034,617	$ 2,581,622	$ 2,581,622	36	1	6	$ 1,254,847	$ 1,254,847	12			$ 6,220	$ 6,220			6	$ 191,928
Arizona	1,256,099	1,066,867	1,047,303	12			71,181	71,181	1			95,405	95,405	1		3	42,210
Arkansas	3,574,060	1,597,621	1,592,659	35	4	2	1,752,024	1,749,539	20	2		195,718	195,448	1		30	36,415
California	7,486,362	5,126,776	4,961,201	29	8		2,310,757	2,242,680	16			73,800	73,800	6			208,681
Colorado	2,631,567	1,234,005	1,200,507	21	1		939,941	939,940	8								491,121
Connecticut	1,712,684	73,479	73,479		1		779,991	758,630	5		1						880,575
Delaware	418,239	130,000	130,000	1								260,500	260,500	2			27,739
Florida	2,827,883	1,660,162	1,657,852	17	5		826,541	826,198	12	1		79,200	79,200	1			264,634
Georgia	4,895,949	59,085	57,593	1	2		852,182	852,182	17	4		457,310	457,310	10		40	3,528,864
Idaho	1,674,479	906,484	900,019	14	1	4	386,349	386,236	5	1	9	13,339	13,339			8	374,885
Illinois	10,307,184	4,260,678	4,259,716	46	1		5,264,447	5,161,247	27	6		808,000	808,000	3			78,221
Indiana	5,111,096	1,797,167	1,664,428	20	10		3,471,023	3,434,423	22	2	162						12,246
Iowa	5,600,679	2,779,978	2,722,408	68	7	1	2,693,205	2,612,629	37	2	5	229,877	216,070	2		2	49,572
Kansas	5,246,258	2,293,091	2,292,841	35		4	3,010,989	2,936,147	23	1	1						17,271
Kentucky	3,672,387	1,054,606	1,054,606	13	3		1,740,249	1,450,516	9	2		628,328	628,328	4	4		538,936
Louisiana	3,213,467						1,855,395	1,855,395	19	2		988,020	943,290	6	2		414,782
Maine	1,426,861	719,316	718,213	13		2	424,381	423,789	7	1							284,859
Maryland	2,061,751	358,388	358,388	3	3		518,504	518,504	3		19	638,005	615,536	3	2		569,323
Massachusetts	4,210,833	890,234	890,149	7	2		2,144,993	2,144,993	16	2		249,991	249,991	1			925,700
Michigan	6,765,197	3,339,443	3,273,461	34	4		3,454,277	3,454,277	11	4							37,459
Minnesota	5,395,441	2,829,450	2,759,413	59	9	37	2,581,680	2,522,579	26	3	3	58,428	58,428		1	1	55,021
Mississippi	3,241,475	1,035,753	1,035,605	28	3	1	1,550,977	1,550,977	24	1		178,870	178,870	5	1	9	476,023
Missouri	6,142,153	789,025	789,024	14			5,194,702	4,998,457	34	1		367,252	253,300	1		2	101,371
Montana	2,722,327	2,496,141	2,494,225	35	6		178,582	178,582	2			61,025	20,000		1		29,520
Nebraska	3,556,441	1,895,865	1,885,845	65	1	6	1,339,912	1,339,912	14	2	1	274,271	274,271	2		17	56,413
Nevada	887,260	692,129	690,197	7	3		211,658	193,432	1			3,630	3,630			5	1
New Hampshire	822,484	341,748	341,748	3	3		395,145	395,100	5	1	1	8,214	8,214			3	77,422
New Jersey	3,983,826	625,806	625,806	5	2		2,553,369	2,542,324	15	5		125,990	125,990	1			689,706
New Mexico	1,725,286	1,053,490	1,053,475	13	1		673,090	670,400	5								1,410
New York	13,577,189	2,720,770	2,715,945	12	12		9,828,011	9,571,965	28	34		681,000	681,000	3	1		608,279
North Carolina	4,823,958	1,669,440	1,669,440	21	12		2,144,703	2,125,152	27	5	108	203,890	203,890	2			825,476
North Dakota	3,207,473	499,551	499,472	16	1		2,022,837	2,019,557	31	3		312,170	312,170	5			376,274
Ohio	8,439,897	347,806	282,313	2	1	2	5,551,298	5,394,809	37	6		2,669,270	2,345,212	17	1	1	417,562
Oklahoma	5,004,711	1,769,995	1,766,832	33	3		1,857,765	1,857,765	23	4	1	342,033	342,033	3	2	10	1,038,080
Oregon	2,334,204	878,991	867,119	8	5	2	1,491,605	1,410,005	8	1		21,892	21,892	1			35,188
Pennsylvania	11,483,613	1,964,345	1,760,257	26	8		7,501,793	6,993,014	45	8	9	1,341,648	1,212,448	10	4		1,517,894
Rhode Island	699,691	624,125	623,059	4	1		61,626	61,626		2							15,006
South Carolina	3,059,956	830,842	821,976	17	4	3	1,168,759	1,158,495	23	6	3	500,047	497,297	3	4	42	582,188
South Dakota	3,249,086	847,205	847,204	22	2	21	1,578,528	1,578,528	36	3	4	488,555	488,555	8		22	334,799
Tennessee	3,903,979	615,105	615,095	13	1	18	2,466,770	2,466,770	27	2	2	504,240	504,240	6		13	317,874
Texas	10,855,982	5,533,373	5,529,395	86	13	5	4,441,488	4,437,420	43	1	11	484,147	484,143	1		163	405,024
Utah	1,230,763	226,332	224,927	2	1	1	966,695	966,695	15								39,140
Vermont	729,857	499,385	493,786	7	5	14	273,801	229,871	3	2	2	6,200	6,200			4	
Virginia	3,774,287	1,667,608	1,596,742	30	8	8	1,085,338	1,046,340	13	9	2	445,114	439,325	5		10	691,881
Washington	3,095,041	1,931,431	1,924,497	18	9	7	1,194,299	1,158,884	5	3		7,908	7,908			2	3,752
West Virginia	2,677,937						1,701,975	1,700,007	16	3	1	269,672	269,672	6		4	708,258
Wisconsin	5,022,683	2,017,945	1,985,716	25	4		2,977,911	2,886,659	12	3							150,308
Wyoming	1,360,841	540,621	540,513	7			651,776	651,775	5								168,553
Dist. of Columbia	410,804	170,643	170,643	2			254,921	226,161	1								14,000
Hawaii	453,703	170,404	170,389	2			351,976	283,314	3								
TOTALS	196,000,000	69,214,326	68,217,103	987	171	144	98,004,266	95,689,928	797	138	345	14,079,179	13,381,125	119	23	397	18,711,844

U. S. GOVERNMENT PRINTING OFFICE: 1937

PUBLICATIONS *of the* BUREAU OF PUBLIC ROADS

Any of the following publications may be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C. As his office is not connected with the Department and as the Department does not sell publications, please send no remittance to the United States Department of Agriculture.

ANNUAL REPORTS

Report of the Chief of the Bureau of Public Roads, 1924. 5 cents.

Report of the Chief of the Bureau of Public Roads, 1927. 5 cents.

Report of the Chief of the Bureau of Public Roads, 1928. 5 cents.

Report of the Chief of the Bureau of Public Roads, 1929. 10 cents.

Report of the Chief of the Bureau of Public Roads, 1931. 10 cents.

Report of the Chief of the Bureau of Public Roads, 1933. 5 cents.

Report of the Chief of the Bureau of Public Roads, 1934. 10 cents.

Report of the Chief of the Bureau of Public Roads, 1935. 5 cents.

Report of the Chief of the Bureau of Public Roads, 1936. 10 cents.

DEPARTMENT BULLETINS

No. 583D . . Reports on Experimental Convict Road Camp, Fulton County, Ga. 25 cents.

No. 1279D . . Rural Highway Mileage, Income, and Expenditures, 1921 and 1922. 15 cents.

TECHNICAL BULLETINS

No. 265T . . . Electrical Equipment on Movable Bridges. 35 cents.

MISCELLANEOUS PUBLICATIONS

No. 76MP . . The Results of Physical Tests of Road-Building Rock. 25 cents.

Federal Legislation and Rules and Regulations Relating to Highway Construction. 15 cents.

No. 191 . . . . . Roadside Improvement. 10 cents.

The Taxation of Motor Vehicles in 1932. 35 cents.

An Economic and Statistical Analysis of Highway-Construction Expenditures. 15 cents.

Highway Bond Calculations. 10 cents.

Single copies of the following publications may be obtained from the Bureau of Public Roads upon request. They cannot be purchased from the Superintendent of Documents.

SEPARATE REPRINT FROM THE YEARBOOK

No. 1036Y . . Road Work on Farm Outlets Needs Skill and Right Equipment.

TRANSPORTATION SURVEY REPORTS

Report of a Survey of Transportation on the State Highway System of Ohio (1927).

Report of a Survey of Transportation on the State Highways of Vermont (1927).

Report of a Survey of Transportation on the State Highways of New Hampshire (1927).

Report of a Plan of Highway Improvement in the Regional Area of Cleveland, Ohio (1928).

Report of a Survey of Transportation on the State Highways of Pennsylvania (1928).

Report of a Survey of Traffic on the Federal-Aid Highway Systems of Eleven Western States (1930).

UNIFORM VEHICLE CODE

Act I.—Uniform Motor Vehicle Administration, Registration, Certificate of Title, and Antitheft Act.

Act II.—Uniform Motor Vehicle Operators' and Chauffeurs' License Act.

Act III.—Uniform Motor Vehicle Civil Liability Act.

Act IV.—Uniform Motor Vehicle Safety Responsibility Act.

Act V.—Uniform Act Regulating Traffic on Highways.

Model Traffic Ordinances.

A complete list of the publications of the Bureau of Public Roads, classified according to subject and including the more important articles in PUBLIC ROADS, may be obtained upon request addressed to the U. S. Bureau of Public Roads, Willard Building, Washington, D. C.

CURRENT STATUS OF UNITED STATES PUBLIC WORKS ROAD CONSTRUCTION

AS PROVIDED BY SECTION 204 OF THE NATIONAL INDUSTRIAL RECOVERY ACT (1934 FUNDS) AND BY THE ACT OF JUNE 18, 1934 (1935 FUNDS)

AS OF APRIL 30, 1937

STATE	APPORTIONMENTS		COMPLETED				UNDER CONSTRUCTION				APPROVED FOR CONSTRUCTION			BALANCE OF FUNDS AVAILABLE FOR NEW PROJECTS	
	Sec. 204 of the Act of June 16, 1933 (1934 Fund)	Act of June 18, 1934 (1935 Fund)	Total Cost	1934 Public Works Funds	1935 Public Works Funds	Mileage	Estimated Total Cost	1934 Public Works Funds	1935 Public Works Funds	Mileage	1934 Public Works Funds	1935 Public Works Funds	Mileage	1934 Public Works Funds	1935 Public Works Funds
Alabama	$ 8,370,133	$ 4,259,842	$15,671,604	$ 8,301,315	$ 3,813,459	770.8	$ 171,795	$ 55,923	$ 115,872	5.8		$ 285,822	1.5	$ 12,895	$ 44,689
Arizona	5,211,960	2,641,935	9,005,933	5,203,675	2,605,032	542.9	24,073		24,073		$ 5,574	810	.1	2,711	12,020
Arkansas	6,748,335	3,428,049	10,969,067	6,627,424	3,371,459	619.9	130,731	80,459	49,922	6.5	33,944	4,200	10.9	6,508	2,469
California	15,607,354	7,932,206	30,631,871	15,607,354	7,735,533	763.9	114,732		114,732						81,941
Colorado	6,874,530	3,486,006	11,269,838	6,874,530	3,465,039	633.2									20,967
Connecticut	2,865,740	1,454,868	4,516,912	2,758,269	1,315,170	74.0	59,618	59,618		.1				47,854	139,697
Delaware	1,819,088	923,395	2,782,833	1,818,804	916,230	130.0						5,400		284	1,765
Florida	5,231,834	2,661,343	9,024,260	5,175,534	2,414,688	307.3	289,764	56,300	233,464	2.9					13,190
Georgia	10,091,185	5,113,491	13,427,069	9,272,425	3,278,773	763.8	1,020,966	327,443	693,523	64.2	131,952	133,980	10.6	359,365	1,007,216
Idaho	4,486,249	2,277,486	7,077,041	4,477,339	2,153,743	501.4	85,967		83,807	.1		1,886		8,910	38,049
Illinois	17,570,770	8,921,401	26,465,811	17,348,739	7,945,886	724.3	1,141,513	129,245	885,007	13.3		7,100		92,786	83,408
Indiana	10,037,843	5,088,963	15,554,741	9,892,557	4,814,845	482.7	227,844	129,083	98,761	2.4		61,727		16,203	113,629
Iowa	10,055,660	5,118,361	15,581,748	10,055,660	4,920,929	1,222.3	209,734		196,600	5.0					832
Kansas	10,089,604	5,117,675	15,426,822	10,089,600	5,009,852	1,132.3	135,923		107,484	13.2				4	339
Kentucky	7,517,359	3,818,311	12,187,003	7,480,730	3,719,296	812.7	67,504		67,504	2.8	11,054	23,834		25,575	7,677
Louisiana	5,828,591	2,963,932	9,135,275	5,763,651	2,694,989	258.9	215,480		215,459	11.5		20,500	6.9	64,940	32,984
Maine	3,369,917	1,711,586	5,245,971	3,346,497	1,671,457	193.5	43,100	15,000	26,540	1.4		800		8,420	12,789
Maryland	3,564,527	1,810,058	5,676,194	3,475,616	1,102,724	152.2	68,343		68,343	1.5		299,044	7.3	88,911	339,947
Massachusetts	6,597,100	3,350,474	10,401,682	6,550,778	3,094,281	115.5						91,944	.1	46,322	164,249
Michigan	12,736,227	6,452,568	20,717,272	12,736,227	6,298,778	768.1	96,788		96,788			40,000	.4		17,002
Minnesota	10,656,569	5,425,551	16,197,923	10,510,789	4,841,459	1,641.9	372,262	58,110	292,626	7.2		216,950	.8	87,669	74,516
Mississippi	6,978,675	3,540,227	12,773,693	6,785,720	3,000,758	724.1	650,119	147,960	488,701	21.4	3,960	14,861	.2	41,035	35,907
Missouri	12,180,306	6,173,740	18,185,313	12,088,271	4,998,938	1,441.2	1,125,699		1,121,765	6.3				92,035	53,036
Montana	7,439,748	3,769,734	11,764,611	7,425,285	3,655,874	1,058.4	56,546		56,546					14,463	57,314
Nebraska	7,828,961	3,964,364	12,970,090	7,812,918	3,746,127	1,035.5	201,659	16,043	185,616	16.4					32,621
Nevada	4,545,917	2,302,356	7,068,575	4,545,917	2,271,616	758.8	21,979		21,979			1,650			7,111
New Hampshire	1,909,839	969,462	2,999,744	1,904,951	949,520	78.3	4,169		4,169					4,888	15,773
New Jersey	6,346,039	3,220,879	9,101,212	6,050,212	2,452,166	85.9	1,313,438	215,511	663,430	11.1		9,212		80,316	96,071
New Mexico	5,792,935	2,941,700	8,898,727	5,749,069	2,910,898	749.9	9,681		9,681			7,047	.2	43,866	14,074
New York	22,330,101	11,327,921	39,972,260	22,118,746	10,637,410	822.6	884,792	199,835	525,499	2.7	5,521	112,200		6,000	52,811
North Carolina	9,522,293	4,840,941	14,951,036	9,205,116	4,516,899	1,345.2	553,051	291,910	261,141	21.5		5,000	.2	25,266	57,902
North Dakota	5,804,448	2,938,967	8,592,708	5,596,661	2,217,011	2,116.1	253,807	137,686	116,121	21.2	43,050	388,620	33.0	27,052	217,215
Ohio	15,484,592	7,865,012	24,759,236	15,378,758	7,524,157	792.1	392,271	90,378	245,354	6.0	8,178	45,000	2.2	7,278	50,501
Oklahoma	9,216,798	4,685,180	14,745,689	9,214,658	4,430,360	806.6	196,489		196,489	.4		31,465		2,141	26,866
Oregon	6,106,896	3,097,814	9,960,993	6,047,835	2,949,337	468.0	64,223		64,223	.8	55,000	12,194	.7	4,061	72,061
Pennsylvania	18,891,004	9,590,788	28,996,588	18,525,500	8,904,961	1,054.0	569,624	192,543	356,300	6.4	146,380	318,502	11.8	26,581	11,025
Rhode Island	1,998,708	1,014,572	3,160,270	1,998,708	1,012,094	89.2	2,478		2,478						
South Carolina	5,459,165	2,770,954	8,025,120	5,220,386	2,472,056	622.0	348,311	148,147	198,079	5.7	40,000	77,808	8.5	50,631	23,011
South Dakota	6,011,479	3,047,643	9,407,360	5,911,486	2,918,908	1,589.5	96,671	5,440	91,231	17.3	51,340	4,390	7.2	43,213	33,114
Tennessee	8,492,619	4,302,991	13,692,251	8,490,706	4,159,606	492.8	115,830		88,814	3.5		46,727	5.9	1,913	7,845
Texas	24,244,024	12,291,253	37,981,565	24,197,559	11,873,156	2,780.7	212,394	2,797	199,611	1.7		185,031	7.5	43,668	33,455
Utah	4,194,708	2,132,691	7,450,900	4,192,008	2,132,691	590.9								2,700	
Vermont	1,867,573	948,007	3,166,359	1,867,452	940,847	141.0								121	7,160
Virginia	7,416,757	3,765,387	11,588,998	7,322,399	3,342,209	621.0	279,711	33,941	240,138	29.1	6,735	10,802	.1	53,681	172,239
Washington	6,115,867	3,106,412	9,397,793	6,112,042	3,026,509	302.7	46,596		46,596			14,823	.3	3,825	18,484
West Virginia	4,474,234	2,280,335	6,479,960	4,334,882	1,806,022	213.3	357,457	54,892	279,519	8.9		66,425	.7	84,460	128,369
Wisconsin	9,724,881	4,941,837	15,457,551	9,724,881	4,888,205	619.7	14,415		14,415			635			38,582
Wyoming	4,501,327	2,287,712	6,931,484	4,457,871	2,235,553	1,040.0	10,551	10,550		.6				32,906	52,159
District of Columbia	1,918,469	973,842	2,887,584	1,918,469	968,979	22.3						4,863			
Hawaii	1,871,062	949,778	2,779,059	1,857,812	362,218	51.8	552,762		535,213	4.1		14,000		13,250	38,347
TOTALS	394,000,000	200,000,000	631,103,599	389,423,791	184,488,707	35,125.2	12,810,860	2,458,814	9,383,613	323.0	542,688	2,565,252	117.1	1,574,707	3,562,428