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D. M. BEACH, *Editor*

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LIFE CHARACTERISTICS OF SURFACES CONSTRUCTED ON PRIMARY RURAL HIGHWAYS[1]

BY THE DIVISION OF CONTROL, PUBLIC ROADS ADMINISTRATION

Reported by ROBLEY WINFREY, Research Associate Professor, Iowa State College, and FRED B. FARRELL, Associate Highway Engineer-Economist, Public Roads Administration

Life characteristics of various surface types constructed on primary rural highways were determined from the analysis of construction and retirement mileage data obtained by several States in connection with the road-life study phase of the State-wide highway-planning surveys. Approximately 210,000 miles of construction up to January 1, 1937, of various surface types in 26 States were involved in the analyses of average service lives. In addition, an analysis was made of the disposition of mileage at the time of retirement, involving slightly over 56,000 miles of retired surfacing in 23 of the 26 States.

Estimates of average service lives were obtained from statistical analyses involving the use of survivor curves. Data were available for some types as early as 1903 and a continuous record of the miles remaining in service for each year's construction was available up to January 1, 1937. Each year's construction was analyzed separately, where possible. In general it was found that the average service life of the lower types decreased and the higher types increased during the period of 1910 to 1936.

The predominating limits of average service lives were as follows: Soil surfaced, 5 to 14 years; gravel or stone, 6 to 13 years; bituminous surface treated, 11 to 21 years; mixed bituminous, 14 to 22 years; bituminous penetration, 15 to 17 years; bituminous concrete, 13 to 20 years; portland cement concrete, 17 to 24 years; and brick or block, 18 to 21 years.

Retirement of a road surface is considered as being effected when (1) the wearing surface undergoes a resurfacing operation (other than a routine maintenance operation), (2) the surface is reconstructed, (3) the road is abandoned, (4) the road is transferred to another public authority for continued maintenance and reconstruction, or (5) the surface reverts to a lower type through lack of adequate maintenance. Approximately 12 percent of all retirements involved construction on new location.

THE large annual increases in usage by the motor vehicle of the highways of the United States during the past few years have brought to the engineer, the legislator, and the general public the realization that there is no permanent type of highway facility. Many structures and roadways which were built to the most modern standards as recently as 10 years ago are rapidly becoming obsolete and in many instances consideration is already being given to their replacement or reconstruction.

In order to realize the maximum service from a highway, the highway engineer is obliged to design for conditions that he estimates will exist 10, 20, 30, and even 50 years in the future. It is obviously an economic waste to construct a road that will last 30 years from a structural standpoint, only to find that it must be abandoned within 10 years because of poor alinement or grades. Further, it is shortsighted policy to build a surface expected to last 20 years under existing traffic conditions if increases in traffic are anticipated that will immediately result in the structural failure of the road surface.

To evaluate the present status of the highway system and to formulate plans for orderly future development, it is necessary to estimate (1) the extent to which existing alinements and grades will be adequate for anticipated conditions in future years, and (2) how long the various types of surfaces, structures, and other appurtenances will afford satisfactory service before replacement is required.

Analyses of the service lives of roadway surfaces and other highway elements are necessary (1) to make available the facts concerning the service lives of the various types of highway construction and (2) so that estimates of revenue required for highway purposes can be prepared which are consistent with the probable kind and extent of necessary replacements. Studies of this character were first undertaken in 1934 at Iowa State College when a study of the street pavements in Des Moines, Iowa, was started.[2]

In January 1935, the studies of service lives of roadway surfaces were extended to State highway systems and other cities under a cooperative agreement between the Public Roads Administration (then the Bureau of Public Roads) and Iowa State College. Under this agreement, studies[3] were made in Buffalo, New York; Des Moines, Iowa; Wayne County, Michigan; Massachusetts; Rhode Island; New Hampshire; and Vermont.

Starting in the fall of 1935, these studies, designated as road-life studies, were incorporated as a phase of the State-wide highway-planning surveys inaugurated in the several States under the direction of the Public Roads Administration. Up to December 1940, 46 States had undertaken this phase of planning surveys.[4]

In addition to the compilation of data upon which to base calculations of average service lives of roadway surfaces, the road-life studies include tabulations and investigations of construction costs, salvage values of retired roadway elements, maintenance costs and the service lives of structures, traffic services, grading, right-of-way, etc. This work is being accomplished by State personnel in the individual States under the supervision of the Public Roads Administration. Involved in this phase of the highway planning survey are painstaking search and recording of the maintenance and construction records for each mile of primary State or Federal-Aid highways.

DATA OBTAINED FOR 9 ROAD SURFACE TYPES IN 26 STATES

This report is confined to an analysis of the data relative to the service life characteristics of various surface types compiled for the rural portions of the

[1] Paper presented at the Twentieth Annual Meeting of the Highway Research Board, December 1940.

[2] A Mortality Curve Study of the Actual Service Lives of Brick-on-Concrete Pavements, Des Moines, Iowa, 1909–1928, by Anson Marston. Proceedings Highway Research Board, Vol. 14, Pt. I, pp. 49–58. 1934.

[3] Preliminary Studies of the Actual Service Lives of Pavements, by Robley Winfrey. Proceedings Highway Research Board, Vol. 15, Pt. I, pp. 47–60. 1935.

[4] Some of the States have published or have available certain results and applications of the road-life studies, and other States are in the process of completing reports. Such information and reports, if available, may be obtained directly from the State highway department.

Figure 1.—States for Which Road-Life Mileage Data Are Included.

primary State or Federal-Aid systems of the following 26 States (fig. 1):[5]

Alabama.	Maryland.	Rhode Island.
Arizona.	Missouri.	South Dakota.
California.	Montana.	Texas.
Colorado.	Nebraska.	Utah.
Florida.	New Mexico.	Vermont.
Idaho.	North Carolina.	Virginia.
Indiana.	North Dakota.	West Virginia.
Kansas.	Ohio.	Wyoming.
Louisiana.	Oklahoma.	

The data compiled for the purposes of this report are those relating to constructed and retired mileages of surfacing from which the following basic summaries were obtained:

1. Miles constructed each year for each surface type (for 26 States).
2. Miles of each year's construction of each surface type remaining in service January 1 each year after construction (for 26 States).
3. Replacement surface types for miles of each surface type retired each year (for 23 States).
4. Method of retirement (resurfaced, reconstructed, abandoned, or transferred) for miles of each surface type retired each year (for 23 States).

Data for Alabama, Ohio, and Vermont were not available for the summaries prepared in connection with items 3 and 4 above.

There are nine major surface types for which individual summaries and analyses are presented:

1. Soil-surfaced roads.
2. Gravel or stone roads.
3. Bituminous surface-treated roads.
4. Mixed bituminous roads.
5. Bituminous penetration roads.
6. Bituminous concrete roads.
7. Portland cement concrete roads.
8. Brick or block roads.
9. Dual-type roads.

The following definitions used in all phases of the planning surveys are followed in determining the general type classification of the surfaces constructed in each individual State:

1. *Soil-surfaced road.*—A road of natural soil, the surface of which has been treated for purposes of stabilization by the addition of a course of mixed soil such as sand-clay, soft shale or topsoil, or an admixture such as bituminous material, portland cement, sodium chloride, or fine granular material (sand or similar material).

2. *Gravel or stone road.*—A road, the wearing course of which consists of gravel, broken stone, slag, chert, caliche, iron ore, hard shale, chats, disintegrated rock or granite, or other similar fragmental material coarser than sand.

3. *Bituminous surface-treated road.*—A graded and drained earth road, a soil-surfaced road, or a gravel or stone road, to which has been added by any process a surface mat of bituminous material and mineral aggregate less than 1 inch in compacted thickness.

4. *Mixed bituminous road.*—A road, the wearing course of which is 1 inch or more in compacted thickness, composed of gravel, stone, sand, or similar material, mixed with bituminous material under partial control as to grading and proportions.

5. *Bituminous penetration road.*—A road, the wearing course of which is 1 inch or more in compacted thickness, composed of gravel, stone, sand, or similar material, bound with bituminous material introduced by downward or upward penetration.

6. *Bituminous concrete road* (includes sheet asphalt and rock asphalt).—A road, the wearing course of which consists of gravel, stone, or sand, mixed with bituminous material in accordance with precise specifications defining gradation of the mineral aggregate and proportions of aggregate and bituminous cement 1 inch or more in compacted thickness, and laid on a base course of either rigid or nonrigid type.

7. *Portland cement concrete road.*—A road, the wearing course of which consists of portland cement concrete, with or without a bituminous mat less than 1 inch in compacted thickness.

8. *Brick or block road.*[6]—A road, the wearing course of which consists of vitrified paving brick, stone block, wood block, asphalt block, or other form of block, with or without a bituminous mat less than 1 inch in compacted thickness.

9. *Dual-type road.*—A road, the wearing course of which consists of two individual types constructed at the same time,[7] each of which has a width of at least 8 feet which may be in contiguous or divided strips, both individual types being of such character as to be classed logically as a part of the traffic-bearing road surface rather than as surfaced shoulders.

5 METHODS OF RETIRING ROAD SURFACES

Retirement of a road surface is considered as being effected when (1) the wearing surface undergoes a resurfacing operation (other than a routine maintenance operation), (2) the surface is reconstructed, (3) the road is abandoned, (4) the road is transferred to another public authority for continued maintenance and reconstruction, or (5) the surface reverts to a lower type through lack of adequate maintenance. With the exception of reversions, which are so few as not to warrant further consideration, retirements are generally considered as resulting from operations classified as construction. It is an accepted fact that a significant amount of construction work is done by maintenance forces in many States, and in the recording of the original data summarized in this report an attempt was made in each State to segregate construction from maintenance in a uniform manner regardless of the accounting classifications in effect in a particular State. The

[5] Acknowledgment is made to the personnel who compiled and reported the information in these States.

[6] In the highway planning surveys, vitrified paving brick roads are reported separately from other types of brick or block roads. Because of the small mileages involved, these two types are combined. Approximately 97 percent of the construction of these two types included in this report is vitrified paving brick.

[7] The qualification that both types comprising the dual-type road must be constructed at the same time does not apply to other phases of the highway planning survey. It is adopted in the road-life study because of the statistical procedures followed in analyzing construction having similar ages.

classifications of construction and maintenance operations generally followed in the road-life study are those included in the Tentative Draft of the Report to the 1938 Association Meeting by the Subcommittee on Accounting of the American Association of State Highway Officials.[8]

Mileage transferred off the State or Federal-Aid highway systems to the county or other local authority is classified throughout all mileage tables as a retirement. A transfer is not a retirement in the sense that the road has rendered its total service to the public from a structural standpoint, although quite frequently this is the case. A transfer is, however, a retirement in the sense that the road has rendered its complete service as a State or Federal-Aid highway. Retirements by transfer are generally the result of functional obsolescence involving alinements and grades which are unsatisfactory for existing traffic conditions. A new road is built on new alinement and improved grades, and the old road remains in service usually because of the necessity of providing for local traffic usage. After the new road is placed in service on the State or Federal-Aid highway system, the State frequently will no longer assume responsibility for the continued maintenance and reconstruction of the old road, and the county or other local authority generally takes over this responsibility; otherwise the old road may be entirely discontinued from service, in which case it is considered as an abandonment.

For most of the 26 States, the mileage data are for the primary rural State highway system. In two or three States, the data are for the rural Federal-Aid system. In general, all mileages in incorporated places having a population greater than 1,000 persons are excluded from the summaries. The data for all States are summarized only to January 1, 1937, since the information for more recent dates is complete for only a few States.

There are many miles of surfaces, primarily of the lower types, for which the date of retirement is known but for which there is no record of the date of initial construction or for which the date of initial construction cannot be closely estimated. The partial data in these cases are not included in the summaries for mileages constructed and remaining in service during the various years.

In general, the data for construction since 1920 are relatively complete for the 26 States. Prior to 1920, however, it is evident that the construction volume recorded in the tables is only a portion of that actually completed on roads which later became a part of the State or Federal-Aid highway systems. This results, primarily, from difficulty in locating records of early construction. In a few cases, the records were found in various field offices, but more frequently, records of such early construction could not be located.

Table 1 is a summary of the mileages involved in the analysis of the average service lives included in this report.

MILEAGES BUILT AND REMAINING IN SERVICE GIVEN FOR VARIOUS SURFACE TYPES

In tables 2, 3, and 4 are listed for each surface type the miles constructed each year, the miles retired each year, and the miles remaining in service on January 1 each year.

[8] Copies of this Tentative Draft were transmitted to all State highway departments under date of June 2, 1938, by E. E. Hall, Secretary, Subcommittee on Accounting, American Association of State Highway Officials.

TABLE 1.—*Total mileages in the 26 States used in the calculation of probable average service life* [1]

No.	Surface type	Miles constructed	Miles remaining in service on 1-1-37
1	Soil surfaced	8, 907	4. 321
2	Gravel or stone	79, 110	37, 187
3	Bituminous surface treated	30, 949	25, 139
4	Mixed bituminous	30, 581	28, 351
5	Bituminous penetration	14, 301	11, 901
6	Bituminous concrete	10, 283	8, 481
7	Portland cement concrete	32, 775	30, 602
8	Brick or block	2, 799	1, 927
9	Dual type	274	249

[1] Involves only mileage of each type for which: (1) Both the original construction date and the retirement date are known if the mileage was retired; and (2) the original construction date is known if the mileage is still in service.

The form in which the mileage data for each surface type were prepared by each State is similar to the arrangement of tables 5 to 13. The two left-hand columns show the year and mileage constructed, whereas the entries in the balance of the table indicate the mileage of each year's construction that remained in service on January 1 of each year after construction. Table 5, for example, records 450 miles of soil-surfaced roads constructed in 1929 by the 26 States included in these summaries. Of these 450 miles built in 1929, there were 435 miles remaining in service on January 1, 1930; 408 miles on January 1, 1931; 356 miles on January 1, 1932; and so forth up to January 1, 1937, when there were 289 miles remaining in service. The totals at the bottom of each year column of tables 5 to 13 represent the total miles in service on January 1 of each calendar year.

TABLE 2.—*Mileage of each surface type constructed each year*

[Compiled from data submitted by 26 States for rural State or Federal-Aid systems]

Year of construction	Soil surfaced	Gravel or stone	Bituminous surface treated	Mixed bituminous	Bituminous penetration	Bituminous concrete	Portland cement concrete	Brick or block	Dual type
	Miles	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*
1903	------	11	------	------	------	------	------	------	------
1904	------	18	------	------	------	------	------	------	------
1905	------	20	------	------	------	------	------	------	------
1906	------	39	------	------	------	------	------	------	------
1907	------	47	12	------	------	------	------	7	------
1908	12	71	16	------	5	------	------	9	------
1909	11	103	45	1	2	------	------	8	------
1910	19	159	60	3	40	------	1	27	------
1911	40	161	40	------	47	------	------	24	------
1912	129	212	122	24	56	------	29	48	------
1913	139	267	82	18	65	71	42	40	------
1914	111	331	136	------	72	115	261	99	------
1915	189	534	289	2	76	290	279	239	------
1916	129	316	330	19	213	132	505	127	------
1917	103	275	136	8	104	53	236	120	------
1918	74	405	214	10	122	122	322	128	------
1919	128	577	168	12	213	52	475	129	------
1920	279	1, 273	260	136	312	213	561	143	------
1921	334	2, 506	329	472	416	377	888	220	9
1922	499	3, 485	176	81	519	346	1, 113	261	41
1923	387	3, 657	438	182	555	545	1, 124	226	27
1924	421	4, 958	486	67	898	623	1, 922	112	3
1925	418	5, 659	996	77	794	471	1, 690	161	17
1926	200	5, 634	1, 567	197	546	476	2, 087	125	20
1927	218	4, 689	1, 770	375	458	718	1, 942	61	14
1928	279	5, 884	2, 108	1, 016	664	501	2, 238	78	8
1929	450	5, 168	2, 056	1, 162	873	682	1, 891	27	11
1930	532	5, 899	3, 747	2, 860	1, 184	514	3, 855	92	16
1931	475	6, 304	2, 631	3, 747	1, 411	606	3, 518	71	31
1932	498	5, 318	2, 169	5, 551	1, 096	590	2, 825	69	16
1933	548	4, 244	2, 444	3, 132	981	484	2, 039	28	6
1934	1, 021	4, 071	3, 042	5, 007	685	735	1, 110	57	22
1935	613	2, 856	2, 060	2, 686	944	514	828	35	20
1936	651	3, 959	3, 020	3, 736	950	1, 053	994	28	13
Total	8, 907	79, 110	30, 949	30, 581	14, 301	10, 283	32, 775	2, 799	274

TABLE 3.—*Mileage of each surface type retired each year* [1]

[Compiled from data submitted by 26 States for rural State or Federal-Aid systems]

Year of retirement	Soil surfaced	Gravel or stone	Bituminous surface treated	Mixed bituminous	Bituminous penetration	Bituminous concrete	Portland cement concrete	Brick or block	Dual type
	Miles	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*
1911		1							
1912		7	3					1	
1913		2	7	1					
1914	4	13	25		1	1			
1915		30	13		5		8	4	
1916		89	16			5	6		
1917	4	39	14		7	6	7		
1918	9	109	31		5	3	21	7	
1919	45	57	43		1	9	18	6	
1920	30	189	37	4	8	27	24	6	
1921	15	638	110	8	22	12	57	7	
1922	12	235	49	5	28	100	35	3	
1923	45	371	51		36	59	53	8	
1924	154	401	59	12	38	32	16	13	
1925	276	573	29	3	45	40	38	41	
1926	379	783	83	10	37	61	71	17	
1927	435	806	71	17	43	81	85	26	
1928	350	2, 211	129	34	72	60	80	51	
1929	385	1, 939	157	45	133	117	143	53	1
1930	393	4, 736	439	97	225	133	202	75	1
1931	395	4, 813	795	172	264	112	135	111	2
1932	253	5, 789	822	222	263	178	234	114	2
1933	372	4, 432	527	271	223	172	205	39	9
1934	288	5, 033	919	336	202	189	191	80	4
1935	328	3, 337	608	441	219	108	163	57	
1936	414	5, 290	773	552	523	297	371	153	6
Total	4, 586	41, 923	5, 810	2, 230	2, 400	1, 802	2, 173	872	25

[1] Includes mileages which are retired as the result of being transferred from the rural State or Federal-Aid systems to the county or other authority for continued maintenance and reconstruction.

TABLE 4.—*Mileage of each surface type remaining in service on January 1 each year*

[Compiled from data submitted by 26 States for rural State or Federal-Aid systems]

Year remaining in service	Soil surfaced	Gravel or stone	Bituminous surface treated	Mixed bituminous	Bituminous penetration	Bituminous concrete	Portland cement concrete	Brick or block	Dual type
	Miles	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*
1904		11							
1905		29							
1906		49							
1907		88							
1908		135	12					7	
1909	12	206	28		5			16	
1910	23	309	73	1	7			24	
1911	42	468	133	4	47		1	51	
1912	82	628	173	4	94		1	75	
1913	211	833	292	28	150		30	122	
1914	350	1, 098	367	45	215	71	72	162	
1915	457	1, 416	478	45	286	185	333	261	
1916	646	1, 920	754	47	357	475	604	496	
1917	775	2, 147	1, 068	66	570	602	1, 103	623	
1918	874	2, 383	1, 190	74	667	649	1, 332	743	
1919	939	2, 679	1, 373	84	784	768	1, 633	864	
1920	1, 022	3, 199	1, 498	96	996	811	2, 090	987	
1921	1, 271	4, 283	1, 721	228	1, 300	997	2, 627	1, 124	
1922	1, 590	6, 151	1, 940	692	1, 694	1, 362	3, 458	1, 337	9
1923	2, 077	9, 401	2, 067	768	2, 185	1, 608	4, 536	1, 595	50
1924	2, 419	12, 687	2, 454	950	2, 704	2, 094	5, 607	1, 813	77
1925	2, 686	17, 244	2, 881	1, 005	3, 564	2, 685	7, 513	1, 912	80
1926	2, 828	22, 330	3, 848	1, 079	4, 313	3, 116	9, 165	2, 032	97
1927	2, 649	27, 181	5, 332	1, 266	4, 822	3, 531	11, 181	2, 140	117
1928	2, 432	31, 064	7, 031	1, 624	5, 237	4, 168	13, 038	2, 175	131
1929	2, 361	34, 737	9, 010	2, 606	5, 829	4, 609	15, 196	2, 202	139
1930	2, 426	37, 966	10, 909	3, 723	6, 569	5, 174	16, 944	2, 176	149
1931	2, 565	39, 129	14, 217	6, 486	7, 528	5, 155	20, 597	2, 193	164
1932	2, 645	40, 620	16, 053	10, 061	8, 675	6, 049	23, 970	2, 153	193
1933	2, 890	40, 149	17, 400	15, 390	9, 508	6, 461	26, 561	2, 108	207
1934	3, 066	39, 961	19, 317	18, 251	10, 266	6, 773	28, 395	2, 097	204
1935	3, 799	38, 999	21, 440	22, 922	10, 749	7, 319	29, 314	2, 074	222
1936	4, 084	38, 518	22, 892	25, 167	11, 474	7, 725	29, 979	2, 052	242
1937	4, 321	37, 187	25, 139	28, 351	11, 901	8, 481	30, 602	1, 927	249

For the purpose of calculating the average service lives, all mileages constructed during a given calendar year are considered to have been placed in service on July 1 of that year. Mileages remaining in service are thus ½ year of age on January 1 of the calendar year following the year of construction, 1½ years of age on January 1 of the second year after construction, etc. By the use of these ages and the mileages remaining in

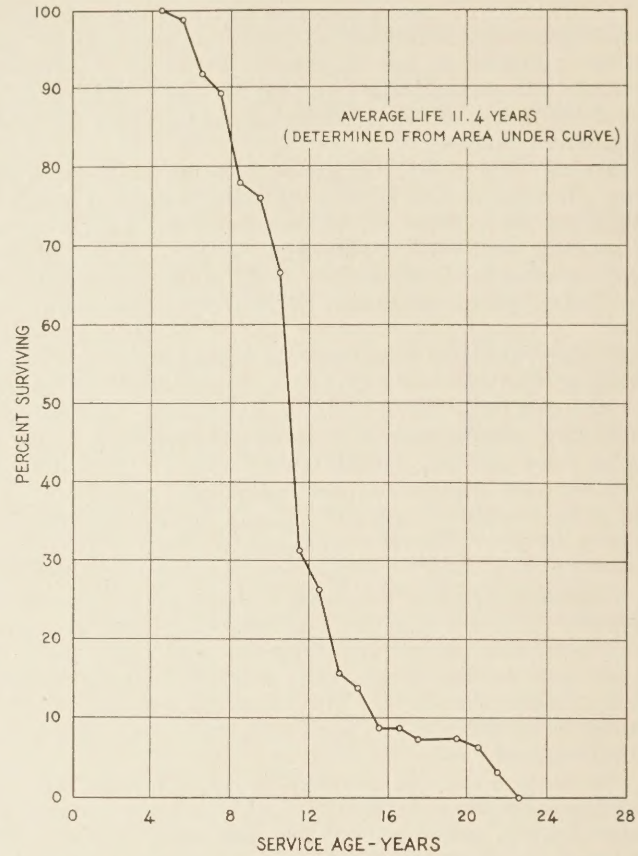

FIGURE 2.—SURVIVOR CURVE FOR 159 MILES OF GRAVEL OR STONE ROADS CONSTRUCTED IN 1910.

service as shown in tables 5 to 13 the probable average life of the construction for each year was calculated.

The mileages that remained in service on January 1 of each year after construction are expressed as percentages of the original construction mileage. These percentages at ages 0, ½, 1½, 2½, etc., years were plotted, using the percentage remaining in service as the ordinate, and the age in years as the abscissa. The plotted points were then connected with straight lines to form original survivor curves, illustrative examples of which are given in figures 2 to 9.

In the event that all mileage of a given surface type constructed during a particular year was retired prior to January 1, 1937, the survivor curve extends to zero percent remaining in service. In such cases (fig. 2) the construction rendered its complete service, the extent of which is measured by the area on the graph below the survivor curve.

AVERAGE SERVICE LIVES CALCULATED

In most instances (figs. 3 to 9), however, a portion of the mileage of a given surface type constructed during a particular year remained in service on January 1, 1937. Such a condition results in a "stub" survivor curve, the end point of which indicates the percentage of the original mileage remaining in service on January 1, 1937. In these cases the area below the stub survivor curve to the left of the ordinate erected at the end point represents the service realized prior to January 1, 1937, and it is necessary to extend the curve to zero percent surviving in order to estimate the average life of the entire original mileage.

TABLE 5.—*Soil-surfaced road mileage remaining in service; mileage constructed each year and mileage remaining in service on January 1 of each year*

[Compiled from data submitted by 26 States for rural State or Federal-Aid systems]

Construction: Year	Construction: Miles	1910[1]	1911	1912	1913	1914	1915	1916	1917	1918	1919	1920	1921	1922	1923	1924	1925	1926	1927	1928	1929	1930	1931	1932	1933	1934	1935	1936	1937
		Miles	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*
1908	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	0	-	-	-	-	-	-	-
1909	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	0	-	-	-	-	-
1910	19	-	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	13	13	7	5	3	3	3	0	-	-	-	-
1911	40	-	-	40	40	40	40	40	40	40	40	40	32	32	32	31	28	28	28	28	28	13	11	9	9	9	0	-	-
1912	129	-	-	-	129	129	125	125	125	125	125	124	124	119	119	112	94	80	55	40	25	25	7	5	5	5	0	-	-
1913	139	-	-	-	-	139	139	139	139	139	139	128	119	117	117	117	114	109	96	94	74	61	35	25	17	10	4	4	4
1914	111	-	-	-	-	-	111	111	111	111	111	111	111	106	104	100	86	75	72	53	41	35	19	18	18	14	8	7	0
1915	189	-	-	-	-	-	-	189	189	185	176	153	148	146	144	135	122	117	101	87	80	67	35	22	18	14	7	7	7
1916	129	-	-	-	-	-	-	-	129	129	129	121	121	121	113	113	107	88	88	81	71	54	22	19	19	15	12	12	12
1917	103	-	-	-	-	-	-	-	-	103	103	101	101	101	101	98	88	79	73	73	61	52	52	37	32	23	19	19	4
1918	74	-	-	-	-	-	-	-	-	-	74	74	74	74	74	74	74	65	57	52	37	30	24	15	10	7	4	4	4
1919	128	-	-	-	-	-	-	-	-	-	-	128	120	120	120	120	120	120	114	92	82	81	81	66	66	62	58	50	45
1920	279	-	-	-	-	-	-	-	-	-	-	-	279	278	278	271	228	183	142	118	107	101	101	101	101	98	96	80	69
1921	334	-	-	-	-	-	-	-	-	-	-	-	-	334	334	329	313	285	237	189	145	97	63	50	40	40	32	31	31
1922	499	-	-	-	-	-	-	-	-	-	-	-	-	-	499	498	470	409	294	205	160	143	110	101	74	67	48	43	38
1923	387	-	-	-	-	-	-	-	-	-	-	-	-	-	-	379	379	317	272	212	139	98	75	40	40	26	23	23	10
1924	421	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	421	419	383	310	278	188	170	161	153	140	119	114	89
1925	418	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	418	401	350	325	255	238	225	216	202	200	198	193
1926	200	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	200	200	183	182	147	103	83	69	69	67	60
1927	218	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	218	218	218	218	209	186	179	169	169	153
1928	279	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	279	277	260	247	245	245	240	234	213
1929	450	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	435	408	356	352	348	320	306	289
1930	532	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	475	359	320	271	258	257	242
1931	475	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	474	388	349	299	292	279
1932	498	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	498	333	298	287	278
1933	548	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	540	506	412	383
1934	1,021	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1,010	875	736
1935	613	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	593	556
1936	651	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	626
Total	8,907	23	42	82	211	350	457	646	775	874	939	1,022	1,271	1,590	2.077	2,419	2,686	2,828	2,649	2,432	2,361	2,426	2,565	2,645	2,890	3,066	3,799	4,084	4,321

[1] No retirement of 1908–09 construction in earlier years.

TABLE 6.—*Gravel or stone road mileage remaining in service; mileage constructed each year and mileage remaining in service on January 1 of each year*

[Compiled from data submitted by 26 States for rural State or Federal-Aid systems]

Construction		1910[1]	1911	1912	1913	1914	1915	1916	1917	1918	1919	1920	1921	1922	1923
Year	Miles	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*
1903	11	11	11	11	10	9	9	8	4	4	4	3	2	1	1
1904	18	18	18	18	18	18	17	16	11	10	9	6	4	2	1
1905	20	20	20	19	18	17	17	16	13	12	10	9	6	1	1
1906	39	39	39	39	35	35	35	32	26	26	23	20	17	5	2
1907	47	47	47	47	46	46	46	46	31	31	26	24	20	9	7
1908	71	71	71	71	71	71	71	71	62	60	55	51	43	26	17
1909	103	103	103	103	103	103	97	97	91	90	87	86	69	37	32
1910	159		159	159	159	159	159	157	146	142	124	121	106	50	42
1911	161			161	161	161	155	151	140	138	138	126	90	35	19
1912	212				212	212	212	203	201	198	193	193	176	104	83
1913	267					267	267	264	259	256	254	244	217	140	128
1914	331						331	325	323	318	316	312	302	213	203
1915	534							534	525	508	453	448	443	365	324
1916	316								315	315	311	307	292	282	271
1917	275									275	271	271	269	246	230
1918	405										405	405	389	354	352
1919	577											573	565	517	498
1920	1,273												1,273	1,269	1,229
1921	2,506													2,496	2,479
1922	3,485														3,482
1923	3,657														
1924	4,958														
1925	5,659														
1926	5,634														
1927	4,689														
1928	5,884														
1929	5,168														
1930	5,899														
1931	6,304														
1932	5,318														
1933	4,244														
1934	4,071														
1935	2,856														
1936	3,959														
Total	79,110	309	468	628	833	1,098	1,416	1,920	2,147	2,383	2,679	3,199	4,283	6,152	9,401

Construction		1924	1925	1926	1927	1928	1929	1930	1931	1932	1933	1934	1935	1936	1937
Year	Miles	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*
1903	11	1	1	1	1	0									
1904	18	1	1	1	0										
1905	20	1	1	1	0										
1906	39	2	1	1	0										
1907	47	6	6	6	4	2	1	1	1	1	1	1	0		
1908	71	7	5	5	1	1	1	1	1	1	1	1	0		
1909	103	30	28	28	24	19	19	18	15	15	15	15	6	6	6
1910	159	25	22	14	14	12	12	12	10	5	0				
1911	161	11	11	10	10	9	9	6	6	4	4	4	1	1	0
1912	212	64	56	53	46	37	31	25	9	9	8	4	4	2	1
1913	267	101	99	97	73	54	51	40	32	23	13	3	3	2	1
1914	331	160	117	98	96	89	85	82	67	64	57	51	38	38	37
1915	534	258	216	180	163	127	113	89	75	75	71	64	63	59	55
1916	316	251	240	204	186	175	161	143	106	67	59	37	29	27	19
1917	275	210	198	152	123	106	99	93	50	25	10	5	0		
1918	405	346	319	292	258	247	228	207	175	138	84	72	66	56	51
1919	577	491	463	426	389	383	356	319	254	192	133	106	101	63	29
1920	1,273	1,202	1,190	1,167	1,070	1,017	911	811	664	560	437	345	316	298	223
1921	2,506	2,456	2,387	2,326	2,278	2,173	1,905	1,722	1,410	1,191	891	745	581	488	368
1922	3,485	3,432	3,340	3,228	3,088	2,979	2,639	2,407	2,029	1,659	1,258	986	800	701	458
1923	3,657	3,632	3,591	3,507	3,448	3,333	3,014	2,833	2,356	1,898	1,586	1,374	1,221	1,030	771
1924	4,958		4,952	4,877	4,745	4,644	4,315	3,962	3,387	2,784	2,282	1,971	1,670	1,467	1,199
1925	5,659			5,656	5,541	5,408	4,979	4,807	4,244	3,841	3,266	2,978	2,653	2,496	2,100
1926	5,634				5,623	5,579	5,359	5,056	4,210	3,656	3,103	2,794	2,518	2,312	1,955
1927	4,689					4,670	4,583	4,421	3,902	3,557	3,062	2,807	2,470	2,296	1,974
1928	5,884						5,866	5,800	5,368	4,897	4,348	3,876	3,405	3,150	2,726
1929	5,168							5,111	4,944	4,367	3,702	3,244	2,891	2,675	2,367
1930	5,899								5,814	5,477	5,067	4,617	4,158	3,877	3,506
1931	6,304									6,114	5,626	4,993	4,449	4,177	3,764
1932	5,318										5,065	4,724	4,218	3,951	3,569
1933	4,244											4,144	3,558	3,256	2,821
1934	4,071												3,780	3,419	3,139
1935	2,856													2,671	2,301
1936	3,959														3,747
Total	79,110	12,687	17,244	22,330	27,181	31,064	34,737	37,966	39,129	40,620	40,149	39,961	38,999	38,518	37,187

[1] No retirement of 1903–09 construction in earlier years.

TABLE 7.—*Bituminous surface-treated road mileage remaining in service; mileage constructed each year and mileage remaining in service on January 1 of each year*

[Compiled from data submitted by 26 States for rural State or Federal-Aid systems]

Construction: Year	Construction: Miles	1910[1]	1911	1912	1913	1914	1915	1916	1917	1918	1919	1920	1921	1922	1923	1924	1925	1926	1927	1928	1929	1930	1931	1932	1933	1934	1935	1936	1937
		Miles	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*
1907	12	12	12	12	12	11	9	6	0																				
1908	16	16	16	16	15	9	8	6	6	6	6	6	3	3	0														
1909	45	45	45	45	45	45	42	42	40	40	35	23	21	19	19	19	18	18	18	18	16	16	16	15	4	0			
1910	60		60	60	58	58	50	43	40	36	36	36	35	24	24	21	17	17	13	13	13	13	9	6	6	4	4	4	4
1911	40			40	40	40	31	30	29	28	28	28	24	16	15	12	10	10	10	10	7	7	4	4	4	4	4	4	4
1912	122				122	122	120	120	120	120	118	115	115	96	93	82	82	82	81	78	67	64	62	54	48	48	48	48	47
1913	82					82	82	82	80	77	68	58	58	47	37	32	29	26	24	24	20	17	12	10	8	8	7	7	6
1914	136						136	136	134	132	126	122	109	91	90	82	74	73	69	66	65	62	44	33	18	15	12	12	12
1915	289							289	289	285	281	275	269	256	246	240	236	235	228	227	226	216	186	169	148	145	134	131	125
1916	330								330	330	328	322	315	308	297	292	264	250	238	226	223	216	197	162	139	134	126	121	119
1917	136									136	133	132	131	116	116	116	113	109	109	106	104	100	90	74	65	62	60	60	57
1918	214										214	213	213	210	209	205	203	203	199	199	196	194	169	138	132	128	126	117	117
1919	168											168	168	167	164	164	161	161	148	147	143	142	122	111	101	101	94	81	63
1920	260												260	258	252	252	251	251	228	228	225	223	212	173	166	137	135	135	133
1921	329													329	329	325	325	320	315	305	297	285	270	240	215	210	192	187	187
1922	176														176	174	174	173	173	173	165	163	150	132	124	117	114	114	87
1923	438															438	438	438	438	438	419	408	390	369	356	350	344	328	284
1924	486																486	486	481	474	474	474	459	456	435	432	426	412	400
1925	996																	996	993	971	970	968	959	922	911	882	876	853	836
1926	1,567																		1,567	1,559	1,510	1,480	1,444	1,369	1,359	1,312	1,272	1,261	1,222
1927	1,770																			1,769	1,765	1,744	1,679	1,652	1,618	1,601	1,562	1,528	1,483
1928	2,108																				2,105	2,066	1,995	1,894	1,832	1,780	1,698	1,670	1,616
1929	2,056																					2,051	2,020	1,964	1,891	1,864	1,792	1,745	1,703
1930	3,747																						3,728	3,477	3,100	3,015	2,762	2,684	2,573
1931	2,631																							2,629	2,553	2,408	2,240	2,170	2,038
1932	2,169																								2,167	2,117	2,018	1,892	1,831
1933	2,444																									2,443	2,361	2,326	2,265
1934	3,042																										3,033	2,943	2,875
1935	2,060																											2,059	2,036
1936	3,020																												3,016
Total	30,949	73	133	173	292	367	478	754	1,068	1,190	1,373	1,498	1,721	1,940	2,067	2,454	2,881	3,848	5,332	7,031	9,010	10,909	14,217	16,053	17,400	19,317	21,440	22,892	25,139

[1] No retirement of 1907-09 construction in earlier years.

TABLE 8.—*Mixed bituminous road mileage remaining in service; mileage constructed each year and mileage remaining in service on January 1 of each year*

[Compiled from data submitted by 26 States for rural State or Federal-Aid systems]

Construction: Year	Construction: Miles	1910	1911	1912	1913	1914	1915	1916	1917	1918	1919	1920	1921	1922	1923
		Miles	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*
1909	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1910	3		3	3	3	2	2	2	2	2	2	2	2	2	2
1911															
1912	24				24	24	24	24	24	24	24	24	23	22	22
1913	18					18	18	18	18	18	18	18	18	17	12
1914															
1915	2							2	2	2	2	2	2	2	2
1916	19								19	19	19	19	16	16	16
1917	8									8	8	8	8	2	2
1918	10										10	10	10	10	10
1919	12											12	12	12	12
1920	136												136	136	136
1921	472													472	472
1922	81														81
1923	182														
1924	67														
1925	77														
1926	197														
1927	375														
1928	1, 016														
1929	1, 162														
1930	2, 860														
1931	3, 747														
1932	5, 551														
1933	3, 132														
1934	5, 007														
1935	2, 686														
1936	3, 736														
Total	30, 581	1	4	4	28	45	45	47	66	74	84	96	228	692	768

Construction: Year	1924	1925	1926	1927	1928	1929	1930	1931	1932	1933	1934	1935	1936	1937
	Miles	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*
1909	1	1	1	1	1	1	1	1	1	1	0			
1910	2	2	2	2	2	2	2	2	2	2	2	2	2	2
1911														
1912	22	20	18	11	10	8	6	5	5	5	4	4	4	4
1913	12	6	6	6	5	4	4	4	2	2	2	2	2	2
1914														
1915	2	2	2	2	2	2	2	2	2	2	2	2	2	2
1916	16	16	16	16	16	15	15	15	15	15	13	13	11	11
1917	2	2	2	2	2	2	2	2	2	2	2	2	2	2
1918	10	10	10	10	10	10	10	10	10	10	10	10	10	10
1919	12	12	12	12	12	12	12	12	12	12	12	12	12	12
1920	136	135	135	135	123	122	119	119	118	116	109	109	109	109
1921	472	469	469	466	465	465	451	446	443	435	415	404	392	392
1922	81	81	81	81	81	81	81	81	76	71	67	67	67	67
1923	182	182	181	181	181	181	177	170	169	161	161	161	160	157
1924		67	67	67	67	67	67	67	67	63	50	35	35	35
1925			77	77	75	75	75	75	75	69	59	58	58	58
1926				197	197	168	156	144	136	120	110	102	96	75
1927					375	375	372	346	336	328	314	301	299	293
1928						1, 016	1, 011	983	948	897	836	780	742	677
1929							1, 160	1, 142	1, 133	1, 097	1, 052	1, 016	997	963
1930								2, 860	2, 764	2, 733	2, 681	2, 597	2, 552	2, 485
1931									3, 745	3, 706	3, 692	3, 652	3, 548	3, 408
1932										5, 543	5, 528	5, 468	5, 301	5, 220
1933											3, 130	3, 122	3, 094	3, 058
1934												5, 003	4, 986	4, 902
1935													2, 686	2, 671
1936														3, 736
Total	950	1, 005	1, 079	1, 266	1, 624	2, 606	3, 723	6, 486	10, 061	15, 390	18, 251	22, 922	25, 167	28, 351

TABLE 9.—*Bituminous penetration road mileage remaining in service; mileage constructed each year and mileage remaining in service on January 1 of each year*

[Compiled from data submitted by 26 States for rural State or Federal-Aid systems]

Construction: Year	Construction: Miles	1910[1]	1911	1912	1913	1914	1915	1916	1917	1918	1919	1920	1921	1922	1923
		Miles	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*
1908	5	5	5	5	5	5	5	0							
1909	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
1910	40		40	40	40	40	39	39	39	39	39	39	39	39	39
1911	47			47	47	47	47	47	47	47	47	47	47	47	46
1912	56				56	56	56	56	56	53	53	53	52	52	52
1913	65					65	65	65	65	65	65	65	64	59	55
1914	72						72	72	72	68	68	68	68	68	62
1915	76							76	76	76	75	74	74	72	70
1916	213								213	213	211	211	211	200	199
1917	104									104	102	102	102	101	101
1918	122										122	122	120	120	119
1919	213											213	209	208	202
1920	312												312	310	305
1921	416													416	416
1922	519														517
1923	555														
1924	898														
1925	794														
1926	546														
1927	458														
1928	664														
1929	873														
1930	1,184														
1931	1,411														
1932	1,096														
1933	981														
1934	685														
1935	944														
1936	950														
Total	14,301	7	47	94	150	215	286	357	570	667	784	996	1,300	1,694	2,185

Construction: Year	1924	1925	1926	1927	1928	1929	1930	1931	1932	1933	1934	1935	1936	1937
	Miles	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*
1908														
1909	2	2	2	2	2	2	2	0						
1910	39	39	30	29	29	29	27	25	25	25	25	25	25	13
1911	45	45	35	35	35	32	22	15	6	6	6	5	4	4
1912	51	44	40	33	33	33	31	30	27	16	13	9	9	8
1913	46	45	45	45	45	42	23	19	17	17	15	15	10	6
1914	56	54	54	47	44	32	32	26	22	22	22	20	20	18
1915	68	68	62	60	59	54	52	38	29	25	25	25	25	25
1916	193	187	187	177	171	165	156	136	116	111	104	97	88	60
1917	96	94	91	85	77	76	74	73	62	51	50	46	44	44
1918	117	112	112	112	112	109	108	107	96	84	77	76	73	64
1919	200	200	200	200	194	194	186	181	164	144	131	122	118	108
1920	303	293	286	284	271	262	254	241	209	195	183	162	152	137
1921	416	416	416	415	415	410	400	389	343	295	277	257	233	213
1922	517	513	508	508	508	506	499	467	454	434	417	407	384	311
1923	555	554	554	554	549	541	536	510	485	471	456	441	441	389
1924		898	898	898	897	884	877	839	830	825	816	775	730	669
1925			793	793	793	791	790	774	766	759	750	744	723	661
1926				545	545	545	532	532	526	517	516	512	508	502
1927					458	458	452	447	442	431	431	417	411	400
1928						664	643	635	631	616	598	594	592	565
1929							873	862	858	841	833	815	791	753
1930								1,182	1,158	1,143	1,089	1,083	1,076	1,057
1931									1,409	1,391	1,380	1,366	1,362	1,333
1932										1,089	1,085	1,084	1,081	1,070
1933											967	967	967	953
1934												685	663	656
1935													944	939
1936														943
Total	2,704	3,564	4,313	4,822	5,237	5,829	6,569	7,528	8,675	9,508	10,266	10,749	11,474	11,901

[1] No retirement of 1908–09 construction in earlier years.

295646—41——2

TABLE 10.—*Bituminous concrete road mileage remaining in service; mileage constructed each year and mileage remaining in service on January 1 of each year*

[Compiled from data submitted by 26 States for rural State or Federal-Aid systems]

Construction		1914	1915	1916	1917	1918	1919	1920	1921	1922	1923	1924	1925	1926	1927	1928	1929	1930	1931	1932	1933	1934	1935	1936	1937
Year	Miles																								
		Miles	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*
1913	71	71	71	71	71	69	69	69	58	55	47	47	44	34	32	25	16	13	10	10	10	7	7	7	7
1914	115		114	114	109	106	103	103	99	93	79	73	73	71	63	62	61	56	39	31	31	31	30	28	23
1915	290			290	290	290	290	287	277	275	244	228	207	199	155	122	90	76	64	62	51	41	35	33	19
1916	132				132	131	131	131	129	129	102	87	87	83	83	83	79	73	72	71	70	56	50	48	44
1917	53					53	53	53	53	53	53	42	42	41	40	40	39	37	33	33	33	33	31	31	29
1918	122						122	116	116	115	98	93	93	93	93	91	89	74	64	62	58	51	51	43	28
1919	52							52	52	52	52	52	52	52	52	52	52	47	47	45	45	45	42	35	23
1920	213								213	213	210	204	196	196	195	180	178	174	159	153	141	136	130	116	102
1921	377									377	377	377	377	377	377	374	373	373	350	318	293	286	261	232	192
1922	346										346	346	346	331	327	321	320	319	311	296	259	247	225	221	216
1923	545											545	545	545	545	545	545	539	528	521	501	467	429	426	416
1924	623												623	623	623	623	619	585	584	571	536	535	514	507	474
1925	471													471	471	471	469	469	457	452	452	451	437	436	396
1926	476														475	475	474	473	473	473	458	456	439	436	431
1927	718															704	704	684	681	680	677	649	638	635	635
1928	501																501	500	496	496	483	480	480	473	467
1929	682																	682	673	655	655	641	637	636	620
1930	514																		514	514	512	505	503	499	470
1931	606																			606	606	588	586	584	571
1932	590																				590	588	581	581	581
1933	484																					480	478	470	468
1934	735																						735	734	729
1935	514																							514	506
1936	1,053																								1,034
Total	10,283	71	185	475	602	649	768	811	997	1,362	1,608	2,094	2,685	3,116	3,531	4,168	4,609	5,174	5,555	6,049	6,461	6,773	7,319	7,725	8,481

TABLE 11.—*Portland cement concrete road mileage remaining in service; mileage constructed each year and mileage remaining in service on January 1 of each year*

[Compiled from data submitted by 26 States for rural State or Federal-Aid systems]

Construction		1911	1912	1913	1914	1915	1916	1917	1918	1919	1920	1921	1922	1923	1924	1925	1926	1927	1928	1929	1930	1931	1932	1933	1934	1935	1936	1937
Year	Miles																											
		Miles	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*
1910	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1911																												
1912	29			29	29	29	29	29	29	29	29	29	28	28	25	25	25	21	21	15	14	14	14	13	13	13	13	13
1913	42				42	42	42	42	42	42	40	39	39	38	38	38	38	32	32	32	28	26	26	25	25	25	25	23
1914	261					261	261	261	258	258	255	255	254	252	252	250	246	217	201	189	180	175	170	144	139	128	124	89
1915	279						271	267	267	265	263	263	255	246	238	235	218	216	216	210	194	177	166	140	139	136	128	116
1916	505							503	500	490	479	461	418	411	402	400	393	391	357	346	335	308	292	258	235	219	201	182
1917	236								235	235	235	235	233	233	231	225	220	213	212	207	187	174	170	142	128	121	117	104
1918	322									313	313	310	310	303	292	291	290	289	282	273	264	227	217	207	193	167	162	137
1919	475										475	473	471	463	445	445	445	439	434	426	387	360	337	305	278	261	247	215
1920	561											561	561	560	558	556	554	554	541	533	518	507	490	473	448	429	420	378
1921	888												888	888	888	888	888	886	879	869	862	843	813	784	755	735	706	668
1922	1,113													1,113	1,113	1,113	1,111	1,104	1,104	1,102	1,101	1,088	1,079	1,076	1,057	1,034	1,015	951
1923	1,124														1,124	1,124	1,124	1,120	1,120	1,120	1,120	1,112	1,110	1,099	1,092	1,081	1,064	1,048
1924	1,922															1,922	1,922	1,921	1,920	1,919	1,919	1,909	1,900	1,897	1,877	1,863	1,857	1,831
1925	1,690																1,690	1,690	1,689	1,689	1,689	1,679	1,675	1,672	1,662	1,655	1,650	1,636
1926	2,087																	2,087	2,087	2,085	2,084	2,084	2,084	2,082	2,078	2,075	2,072	2,064
1927	1,942																		1,942	1,942	1,940	1,940	1,940	1,938	1,938	1,934	1,925	1,912
1928	2,238																			2,238	2,230	2,229	2,228	2,228	2,228	2,225	2,222	2,218
1929	1,891																				1,891	1,891	1,890	1,890	1,889	1,889	1,887	1,885
1930	3,855																					3,853	3,853	3,852	3,851	3,851	3,846	3,843
1931	3,518																						3,515	3,513	3,513	3,512	3,512	3,510
1932	2,825																							2,822	2,818	2,816	2,814	2,814
1933	2,039																								2,038	2,034	2,034	2,033
1934	1,110																									1,110	1,109	1,109
1935	828																										828	828
1936	994																											994
Total	32,775	1	1	30	72	333	604	1,103	1,332	1,633	2,090	2,627	3,458	4,536	5,607	7,513	9,165	11,181	13,038	15,196	16,944	20,597	23,970	26,561	28,395	29,314	29,979	30,602

TABLE 12.—*Brick or block road mileage remaining in service; mileage constructed each year and mileage remaining in service on January 1 of each year*

[Compiled from data submitted by 26 States for rural State or Federal-Aid systems]

Construction: Year	Construction: Miles	1910 [1]	1911	1912	1913	1914	1915	1916	1917	1918	1919	1920	1921	1922	1923
		Miles	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*
1907	7	7	7	7	6	6	6	3	3	3	1	1	1	1	1
1908	9	9	9	9	9	9	9	8	8	8	8	8	7	7	7
1909	8	8	8	8	8	8	8	8	8	8	8	8	8	7	7
1910	27		27	27	27	27	27	27	27	27	27	23	23	21	18
1911	24			24	24	24	24	24	24	24	24	24	22	22	22
1912	48				48	48	48	48	48	48	45	43	41	41	41
1913	40					40	40	40	40	40	40	40	40	40	40
1914	99						99	99	99	99	99	99	99	98	98
1915	239							239	239	239	239	239	239	238	238
1916	127								127	127	127	127	127	127	127
1917	120									120	119	119	118	118	118
1918	128										127	127	127	127	127
1919	129											129	129	127	127
1920	143												143	143	143
1921	220													220	220
1922	261														261
1923	226														
1924	112														
1925	161														
1926	125														
1927	61														
1928	78														
1929	27														
1930	92														
1931	71														
1932	69														
1933	28														
1934	57														
1935	35														
1936	28														
Total	2,799	24	51	75	122	162	261	496	623	743	864	987	1,124	1,337	1,595

Construction: Year	1924	1925	1926	1927	1928	1929	1930	1931	1932	1933	1934	1935	1936	1937
	Miles	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*
1907	1	1	1	1	1	1	1	1	1	1	1	1	0	
1908	7	7	6	5	4	4	4	4	4	3	3	3	3	1
1909	7	6	6	6	5	5	5	4	4	2	2	2	2	1
1910	17	17	17	14	14	14	14	9	8	7	7	7	6	5
1911	21	19	19	19	19	19	19	18	16	16	16	13	13	13
1912	40	37	37	34	34	30	27	18	17	13	11	11	10	10
1913	35	35	34	34	31	26	24	23	23	22	21	21	19	16
1914	98	98	98	98	98	96	96	91	71	67	62	55	47	37
1915	238	236	233	233	229	210	200	197	187	179	173	141	137	112
1916	127	127	114	114	114	109	108	102	100	80	74	71	69	61
1917	118	118	118	116	106	104	103	98	94	89	86	78	75	71
1918	127	126	122	122	122	122	122	114	99	87	87	85	84	73
1919	127	124	124	123	122	119	114	100	98	91	88	87	84	70
1920	143	142	125	120	120	120	102	98	85	81	79	75	70	69
1921	220	220	219	217	211	208	204	201	199	174	171	171	168	157
1922	261	261	261	261	261	261	257	252	233	218	215	204	192	169
1923	226	226	225	225	225	225	220	218	204	203	200	198	191	185
1924		112	112	112	112	111	111	111	111	111	109	103	99	87
1925			161	161	161	157	157	157	152	150	150	149	149	138
1926				125	125	122	122	120	120	119	119	119	119	114
1927					61	61	61	61	60	60	60	60	60	57
1928						78	78	77	77	77	77	77	77	76
1929							27	27	27	27	27	27	27	26
1930								92	92	91	91	91	91	91
1931									71	71	71	71	71	71
1932										69	69	69	69	69
1933											28	28	28	28
1934												57	57	57
1935													35	35
1936														28
Total	1,813	1,912	2,032	2,140	2,175	2,202	2,176	2,193	2,153	2,108	2,097	2,074	2,052	1,927

[1] No retirement of 1907–09 construction in earlier years.

TABLE 13.—*Dual-type road mileage remaining in service; mileage constructed each year, and mileage remaining in service on January 1 of each year*

[Compiled from data submitted by 26 States for rural State or Federal-Aid systems]

Construction		1922	1923	1924	1925	1926	1927	1928	1929	1930	1931	1932	1933	1934	1935	1936	1937
Year	Miles																
		Miles	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*
1921	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	7
1922	41		41	41	41	41	41	41	41	41	40	40	40	31	31	31	30
1923	27			27	27	27	27	27	27	26	26	25	23	23	19	19	16
1924	3				3	3	3	3	3	3	3	3	3	3	3	3	3
1925	17					17	17	17	17	17	17	17	17	17	17	17	17
1926	20						20	20	20	20	20	20	20	20	20	20	20
1927	14							14	14	14	14	14	14	14	14	14	14
1928	8								8	8	8	8	8	8	8	8	8
1929	11									11	11	11	11	11	11	11	11
1930	16										16	15	15	15	15	15	15
1931	31											31	31	31	31	31	31
1932	16												16	16	16	16	16
1933	6													6	6	6	6
1934	22														22	22	22
1935	20															20	20
1936	13																13
Total	274	9	50	77	80	97	117	131	139	149	164	193	207	204	222	242	249

Average service lives were determined in accordance with the particular conditions pertaining to each survivor curve. For the older construction, particularly for the lower types of surface, survivor curves that reach zero percent remaining in service were obtained in many instances, and hence the average service life is equal to the area below the survivor curve divided by 100. For the stub survivor curves generally obtained for the higher types of surface and for the more recent construction, it is necessary to estimate the future trend of the curves from the end point of the actual experience to zero percent remaining in order to obtain approximations of the total service to be expected from the mileage constructed. These future trends of stub survivor curves were estimated by one of the following two methods:

A. By projecting the stub survivor curve to zero percent remaining in accordance with the retirement trend reflected by the stub survivor curve as judged by visual inspection. This method was applied only to stub survivor curves of lengths sufficient to afford a reasonable and definite indication of the probable trend for the mileages remaining in service.

B. By matching the stub survivor curve with one of the 18 type survivor curves described in Bulletin 125 of the Iowa State College Engineering Experiment Station.[9] These 18 basic type survivor curves were developed as a result of a study of retirement trends for various types of industrial properties. The matching of a particular type curve with the stub survivor curve permits an estimate to be made of the probable future trend of mileages remaining in service.

For a survivor curve that reaches zero percent remaining for the reason that all the mileage was retired or that was extended to zero percent remaining in accordance with method A above, the probable average life was determined by dividing the area below the survivor curve by 100 percent. The total area below the survivor curve was obtained from a summation of the areas under the curve for each of the age intervals 0 to ½ year, ½ to 1½ years, 1½ to 2½ years, etc., to zero percent remaining. The area for each of these intervals is equal to the average percent surviving during the interval multiplied by the length of the interval which is 0.5 year for the 0 to ½ year age interval and 1.0 year for each succeeding interval (from ½ to 1½ years, 1½ to 2½ years, etc.). The average percent surviving during a given interval is assumed to be the arithmetic average of the percents surviving at the beginning and end of the interval.

[9] Statistical Analysis of Industrial Property Retirements, by Robley Winfrey, December 1935. See also Proc. Highway Research Board, Vol. 15, Pt. I, pp. 47 to 60, or a description of the matching process.

For cases in which the type survivor curves were utilized as in method B, an estimate of the average service life was obtained directly by matching the stub survivor curve with the type survivor curve affording the best fit. When matching stub survivor curves with the type survivor curves in Bulletin 125 of the Iowa Engineering Experiment Station, it is obvious that the longer stub curves enable more reliable estimates to be made of the average service life. For short stub curves for which more than one type curve and average life satisfactorily match the stub curve, the type curve and average live selected were those consistent with indicated trends for other years of construction.

The general methods employed in determining the probable average service lives from survivor curves of various lengths are briefly described as follows:

Percent remaining at end point of survivor curve	*Usual method of determining probable average service life*
0	From the area under the survivor curve.
15 or less	From the area under the stub survivor curve and its projection to zero percent remaining by judgment based on the indicated trend.
15–40	Stub survivor curve matched with a type survivor curve from Bulletin 125 if a reasonable fit could be obtained; otherwise from the area under the stub survivor curve and its projection to zero percent remaining by judgment based on the indicated trend.
40–100	Stub survivor curve matched with a type survivor curve from Bulletin 125. In some cases construction for 2 or more consecutive years was combined into like age groups if the stub survivor curves for each of the individual years follows approximately the same trend.

SURVIVOR CURVES PLOTTED FOR VARIOUS SURFACE TYPES

Figures 2 to 9 represent examples of survivor curves from which the average service lives were determined in accordance with the foregoing methods for various surface types and years of construction. Figure 2 illustrates construction for which the survivor curve reaches zero percent remaining in service. The gravel or stone roads constructed in 1910 reached zero percent remaining on January 1, 1933, at an age of 22½ years. The average service life of 11.4 years was calculated from the area below the survivor curve.

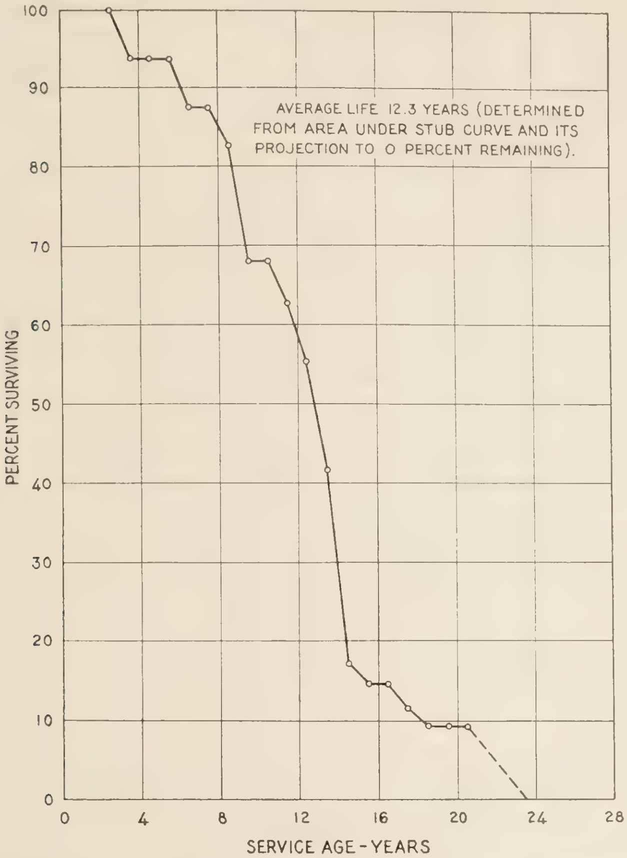

FIGURE 3.—SURVIVOR CURVE FOR 129 MILES OF SOIL-SURFACED ROADS CONSTRUCTED IN 1916.

In figure 3 the stub survivor curve for soil-surfaced roads constructed in 1916 is shown as reaching 9 percent remaining in service at age 20½ years. In this instance the stub survivor curve was projected to zero percent remaining in service in accordance with judgment and the past trend. The probable average service life of 12.3 years was determined from the area below the stub curve and its projection to zero percent remaining in service.

Figures 4 and 5 illustrate alternate procedures used when the end points of the stub survivor curves are between 15 and 40 percent remaining in service. Figure 4 shows the stub survivor curve obtained for portland cement concrete surfaces built in 1914. The end point of the stub curve is 34 percent remaining at 22½ years of age. The trend of the stub survivor curve is such that the average service life of 20 years can be estimated by matching the stub curve with the type survivor curves. An S_2 type [10] survivor curve of 20 years average life was selected as the curve giving the best fit. Beyond the age represented by the end point of the stub survivor curve the percentages remaining in service in future years are presumed to follow the trend of the type survivor curve.

When matching type survivor curves with stub curves, no attempt was made to obtain type survivor curves that match the stub curve with the minimum

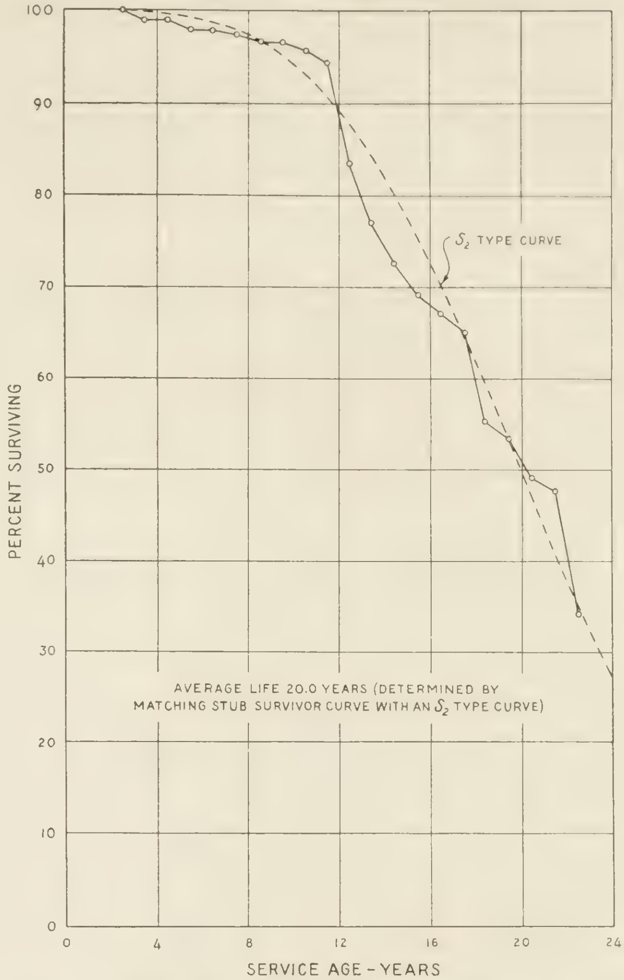

FIGURE 4.—SURVIVOR CURVE FOR 261 MILES OF PORTLAND CEMENT CONCRETE ROADS CONSTRUCTED IN 1914.

mathematical deviation. When more than one type survivor curve and average life could be considered as satisfactorily matching the stub, care was taken to select the type curve and average life that were consistent with other years of construction. It was found through experience that undue refinement in matching is unwarranted in most cases. Approximate matching by visual methods in superimposing the stub curves on the various type survivor curves (drawn to the same scale) yields results as satisfactory from the standpoint of reliability as those obtained from more refined procedures involving precise mathematical adjustments. For purposes of comparison, figure 4 shows both the stub survivor curve for portland cement concrete roads constructed in 1914 and the S_2 type survivor curve visually selected as being the best matching curve.

On figure 5 is represented the stub survivor curve obtained for bituminous concrete roads constructed in 1916. At the end point (20½ years) of the stub curve, 33.3 percent remained in service. Because the trend of the stub curve is such that it cannot be satisfactorily matched with any of the type survivor curves, it was projected to zero percent remaining in service in accordance with the trend reflected by the stub curve with consideration being given both to the trends of the type survivor curves that most nearly match the

[10] The 18 type curves presented in Bulletin 125 are designated by their shape as indicated by both the modal age and modal frequency. The letters L, S, and R are given, respectively, to the types having their year of greatest retirement to the left of, coincident with, and to the right of the age corresponding to average life. Subscript numbers are added to the letters to show the relative percentage of retirement at the modal age, the larger number being used for the larger retirements or steeper survivor curves.

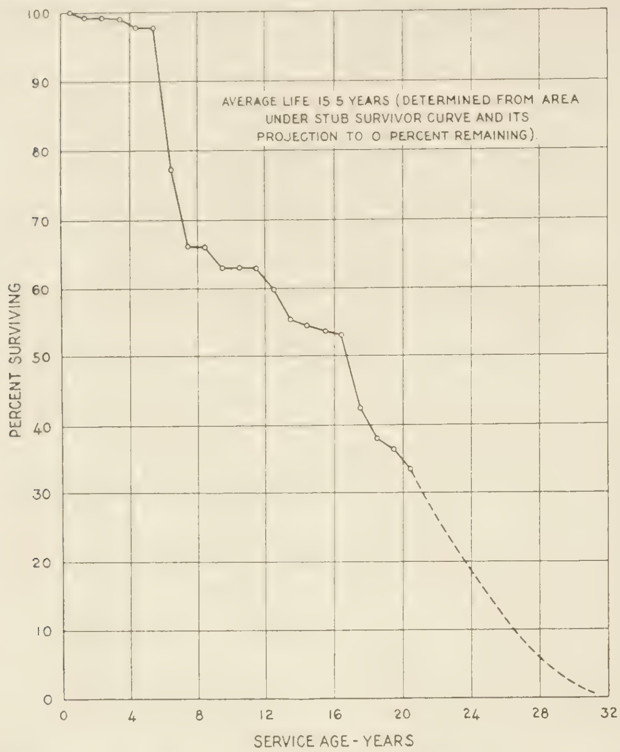

Figure 5.—Survivor Curve for 132 Miles of Bituminous Concrete Roads Constructed in 1916.

stub curve and to the trends for other years of construction. The probable average service life of 15.5 years was determined from the area below the stub curve and its projection to zero percent remaining in service.

Figure 6 shows the stub survivor curve obtained for bituminous penetration roads built in 1924. The end point of the stub curve is 75 percent remaining in service at 12½ years. The trend of the stub survivor curve is such that the probable average service life of 15 years can be estimated satisfactorily by matching the stub curve with the type survivor curves. An R_3 type curve of 15 years average life was selected by visual inspection as the curve giving the best fit. For purposes of comparison, figure 6 shows both the stub survivor curve and the type survivor curve.

Figure 7 illustrates an instance where type survivor curves from Bulletin 125 were matched with a stub curve whose end point is higher than 90 percent. The stub curve for portland cement concrete roads constructed in 1924 extends only to 95 percent remaining in service, and the matching type curve selected is an R_3 curve of 27 years average life.

On figure 8 are plotted the stub survivor curves for bituminous surface-treated roads built during 1919–23. It is apparent that the stub curves for the individual years follow approximately the same trend. When difficulty is experienced in obtaining satisfactory estimates for individual years of construction and the successive years of construction show close agreement with respect to survivor characteristics, the data for the individual years may be combined into like-age groups for purposes of analysis. This was done for the bituminous surface-treated roads constructed during 1919–23 and the composite stub survivor curve obtained from the grouping is shown in figure 9.

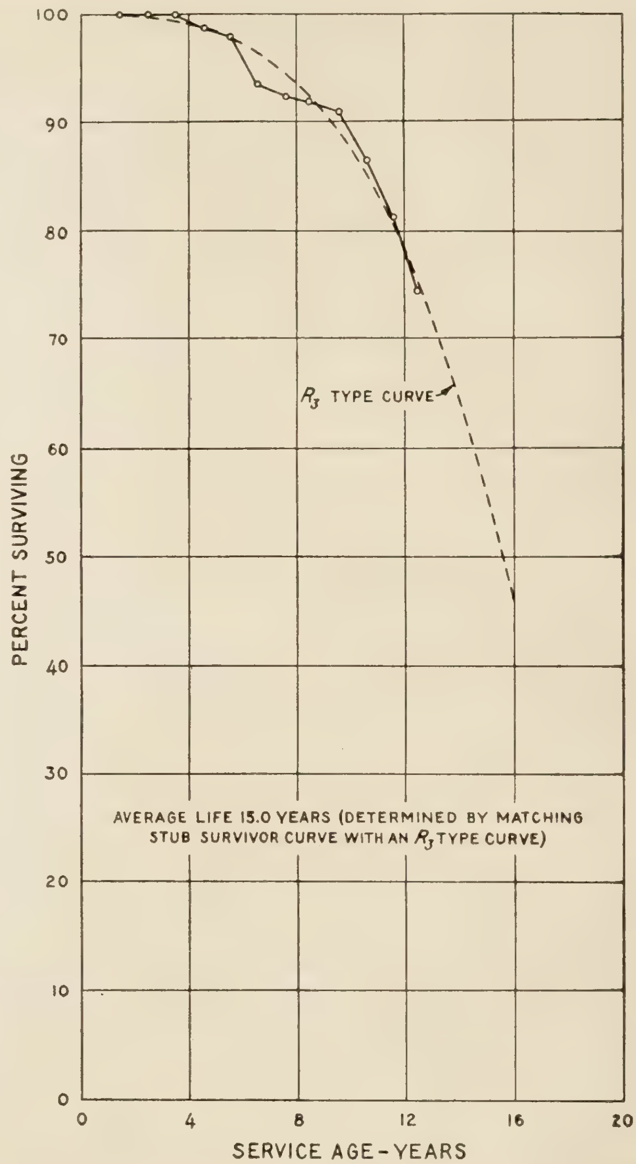

Figure 6.—Survivor Curve for 898 Miles of Bituminous Penetration Roads Constructed in 1924.

Table 14 shows the procedure for grouping the data for the individual years of construction in order to obtain a composite curve. The trend of the composite stub survivor curve thus obtained is such that the average service life of 15.5 years can be estimated by matching the stub curve with the type survivor curves. Type S_1 at 15.5 years average life was selected by visual inspection as the curve giving the best fit. For purposes of comparison, figure 9 shows both the composite stub survivor curve for these bituminous surface-treated roads and the S_1 type survivor curve.

Tables 15, 16, and 17 give in summarized form the probable average lives for the nine surface types and indicate the method used in arriving at the estimate. The estimates of average lives for the earlier years of construction of each type should be more reliable than those for the more recent years of construction. The reason for this is that the greater percentage of retirements from the early construction leaves less future life to be estimated. On the other hand the mileages of early construction are so limited that the resulting

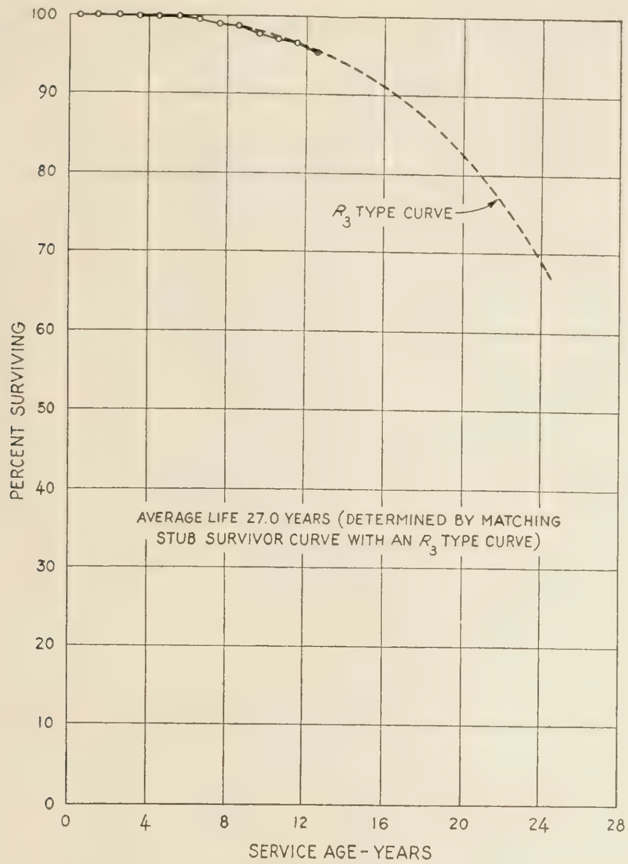

FIGURE 7.—SURVIVOR CURVE FOR 1,922 MILES OF PORTLAND CEMENT CONCRETE ROADS CONSTRUCTED IN 1924.

TABLE 14.—*Calculation of composite stub survivor curve for the 1919 to 1923 construction of bituminous surface-treated roads*

[Mileage data obtained from table 7]

Age, years	Remaining in service								
	Year of construction					A [1] Total	B [1]	C [1]	D [1]
	1919	1920	1921	1922	1923				
	Miles	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Percent*	*Miles*	*Percent*
0	168	260	329	176	438	1,371	100.0		
½	168	260	329	176	438	1,371	100.0		
1½	168	258	329	174	438	1,367	99.7		
2½	167	252	325	174	438	1,356	98.9		
3½	164	252	325	173	438	1,352	98.6		
4½	164	251	320	173	438	1,346	98.2		
5½	161	251	315	173	419	1,319	96.2		
6½	161	228	305	165	408	1,267	92.4		
7½	148	228	297	163	390	1,226	89.4		
8½	147	225	285	150	369	1,176	85.8		
9½	143	223	270	132	356	1,124	82.0		
10½	142	212	240	124	350	1,068	77.9		
11½	122	173	215	117	344	971	70.8		
12½	111	166	210	114	328	929	67.8		
13½	101	137	192	114	284	828	60.4		
14½	101	135	187	87		510	56.6	544	93.8
15½	94	135	187			416	55.6	423	98.3
16½	81	133				214	51.9	229	93.4
17½	63					63	40.4	81	77.8

[1] The entries in columns A, B, C, and D for ages from 14½ years to 17½ years are obtained as follows:

Column A: The entry of 510 miles at the age of 14½ years is the summation of th mileages remaining for only 4 years of construction (1919 to 1922). The experience of the 1923 construction extends only to January 1, 1937, at 13½ years of age and must necessarily be omitted. Similarly, the entries in column A at ages of 15½, 16½, and 17½ years include 3, 2, and 1 year of construction, respectively.

Column C: The mileage entries in this column for ages from 14½ years to 17½ years represent the mileages existing 1 year prior to the corresponding mileage entries in column A. Thus, the entry of 544 miles at 14½ years of age is the sum of the mileages of 1919 to 1922 construction which existed at 13½ years of age.

Column D: The entries in this column represent the percentage of the mileage which remained in service throughout the preceding year, obtained by dividing the entries in column A by the entries in column C. Thus, of the mileage existing at 13½ years of age, there was 93.8 percent still in service at 14½ years of age (510 divided by 544).

Column B: Of the original construction of 1,371 miles there was 60.4 percent remaining in service at an age of 13½ years (828 divided by 1,371). Column D (for 4 of the 5 years of construction) indicates that 93.8 percent of mileage in service at an age of 13½ years was still in service at 14½ years of age. Thus, 0.604×0.938 or 56.6 percent of the original 100 percent may be considered as still in service at 14½ years of age Similarly, 98.3 percent (from column D) of the mileage in service (or 56.6 percent) at an age of 14½ years was still in service at 15½ years of age. Therefore, 0.566×0.983 or 55.6 percent of the original 100 percent may be considered as still in service at 15½ years of age. This same procedure is followed for obtaining the stub survivor curve entries at 16½ and 17½ years of age in column B.

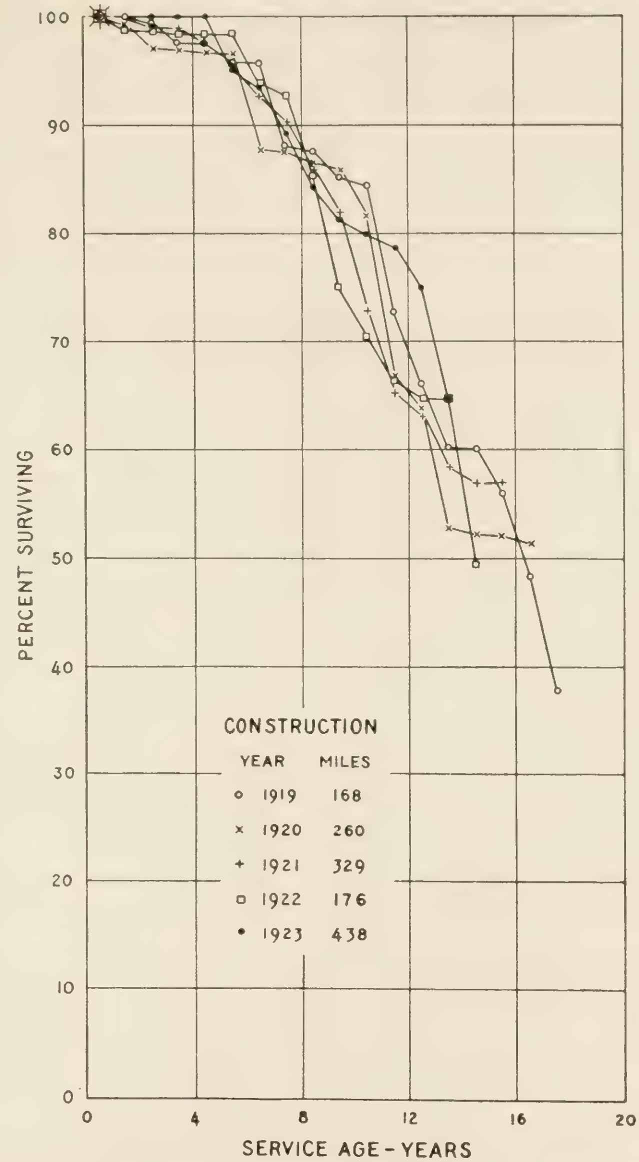

FIGURE 8.—SURVIVOR CURVES FOR 1,371 MILES OF BITUMINOUS SURFACE-TREATED ROADS CONSTRUCTED IN 1919–23.

survivor curves frequently follow erratic trends, as compared to the generally smooth curves obtained for the larger mileages of construction of later years. Estimates of average lives are given in tables 15, 16, and 17 only when the retirements were sufficient and the trend definite enough to warrant making the estimate. It will be noticed that generally no estimate is made unless the end point of the survivor curve is below 90 percent, and even for stub curves having end points between 85 and 95 percent, the probable error in the prediction may be large. An added degree of reliability is afforded, however, by giving consideration to the trend of probable average lives for the prior years.

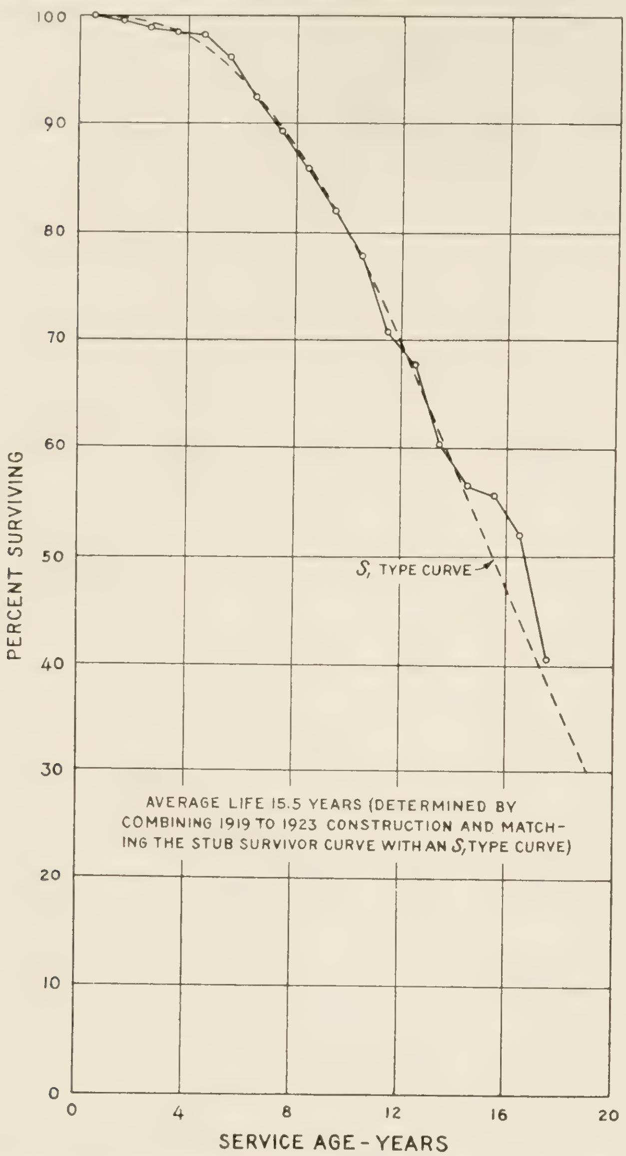

FIGURE 9.—COMPOSITE SURVIVOR CURVE FOR 1,371 MILES OF BITUMINOUS SURFACE-TREATED ROADS CONSTRUCTED 1919–23.

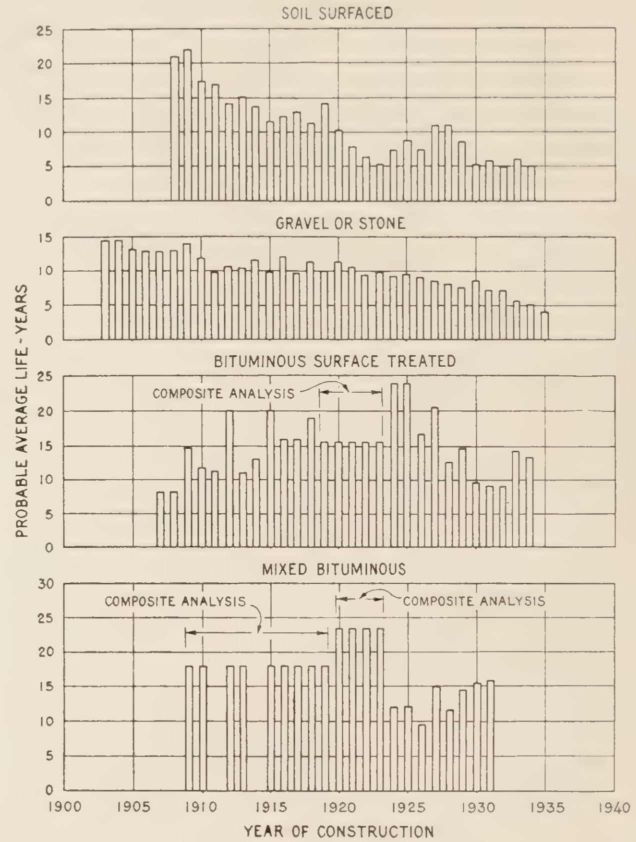

FIGURE 10.—PROBABLE AVERAGE LIVES FOR SEVERAL TYPES OF ROAD SURFACES CONSTRUCTED IN VARIOUS YEARS.

AVERAGE LIFE OF HIGH-TYPE SURFACES INCREASING

Figures 10 and 11 indicate the trends and show the irregularities of changes in average lives. Administrative policy has played a predominating part in the retirement of some types of surfacing. For example, the probable average service life of gravel or stone roads (the most extensive type of construction) has gradually been reduced to approximately 5 years for more recent construction, primarily as the result of a continually increasing practice of placing a bituminous surface on the gravel or stone within a limited time after construction. The conditions causing retirements of high-type surfaces are less influenced by changes of administrative policy than are those of low-type surfaces. Of interest, therefore, is the decrease in probable average service life of portland cement concrete constructed during the period 1916–20. This decrease probably results from the deteriorating effect of increases in volume and weight of traffic during and immediately following the World War period on those roads built under unfavorable conditions at that time.

For the purpose of obtaining definite indications, if any, of average service life trends, table 18 was prepared from tables 15, 16, and 17 by combining the individual construction years into six arbitrary construction-year groupings: 1903–10, 1911–15, 1916–20, 1921–25, 1926–30, and 1931–36. The averages were obtained by weighting the estimated average service life for a particular type during a given year with the mileage constructed during that year. The table indicates that the average service life of the lower types is decreasing, probably because of the administrative policy of keeping the lower type roads in serviceable condition by periodic resurfacing and reconstruction as well as by their gradual improvement to a higher type through stage construction. For the higher types, there is evidence that the average service life is increasing, probably because of substantial advances made in design standards, specifications, and construction methods.

In table 19 is recorded for each type of surface the average age of the miles remaining in service on January 1 of each year from 1920 to 1937. To calculate this average age each individual entry on tables 5 to 13 was multiplied by its particular age. Vertical totals of age-miles for each year were then divided by the corresponding miles remaining in service on January 1 to get the average ages. In general, the average ages increase from 1920 to 1937. Very heavy construction of a given type during a particular year either reduces the average age or slows up the increase during the same year for that type.

Tables 20 to 28 indicate the percentage distribution of retired mileages of each surface type according to

TABLE 15.—*Probable average service lives of each year's construction of soil-surfaced, gravel or stone, and bituminous surface-treated roads*

[Compiled from data submitted by 26 States for rural State or Federal-Aid systems]

Year of construction	Soil-surfaced roads				Gravel or stone roads				Bituminous surface-treated roads			
	Miles built	Percent remaining in service on 1-1-37	Estimated average service life in years [1]	Method of determination [2]	Miles built	Percent remaining in service on 1-1-37	Estimated average service life in years [1]	Method of determination [2]	Miles built	Percent remaining in service on 1-1-37	Estimated average service life in years [1]	Method of determination [2]
1903					11	0	14.4	I				
1904					18	0	14.4	I				
1905					20	0	13.1	I				
1906					39	0	12.7	I				
1907					47	0	12.7	I	12	0	8.2	I
1908	12	0	21.0	I	71	0	12.8	I	16	0	8.3	I
1909	11	0	22.0	I	103	6	14.0	II	45	0	14.8	I
1910	19	0	17.5	I	159	0	11.4	I	60	7	11.8	II
1911	40	0	16.9	I	161	0	9.7	I	40	10	11.3	II
1912	129	0	14.1	I	212	0	11.0	I	122	39	20.0	L_1
1913	139	3	15.0	II	267	0	10.8	I	82	7	11.2	II
1914	111	0	13.8	I	331	11	11.4	II	136	9	12.9	II
1915	189	4	11.4	II	534	10	9.9	II	289	43	20.0	L_1
1916	129	9	12.3	II	316	6	12.0	II	330	36	16.0 (1916–1917)	S_0
1917	103	4	12.8	II	275	0	9.6	I	136	42		
1918	74	5	11.2	II	405	13	11.3	II	214	55	19.0	L_2
1919	128	35	14.0	S_0	577	5	10.1	II	168	38	15.5 (1919–1923)	S_1
1920	279	25	10.2	II	1,273	18	11.3	II	260	51		
1921	334	9	7.8	II	2,506	15	10.6	II	329	57		
1922	499	8	6.4	II	3.485	13	9.5	II	176	49		
1923	387	3	5.3	II	3,657	21	9.8	II	438	65		
1924	421	21	7.3	II	4,958	24	9.1	II	486	82	24.0 (1924–1925)	L_1
1925	418	46	8.7	II	5,659	37	9.5	II	996	84		
1926	200	30	7.3	II	5,634	35	9.1	II	1,567	78	17.0	R_1
1927	218	70	11.0 (1927–1928)	R_2	4,689	42	8.5	L_1	1,770	84	20.5	R_1
1928	279	76			5,884	46	8.0	L_1	2,108	77	12.5	R_1
1929	450	64	8.5	R_1	5,168	46	7.5	L_0	2,056	83	14.5	R_1
1930	532	45	5.2	II	5,899	59	8.5	L_0	3,747	69	9.5	L_0
1931	475	59	5.9	II	6,304	60	7.0 (1931–1932)	L_0	2,631	78	9.0 (1931–1932)	S_0
1932	498	56	5.0	II	5,318	67			2,169	84		
1933	548	70	6.0	L_0	4,244	67	5.5	L_0	2,444	93	14.0	R_1
1934	1,021	72	5.0	L_0	4,071	77	5.0	L_0	3,042	94	13.0	R_1
1935	613	91			2,856	80	4.0	L_0	2,060	99		
1936	651	96			3,959	95			3,020	100		

[1] The last entry in this column is the estimate for the most recent year for which the retirement experience is sufficient to enable a reasonable estimate of the average life to be made.
[2] Method I.—Average service life calculated from the area under the original survivor curve.
Method II.—Average service life calculated from the area under the stub survivor curve and its projection to 0 percent remaining by extension of past trend.
Method S_0, R_2, etc.—These designations indicate that an estimate of the average service life was obtained by matching the stub survivor curve with the type survivor curves in Bulletin 125.

TABLE 16.—*Probable average service lives of each year's construction of mixed bituminous, bituminous penetration, and bituminous concrete roads*

[Compiled from data submitted by 26 States for rural State or Federal-Aid systems]

Year of construction	Mixed bituminous roads				Bituminous penetration roads				Bituminous concrete roads			
	Miles built	Percent remaining in service on 1-1-37	Estimated average service life in years [1]	Method of determination [2]	Miles built	Percent remaining in service on 1-1-37	Estimated average service life in years [1]	Method of determination [2]	Miles built	Percent remaining in service on 1-1-37	Estimated average service life in years [1]	Method of determination [2]
1908					5	0	7.0	I				
1909	1	0	18.1 (1909–1919)	II	2	0	21.0	I				
1910	3	67			40	33	23.5	II				
1911					47	9	18.3	II				
1912	24	17			56	14	17.7	II				
1913	18	11			65	9	15.8	II	71	10	13.1	II
1914					72	25	15.8	II	115	20	14.8	II
1915	2	100			76	33	16.4	II	290	7	12.6	II
1916	19	58			213	28	14.8	II	132	33	15.5	II
1917	8	25			104	42	16.0	R_2	53	55	18.5	S_0
1918	10	100			122	53	18.0	R_2	122	23	13.4	II
1919	12	100			213	51	16.5	R_2	52	44	17.0	S_1
1920	136	80	23.5 (1920–1923)	S_1	312	44	14.0	R_2	213	48	16.5	S_0
1921	472	83			416	51	14.5	S_3	377	51	15.0	S_3
1922	81	83			519	60	14.5	R_3	346	63	16.0	S_1
1923	182	86			555	70	15.0	R_3	545	76	15.0	S_3
1924	67	52	12.0 (1924–1925)	R_4	898	75	15.0	R_3	623	76	21.0	S_0
1925	77	75			794	83	16.5 (1925–1926)	R_3	471	84	21.0	L_2
1926	197	38	9.5	L_0	546	92			476	91	20.0	L_2
1927	375	78	15.0	R_1	458	88	17.5	R_2	718	88		
1928	1,016	67	11.5	S_0	664	85	19.0	R_1	501	93		
1929	1,162	83	14.5	S_0	873	86	14.0	R_2	682	91		
1930	2,860	87	15.5	R_1	1,184	89	18.0	R_1	514	92		
1931	3,747	91	16.0	L_1	1,411	95			606	94		
1932	5,551	94			1,096	98			590	99		
1933	3,132	98			981	97			484	97		
1934	5,007	98			685	96			735	99		
1935	2,686	100			944	99			514	98		
1936	3,736	100			950	99			1,053	98		

[1] The last entry in this column is the estimate for the most recent year for which the retirement experience is sufficient to enable a reasonable estimate of the average life to be made.
[2] Method I.—Average service life calculated from the area under the original survivor curve.
Method II.—Average service life calculated from the area under the stub survivor curve and its projection to 0 percent remaining by extension of past trend.
Method S_0, R_2, etc.—These designations indicate that an estimate of the average service life was obtained by matching the stub survivor curve with the type survivor curves in Bulletin 125.

Table 17.—*Probable average service lives of each year's construction of portland cement concrete, brick or block, and dual-type roads*

[Compiled from data submitted by 26 States for rural State or Federal-Aid systems]

Year of construction	Portland cement concrete roads: Miles built	Percent remaining in service on 1-1-37	Estimated average service life in years [1]	Method of determination [2]	Brick or block roads: Miles built	Percent remaining in service on 1-1-37	Estimated average service life in years [1]	Method of determination [2]	Dual-type roads: Miles built	Percent remaining in service on 1-1-37	Estimated average service life in years [1]	Method of determination [2]
1907					7	0	11.3	I				
1908					9	11	20.4	II				
1909					8	13	21.1	II				
1910	1	100	27.0	([3])	27	19	18.5	II				
1911					24	54	25.5	S_1				
1912	29	45	20.0	S_2	48	21	17.8	II				
1913	42	55	22.5	S_1	40	40	21.3	II				
1914	261	34	20.0	S_2	99	37	21.1	II				
1915	279	42	19.0	S_0	239	47	21.0	S_3				
1916	505	36	16.5	R_1	127	48	19.5	S_2				
1917	236	44	16.5	R_3	120	59	21.5	S_1				
1918	322	43	16.5	R_2	128	57	19.5	S_2				
1919	475	45	16.5	S_1	129	54	19.0	S_1				
1920	561	67	17.5	R_3	143	48	15.5	S_0				
1921	888	75	20.0	S_2	220	71	20.0	S_1	9	78	16.5	S_6
1922	1,113	85	23.0	R_3	261	65	17.0	S_2	41	73	15.5	R_4
1923	1,124	93	25.0	R_3	226	82	17.5	R_3	27	59	14.0	S_3
1924	1,922	95	27.0	R_3	112	78	14.5	S_4	3	100		
1925	1,690	97			161	86	21.0	R_2	17	100		
1926	2,087	99			125	91			20	100		
1927	1,942	98			61	94			14	100		
1928	2,238	99			78	98			8	100		
1929	1,891	100			27	96			11	100		
1930	3,855	100			92	99			16	94		
1931	3,518	100			71	100			31	100		
1932	2,825	99			69	100			16	100		
1933	2,039	100			28	100			6	100		
1934	1,110	100			57	100			22	100		
1935	828	100			35	100			20	100		
1936	994	100			28	100			13	100		

[1] The last entry in this column is the estimate for the most recent year for which the retirement experience is sufficient to enable a reasonable estimate of the average life to be made.
[2] Method I.—Average service life calculated from the area under the original survivor curve.
Method II.—Average service life calculated from the area under the stub survivor curve and its projection to 0 percent remaining by extension of past trend.
Method S_0, R_2, etc.—These designations indicate that an estimate of the average service life was obtained by matching the stub survivor curve with the type survivor curves in Bulletin 125.
[3] Assumed.

Table 18.—*Weighted probable average service life for various construction year groupings for each surface type*

[Compiled from data submitted by 26 States for rural State or Federal-Aid systems]

Construction-year grouping	Weighted probable average service life [1] of— Soil surfaced	Gravel or stone	Bituminous surface-treated	Mixed bituminous	Bituminous penetration	Bituminous concrete	Portland cement concrete	Brick or block	Dual type
	Years	*Years*	*Years*	*Years*	*Years*	*Years*	*Years*	*Years*	*Years*
1903–1910	[2] 19.7	12.7	12.1	[2] 18.1	[2] 21.6		[2] 27.0	[2] 18.3	
1911–1915	13.6	10.5	17.0	[2] 18.1	16.7	13.2	19.7	20.9	
1916–1920	11.7	11.0	16.4	22.1	15.5	15.8	16.8	18.9	
1921–1925	7.1	9.6	20.7	21.6	15.2	17.9	[3] 24.4	18.2	[2 4] 15.1
1926–1930	8.1	8.3	13.8	14.3	17.0	[5] 20.0			
1931–1936	[6] 5.4	[7] 6.0	[6] 11.4	[8] 16.0					

[1] Weighted in accordance with the constructed mileage and the estimates of average service life.
[2] Average service life computations based upon the experience of a very limited mileage of original construction.
[3] Average for 1921–24.
[4] Average for 1921–23.
[5] 1926 only.
[6] Average for 1931–34.
[7] Average for 1931–35.
[8] 1931 only.

method of retirement and replacement type. Retirements are summarized into year groupings as follows:

1. 1927 and prior.
2. 1928–30.
3. 1931–33.
4. 1934–36.
5. Total through 1936.

The methods of retirement are as follows:

1. *Resurfaced.*—Roads which are resurfaced or used as a base for the replacement type are so classified when the old surface is utilized more or less intact (with the exception of necessary scarifying, reshaping, or partial reworking of the surface) in the new construction which retires the old surface. Examples of this method are the retirement of a soil-surfaced road by surface treating, or the retirement of a gravel or stone road by utilizing it as a base or foundation for a mixed bituminous road or a bituminous penetration road, etc. For surfaces which are retired by this method, it is obvious that the new or replacement construction must

Table 19.—*Average age of surfaces existing on January 1 of each year, 1920–37*

[Compiled from data submitted by 26 States for rural State or Federal-Aid systems]

Surface type	1920	1921	1922	1923	1924	1925	1926	1927	1928	1929	1930	1931	1932	1933	1934	1935	1936	1937
	Years	*Years*	*Years*	*Years*	*Years*	*Years*	*Years*	*Years*	*Years*	*Years*	*Years*	*Years*	*Years*	*Years*	*Years*	*Years*	*Years*	*Years*
Soil surfaced	4.6	4.5	3.8	4.2	4.4	4.6	4.8	5.4	5.9	6.0	5.6	5.0	4.9	5.0	5.2	4.5	4.9	5.1
Gravel or stone	4.4	3.8	2.7	2.4	2.5	2.6	2.7	3.0	3.5	3.7	4.1	4.3	4.5	4.7	5.1	5.4	6.0	6.3
Bituminous surface treated	3.9	4.2	4.3	4.8	4.8	4.8	4.4	3.9	3.8	3.8	4.0	3.7	3.9	4.4	4.7	5.0	5.5	5.8
Mixed bituminous	4.6	2.6	1.5	2.2	2.7	3.4	4.1	4.3	4.2	3.4	3.2	2.5	2.4	2.4	2.8	3.1	3.7	4.1
Bituminous penetration	3.6	3.6	3.6	3.6	3.7	3.6	3.8	4.3	4.8	5.2	5.4	5.3	5.3	5.5	5.9	6.4	6.8	7.0
Bituminous concrete	3.8	3.9	3.6	3.6	3.5	3.5	3.8	4.1	4.3	4.7	4.9	5.3	5.7	6.0	6.5	6.7	7.2	7.1
Portland cement concrete	2.8	3.2	3.2	3.3	3.5	3.5	3.7	3.9	4.2	4.5	4.9	4.8	5.0	5.4	5.9	6.6	7.3	8.0
Brick or block	3.9	4.3	4.5	4.7	5.0	5.6	6.1	6.7	7.5	8.1	9.0	9.5	10.0	10.5	11.3	11.7	12.4	13.0
Dual type			.6	.7	1.3	2.2	2.8	3.2	3.8	4.6	5.2	5.6	5.7	6.1	6.8	7.0	7.4	7.8
Total (weighted average)	3.9	3.8	3.3	3.3	3.3	3.4	3.5	3.7	4.0	4.2	4.5	4.5	4.6	4.7	5.1	5.4	6.0	6.3

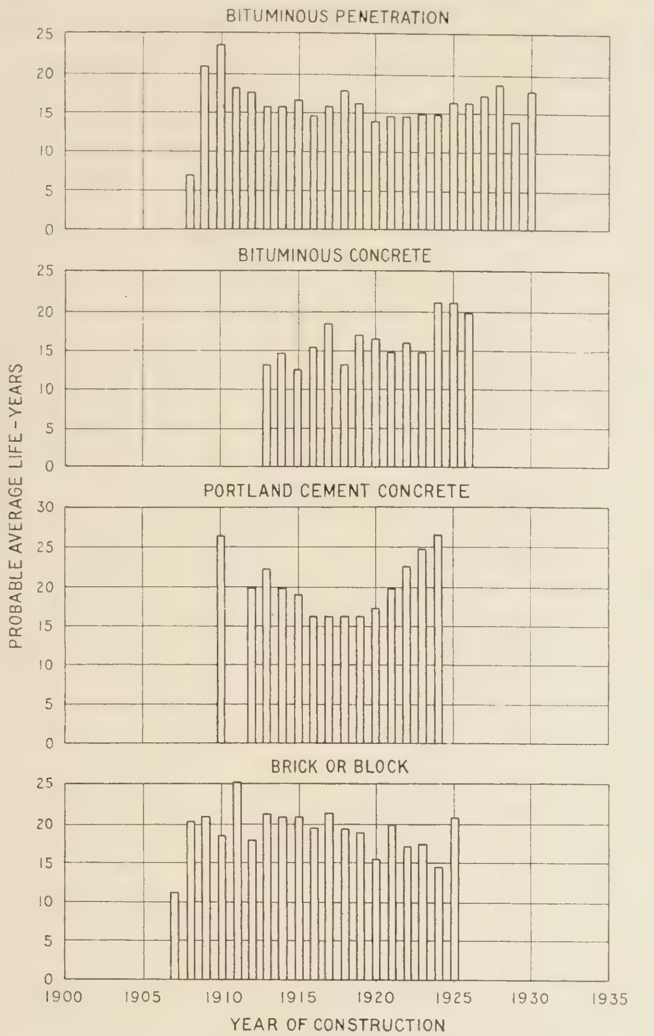

FIGURE 11.—PROBABLE AVERAGE LIVES FOR SEVERAL TYPES OF ROAD SURFACES CONSTRUCTED IN VARIOUS YEARS.

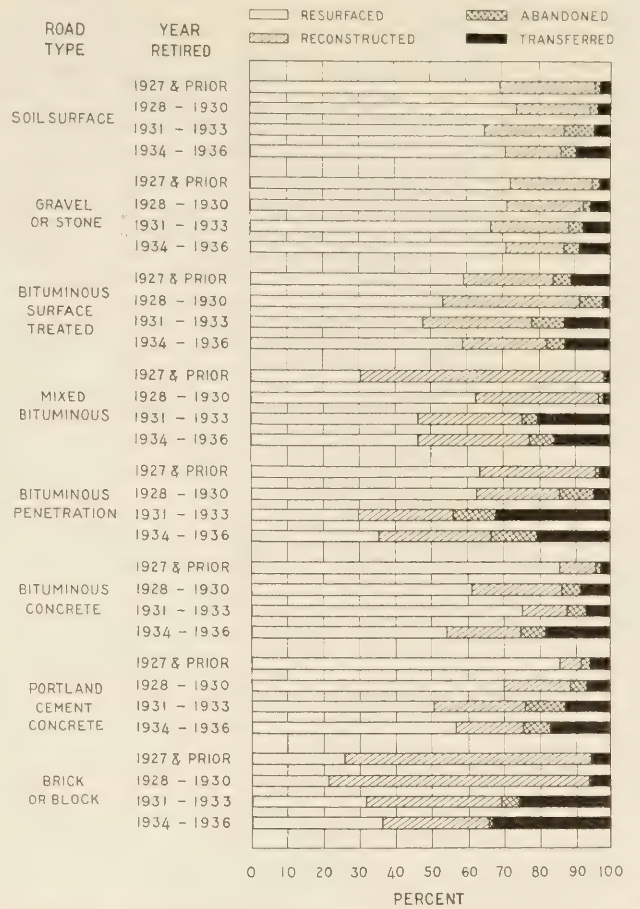

FIGURE 12.—METHODS OF RETIREMENT OF VARIOUS TYPES OF ROAD SURFACES FOR FOUR GROUPS OF YEARS.

necessarily be along the same alinement and practically the same grade.

2. *Reconstructed.*—When surfaces are retired by reconstruction there is little or no salvage of the old surface and base, if any, into the new type constructed.

TABLE 20.—*Soil-surfaced road retirements; percentage distribution of retired mileages of soil surfaced roads according to method of retirement and replacement type*

[Compiled from data submitted by 23 States for rural State or Federal-Aid systems]

Replacement type [1]	1927 and prior, 1,295 miles retired					1928–30, 978 miles retired					1931–33, 1,012 miles retired					1934–36, 1,000 miles retired					Total through 1936, 4,285 miles retired				
	Resurfaced	Reconstructed	Abandoned	Transferred	Total	Resurfaced	Reconstructed	Abandoned	Transferred	Total	Resurfaced	Reconstructed	Abandoned	Transferred	Total	Resurfaced	Reconstructed	Abandoned	Transferred	Total	Resurfaced	Reconstructed	Abandoned	Transferred	Total
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
None [2]																			2.3	2.3				0.5	0.5
Graded and drained earth		3.0		0.2	3.2		3.5		2.5	6.0		1.1	3.4	3.3	7.8		2.3		5.2	7.5		2.5	0.8	2.6	5.9
Soil surfaced	3.6	1.6	0.2	.9	6.3	3.3	2.2			5.5	27.4	5.5			32.9	44.6	2.7		1.3	48.6	18.7	2.9	.1	.6	22.3
Gravel or stone	2.5	1.8	.4		4.7	3.0	1.8	0.9		5.7	5.4				5.4	5.8	1.2	1.0		8.0	4.0	1.2	.6		5.8
Bituminous surface treated	27.3	4.8	.3	1.4	33.8	44.4	9.1	1.7		55.2	20.1	4.2	.7		25.0	12.2	5.7	.8	.7	19.4	26.0	5.9	.8	.6	33.3
Mixed bituminous	.2				.2	5.4	.6			6.0	7.5	7.0	4.6		19.1	7.7	2.9	1.5	.3	12.4	4.9	2.5	1.4	.1	8.9
Bituminous penetration	.5		.5		1.0	1.3				1.3	2.1	.4			2.5	.5	.9	.1		1.5	1.0	.3	.2		1.5
Bituminous concrete	1.2	10.5			11.7	1.9	1.2			3.1	.4	2.8			3.2			.1		.1	.9	4.1			5.0
Portland cement concrete [3]	34.7	4.2		.2	39.1	14.8	2.2		.2	17.2	2.0	1.3		.8	4.1	.1			.1	.2	14.4	2.1		.3	16.8
Total	70.0	25.9	1.4	2.7	100.0	74.1	20.6	2.6	2.7	100.0	64.9	22.3	8.7	4.1	100.0	70.9	15.7	3.5	9.9	100.0	69.9	21.5	3.9	4.7	100.0

[1] No brick or block roads or dual-type roads were encountered which replaced soil-surfaced roads.
[2] "None" indicates the mileage is dropped from the system and there is no new construction which may be considered as replacing the mileage which is transferred.
[3] The use of the term "resurfaced" in lieu of "reconstructed" as a method of retirement in the case of soil-surfaced roads which are replaced by portland cement concrete is not precise. An attempt, however, is made in the case of "resurfaced" to indicate the extent to which the retired soil-surfaced road is utilized as a base for the portland cement concrete. (This same qualification applies, in a lesser degree, to replacements by other types.)

TABLE 21.—*Gravel or stone road retirements; percentage distribution of retired mileages of gravel or stone roads according to method of retirement and replacement type*

[Compiled from data submitted by 23 States for rural State or Federal-Aid systems]

Replacement type [1]	1927 and prior, 4,282 miles retired					1928–30, 7,725 miles retired					1931–33, 15,346 miles retired					1934–36, 13,609 miles retired					Total through 1936, 40,962 miles retired				
	Resurfaced	Reconstructed	Abandoned	Transferred	Total	Resurfaced	Reconstructed	Abandoned	Transferred	Total	Resurfaced	Reconstructed	Abandoned	Transferred	Total	Resurfaced	Reconstructed	Abandoned	Transferred	Total	Resurfaced	Reconstructed	Abandoned	Transferred	Total
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
None [2]				0.2	0.2			0.1	0.2	0.3			0.1	0.9	1.0			0.2	1.2	1.4			0.1	0.8	0.9
Graded and drained earth		1.3	0.3	.2	1.8		2.3	.4	1.4	4.1		2.6	1.1	1.8	5.5		4.3	1.2	4.1	9.6		3.0	.9	2.3	6.2
Soil surfaced		.5			.5							.1			.1	0.3	.1			.4	0.1	.1			.2
Gravel or stone	14.1	5.4	.7	1.2	21.4	11.6	1.6	.7	1.3	15.2	5.4	1.4	1.5	.9	9.2	5.7	2.9	1.0	.9	10.5	7.6	2.4	1.1	1.0	12.1
Bituminous surface treated	17.4	.2	.1	.1	17.8	20.7	.2			20.9	11.5	.1	.1		11.7	23.7	.8	.1	.1	24.7	17.8	.4	.1	.1	18.4
Mixed bituminous	26.3	.6	.1		27.0	26.8	1.1	.5	.2	28.6	43.0	1.9	.8	.6	46.3	35.6	4.0	1.7	.7	42.0	35.7	2.3	1.0	.5	39.5
Bituminous penetration	7.2	1.1	.1	.2	8.6	7.5	.2	.1	.1	7.9	5.6	.2	.3		6.1	3.9	.1	.3		4.3	5.6	.2	.2	.1	6.1
Bituminous concrete	5.5	2.2	.2		7.9	3.2				3.2	.8	.1			.9	1.5	.1	.1		1.7	2.0	.3	.1		2.4
Portland cement concrete [3]	1.7	11.7	.4	.9	14.7	1.5	16.2	.3	1.8	19.8	.6	15.1	.5	3.0	19.2	.3	3.6	.3	1.1	5.3	.8	11.1	.4	1.9	1.4
Brick or block	.1				.1												.1			.1					
Total	72.3	23.0	1.9	2.8	100.0	71.3	21.6	2.1	5.0	100.0	66.9	21.5	4.4	7.2	100.0	71.0	16.0	4.9	8.1	100.0	69.6	19.8	3.9	6.7	100.2

[1] No dual-type roads were encountered which replaced gravel or stone roads.

[2] "None" indicates the mileage is dropped from the system and there is no new construction which may be considered as replacing the mileage which is abandoned or transferred.

[3] The use of the term "resurfaced" in lieu of "reconstructed" as a method of retirement in the case of gravel or stone roads which are replaced by portland cement concrete is not precise. An attempt, however, is made in the case of "resurfaced" to indicate the extent to which the retired gravel or stone road is utilized as a base for the portland cement concrete. (This same qualification applies, in a lesser degree, to replacements by other types.)

TABLE 22.—*Bituminous surface treated road retirements; percentage distribution of retired mileages of bituminous surface-treated roads according to method of retirement and replacement type*

[Compiled from data submitted by 23 States for rural State or Federal-Aid systems]

Replacement type	1927 and prior, 148 miles retired					1928–30, 352 miles retired					1931–33, 1,085 miles retired					1934–36, 1,625 miles retired					Total through 1936, 3,210 miles retired				
	Resurfaced	Reconstructed	Abandoned	Transferred	Total	Resurfaced	Reconstructed	Abandoned	Transferred	Total	Resurfaced	Reconstructed	Abandoned	Transferred	Total	Resurfaced	Reconstructed	Abandoned	Transferred	Total	Resurfaced	Reconstructed	Abandoned	Transferred	Total
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
None [1]									0.1	0.1			0.2	2.6	2.8				3.5	3.5			0.1	2.6	2.7
Graded and drained earth							2.6	0.5		3.1		5.6	3.4	7.9	16.9		2.6	3.8	5.1	11.5		3.5	3.1	5.3	11.9
Soil surfaced		0.4			0.4												.3			.3		.2			.2
Gravel or stone		.1		0.5	.6		8.7	.3		9.0		4.2			4.2		9.1	.4	1.0	10.5		7.0	.2	.6	7.8
Bituminous surface treated [2]	36.8	.8			37.6	24.7	4.4	.6	.5	30.2	19.4	1.9	.6	.2	22.1	24.5	2.3	.5	1.1	28.4	23.4	2.3	.5	.7	26.9
Mixed bituminous	5.5				5.5	8.4	.5	3.3	.3	12.5	15.2	2.3	2.3		19.8	19.1	3.9		.1	23.1	16.0	2.8	1.1	.1	20.0
Bituminous penetration	9.2	10.6			19.8	9.1	5.3	1.4		15.8	5.6	2.0	.2		7.8	8.2	.6	.6		9.4	7.5	2.1	.5		10.1
Bituminous concrete	4.8	2.2	4.3	7.0	18.3	7.0	3.3			10.3	4.9	.5	.7		6.1	6.9	.4			7.3	6.1	.8	.4	.3	7.6
Portland cement concrete [3]	3.0	10.7	.9	3.1	17.7	3.8	13.6	1.6		19.0	2.7	13.8	1.8	2.0	20.3		4.2	.1	1.6	5.9	1.5	8.8	.9	1.6	12.8
Brick or block	.1				.1																				
Dual type																	.1			.1					
Total	59.4	24.8	5.2	10.6	100.0	53.0	38.4	7.7	.9	100.0	47.8	30.3	9.2	12.7	100.0	58.7	23.5	5.4	12.4	100.0	54.5	27.5	6.8	11.2	100.0

[1] "None" indicates the mileage is dropped from the system and there is no new construction which may be considered as replacing the mileage which is abandoned or transferred.

[2] Because of the difficulties involved in the determination of the thickness of bituminous mats, it is probable that a portion of the large percentages of bituminous surface-treated roads which are resurfaced and indicated as being replaced by bituminous surface treated roads should in reality be indicated as being replaced by mixed bituminous roads. The data, however, are recorded as submitted.

[3] The use of the term "resurfaced" in lieu of "reconstructed" as a method of retirement in the case of bituminous surface-treated roads which are replaced by portland cement concrete is not precise. An attempt, however, is made in the case of "resurfaced" to indicate the extent to which the retired bituminous surface-treated road is utilized as a base for the portland cement concrete. (This same qualification applies, in a lesser degree, to replacements by other types.)

This classification includes old surfaces and bases that are torn up and not reused. Usually, for types that are retired by this method, the replacement type is built along the same general alinement involving only minor improvements in horizontal curvature and sight distance. Substantial improvements are usually made with respect to grades and vertical curves, however.

3. *Abandoned.*—For roads that are abandoned, the new construction is on new location. Sometimes, however, a road is dropped entirely from the system and there is no new construction that may be considered as replacing the mileage abandoned. In such cases, the replacement type is indicated as "none."

4. *Transferred.*—Retirement by transfer is similar to abandonment except that the road is continued in service after being dropped from the State or Federal-Aid system by being maintained and resurfaced or reconstructed, when necessary, by the county or other local authority.

It is obvious that a fine distinction between the various methods of retirement cannot be made. The classifications are general in character and should be so interpreted.

TYPES OF SURFACES BUILT TO REPLACE OLD SURFACES LISTED

The replacement type indicated on tables 20 to 28 is the surface type of the new road constructed to replace the surface of the old road. It is to be noted that the replacement type may be upon entirely new location or there may be no replacement type as men-

TABLE 23.—*Mixed bituminous road retirements; percentage distribution of retired mileages of mixed bituminous roads according to method of retirement and replacement type*

[Compiled from data submitted by 23 States for rural State or Federal-Aid systems]

Replacement type [1]	1927 and prior, 64 miles retired					1928–30, 159 miles retired					1931–33, 617 miles retired					1934–36, 1,304 miles retired					Total through 1936, 2,144 miles retired				
	Resurfaced	Reconstructed	Abandoned	Transferred	Total	Resurfaced	Reconstructed	Abandoned	Transferred	Total	Resurfaced	Reconstructed	Abandoned	Transferred	Total	Resurfaced	Reconstructed	Abandoned	Transferred	Total	Resurfaced	Reconstructed	Abandoned	Transferred	Total
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
None [2]														0.1	0.1			0.3	0.8	1.1			0.2	0.5	0.7
Graded and drained earth		6.6			6.6							1.3	0.4	.1	1.8		1.1	.1	2.4	3.6		1.3	.1	1.5	2.9
Soil surfaced																	.5		.2	.7		.3		.1	.4
Gravel or stone		2.3			2.3		11.5			11.5		1.8	1.6	.2	3.6		2.8	2.2	1.2	6.2		3.1	1.8	.8	5.7
Bituminous surface treated		1.1			1.1		5.2	0.1		5.3		1.1			1.1		4.5	1.0		5.5		3.5	.6		4.1
Mixed bituminous	1.1		0.2		1.3	37.9	8.9	1.3		48.1	27.8	2.2	1.5	6.8	38.3	41.4	7.9	3.2	3.6	56.1	36.0	6.1	2.5	4.2	48.8
Bituminous penetration	19.8	8.6		1.1	29.5	6.1	1.6			7.7	3.9	1.2	.6		5.7	1.1	.1			1.2	2.8	.8	.2		3.8
Bituminous concrete	9.1	33.7			42.8	1.9	.4			2.3	10.5	.8		.3	11.6	3.8	1.8			5.6	5.7	2.4		.1	8.2
Portland cement concrete [3]		16.1	.3		16.4	16.2	7.0	.2	1.6	25.0	4.4	20.5	.4	12.5	37.8	.1	12.1	.5	7.0	19.7	2.5	14.2	.5	8.0	25.2
Dual type						.1				.1						.2	.1			.3	.1	.1			.2
Total	30.0	68.4	.5	1.1	100.0	62.2	34.6	1.6	1.6	100.0	46.6	28.9	4.5	20.0	100.0	46.6	30.9	7.3	15.2	100.0	47.1	31.8	5.9	15.2	100.0

[1] No brick or block roads were encountered which replaced mixed bituminous roads.
[2] "None" indicates the mileage is dropped from the system and there is no new construction which may be considered as replacing the mileage which is abandoned or transferred.
[3] The use of the term "resurfaced" in lieu of "reconstructed" as a method of retirement in the case of mixed bituminous roads which are replaced by portland cement concrete is not precise. An attempt, however, is made in the case of "resurfaced" to indicate the extent to which the retired mixed bituminous road is utilized as a base for the portland cement concrete. (This same qualification applies, in a lesser degree, to replacements by other types.)

TABLE 24.—*Bituminous penetration road retirements; percentage distribution of retired mileages of bituminous penetration roads according to method of retirement and replacement type*

[Compiled from data submitted by 23 States for rural State or Federal-Aid systems]

Replacement type	1927 and prior, 158 miles retired					1928–30, 299 miles retired					1931–33, 533 miles retired					1934–36, 878 miles retired					Total through 1936, 1,868 miles retired				
	Resurfaced	Reconstructed	Abandoned	Transferred	Total	Resurfaced	Reconstructed	Abandoned	Transferred	Total	Resurfaced	Reconstructed	Abandoned	Transferred	Total	Resurfaced	Reconstructed	Abandoned	Transferred	Total	Resurfaced	Reconstructed	Abandoned	Transferred	Total
	Pct.	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
None [1]				1.2	1.2								0.2	0.4	0.6			0.2	0.3	0.5			0.2	0.4	0.6
Graded and drained earth							0.2	1.0		1.2		0.5	2.6	10.2	13.3		1.5	5.4	11.5	18.4		0.9	3.4	8.3	12.6
Soil surfaced																	.3			.3		.1			.1
Gravel or stone		2.5		.4	2.9		2.7	1.3		4.0		4.8	.4	1.0	6.2		3.3	3.0	.8	7.1		3.6	1.7	.7	6.0
Bituminous surface treated							6.3	1.7		8.0		2.4	.3	.9	3.6		4.8	.1	2.5	7.4		3.9	.4	1.4	5.7
Mixed bituminous	4.0				4.0	7.8	.1		0.4	8.3	5.4	2.6	5.5	1.8	15.3	9.5	3.2			12.7	7.6	2.2	1.6	.6	12.0
Bituminous penetration	30.2	6.6	0.4	1.3	38.5	34.4	3.1	5.2	.1	42.8	18.5	1.7	1.6	5.3	27.1	16.0	12.8	3.6	1.8	34.2	20.9	7.5	3.0	2.4	33.8
Bituminous concrete	20.1	2.6			22.7	9.5	3.1	.9	.5	14.0	3.8	3.3			7.1	9.1	.7		.1	9.9	8.6	2.0	.2	.2	11.0
Portland cement concrete [2]	9.1	13.7	.9		23.7	10.4	8.0		3.1	21.5	1.6	11.2	1.4	12.4	26.6	.9	4.0	.6	3.4	8.9	3.3	7.5	.8	5.6	17.2
Brick or block		7.0			7.0							.1			.1		.2			.2		.7			.7
Dual type						.2				.2	.1				.1		.4			.4	.1	.2			.3
Total	63.4	32.4	1.3	2.9	100.0	62.3	23.5	10.1	4.1	100.0	29.4	26.6	12.0	32.0	100.0	35.5	31.2	12.9	20.4	100.0	40.5	28.6	11.3	19.6	100.0

[1] "None" indicates the mileage is dropped from the system and there is no new construction which may be considered as replacing the mileage which is abandoned or transferred.
[2] The use of the term "resurfaced" in lieu of "reconstructed" as a method of retirement in the case of bituminous penetration roads which are replaced by portland cement concrete is not precise. An attempt, however, is made in the case of "resurfaced" to indicate the extent to which the retired bituminous penetration road is utilized as a base for the portland cement concrete. (This same qualification applies, in a lesser degree, to replacements by other types.)

tioned above under the classifications of abandoned and transferred. Table 20, for example, indicates that during the period 1931–33, there were 1,012 miles of soil-surfaced roads retired in the 23 States for which this series of tables is prepared. The entries indicate that 64.9 percent of the soil-surfaced roads retired from 1931 to 1933 were resurfaced, 22.3 percent were reconstructed, 8.7 percent were abandoned, and 4.1 percent were transferred to other authorities for continued maintenance and reconstruction. The distribution of each of these percentages according to the replacement type is also indicated. Of all retirements of soil-surfaced roads during 1931 to 1933, the maximum individual retirement entry is the 27.4 percent for soil-surfaced roads retired by being resurfaced with a soil-surface, and the next largest entry is 20.1 percent retired by being resurfaced by the addition of a bituminous mat less than 1 inch in compacted thickness.

Table 20 also indicates that for soil-surfaced roads retired during the years 1931 to 1933, 4.1 percent were replaced by portland cement concrete surfaces. The distribution of the 4.1 percent is as follows: 2.0 percent were resurfaced along the same line and grade, 1.3 percent were reconstructed along the same general alinement, and 0.8 percent were transferred to other authorities for continued maintenance and reconstruction. The new portland cement concrete roads which replaced the old soil-surfaced roads transferred were on new alinements.

Table 29 and figure 12 summarize the percentages retired by each method for each group of years for each surface type. Most of the indicated trends are not particularly significant, and there is considerable variation among the different types with respect to method of retirement. Resurfacing is an especially significant method of retirement since it affords an approximate measure of the relative extent to which the various types of surfacing construction are salvaged when they are retired.

TABLE 25.—*Bituminous concrete road retirements; percentage distribution of retired mileages of bituminous concrete roads according to method of retirement and replacement type*

[Compiled from data submitted by 23 States for rural State or Federal-Aid systems]

Replacement type [1]	1927 and prior, 434 miles retired					1928–30, 305 miles retired					1931–33, 387 miles retired					1934–36, 549 miles retired					Total through 1936, 1,675 retired				
	Resurfaced	Reconstructed	Abandoned	Transferred	Total	Resurfaced	Reconstructed	Abandoned	Transferred	Total	Resurfaced	Reconstructed	Abandoned	Transferred	Total	Resurfaced	Reconstructed	Abandoned	Transferred	Total	Resurfaced	Reconstructed	Abandoned	Transferred	Total
	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.
None [2]																		0.1	5.3	5.4				1.8	1.8
Graded and drained earth		0.3			0.3		4.9		0.1	5.0		0.4	2.3	1.6	4.3		1.1	2.9	7.7	11.7		1.4	1.5	2.9	5.8
Gravel or stone		.3			.3		.5			.5		1.2	.1		1.3		3.2			3.2		1.5			1.5
Bituminous surface treated							.1	0.5		.6		1.5	.4		1.9		4.4	.1	.1	4.6		1.8	.2		2.0
Mixed bituminous						1.3		.3		1.6	1.8	.3			2.1	11.3	2.0	.7	.4	14.4	4.4	.7	.3	.1	5.5
Bituminous penetration	5.6	.5	0.6		6.7	2.6	.1	4.0		6.7	1.0	.1	.6	.1	1.8	3.3	.8			4.1	3.2	.4	1.0		4.6
Bituminous concrete	45.0	5.8		2.4	53.2	49.1	5.2		3.2	57.5	71.0	1.1	.1	2.4	74.6	38.9	2.5	.7	1.3	43.4	49.8	3.5	.3	2.2	55.8
Portland cement concrete [3]	30.4	3.4	.8		34.6	7.0	14.3	.5	5.1	26.9	1.3	8.2	2.2	2.2	13.9	.3	6.1	2.6	3.2	12.2	9.6	7.4	1.7	2.5	21.2
Brick or block												.1			.1										
Dual type	4.9				4.9	1.1	.1			1.2						.4	.6			1.0	1.6	.2			1.8
Total	85.9	10.3	1.4	2.4	100.0	61.1	25.2	5.3	8.4	100.0	75.1	12.9	5.7	6.3	100.0	54.2	20.7	7.1	18.0	100.0	68.6	16.9	5.0	9.5	100.0

[1] No soil-surfaced roads were encountered which replaced bituminous concrete roads.

[2] "None" indicates the mileage is dropped from the system and there is no new construction which may be considered as replacing the mileage which is abandoned or transferred.

[3] The use of the term "resurfaced" in lieu of "reconstructed" as a method of retirement in the case of bituminous concrete roads which are replaced by portland cement concrete is not precise. An attempt, however, is made, in the case of "resurfaced" to indicate the extent to which the retired bituminous concrete road is utilized as a base for the portland cement concrete. (This qualification applies, in a lesser degree, to replacements by other types.)

TABLE 26.—*Portland cement concrete road retirements; percentage distribution of retired mileages of portland cement concrete roads according to method of retirement and replacement type*

[Compiled from data submitted by 23 States for rural State or Federal-Aid systems]

Replacement type	1927 and prior, 418 miles retired					1928–30, 365 miles retired					1931–33, 484 miles retired					1934–36, 595 miles retired					Total through 1936, 1,862 miles retired				
	Resurfaced	Reconstructed	Abandoned	Transferred	Total	Resurfaced	Reconstructed	Abandoned	Transferred	Total	Resurfaced	Reconstructed	Abandoned	Transferred	Total	Resurfaced	Reconstructed	Abandoned	Transferred	Total	Resurfaced	Reconstructed	Abandoned	Transferred	Total
	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.
None [1]				0.2	0.2			0.1	2.7	2.8			1.0	1.8	2.8			0.2	2.6	2.8			0.3	1.9	2.2
Graded and drained earth		0.2			.2		2.9	1.4	.2	4.5			.4	2.4	2.8		0.4	.5	3.2	4.1		0.7	.5	1.7	2.9
Soil surfaced														.5	.5									.1	.1
Gravel or stone		3.2	0.2		3.4		1.3	.4	.1	1.8			.2	.2	.4		.3	.6	.4	1.3		1.1	.3	.2	1.6
Bituminous surface treated							.3	.2		.5		0.2	.1	.2	.5		.3	.1		.4		.2	.1		.3
Mixed bituminous	0.4	.1			.5	3.4	1.1			4.5	4.5	1.5	1.7		7.7	12.8	1.8	1.6	1.9	18.1	6.0	1.2	1.0	.6	8.8
Bituminous penetration	19.4	.6	1.9		21.9	19.4	3.1	.1	.2	22.8	9.4	.9	.1	.1	10.5	4.4	.1	.1		4.6	12.0	1.0	.5	.1	13.6
Bituminous concrete	52.5	.2		1.6	54.3	35.4	1.3			36.7	28.8	3.5	3.8	.1	36.2	29.9	3.9	.3	.3	34.4	35.7	2.5	1.1	.5	39.8
Portland cement concrete [2]	10.8	2.2	.6	3.5	17.1	11.5	8.5	2.4	3.3	25.7	5.4	19.3	3.6	7.6	35.9	5.0	11.9	4.0	8.4	29.3	7.7	11.0	2.8	6.1	27.6
Brick or block	.1				.1						.8				.8	1.9				1.9	.9				.9
Dual type	2.3				2.3	.7				.7	1.9				1.9	2.6	.3	.2		3.1	2.0	.1	.1		2.2
Total	85.5	6.5	2.7	5.3	100.0	70.4	18.5	4.6	6.5	100.0	50.8	25.4	10.9	12.9	100.0	56.6	19.0	7.6	16.8	100.0	64.3	17.8	6.7	11.2	100.0

[1] "None" indicates the mileage is dropped from the system and there is no new construction which may be considered as replacing the mileage which is abandoned or transferred.

[2] Portland cement concrete roads which have been recapped by portland cement concrete are indicated as "resurfaced" opposite the entry for the portland cement concrete replacement type.

Table 30 was prepared to illustrate the approximate extent to which right-of-way was reused at the time the surfacing was retired. The mileages resurfaced or reconstructed were used as a measure of the extent to which right-of-way was salvaged at the time of retirement. The mileages of rights-of-way that were not salvaged insofar as the rural State or Federal-Aid systems were concerned were those that were abandoned or transferred. This table indicates a rather definite trend, both by surface types and years. In general, when the surfaces on roadways involving the higher types of surfaces are retired, there is less utilization of the original alinements than for roadways involving the lower types of surfaces. The yearly trend for all types is consistently toward less mileage resurfaced or reconstructed on existing alinement. This is evidenced by the decrease from 95 percent to 84 percent in utilizing in the replacement construction the alinements existing at the time of retirement for the periods of 1927 and prior and 1934 to 1936, respectively.

SUMMARY

The preparation of programs, particularly of long range estimates, of finance and construction for highway systems must involve consideration of the probable average life of existing construction.

While it is possible to determine the exact average life of construction already retired from service, the average life of existing construction cannot be determined with absolute certainty until it is retired. It follows then that the only analytical method of approach is to analyze the retirements to date to determine the average life of past construction. The facts and trends brought to light by such an analysis may then be used as a basis for arriving at reasonable estimates of the average lives of existing or future construction.

For certain studies in engineering and economics it would be most helpful to know the true average life of the recently completed construction, but because of

TABLE 27.—*Brick or block road retirements; percentage distribution of retired mileages of brick or block roads, according to method of retirement and replacement type*

[Compiled from data submitted by 23 States for rural State or Federal-Aid systems]

Replacement type [1]	1927 and prior, 61 miles retired				1928-30, 62 miles retired					1931-33, 109 miles retired					1934-36, 68 miles retired					Total through 1936, 300 miles retired				
	Resurfaced	Reconstructed	Transferred	Total	Resurfaced	Reconstructed	Abandoned	Transferred	Total	Resurfaced	Reconstructed	Abandoned	Transferred	Total	Resurfaced	Reconstructed	Abandoned	Transferred	Total	Resurfaced	Reconstructed	Abandoned	Transferred	Total
	Pct.	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
None [2]																		5.0	5.0				1.1	1.1
Graded and drained earth																1.9	1.0	7.1	10.0		0.4	0.2	1.6	2.2
Gravel or stone								0.2	0.2			0.9		0.9				.4	.4			.3	.1	.4
Bituminous surface treated		21.3		21.3		20.2			20.2		0.9			.9		.4		.7	1.1		8.9		.2	9.1
Mixed bituminous	3.5			3.5						1.9	2.5			4.4	23.7			.3	24.0	6.8	.9		.1	7.8
Bituminous penetration	4.1	2.6		6.7														.3	.3	.8	.5		.1	1.4
Bituminous concrete	13.9	3.0		16.9	19.8	10.1			29.9	16.3	4.6			20.9	7.2	6.5		1.0	14.7	14.5	5.8		.2	20.5
Portland cement concrete [3]	2.1	33.5	5.7	41.3	1.8	34.0	0.6	5.0	41.4	12.9	29.3	4.4	25.0	71.6	3.2	13.4		16.9	33.5	6.2	27.5	1.8	15.2	50.7
Brick or block [3]	2.1	8.2		10.3		8.3			8.3		.4		.4	.8		.3		1.6	1.9	.4	3.6		.5	4.5
Dual type										.5				.5	2.2	6.9			9.1	.7	1.6			2.3
Total	25.7	68.6	5.7	100.0	21.6	72.6	.6	5.2	100.0	31.6	37.7	5.3	25.4	100.0	36.3	29.4	1.0	33.3	100.0	29.4	49.2	2.3	19.1	100.0

[1] No soil-surfaced roads were encountered which replaced brick or block roads.
[2] "None" indicates the mileage is dropped from the system and there is no new construction which may be considered as replacing the mileage which is transferred.
[3] Brick or block roads upon which have been placed a "second story" of portland cement concrete or brick or block are indicated as "resurfaced" opposite the entries for the portland cement concrete or brick or block replacement types.

TABLE 28.—*Dual type road retirements; percentage distribution of retired mileages of dual type roads according to method of retirement and replacement type*

[Compiled from data submitted by 23 States for rural State or Federal-Aid systems

Replacement type [1]	Total [2] through 1936, 26 miles retired				
	Resurfaced	Reconstructed	Abandoned	Transferred	Total
	Percent	*Percent*	*Percent*	*Percent*	*Percent*
Mixed bituminous	21.2	2.3			23.5
Bituminous penetration	18.1	1.2			19.3
Bituminous concrete	29.0	.4		5.0	34.4
Portland cement concrete	3.9	7.0	4.6	2.7	18.2
Dual type	1.5			3.1	4.6
Total	73.7	10.9	4.6	10.8	100.0

[1] The replacement types not listed were not encountered as replacing dual-type roads.
[2] Only the totals are shown for dual-type roads. The mileage retired during various years is too small to warrant distribution by year groups.

very few retirements, particularly from the higher types of surfaces, it becomes necessary to estimate these average lives on a basis of the trend of average life of prior construction. Such estimates will become fact or approach fact only as those forces that caused retirement in the past continue to act in the same relative magnitudes or continue to change at the same general rates. Standards of design and construction and traffic conditions have not changed materially enough in any short interval of time in the past to have caused any abrupt change in the trend of average lives of road surfaces, nor are they likely to do so in the future. The changes have been gradual in the past and are likely to continue to be gradual, but over a long period of years they have caused, and may again cause, significant changes in the average lives of roadway surfaces.

For other types of physical properties the survivor curve method of determining probable average lives is being used with increasing frequency and it should be equally advantageous when applied to highways. For human lives it has been successfully used for a hundred years. In contrast to human lives, however, physical properties are subjected to wide fluctuation in condi-

TABLE 29.—*Summary of retirements; percentages of retired mileages of each surface type according to method of retirement during various years*

[Compiled from data submitted by 23 States for rural State or Federal Aid systems]

Type retired	1927 and prior					1928-30					1931-33					1934-36					Total through 1936				
	Resurfaced	Reconstructed	Abandoned	Transferred	Total	Resurfaced	Reconstructed	Abandoned	Transferred	Total	Resurfaced	Reconstructed	Abandoned	Transferred	Total	Resurfaced	Reconstructed	Abandoned	Transferred	Total	Resurfaced	Reconstructed	Abandoned	Transferred	Total
	Pct.	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
Soil surfaced	70.0	25.9	1.4	2.7	100.0	74.1	20.6	2.6	2.7	100.0	64.9	22.3	8.7	4.1	100.0	70.9	15.7	3.5	9.9	100.0	69.9	21.5	3.9	4.7	100.0
Gravel or stone	72.3	23.0	1.9	2.8	100.0	71.3	21.6	2.1	5.0	100.0	66.9	21.5	4.4	7.2	100.0	71.0	16.0	4.9	8.1	100.0	69.6	19.8	3.9	6.7	100.0
Bituminous surface treated	59.4	24.8	5.2	10.6	100.0	53.0	38.4	7.7	.9	100.0	47.8	30.3	9.2	12.7	100.0	58.7	23.5	5.4	12.4	100.0	54.5	27.5	6.8	11.2	100.0
Mixed bituminous	30.0	68.4	.5	1.1	100.0	62.2	34.6	1.6	1.6	100.0	46.6	28.9	4.5	20.0	100.0	46.6	30.9	7.3	15.2	100.0	47.1	31.8	5.9	15.2	100.0
Bituminous penetration	63.4	32.4	1.3	2.9	100.0	62.3	23.5	10.1	4.1	100.0	29.4	26.6	12.0	32.0	100.0	35.5	31.2	12.9	20.4	100.0	40.5	28.6	11.3	19.6	100.0
Bituminous concrete	85.9	10.3	1.4	2.4	100.0	61.1	25.2	5.3	8.4	100.0	75.1	12.9	5.7	6.3	100.0	54.2	20.7	7.1	18.0	100.0	68.6	16.9	5.0	9.5	100.0
Portland cement concrete	85.5	6.5	2.7	5.3	100.0	70.4	18.5	4.6	6.5	100.0	50.8	25.4	10.9	12.9	100.0	56.6	19.0	7.6	16.8	100.0	64.3	17.8	6.7	11.2	100.0
Brick or block	25.7	68.6		5.7	100.0	21.6	72.6	.6	5.2	100.0	31.6	37.7	5.3	25.4	100.0	36.3	29.4	1.0	33.3	100.0	29.4	49.2	2.3	19.1	100.0
Dual type [1]																					73.7	10.9	4.6	10.8	100.0
Total	72.2	22.8	1.9	3.1	100.0	69.9	22.6	2.7	4.8	100.0	63.7	22.4	5.2	8.7	100.0	65.8	18.5	5.5	10.2	100.0	66.6	21.1	4.5	7.8	100.0

[1] Only the totals are shown for dual-type roads. The mileage retired during various years is too small to warrant percentage distributions by year groups.

TABLE 30.—*Salvage of right-of-way at time of retirement of surfacing; percentages of surfaced mileage retired by resurfacing or reconstruction [1] used as a measure of the extent to which the right-of-way is utilized in the replacement construction*

[Compiled from data submitted by 23 States for rural State or Federal-Aid systems]

Type retired	1927 and prior			1928–30			1931–33			1934–36			Total through 1936		
	Total surfaced mileage retired	Amount resurfaced or reconstructed (right-of-way reused)		Total surfaced mileage retired	Amount resurfaced or reconstructed (right-of-way reused)		Total surfaced mileage retired	Amount resurfaced or reconstructed (right-of-way reused)		Total surfaced mileage retired	Amount resurfaced or reconstructed (right-of-way reused)		Total surfaced mileage retired	Amount resurfaced or reconstructed (right-of-way reused)	
	Miles	*Miles*	*Percent*	*Miles*	*Miles*	*Percent*	*Miles*	*Miles*	*Percent*	*Miles*	*Miles*	*Percent*	*Miles*	*Miles*	*Percent*
Soil surfaced	1, 295	1, 242	96	978	926	95	1, 012	883	87	1, 000	866	87	4, 285	3, 917	91
Gravel or stone	4, 282	4, 077	95	7, 725	7, 169	93	15, 346	13, 564	88	13, 609	11, 829	87	40, 962	36, 639	89
Bituminous surface treated	148	125	84	352	322	91	1, 085	848	78	1, 625	1, 337	82	3, 210	2, 632	82
Mixed bituminous	64	63	98	159	154	97	617	465	75	1, 304	1, 010	77	2, 144	1, 692	79
Bituminous penetration	158	152	96	299	256	86	533	299	56	878	585	67	1, 868	1, 292	69
Bituminous concrete	434	417	96	305	263	86	387	340	88	549	412	75	1, 675	1, 432	85
Portland cement concrete	418	384	92	365	324	89	484	369	76	595	450	76	1, 862	1, 527	82
Brick or block	61	58	95	62	58	94	109	75	69	68	45	66	300	236	79
Dual type				3	2	67	14	11	79	9	9	100	26	22	85
Total (approximate) [2]	6, 860	6, 518	95	10, 248	9, 474	92	19, 587	16, 854	86	19, 637	16, 543	84	56, 332	49, 389	88

[1] The terms "resurfacing" and "reconstruction" are limited to work done along the same alinement (or right-of-way) as the road which is retired or replaced. The differences between "Total surfaced mileage retired" and "Amount (miles) resurfaced or reconstructed" represent mileages which are abandoned or transferred at the time of retirement.

[2] The percentages indicated for the total are based upon the observed distribution and amounts of surfaced mileage retired as summarized directly from the data submitted by 23 States for rural State or Federal-Aid systems. The percentages are a lineal measure only; no adjustment is made for differences in right-of-way widths which may reasonably be expected between the lower and higher types of surfacing.

tions of service, in standards of design and construction, in economic and social forces surrounding their use, and in the policies of management. All of these combine to complicate the problem and to cast shadows of uncertainty upon predicted average lives of highway surfaces as well as upon other similar predictions. In spite of these uncertainties, much is to be gained by the type of analyses presented herein when the results are used within their limitations.

The estimated average lives shown in tables 15, 16, and 17 are probably within 10 percent of the ultimate values for the curves having end points of less than 70 percent surviving when the mileage constructed is 100 or more miles. For the shorter survivor curves, the amount of error is more uncertain, but where estimates of average lives are given for such short curves the mileage tables, 5 to 13, afford positive evidence upon which the estimates are based. Although many of the average life estimates are recorded to the nearest one-half year and still others to the nearest one-tenth year, it should not be assumed that they are accurate to this extent. These apparently precise estimates merely result from the method of calculation which permits relatively close determinations to be made on the basis of experience to date.

Closely related to the analysis of the probable average lives of roadway surfaces, but not considered in this report, are salvage value and economic life. Average lives presented herein relate solely to the period of time between the date of completion of the surface construction and the date of retirement without regard to the value or condition of the surface at the time it was retired. Salvage value, of course, is an important consideration when determining total life cost of a particular improvement or when making comparisons of the economics of two or more types of construction. Future annual maintenance cost, future salvage value, and the value of the services rendered are factors to consider when the economic life is sought. It is expected that future studies will include analyses of both salvage value and economic life in order that the full economic picture of roadway surfacings will be available for use in selection of design standards and for long-range planning.

While this report is restricted to road surfacing, the additional problems in connection with right-of-way, grading, and structures are being studied in the highway-planning surveys. The road-life studies also include roadway and bridge construction and maintenance cost studies. Eventually, data will be available for many specific analyses of highway costs, economic selection of projects, and other administrative and engineering problems, which in some way depend upon service lives for their solutions. The knowledge will be extended as additional States complete the compilations outlined in the original road-life studies and as they are continued and extended. Further, analyses by individual States will afford results of more specific application to the individual highway systems than can be obtained wholly by this analysis of the combined data from 26 States

STATUS OF FEDERAL-AID HIGHWAY PROJECTS

AS OF FEBRUARY 28, 1941

STATE	COMPLETED DURING CURRENT FISCAL YEAR			UNDER CONSTRUCTION			APPROVED FOR CONSTRUCTION			BALANCE OF FUNDS AVAILABLE FOR PROGRAMMED PROJECTS
	Estimated Total Cost	Federal Aid	Miles	Estimated Total Cost	Federal Aid	Miles	Estimated Total Cost	Federal Aid	Miles	
Alabama	$4,065,913	$1,925,534	101.3	$5,299,705	$2,641,333	190.4	$954,074	$474,687	32.5	$3,282,072
Arizona	1,052,086	727,201	47.7	1,968,869	1,313,364	83.1	512,191	305,161	10.9	1,732,355
Arkansas	5,018,875	2,303,379	124.7	1,184,416	590,832	54.8	258,736	128,997	5.0	1,731,782
California	6,301,274	3,231,185	129.3	8,078,506	4,284,109	122.4	2,347,997	1,155,903	36.8	4,097,539
Colorado	2,171,951	1,178,824	188.7	2,045,647	1,189,802	81.4	858,796	484,017	89.1	3,314,637
Connecticut	1,936,006	938,685	16.2	1,187,936	580,855	11.3	699,855	338,145	7.5	1,313,013
Delaware	1,395,078	696,823	28.0	797,595	372,075	4.6	121,414	60,041	4.9	1,476,275
Florida	2,512,745	1,248,025	62.5	1,905,762	961,169	59.7	551,777	275,889	25.3	3,675,206
Georgia	3,050,650	1,517,589	184.8	7,191,776	3,596,388	282.4	1,598,960	799,480	74.7	6,926,356
Idaho	1,524,898	913,923	151.0	1,040,215	640,970	56.9	474,510	292,457	12.5	2,318,053
Illinois	6,590,396	3,248,367	149.7	7,228,876	3,615,023	143.4	2,329,000	1,164,500	74.4	5,281,660
Indiana	5,158,186	2,540,688	120.9	6,580,944	3,184,331	94.6	2,395,568	1,090,573	46.7	2,444,312
Iowa	5,493,005	2,572,928	193.0	3,831,595	1,716,859	115.0	1,154,048	470,600	66.9	2,550,989
Kansas	4,108,667	2,025,851	364.2	5,892,511	2,965,594	319.0	2,617,913	1,296,938	146.1	5,043,277
Kentucky	3,080,271	1,534,114	91.1	3,035,287	1,523,324	86.9	1,487,767	743,883	49.0	3,879,008
Louisiana	1,226,957	607,890	16.0	12,538,876	3,318,425	63.2	973,952	479,288	34.9	4,263,291
Maine	1,311,372	637,396	29.2	1,599,027	821,653	21.0	18,200	9,100	.6	1,042,591
Maryland	1,267,901	625,992	29.1	2,873,923	1,436,361	22.3	797,339	398,151	7.7	1,884,261
Massachusetts	1,835,469	914,828	22.9	2,214,791	1,117,056	13.0	61,470	30,705	.5	4,293,229
Michigan	6,119,174	2,871,853	215.0	8,248,810	4,111,805	198.8	775,610	387,805	24.3	3,026,032
Minnesota	6,111,975	2,967,938	459.5	4,162,539	2,077,887	232.8	2,102,852	1,050,496	91.7	4,914,777
Mississippi	2,846,806	1,220,612	120.0	6,274,674	2,916,847	327.9	2,168,000	1,061,250	133.6	2,280,445
Missouri	3,407,975	1,686,908	169.0	8,126,965	3,800,762	197.6	4,922,604	2,172,206	139.6	4,943,089
Montana	4,123,613	2,334,341	285.2	2,202,220	1,242,712	116.7	1,373,540	777,529	62.1	4,537,214
Nebraska	4,626,452	2,194,646	548.3	3,824,474	1,932,275	445.3	1,829,331	914,665	197.5	3,825,982
Nevada	1,553,216	1,325,261	80.0	1,055,321	918,973	43.5	630,806	511,815	37.2	1,514,532
New Hampshire	1,445,362	703,792	36.4	419,795	209,610	9.0				1,415,904
New Jersey	2,258,218	1,117,617	11.8	6,330,152	3,164,996	49.1	511,945	255,972	3.1	1,749,642
New Mexico	2,059,907	1,248,046	174.5	1,470,466	904,400	65.2	700,360	434,873	36.7	2,152,017
New York	11,443,080	5,610,806	198.8	11,258,818	5,601,260	137.8	629,727	313,109	12.0	4,956,428
North Carolina	4,320,050	2,158,272	232.3	4,887,632	2,429,130	209.0	905,578	452,250	37.5	3,129,479
North Dakota	1,919,089	1,029,145	191.2	2,560,588	1,454,119	197.4	2,585,944	1,330,890	218.5	4,602,432
Ohio	7,157,899	3,578,131	93.1	11,268,622	5,608,937	90.3	6,254,740	3,073,187	48.3	4,776,524
Oklahoma	2,668,030	1,414,276	120.4	2,830,634	1,457,547	88.1	1,890,676	984,512	77.2	5,522,902
Oregon	3,117,234	1,863,021	155.0	2,709,022	1,468,246	57.3	1,450,723	754,373	45.9	1,597,755
Pennsylvania	6,225,906	3,078,918	80.7	13,252,569	6,577,252	109.1	2,728,167	1,312,552	24.0	4,345,598
Rhode Island	1,294,668	644,176	13.3	928,546	463,642	7.9	4,760	2,380		1,256,946
South Carolina	1,950,769	945,285	138.1	2,114,797	997,575	116.8	1,894,510	805,760	67.8	2,669,868
South Dakota	3,125,094	1,755,269	530.4	3,953,863	2,489,603	479.3	989,980	578,360	151.3	3,416,623
Tennessee	2,438,087	1,210,168	57.1	3,686,120	1,843,060	127.8	1,825,138	912,569	39.4	4,734,453
Texas	7,763,471	3,768,775	464.1	10,987,670	5,430,351	507.2	3,933,059	1,901,655	137.6	8,710,135
Utah	993,637	714,180	73.1	993,347	742,959	41.6	463,353	234,850	11.5	1,672,217
Vermont	1,194,683	589,160	36.6	873,156	442,716	23.6	348,476	174,238	9.4	564,423
Virginia	2,568,018	1,197,907	72.5	3,636,400	1,722,190	66.8	959,243	457,774	12.3	2,658,908
Washington	3,305,203	1,687,958	86.5	3,065,148	1,628,349	28.1	15,022	6,900		1,900,971
West Virginia	1,986,952	989,890	74.2	3,489,084	1,738,340	73.9	932,236	462,685	9.6	1,926,530
Wisconsin	5,210,546	2,544,019	179.1	2,459,628	1,218,235	98.8	689,828	315,373	20.8	5,322,441
Wyoming	1,804,873	1,106,809	196.2	983,553	635,322	120.0	661,655	422,926	45.2	1,535,736
District of Columbia	513,511	256,756	5.1	602,937	269,909	.8	230,936	115,400	1.8	576,197
Hawaii	120,132	58,848	1.7	706,414	370,548	10.2	138,944	69,472	2.5	1,954,355
Puerto Rico	519,644	257,240	10.9	1,370,673	677,010	20.3	236,780	116,830	2.4	1,019,059
TOTALS	165,294,974	83,519,245	7,160.4	207,230,894	102,416,090	6,123.4	64,998,090	32,363,171	2,426.8	159,759,520

STATUS OF FEDERAL-AID SECONDARY OR FEEDER ROAD PROJECTS

AS OF FEBRUARY 28, 1941

STATE	COMPLETED DURING CURRENT FISCAL YEAR			UNDER CONSTRUCTION			APPROVED FOR CONSTRUCTION			BALANCE OF FUNDS AVAILABLE FOR PROGRAMMED PROJECTS
	Estimated Total Cost	Federal Aid	Miles	Estimated Total Cost	Federal Aid	Miles	Estimated Total Cost	Federal Aid	Miles	
Alabama	$ 190,944	$ 95,263	9.4	$ 1,308,357	$ 654,158	60.7	$ 23,400	$ 11,700		$ 629,036
Arizona	233,227	152,258	23.6	142,651	105,759	.8				457,458
Arkansas	416,160	179,101	14.8	382,578	190,843	27.5	77,488	38,337	5.3	309,298
California	879,073	480,972	37.4	778,267	537,361	11.7	504,213	265,990	10.1	844,524
Colorado	45,873	25,854	1.6	252,726	141,919	5.3	66,893	37,701	10.8	392,826
Connecticut	370,531	179,413	4.6	105,456	49,907	1.8	194,675	87,585	4.3	186,667
Delaware	127,253	55,913	12.7	46,219	22,675	2.9				351,232
Florida	12,030	6,015		1,070,042	501,194	20.2	85,045	42,523	.2	329,157
Georgia	147,586	73,258	18.6	895,648	432,824	69.6	225,321	112,660	27.7	1,381,251
Idaho	152,006	93,357	24.0	166,859	99,425	6.7	145,090	46,001	7.2	283,587
Illinois	1,700,212	827,554	80.6	979,350	474,675	32.9	491,090	220,250	34.4	703,318
Indiana	476,372	229,757	31.0	163,864	87,389	8.1	219,571	109,785	10.0	1,230,526
Iowa	2,365,566	1,121,278	500.6	608,169	289,200	184.9	192,990	80,260	56.3	496,012
Kansas	321,450	160,409	49.0	913,408	459,612	46.8	175,115	87,558	51.8	1,573,986
Kentucky	792,145	268,935	65.5	569,227	138,095	18.2	373,349	106,751	21.6	552,479
Louisiana	105,321	52,661	10.9	192,608	96,249	14.9				718,740
Maine	298,852	142,635	17.0	40,606	20,303	1.5				157,657
Maryland	128,300	64,150	5.5	98,390	49,195	4.5	225,000	97,500	12.6	452,166
Massachusetts	456,347	225,862	10.3	244,546	138,203	3.6				678,018
Michigan	1,543,568	756,191	128.6	428,360	214,180	19.6	537,700	268,850	39.5	762,160
Minnesota	781,216	381,710	117.6	619,938	309,969	88.6	457,370	228,685	45.4	1,153,271
Mississippi	272,962	136,481	12.5	660,552	326,126	37.0	473,100	213,965	24.2	670,341
Missouri	735,526	363,972	96.5	134,298	67,149	12.7	357,996	157,860	34.6	1,093,519
Montana	641,506	362,577	80.3	131,028	73,938	9.3	301,938	170,675	60.9	804,353
Nebraska	546,969	262,583	99.7	603,128	301,342	67.4	62,260	31,130	17.3	546,655
Nevada	199,750	165,179	40.9	178,899	155,725	14.3				236,648
New Hampshire	143,639	68,883	3.4	71,533	34,946	3.6				220,624
New Jersey	319,476	159,633	10.6	347,262	188,145	11.4	117,660	58,830	.9	638,931
New Mexico	94,763	59,142	13.1	634,137	343,277	28.8	96,486	49,568	3.7	326,218
New York	2,027,620	970,482	67.9	1,347,060	673,530	40.0	172,260	62,297	.6	851,637
North Carolina	947,399	471,528	82.2	378,303	191,763	40.1	192,090	82,915	14.0	550,758
North Dakota	42,143	23,432	.3	169,224	90,702	3.6				1,279,920
Ohio	1,711,142	852,793	59.9	1,775,720	886,600	53.7	200,100	100,050	11.3	1,268,410
Oklahoma	667,352	353,621	47.8	261,280	138,008	17.4	259,900	136,802	13.4	1,171,889
Oregon	371,724	205,456	56.4	219,787	102,454	16.2	261,853	127,382	22.2	395,118
Pennsylvania	1,758,458	870,797	59.8	725,796	362,898	13.4	497,036	233,968	11.3	693,603
Rhode Island	249,118	122,207	3.6	90,306	47,016	.9	4,740	2,370		124,034
South Carolina	572,292	209,926	79.0	350,840	116,990	16.9	361,467	158,700	45.6	307,042
South Dakota				28,926	19,392	9.0				1,543,133
Tennessee	151,200	72,135	8.7	287,466	143,733	10.0				1,235,745
Texas	1,302,603	636,573	193.1	1,264,712	626,753	103.2	222,500	100,950	29.3	1,581,348
Utah	88,404	49,100	9.5	185,785	123,660	22.1	55,085	27,542	2.5	294,647
Vermont	335,084	108,809	13.1	193,984	56,235	7.6				97,260
Virginia	387,164	181,027	24.8	549,368	256,641	19.7				511,438
Washington	469,388	245,605	28.2	423,037	226,288	28.4	56,760	30,500	.5	368,988
West Virginia	338,127	168,327	18.5	90,300	45,150	2.4				621,964
Wisconsin	329,706	163,752	7.4	756,096	379,085	25.6	549,321	229,744	25.3	770,535
Wyoming	433,021	260,037	42.8	153,530	95,100	9.1	201,617	64,262	9.7	218,678
District of Columbia	112,164	56,082	1.4	2,192	1,096					115,944
Hawaii	264,732	132,578	8.6	1,096	1,096					250,559
Puerto Rico	143,800	70,400	6.4	213,613	104,380	9.7				167,407
TOTALS	27,201,264	13,375,663	2,339.7	22,236,527	11,192,353	1,264.3	8,438,479	3,881,646	664.5	32,600,715

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