ANTICIPATED FUTURE DEVELOPMENT OF THE PRIMARY STATE ROAD SYSTEM IN WEST VIRGINIA

By B. M Higginbotham

Financial Manager, Planning Division, State Road Commission of West Virginia

SYNOPSIS

From the construction and retirement mileage data collected by the West Virginia State-wide Highway Planning Survey in connection with the road life study, the service lives and retirement characteristics of each surface type were developed for roads constructed from 1917 to 1938 on the rural primary State road system of West Virginia.

It was the desire of the Highway Planning Division of West Virginia to determine what the probable future development of the primary road system would be up to 1960, on the basis of past performance and indicated trends The approach is entirely a statistical one based only upon an analysis of construction and retirement mileage data from 1917 to 1938 Survivor curves for the various surface types show the percentage remaining in service at the end of each year. From these curves the probable mileage to be retired of each surface type was obtained for each year during the forecast period, 1940 to 1960. From the basic data for 1917 to 1938, the new types constructed which replaced types retired were obtained and trends of new construction types were estimated therefrom by establishing the relation between the type of surface constructed and the type of surface replaced at the time of retirement

There is also an increase in the primary State road mileage The percentage of increase each year was tabulated, plotted, and a smooth "curve of average per cent of increase" was fitted to the plotted data On the basis of past trends there is no indicated increase in the total primary State road mileage after 1945.

It is desirable at some future time to have no unimproved mileage on the system In the calculations it was assumed that the unimproved mileage existing on January 1, 1939 will be retired uniformly each year until exhausted by 1955.

Tables were prepared indicating (1) the probable miles of each type in use January 1 of each year from 1940 to 1960, inclusive, (2) the probable miles to construct each of those years, and (3) the probable miles to be graded and drained each of those years for each type on the entire primary rural State road system The existing mileage of the primary rural State road system is estimated to increase from 4,799 miles on January 1, 1940 to 4,887 miles on January 1, 1960, also from 1940 to 1960, the average annual surfacing construction and reconstruction program is estimated to be 290 miles

The probable mileage to be graded and drained each year was likewise determined and it is estimated that an average annual construction of 56 miles of grading and drainage will be involved with the average annual surfacing program of 290 miles.

The West Virginia Road Life study has made available data from which the life expectancy of various pavements may be computed. This study is based upon data obtained from the construction and maintenance records of the State Road Commission which have been correlated in a manner that will permit scheduling the mileage to be replaced and constructed over a period of years in the future in accordance with funds available for these purposes. In addition, an analysis of construction and maintenance costs, made in conjunction with and correlated with the age, traffic, climate, and design of the road, will be of assistance in the selection of the proper pavement type.

Of the 4,763 miles (1939) of primary State roads in West Virginia, it is estimated from the road life study that over 300 miles must be resurfaced or reconstructed each year for the next five years, and almost 300 miles each year for the next 20 years. Of this, an average of

almost 60 miles each year must be on an entirely new location. From another estimate based on standards developed by the Highway Planning Division of West Virginia, entirely separate from road life, new location will amount to about 85 miles each year for the next 20 years. Based on past experience there is a place for all pavement types in use in West Virginia. This is dependent upon local conditions and materials.

SURFACE TYPES

The road life analysis of the rural state road system has been used as the basis of study, and the findings have been expanded to include the total primary state road system. The analysis pertains to all road types higher than unimproved, comprising graded and drained, gravel, stone base, surface treated, mixed bituminous, bituminous penetration, bituminous concrete, portland cement concrete, and brick surfaces on various types of bases.

PAVEMENT LIFE

The average lives of various surface types have been estimated by carefully compiling data on every project and assembling these data into tables showing for each surface type the mileage constructed each year and the mileage remaining in service on January 1 of each following year. The assembled data were analyzed and average life estimates were obtained as indicated in Table 1.

Survivor curves were plotted for each of the surface type groupings indicated in Table 1, and average lives were determined in accordance with the analysis procedures outlined in Bulletin 125 of the Iowa Engineering Experiment Station, and in a manner very similar to the methods used in the treatise "Life Characteristics of Surfaces Constructed on Primary Rural Highways," by Robley Winfrey and Fred B. Farrell [1] To illustrate the procedures employed, several survivor curves are reproduced as shown in Figures 1 to 6. The figures indicate for the various surface types the actual survivor curve points together with the type survivor curve which is considered most representative of the retirement experience to date.

It has been found that the earlier constructed plain concrete has an estimated average life of 23 years, whereas the reinforced concrete constructed since 1926 has an estimated average life of 35 years, and the survivor curve is of an entirely different type. Retirement mileages are very small for portland cement concrete constructed since 1926. The survivor curve for this construction therefore does not afford an indication of average life which is as reliable as that for the older construction. However, on the basis of actual retirement experience to January 1, 1939, the average life of the more recently constructed portland cement concrete is estimated as indicated.

The estimates in this treatise have been developed from a study of surface construction and retirement and reflect all influences, such as financial conditions, political influences, the composite judgment of those responsible for the road construction program of the State, the availability of local road building material, varying weather conditions in different sections of the State, legislative enactments, etc, which have entered into the construction of roads in West Virginia during the past.

It becomes necessary to reconstruct, widen or modernize pavements from time to time. There are several reasons for this but the most important ones are functional obsolescence, structural deterioration, or a combination of the two.

A road must be considered as obsolete if the alignment, sight distances, curves, or grades prevent the free movement of the vehicles using it or constitute a danger to the traveling public. Hence, obsolescence sometimes causes an early retire-

[1] Proceedings, Highway Research Board, Vol. 20, p 165 (1940).

TABLE 1

THE RURAL STATE ROAD SYSTEM BY SURFACE TYPES, ESTIMATED AVERAGE LIFE, CONSTRUCTION PERIOD, MILES CONSTRUCTED, AND MILES REMAINING IN SERVICE ON JANUARY 1, 1939

Surface type	Estimated average life	Construction period	Miles constructed	Miles Remaining January 1, 1939
	Yr.			
Surface treatment	12	1922 – 1938	1,187 180	886 923
Mixed bituminous	16	1925 – 1938	582 467	510 332
Mixed bituminous retread, 1 in. to 2½ in. in thickness	16	1931 – 1938	62 049	58.208
Mixed bituminous retread, 2½ in. and over in thickness	16	1930 – 1938	81 481	79 652
Bituminous penetration, 1 in. to 2½ in. in thickness	14	1919 – 1938	135 470	85 091
Bituminous penetration, 2½ in. and over in thickness	18	1917 – 1938	768.427	563.136
Bituminous concrete	25	1917 – 1922	12 248	10 188
Bituminous concrete	17	1923 – 1924	55 871	36 897
Bituminous concrete	27½	1925 – 1938	153.743	150.179
Bituminous concrete, new concrete base	16	1917 – 1938	31 252	11.962
Bituminous concrete, old concrete base	15	1921 – 1938	56 752	50 908
Bituminous concrete retread, 1 in. to 2½ in. in thickness	25	1929 – 1938	57 112	57 112
Bituminous concrete retread, 2½ in. and over in thickness	25	1930 – 1938	44 298	44 298
Portland cement concrete	23	1917 – 1926	467.340	355 604
Portland cement concrete	35	1927 – 1938	623 230	618 399
Brick	16½	1917 – 1938	146.877	69.707

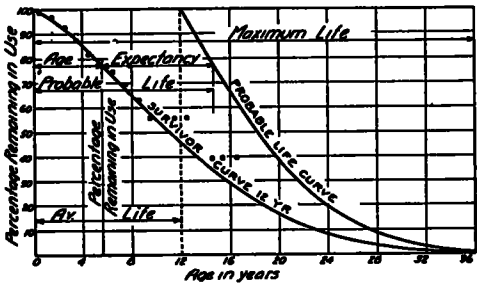

Figure 1. Survivor and Probable Life Curves. Surface Treated Surface, 12-Yr. Average Life. Construction Period 1922-1938.

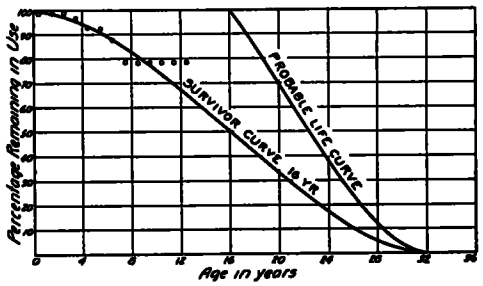

Figure 2. Survivor and Probable Life Curves. Mixed Bituminous Surface, 16-Yr. Average Life. Construction Period 1925-1938.

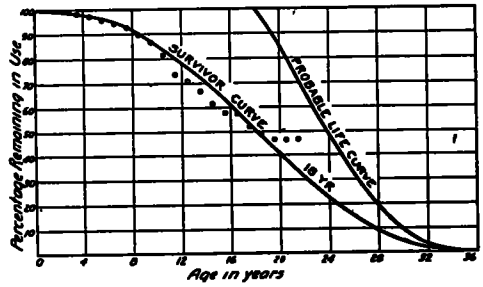

Figure 3. Survivor and Probable Life Curves. Bituminous Penetration Surface, 18-Yr. Average Life. Construction Period 1917-1938.

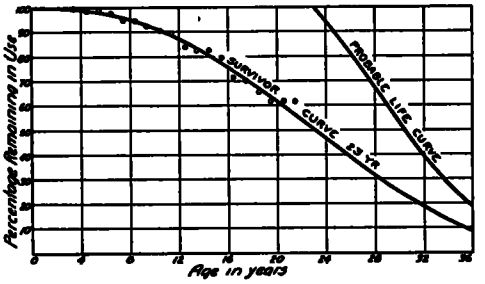

Figure 4. Survivor and Probable Life Curves. Concrete Surface, 23-Yr. Average Life. Construction Period 1917-1926.

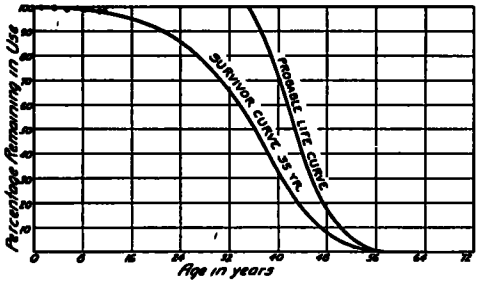

Figure 5. Survivor and Probable Life Curves. Reinforced Concrete Surface, 35-Yr. Average Life. Construction Period 1927-1938.

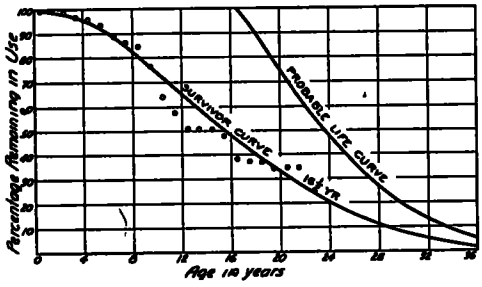

Figure 6. Survivor and Probable Life Curves. Brick Surface, 16½-Yr. Average Life. Construction Period 1917-1938.

ment of an otherwise serviceable pavement A road has deteriorated when it becomes rough, uneven, and dangerous and the cost of maintaining it in a satisfactory condition is excessive

When either or both of these conditions exist, it is necessary to reconstruct a pavement. When the old pavement is retired, it means a pavement death which affects the average life of all pavements of that type. The road life study, in estimating the average life of pavement, utilized all retirements including those occasioned by obsolescence and the expectancies indicated must be considered in the light of having been developed from past experience. If construction and maintenance policies in the future continue a gradual development as they have in the past, future retirements may be expected to follow the indicated trends. The experience for small mileages of certain pavement types should not be considered as necessarily representative of that type of pavement

It is pointed out also that pavement life is governed to a large extent by economic conditions. Sometimes, because of lack of funds, a pavement has to be used after it is economically unsound to continue its use

Indicated Service Lives

Estimated mileages remaining in service at various ages are dependent upon the type of survivor curve and average life determined to be representative of the survivor experience for each of the various surface types. This is illustrated in Table 2 which shows the percentages of the original construction remaining in service up to 40 years of age for each of the survivor curves illustrated in Figures 1 to 6. A similar table was prepared from the construction experience of all the various surfaces constructed in West Virginia for which records are available and covers practically every mile of road on the rural primary state road system. It should be emphasized that the average life will probably change for any given type of pavement if the loading conditions change, if the number of vehicles using it increases or decreases materially, or if the pavement design materially changes. For example, the introduction of the thickened edge and steel reinforcing in concrete design very definitely lengthened the life of concrete pavement according to the studies made in West Virginia.

Probable Remaining Life (Expectancy) of Pavements

From the survivor curve data for each type the probable remaining life (expectancy) of the survivors at each age for each of the major surface types was computed from the area under the survivor curve to the right of each age-ordinate (Table 3).

Indicated Future Development

The estimates in the tables and charts are based entirely on past performance. The estimates which follow result from an independent approach to the problem of the probable future development of the primary state road system in which are involved statistical analyses of road life data only.

There is a natural increase each year in primary state road mileage. On the basis of past trends, there is no indicated increase in the total primary state road mileage after 1945. Figure 7 shows this graphically, together with a smooth curve marked "average per cent of increase" extended to zero at 1945. This increase was distributed among the new types of construction in direct proportion to their existing mileages for the year.

The survivor curves of the various sub-types show the percentage remaining at the end of each year. The portion of the originally constructed mileage remaining in service at a given age will even-

tually be retired and probably replaced; however, the replacement type may be the same as the original type or it may be of a different type.

age remaining for a period of years in the future. Arbitrarily, the year 1955 has been taken to have all unimproved mileage retired, the present unimproved mile-

TABLE 2

PERCENTAGE REMAINING OF EACH MAJOR SURFACE TYPE AT ANY GIVEN AGE

Age	Surface treatment 12 years	Mixed bituminous 16 years	Bituminous penetration 18 years	Concrete built 1917 to 1926, inc 23 years	Concrete built 1927 to 1938, inc 35 years	Brick 16½ years
0	100 0	100 0	100 0	100 0	100 0	100 0
1	97 7	99 4	100 0	100 0	100 0	99 4
2	93 8	97 9	99 8	99 8	100 0	98 2
3	89 8	96 7	99 3	99 6	99 9	97 4
4	84 8	94 3	98 6	99 2	99 8	96 4
5	79 9	91 9	97 5	98 6	99 7	93 3
6	74 7	89 1	96 2	97 8	99 6	90 1
7	69 4	86 1	94 2	96 9	99 4	86 6
8	64 3	82 5	91 9	95 5	99 2	82 7
9	59 3	79 0	89 0	94 0	99 0	78 3
10	54 3	75 2	85 5	91 9	98 7	73 8
11	49 4	71 5	82 0	89 9	98 2	69 4
12	44 8	67 2	78 1	87 7	97 9	64 9
13	40 2	62 8	73 9	85 0	97 6	60 5
14	36 0	58 5	69 4	82 2	97 1	56 2
15	32 0	54 2	65 0	79 2	96 6	51 8
16	28 3	50 0	60 3	76 1	95 8	47 7
17	24 8	45 8	55 2	72 6	94 9	43 6
18	21 5	41 3	50 0	69 2	94 0	39 7
19	18 6	37 3	44 8	65 6	93 0	36 2
20	15 9	32 9	39 7	61 6	91 9	32 5
21	13 5	28 8	35 0	57 9	90 7	29 2
22	11 3	25 0	30 6	53 8	89 2	26 0
23	9 4	21 1	26 1	50 0	87 7	23 0
24	7 7	17 5	21 9	46 2	86 0	20 2
25	6 3	14 1	18 0	42 2	84 3	17 6
26	5 1	11 0	14 5	38 3	82 4	15 2
27	4 0	8 3	11 0	34 8	80 3	13 1
28	3 1	5 7	8 1	31 0	78 1	11 2
29	2 4	3 4	5 8	27 5	75 4	9 4
30	1 8	1 9	3 8	24 1	72 6	7 8
31	1 3	0 9	2 5	20 9	69 3	6 5
32	0 9	0 0	1 4	17 8	65 9	5 2
33	0 7		0 7	15 0	62 2	4 2
34	0 4		0 2	12 5	58 3	3 4
35	0 3		0 0	10 0	54 4	2 6
36	0 2		0 0	8 1	50 6	2 0
37	0 1			6 0	46 0	1 5
38	0 1			4 9	41 8	1 1
39	0 1			3 3	37 4	0 8
40	0 05			2 1	33 1	0 6

It is desirable at some future time to have no unimproved mileage on the system, but based on past experience there will continue to be some unimproved mile-

age being retired uniformly each year until exhausted at that time.

Table 4 indicates the miles in use January 1 of each year. The percentage of

untreated roads shown in column 4 generally represents highways having a traffic volume of less than 100 vehicles per day. The percentages of low type pavement shown in column 7 represent mileages carrying a density of 100 to 600 vehicles per day and the percentages shown in column 12 represent high type pavement with more than 600 vehicles per day. Tables 6 and 7 indicate the miles to construct and the miles to be graded and drained each year from 1939 to 1960,

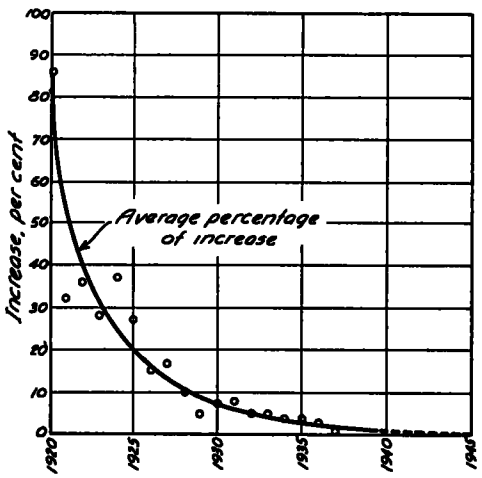

Figure 7. Percentage of Increase in Mileage of the State Road System (Municipal and Rural) Each Year over the Preceding Year. Historic to 1939, Forecast to 1960, No Increase 1945 to 1960.

inclusive, for the entire primary state road system and include earth and metal surfaced roads. Figures 8, 9, and 10 show graphically the same information as the first two tables. Figure 11 shows the retirements from 1917 to 1960, inclusive. The mileage to be graded and drained each year was determined by examining the mileage constructed during the preceding nine years. From this examination the percent of each type which was to be graded and drained was ascertained. These percents were then applied to determine future construction.

TRENDS OF NEW CONSTRUCTION

Trends of new construction types on the rural primary system were determined by preparing a series of about 65 interlocking and inter-dependent tables. To include all of these tables would make this paper too voluminous and would serve no real purpose. However, sample tables are included to show the method used to arrive at trends and the anticipated future developments.

Tables were prepared for each type of pavement or road in use in West Virginia Table 7 for mixed bituminous surface is reproduced here for illustrative purposes. The complete tables show the probable total mileage constructed, in use, and retired for each year 1939 to 1960.

Tables for each type of retirement and its replacement types for the 9[2] year period immediately preceding the year under consideration were prepared one year at a time; Table 8 for mixed bituminous retirements and reconstruction types is reproduced here. The complete tables show for retirements during each year the percentage distribution of replacement types, as determined in each instance from the preceding nine years of retirement and replacements. This series of tables indicates the trends concerning types of replacement construction.

The series 9 tables, one for each year beginning with 1939 and extending to 1959, were prepared one year at a time in order to apply the percentages from them to probable retired mileages from series 7 tables, thus determining for each year

[2] On January 1, 1939, West Virginia had approximately 18 years experience in improved road building, the first 9 of which was somewhat experimental. The experience gained during this early period crystallized into definite and fixed standards by 1930. It was the desire of the Highway Planning Division in this study to get recent trends and at the same time to go back far enough to get sufficient retirements to develop trends, hence the adoption of the 9-year period

TABLE 3

AGE AND PROBABLE REMAINING LIFE (EXPECTANCY) OF MILEAGES IN SERVICE ON JANUARY 1, 1939

Age Year	Surface Treatment		Mixed Bituminous		Bituminous Penetration		Concrete built 1917-1926, inc.		Concrete built 1927-1938, inc		Brick	
	Miles January 1, 1939	Years probable life	Miles January 1, 1939	Years probable life	Miles January 1, 1939	Years probable life	Miles January 1, 1939	Years probable life	Miles January 1, 1939	Years probable life	Miles January 1, 1939	Years probable life
0	0	12 0	0	16 0	0	18 0	0	23 0	0	35.0	0	16.5
½	85.9	11 6	57 2	15 6	14 7	17 5	0	22 5	17 6	34 5	0 7	16 1
1½	72 6	11 0	41 7	14 8	7 7	16 6	0	21 5	14 9	33 5	0	15 2
2½	83 7	10 4	76 1	14 0	2 3	15 7	0	20 5	10 5	32 5	0	14 3
3½	48 6	9 9	19 3	13 2	2 3	14 7	0	19 6	46 1	31 6	0	13 5
4½	88 3	9 5	51 1	12 5	0	13 8	0	18 7	33 3	30 6	0	12 8
5½	122 6	9.1	0 6	11 8	0	13 0	0	17 8	21 2	29 6	0	12 2
6½	91 2	8 8	58 2	11 2	0 3	12 2	0	17 0	68 2	28 6	0	11 7
7½	127 6	8 4	93 8	10 6	30 6	11 4	0	16 2	142 0	27 7	0 9	11 2
8½	82.0	8.0	90 5	10 0	79 6	10 8	0	15 5	70 7	26 7	0	10 7
9½	5 6	7 7	5 2	9 5	23 3	10 1	0	14 7	60 1	25 7	0	10 2
10½	21 1	7 4	1 2	9 0	55 8	9.5	0	14 0	78 7	24 8	0 6	9 8
11½	15.0	7.1	2 2	8 5	69 0	8 9	0	13 3	55 8	23 8	0	9 4
12½	6.8	6 8	4 2	8 0	49 7	8 4	56 8	12 7			19 5	9 1
13½	28 3	6 5	9.0	7 5	90 9	7.9	38 7	12 0			11 4	8 7
14½	3.7	6 2			53 3	7 3	83 0	11 5			3 4	8 4
15½	0 1	5 9			15 7	6 8	53 7	10 9			5 7	8 1
16½	3 8	5 6			17 7	6 4	45 3	10 4			3 0	7 8
17½	..				2 2	5 9	21 0	9 9			8 1	7 5
18½					33 1	5 5	20 0	9 4			3 9	7 1
19½					6 6	5 1	32 9	8 9			6 8	6 8
20½					3 7	4 8	3 3	8 5			0 7	6 6
21½					4 5	4 4	0 9	8 0			1 2	6 3
22½							.				2 7	6 0
23½											1 1	5 7
Total miles	886 9		510 3		563 1		355 6		618 4		69 7	

TABLE 4

PROBABLE MILEAGE IN USE JANUARY 1 OF EACH YEAR 1940 TO 1960

Year	Untreated			Low-type			High-type					Total
	Earth[a]	Gravel and stone base	Per cent	Surface treatment	Mixed bituminous	Per cent	Bituminous penetration	Bituminous concrete	Concrete	Brick	Per cent	
1940	358	484	17 54	907	728	34 07	652	438	1,096	136	48 39	4,799
1941	322	452	16 01	922	789	35 39	622	474	1,129	125	48 60	4,835
1942	293	417	14 62	932	843	36 53	589	514	1,156	114	48 85	4,858
1943	270	388	13 51	933	896	37 54	553	553	1,177	102	48 95	4,872
1944	251	363	12 58	924	947	38 32	517	593	1,196	91	49 10	4,882
1945	235	336	11 68	915	992	39 03	482	634	1,211	82	49 29	4,887
1946	221	309	10 85	906	1,034	39 69	448	669	1,226	74	49 46	4,887
1947	207	284	10 05	896	1,071	40 25	415	707	1,242	65	49 70	4,887
1948	191	263	9 29	883	1,106	40 69	384	745	1,259	57	50 02	4,888
1949	175	246	8 61	869	1,139	41 08	353	779	1,277	50	50 31	4,888
1950	159	231	7 98	855	1,168	41 40	324	813	1,293	44	50 62	4,887
1951	144	220	7 45	840	1,195	41 63	297	845	1,309	38	50 92	4,888
1952	128	211	6 94	826	1,218	41 81	273	875	1,324	33	51 25	4,888
1953	113	203	6 47	812	1,238	41 94	251	903	1,339	28	51 59	4,887
1954	98	197	6 03	800	1,255	42 04	232	930	1,353	24	51 93	4,889
1955	82	192	5 61	789	1,269	42 10	216	954	1,367	19	52 29	4,888
1956	70	185	5 22	779	1,279	42 12	201	975	1,381	16	52 66	4,886
1957	57	179	4 83	773	1,286	42 14	189	994	1,395	13	53 03	4,886
1958	45	176	4 52	768	1,290	42 11	179	1,009	1,409	11	53 37	4,887
1959	32	173	4 19	766	1,290	42 07	171	1,002	1,423	10	53 74	4,887
1960	20	173	3 95	766	1,286	41 99	165	1,032	1,436	9	54 06	4,887

[a] Includes designated mileage for which there is no road

TABLE 5

PROBABLE MILEAGE OF SURFACING CONSTRUCTION OR RECONSTRUCTION REQUIRED EACH YEAR, 1940 TO 1960, TO PROVIDE MILEAGES IN USE AS INDICATED IN TABLE 4

Year	Earth	Gravel and stone base	Low-type surface treatment	Low-type mixed bituminous	Bituminous penetration	Bituminous concrete	Concrete	Brick[a]	Total
1940	23	23	75	83	13	44	52		313
1941	25	23	77	83	9	49	47		313
1942	27	23	67	82	9	49	43		300
1943	26	23	60	84	9	51	43		296
1944	26	23	61	80	9	52	42		293
1945	27	19	62	82	9	48	41		288
1946.	27	20	63	79	10	51	43		293
1947	24	20	59	82	11	52	43		291
1948	24	21	59	83	9	49	46		291
1949	24	22	59	82	9	50	46		292
1950	24	22	58	82	9	50	46		291
1951	24	22	58	83	9	49	47		292
1952	23	22	58	83	8	49	48		291
1953	23	22	59	82	8	49	49		292
1954	22	22	60	82	8	49	50		293
1955	9	19	60	81	8	48	52		277
1956	9	19	60	81	8	48	53		278
1957	9	19	61	80	8	47	54		278
1958	8	19	61	79	7	47	55		276
1959	8	20	61	78	7	46	56		276
1960	8	20	62	77	7	46	58		278

[a] Construction will continuously decrease from 0.40 mile in 1940 to 0 15 mile in 1960

TABLE 6

PROBABLE MILEAGE REQUIRING GRADING AND DRAINAGE CONSTRUCTION EACH YEAR, 1940 to 1960, IN CONNECTION WITH THE SURFACING CONSTRUCTION AND RECONSTRUCTION INDICATED IN TABLE 5

Year	Earth	Gravel and stone base	Low-type surface treatment	Low-type mixed bituminous	Bituminous penetration	Bituminous concrete	Concrete	Brick[a]	Total
1940	23	4	5	8	2	1	21		64
1941	25	4	5	8	1	1	19		63
1942	27	4	5	7	1	1	18		63
1943	26	4	4	7	1	1	18		61
1944	26	4	4	7	1	1	17		60
1945	27	3	4	8	2	1	17		62
1946	27	3	4	7	2	1	17		61
1947	24	3	4	7	2	1	18		59
1948	24	3	4	7	1	1	19		59
1949	24	3	4	7	1	1	19		59
1950	24	3	4	7	1	1	19		59
1951	24	4	4	7	1	1	19		60
1952	23	3	4	7	1	1	19		58
1953	23	4	4	7	1	1	20		60
1954	22	3	4	7	1	1	20		58
1955	9	3	4	7	1	1	21		46
1956	9	3	4	7	1	1	22		47
1957	9	3	4	7	1	1	22		47
1958	8	3	4	7	1	1	23		47
1959	8	3	4	6	1	1	23		46
1960	8	3	4	6	1	1	24		47

[a] Construction will continuously decrease from 0.26 mile in 1940 to 0.10 mile in 1960.

TABLE 7

ESTIMATED MILES CONSTRUCTED, REMAINING IN USE, AND RETIRED EACH YEAR 1939 TO 1945[a]

Mixed Bituminous

Construction Year	Miles	Miles remaining January 1 each of the following years						
		1939	1940	1941	1942	1943	1944	1945[a]
1922	0 029	0 029	0					
1923								
1924								
1925	9 280	8 960	5 2	4 8	4 4	4 0	3 6	3 2
1926	12 888	4 173	7 8	7 3	6 7	6 2	5 6	5 0
1927	2 195	2 175	1 4	1 3	1 2	1 1	1 0	0 9
1928	16 388	1 250	11 3	10 7	9 9	9 2	8 5	7 8
1929	8 036	5 193	5 9	5 6	5 2	4 9	4 5	4 2
1930	104 134	90 555	80 2	76 2	72 1	67 7	63 2	58 7
1931	111 750	93 839	90 2	86 0	81 8	77 3	72 6	67 8
1932	61 369	58 193	51 7	49 5	47 3	44 9	42 5	39 9
1933	0 602	0 602	0 5	0 5	0 5	0 5	0 4	0 4
1934	52 753	51 108	47 7	46 1	44 4	42 6	40 6	38 6
1935	19 528	19 309	18 2	17 7	17 1	16 4	15 8	15 0
1936	76 807	76 132	73 4	71 6	69 4	67 1	64 7	62 0
1937	46 262	41 687	45 1	44 2	43 1	41 8	40 4	39 0
1938	60 495	57 156	59 8	59 0	57 8	56 4	54 7	52 9
			498 4					
1939	53 250		53 14	52 66	51 92	50 91	49 63	48 14
				533 16				
1940	51 100			51 00	50 54	49 82	48 85	47 63
					563 36			
1941	46 990				46 90	46 47	45 82	44 92
						587 30		
1942	46 900					46 81	46 38	45 73
							608 78	
1943	47 810						47 71	47 28
								629 10
Original carried to 1959.								
Total miles in use each year.		510 361	551 54	584 16	610 26	634 11	656 49	677 42
Tota miles in use succeeding year		498 400	533.16	563 36	587 30	608 78	629 10	648 06
Miles retired each year		11 961	18 38	20 80	22 96	25 33	27 39	29 36

S 16-Year curve:

Age in years 0, ½, 1½, 2½, 3½, 4½, 5½, 6½, 7½, 8½, 9½, 10½, 11½, 12½, 13½, 14½, 15½, 16½, 17½, 18½, 19½, etc.

Per cent in use 100 0, 99 8, 98 9, 97.5, 95.6, 93 2, 90 4, 87 4, 84 2, 80.7, 77.0, 73.2, 69 2, 65 0, 60.7, 56.4, 52 1, 47.8, 43.5, 39.1, 34.8, etc.

[a] The original table extended to the year 1960

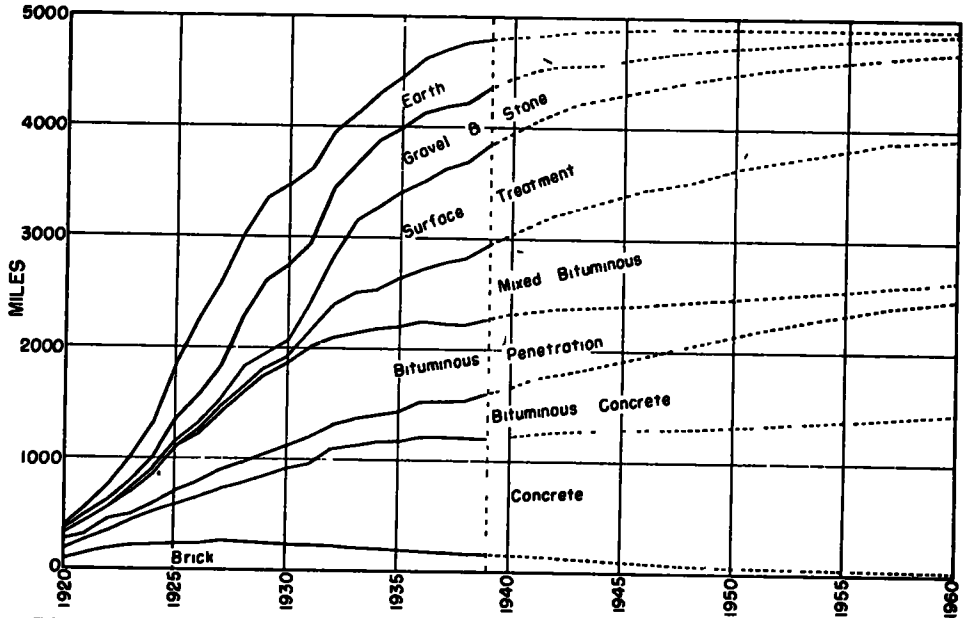

Figure 8. Cumulative Miles of Each Surface Type in Use January 1 of Each Year. Historic to 1939—Forecast to 1960

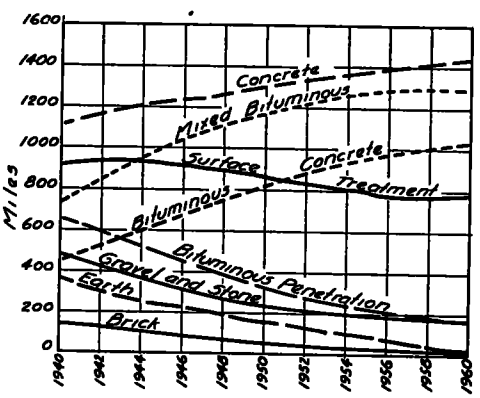

Figure 9 Probable Mileage of Each Surface Type in Use January 1 of Each Year 1940 to 1960.

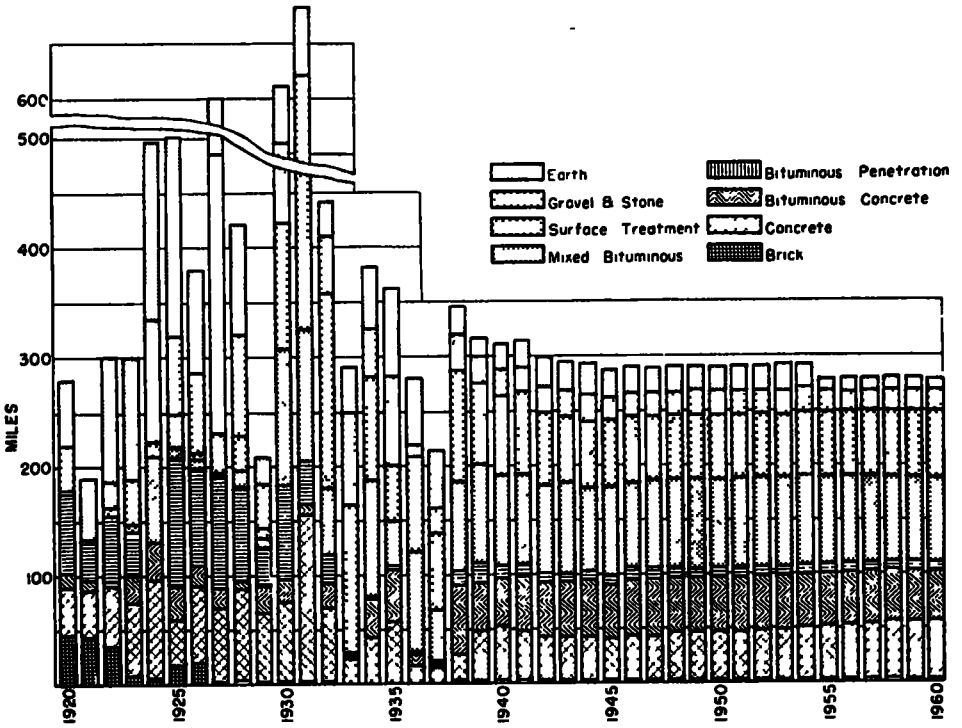

Figure 10. Surface Mileage by Types Constructed and Reconstructed Each Year. Historic to 1939—Forecast to 1960

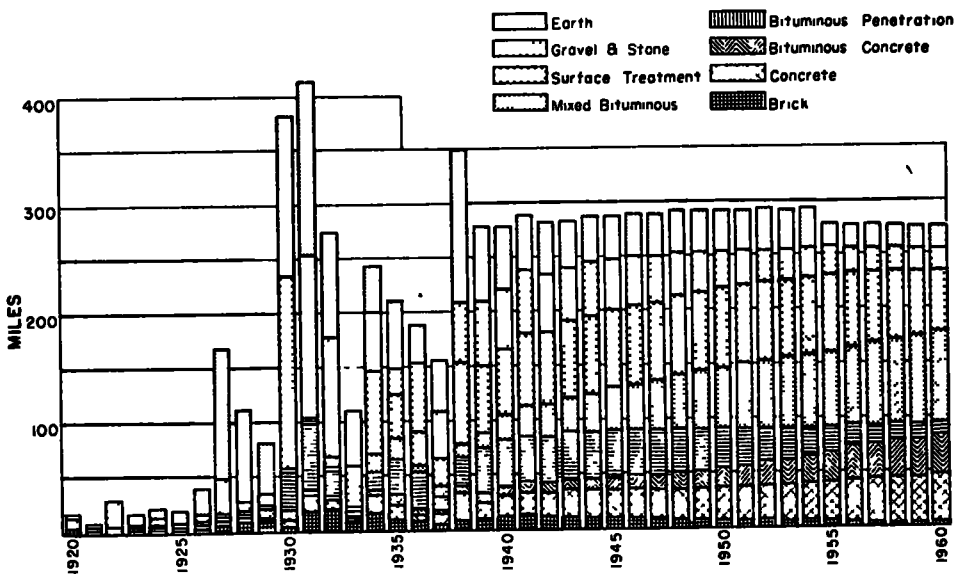

Figure 11. Surface Mileage by Types Retired Each Year. Historic to 1939—Forecast to 1960

TABLE 8

MIXED BITUMINOUS RETIREMENTS AND RECONSTRUCTION TYPES 1930-1945 (TO 1959 IN ORIGINAL)

Reconstruction Types

Const Year	A Graded and drained	B Gravel	C Stone base	D Surface treatment	E Mixed Bituminous	F Mixed bit ret	J Bituminous concrete	L Concrete	Total retired
1930	.	.		.	.				
1931		0 320			.				0 320
1932		.	.		0 308			3 080	3 388
1933			0 168	5 217					5 385
1934			.		..	15 169	.	1 518	16 687
1935	0 075		14 970		.. .. ..	.. .	.. .	3.102	18 147
1936				.	1 579	2.843	.		4 422
1937	0 074	.		14 861	0 199	2 301	0 105	0 363	17.903
1938.			.	0 698	0 188	.....	1 282	. . .	2 168
Total	0 149	0 320	15 138	20 776	2 274	20 313	1 387	8.063	68 420
1939 percent	0.22	0 47	22 12	30 36	3 33	29.69	2 03	11 78	100 00
1939 .	0 030	0 060	2 640	3 630	0.400	3 550	0 240	1 410	11.960
Total .	0 179	0 380	17.778	24 406	2 674	23.863	1 627	9.473	80 380
1940 percent	0 22	0 47	22.12	30 36	3 33	29.69	2 03	11.78	100 00
1940 . .	0.040	0 090	0.070	5 580	0.610	5.450	0 370	2.170	18 380
Total	0.219	0 150	21 848	29 986	3 284	29 313	1 997	11 643	98 440
1941 percent	0 22	0.15	22 19	30 46	3 34	29.78	2.03	11 83	100 00
1941.	0 050	0 030	4 620	6 340	0 690	6.190	0 420	2 460	20 800
Total .	0 269	0 180	26 468	36 326	3 666	35 503	2 417	11 023	115 852
1942 percent	0.23	0.16	22 85	31 36	3 16	30 64	2 09	9 51	100 00
1942 ...	0 050	0 040	5 250	7 200	0 730	7 030	0 480	2 180	22 960
Total .	0 319	0 220	31 550	38 309	4 396	42 533	2 897	13 203	133 427
1943 percent	0 24	0 16	23 65	28 71	3 29	31 88	2 17	9 90	100 00
1943. . .	0 060	0 040	5 990	7 280	0 830	8 070	0 550	2 510	25 330
Total ..	0 379	0 260	37.540	45 589	5 226	35 434	3 447	14 195	142 070
1944 percent	0 27	0 18	26 42	32 09	3 63	24 94	2 43	9 99	100 00

Retirements 1930-1938 | Retirements 1931-1939 | Retirements 1932-1940 | Retirements 1933-1941 | Retirements 1934-1942 | Retirements 1935-1943

Reconstruction 1931-1938 Percentage

Reconstruction 1933-1941 Percentage

Reconstruction 1934-1942 Percentage

Reconstruction 1935-1943 Percentage

Original carried to 1959.

TABLE 9-A

Replacement Types for Mileages Retired During 1939

Type retired	Jan 1, 1939 miles remaining	Miles retired and replacement type													1939 mileage retired	Jan 1, 1940 miles remaining
		A	B	C	D	E	F	G	H	I	J	K	L	M		
		Grade and drain	Gravel	Stone base	Surface treatment	Mixed bituminous	Mixed bit retread	Bit pen 1-2½ in	Bit pen 2½ in	Bit pen rigid base	Bituminous concrete	Bit concrete retread	Concrete	Brick		
Unimproved	242 567	11 37		3 33									0 05		14 75	227 817
Grade and drain	161 776	1 86	4 76	7 03	21 13	8 98			2 87		0 63	..	7 04	0 08	54 38	129 000
Gravel	325 761	0 24	0 97	1 41	15 05	5 60			0 19				6 00		29 46	304 561
Stone base	189 395	0 05		0 75	16 39	8 33		1 21	3 23		0 28		0 26		30 50	176 465
Surface tr .	886 923	0 07	0 24		7 89	14 50	13 69		3 49		6 31	9 98	2 25		58 42	903 323
Mixed bit. .	510 361	0 03	0 06	2 64	3 63	0 40	3 55			.	0 24	.	1 41		11 96	551 541
Mixed bit. ret.	140 349				0 30	0 95		.		..			0 51		1 76	166 129
Bit pen. 1-2½ in	90 240	0 62			0 13	0 91	1 28	0 20	0 30		0 89	1 53	1 83	.	7 69	84 210
Bit. pen 2½ in.	563 136	3 28	0 54	0 22	1 38	5 46	3 81	0 05	2 63		3 64	3 62	6 41		31 04	547 216
Bit. pen. R. B.	1 466					0 77									0 77	0 946
Bit. concrete	260 144				0 01	0 30	1 94		0 61		1 29	1 63	2 78		8 64	273 464
Bit. concrete ret.	103 931															122 951
Concrete	979 656	1 20	0 70		0 01	0 47		.		0 22	5 24	.	6 88	0 08	14 80	1,008 316
Brick	89 743	0 32	0 01	0 10	0 01	0 08	.				0 83		2 88	0 08	4 31	65 703
Total .	4,525 448	19 04	7 28	15 48	65 93	46 83	24 27	1 46	13 32	0 22	19 35	16 76	38 30	0 24	268 480	Retired miles reconstructed
Increase	36 200	2 57	0 98	2 09	8 89	6 31	3 27	0 20	1 80	0 03	2 61	2 26	5 16	0 03	36 200	Increase miles constructed
Grand total	4,561 648	21 61	8 26	17 57	74 82	53 14	27 54	1 66	15 12	0 25	21 96	19 02	43 46	0 27	304 680	4,561 648

TABLE 9-B

Replacement Types for Mileages Retired During 1940

Type retired	Jan 1, 1940 miles remaining	Miles retired and replacement type													1940 mileage retired	Jan 1, 1941 miles remaining
		A	B	C	D	E	F	G	H	I	J	K	L	M		
		Grade and drain	Gravel	Stone base	Surface treatment	Mixed bituminous	Mixed bit retread	Bit. pen 1-2½ in	Bit. pen 2½ in	Bit. pen rigid base	Bituminous concrete	Bit concrete retread	Concrete	Brick		
Unimproved	227 817	10 69		3 13			.	.		.			0 05		13 87	213 947
Grade and drain	129 006	1 55	4 03	4 60	19 90	7 25			1 04		0 41	.	5 17	0 08	44 03	105 746
Gravel	304 561	0 02	0 79	0 29	13 81	5 15	..		0 09				6 55		26 70	284 911
Stone base	176 465	0 05		0 83	15 74	7 32		1 34	1 77		0 31		0 21		27 57	163 775
Surface treatment	903 323	0 07	0 07		8 05	14 80	13 97	.	3 56		6 45	10 18	2 06		59 21	917 573
Mixed bituminous	551 541	0 04	0 09	4 07	5 58	0 61	5 45				0 37		2 17	.	18 38	584 161
Mixed bit ret	166 129		.	. .	0 74	1 40							1 22		3 36	192 559
Bit pen. 1-2½ in.	84 210	0 65			0 14	0 96	1 28	0 21	0 04	.	0 93	1 61	1 78		7 60	78 410
Bit. pen 2½ in.	547 216	3 55	0 41	0 24	1 49	5 93	4 12	0 06	2 84		3 95	3 92	6 71		33 22	524 606
Bit. pen R. B	0 946			.		0 60									0 60	0 656
Bit. concrete	273 464			.	0 02	0 81	1 77		0 12		0 94	1 10	2 65		7 41	289 024
Bit concrete ret	122 951			.	0 05								0 05		0 10	141 681
Concrete	1,008 316	1 51	0 88		0 02	0 59	.			0 28	6 04		8 18	0 10	17 60	1,036 136
Brick	65 703	0 41	0 02	0 12	0 02	0 11				.	1 10		3 74	0 08	5 60	60 393
Total	4,561 648	18 54	6 29	13 28	65 56	45 53	26 59	1 61	9 46	0 28	20 50	16 81	40 54	0 26	265 250	Retired miles reconstructed
Increase	31 930	2 23	0 76	1 60	7 90	5 47	3 20	0 19	1 15	0 03	2 47	2 02	4 88	0 03	31 930	Increase miles constructed
Grand total	4,593 578	20 77	7 05	14 88	73 46	51 00	29 79	1 80	10 61	0 31	22 97	18 83	45 42	0 29	297 180	4,593 478

the total probable mileage of replacement construction for each type The natural increase of mileage on the system was added as determined from the curve shown in Figure 7 Two of this series of tables are reproduced here 9A (1939), and 9B (1940) These summary tables were compiled for each year by (1) posting on the series 7 tables the totals of replacements shown on Table 9A, (2) computing construction mileage required to provide the indicated mileages remaining at ½ year of age, (3) computing probable mileages remaining on January 1 of each year to 1960, in accordance with the survivor curve percentage

The forecasts, as determined from the foregoing for the rural primary system, were then expanded to cover the entire system as shown in Tables 4 and 5 Actual mileages in 1941, 2½ years after this forecast was made, are very close to the predicted mileages for high type pavement, a little higher for low type surfaces and a little lower for untreated roads