Lives of Highway Surfaces—Half Century Trends

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That highways do wear out is an accepted fact. Since the war our construction program has been greatly expanded. What influence has this stepped-up program had on the service lives of our roads? Are the miles actually retired greater or less than those developed in past estimates? This report attests to the validity of previous estimates and adds seven years experience to the information presented in the 1948 report.

Among the major objectives of the road life study phase of the highway planning surveys is the development of factual data relating to (1) how long road surfaces remain in service before they are replaced, and (2) what is done to the road surfaces at the time of replacement. This is the third report presented on this subject in the past 16 years. The first report was in 1940 and the second in 1948.

In the present report the life experience of road surfaces on primary rural highways covers the period from January 1, 1900 to January 1, 1953. The basic data were submitted by 25 states and Puerto Rico for rural state or federal-aid primary systems and include 344,108 miles of construction and 192,741 miles of retirements. Results of the analysis show that the number of years a surface remains in service before it is resurfaced, reconstructed, or otherwise replaced ranges from 5.2 years for lower type surfaces to 25.5 years for the higher type surfaces.

Of the 183,976 miles analyzed by method of retirement through 1952, 57 percent were resurfaced, 31 percent reconstructed, 9 percent transferred to other public agencies, and 3 percent abandoned. Since the war the proportion resurfaced has decreased and the proportion reconstructed has increased.

Data for nine states are common to all three reports. For these nine states, an estimate was made of what mileages would still be in service in 1953 if road surfaces continued to be retired at the rates shown in the 1940 and 1948 reports. This estimate was then checked against the actual mileages remaining in 1953. There was close agreement between the actual and estimated miles remaining. The differences between the previous forecasts and the present report may be partly due to the lagging highway program during the war and postwar periods.

On January 1, 1953, the average age was 13.0 years for low type, 10.9 years for intermediate type, and 13.3 years for high type surfaces. Corresponding remaining life expectancies are 2.9, 5.9, and 9.3 years, respectively.

The service life data developed in this report were used in estimating the probable mileages remaining in service in future years. During the 10 years, January 1, 1953 to January 1, 1963, it is estimated that 96 percent of the low, 83 percent of the intermediate, and 61 percent of the high type surfaces in service at the beginning of the period will be retired through resurfacing, reconstruction, abandonment or transfer.

● THE highway systems of the nation are a vital segment of our national economy. The proper management of these systems and the protection of the investment they represent require detailed knowledge of their performance. Many facts are needed with respect to their construction, maintenance, operation and administration. To supply these facts is one function of the highway planning surveys which were established in the middle 1930's by the state highway departments in cooperation with the Bureau of Public Roads.

Despite their extent and advanced stage of development most of the nation's highways are inadequate for the demands of present day traffic. Much of the current inadequacy dates back to World War II when highway construction was cut to a minimum as a result of the defense effort. Highways were kept in operating condition with a minimum of expenditure to conserve labor, equipment, and materials. At the end of the war an outdated highway system was called upon to handle heavier traffic demands than ever before. To solve their problem, many states undertook highway needs studies. Attention was directed to both long range and short range planning.

Funds were limited and progress was slow. In the meantime, the needs continued to mount. There was need for updating of the facts relating to the performance of roads and how fast they were wearing out and how long they would remain in service. The proper evaluation of these data is necessary to determine the dimensions of future needs. The data necessary for these evaluations are obtained from the road life studies of the highway planning surveys. They cover such items as rates of wearing out, construction cost, maintenance cost, extent of functional obsolescence and structural deterioration, and life of the investment. The findings must be appraised in the light of changing traffic volumes, heavier loads and higher speeds.

One of the objectives of the road life studies in the individual states is the development of an organized body of information concerning life characteristics of highway surfaces. The first comprehensive analysis of such data was presented in the article "Life Characteristics of Surfaces Constructed On Primary Rural Highways" by Robley Winfrey and Fred B. Farrell published in the Proceedings of the twentieth annual meeting of the Highway Research Board in December 1940. In that report were included the results of service life analyses on 210,000 miles of construction up to January 1, 1937 for various surface types in 26 states.

There was little activity in the road life studies from 1940 through World War II. However, most states resumed operations once the war was over and a second report on service lives was prepared in 1948 by Fred B. Farrell and Henry R. Paterick. This report covered 16 states and was presented at the twenty-eighth annual meeting of the Highway Research Board in 1948. Included in the report were the service life analyses on 248,783 miles of construction and 129,593 miles of retirements up to January 1, 1946.

In the present report, data for 25 states and Puerto Rico are included (see Figure 1):

Arizona	Nevada
California	New Mexico
Connecticut	Oklahoma
Delaware	Pennsylvania
Florida	Rhode Island
Georgia	South Dakota
Illinois	Tennessee
Indiana	Texas
Kansas	Washington
Minnesota	West Virginia
Mississippi	Wisconsin
Missouri	Wyoming
Montana	Puerto Rico

Nine of the above listed states were also in the 1940 report and the 1948 report: Indiana, Kansas, Missouri, Montana, New Mexico, Oklahoma, Texas, West Virginia, and Wyoming. In addition to the above nine states, this report also includes four states listed in the 1948 report. They are: Illinois, Minnesota, Nevada, and Wisconsin.

BASIC DATA COMPILED

This report embraces 344,108 miles of construction of various surface types on the rural portions of the primary state or federal-aid systems for 25 states and Puerto Rico. In general, all mileage in incorporated places of greater than 1,000 persons has been excluded. Construction of widening has also been omitted in those cases where the widening was done as a separate operation. Where the widening was done in conjunction with the resurfacing or reconstruction of the previous surface, the mileage of the new construction,

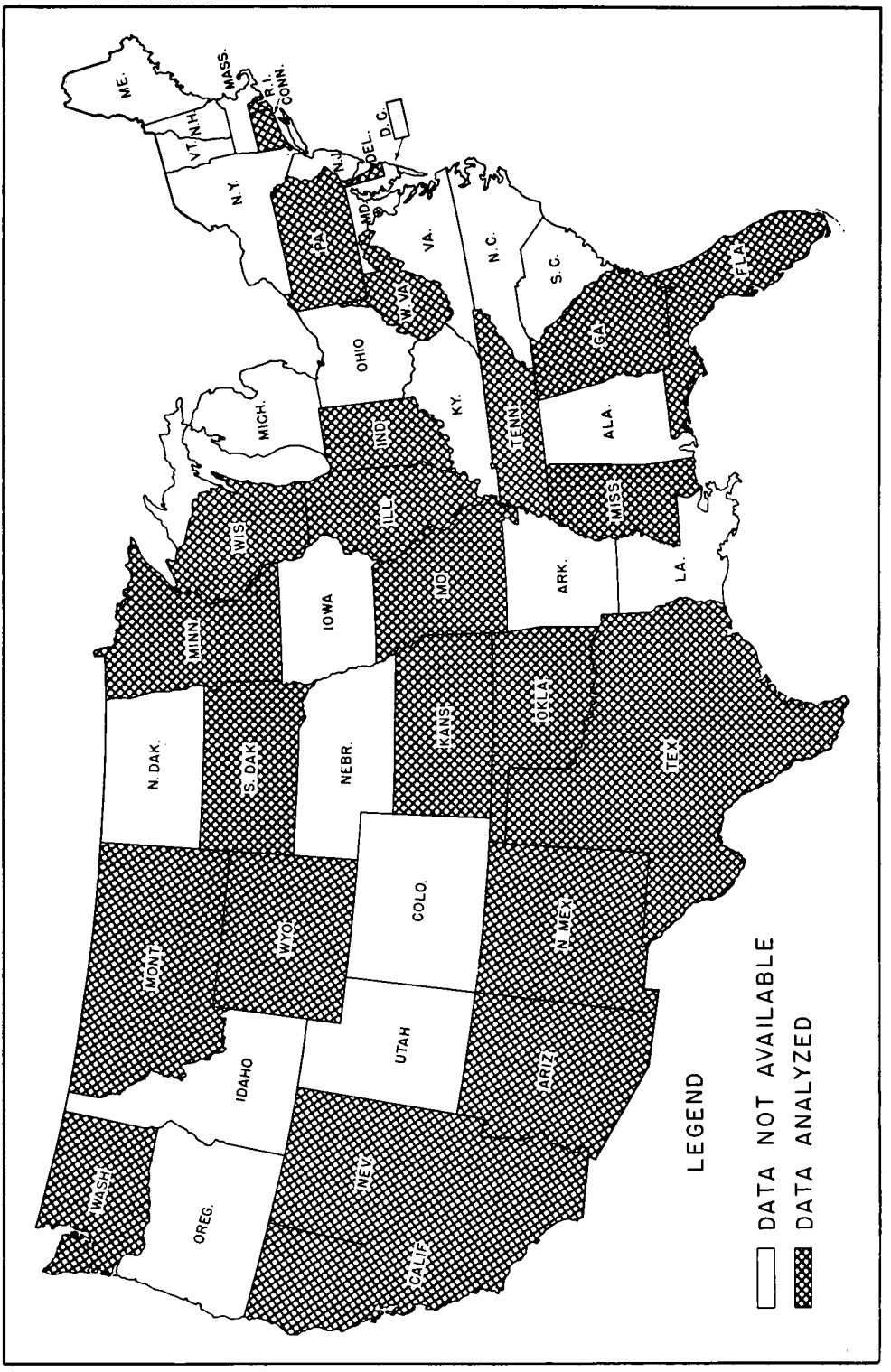

Figure 1. States for which road life mileage tables are included in this analysis.

which includes widening, is represented in the tabulations. The basic summaries cover the period from January 1, 1900 to January 1, 1953, and include:

1. Mileage constructed each year for each surface type (for 25 states and Puerto Rico).
2. Mileage of each year's construction of each surface type remaining in service on January 1, each year after construction (for 25 states and Puerto Rico).
3. Method of retirement (resurfaced, reconstructed, abandoned or transferred) for mileage of each surface type retired each year (24 states and Puerto Rico).

Data for Mississippi were not available for the summaries prepared in connection with item 3. Information for California is for federal-aid routes 1, 2, 3, 7, and 8 and for Montana for US 10 only.

There are eight major surface types for which individual service-life analyses were made:

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

Definitions of these surface types, used in all phases of the highway planning surveys in determining the general type classifications constructed in the individual states, will be found in the appendix. Definitions of the four methods of retirement will also be found in the appendix.

AVERAGE LIFE DEFINED

The average service life of a road surface is the average period of time after construction that the surface remains in service prior to being replaced, resurfaced, reconstructed, or otherwise taken out of service for any reason or by any method. Stated in another manner, it is that period of time after construction during which the only operations performed on the road surface are those of maintenance as practiced by the various states. It is a recognized fact, however, that a significant amount of construction work is done by maintenance funds in many states. This is particularly true in the low and intermediate types. In recording 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 particular accounting practices in effect in a given state. The 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 meeting of the Subcommittee on Uniform Accounting of the American Association of State Highway Officials.[1]

ANALYSIS PROCEDURES

Survivor curve analysis procedures employed in this report are substantially the same as those discussed at some length in the 1940 report. Reference should be made to this earlier report for an explanation of the mechanics of computing average service life. In the 1940 report, a single analysis was made of combined data for all the states while in the 1948 report and in the present report, individual analyses were made for each state and the results combined by weighting. The two procedures will yield the same results, however. One of the advantages of analyzing the data by individual states is that results are retained for each state and are available for use in further state studies.

The average life data included in this report represent estimates based on actual experience. During the years of construction covered in this report there have been changes in construction methods and design standards. There have been periods of accelerated activity and periods when little or no construction was accomplished. Some roads have been kept in service too long while others have been rebuilt before the end of their useful life. Maintenance has frequently been inadequate. There have been instances of over-design and under-design. Throughout the past 35 years, nevertheless, there have been sustained improvements in the standards of highway design, construction, maintenance, and administration. Each of these has its influence upon service life, but individual effects cannot be evaluated with certainty. As a result of improvements which are continuously being made in design standards, for example, such factors as excessive

[1] Copies of this tentative draft were transmitted to all state highway departments under date of June 2, 1938 by the Subcommittee on Uniform Accounting, American Association of State Highway Officials.

grades, sharp curves, narrow roadway widths, and restricted sight distances formerly contributing to early obsolescence or structural failure are gradually being reduced to a minimum, or even eliminated.

Reference was made in the 1948 report to the large backlog of needed replacements of highway facilities which accumulated during World War II. An adjustment was made in analysis procedures on the assumption that there would be a somewhat higher than average rate of retirement for about 10 years after the war. The actual experience shows that for the first seven years of the 10-year period, replacement rates have not been quite as high as predicted. However, state highway needs studies which are under way or have been completed show that deficiencies exist in amounts sufficient to warrant continuation of this assumption. In fact, if the accumulated deficiencies in the highway plant are to be overcome at the rates recommended in some of these long-range studies, it is likely that the probable remaining service lives may, in some instances, prove to be somewhat less than indicated by the data presented in this report.

FACTORS INFLUENCING RESULTS

In actual practice only a small percentage of road sections have a life exactly equal to the average. Thus, when there is need for an estimate of service life for a particular road section, it is necessary to consider such factors as age, structural condition, design features, location, and traffic usage which reflect conditions peculiar to that section. Only by the exercise of expert engineering judgment in the evaluation of these factors is it possible to arrive at an estimate of the remaining service life for a particular road section.

There are many factors that have impact on construction practice and in turn influence the trend of age of road surfaces and of expected service. These include administrative policy, availability of materials and manpower, change or influence of politics, increased activity due to state legislative action, construction activity in neighboring states and in other fields of construction, civil defense activity, and any unusual or extended nationwide highway program.

Limitations in a study such as this are understandable as data were submitted by 26 different reporting units. Each has slightly differing practices with respect to constructing and maintaining roads and in reporting of data. These, in addition to those factors mentioned above, tend to have their influence on service lives, age and expectancy, methods of retirement, etc. Even with these limitations, the findings are useful. Comparisons can be made, and the range of speculation as to trends or unusual changes with respect to road surface lives can be narrowed.

MILEAGE IN SERVICE

In Table 1 is listed for each surface type, by 5-year construction periods, the mileage constructed during each period and the mileage remaining in service on January 1, 1953. Approximately 42 percent of the surfaced mileage on the primary rural state highway systems of the United States is represented by these data. The proportions of each surface type included in this study are as follows:

	Percent
Soil surfaced	5
Gravel or stone	20
Bituminous surface treated	36
Mixed bituminous	43
Bituminous penetration	37
Bituminous concrete	50
Portland cement concrete	58
Brick or block	48
Average, all types	42

There are some mileages, particularly of the lower types, for which the dates of retirement are known but for which the dates of initial construction were not available. This results primarily from the difficulty in locating records of early construction. The partial data in those cases are not included in the analysis.

The probable average service lives for each surface type are shown in Table 2, for 5-year construction periods. Estimates of average lives are given in this table for all constructed mileages reported. Because of the smaller mileages involved, the retirement trends for earlier construction are frequently more erratic than the trends for the larger mileages of more recent construction. The average life estimates for this earlier construction are more reliable, however, because of the greater experience.

TABLE 1
MILEAGES CONSTRUCTED AND MILEAGES REMAINING IN SERVICE ON JANUARY 1, 1953, FOR EACH SURFACE TYPE*

Construction-year Grouping	Soil Surfaced		Gravel or Stone		Bituminous Surface Treated		Mixed Bituminous	
	Miles constructed	Miles remaining in service	Miles constructed	Miles remaining in service	Miles constructed	Miles remaining in service	Miles constructed	Miles remaining in service
1920 and prior	488.1	6.2	10,713.6	11.5	2,864.4	596.0	64.0	6.9
1921–25	1,165.9	5.5	22,493.4	421.5	3,665.1	896.8	317.7	43.2
1926–30	712.6	—	24,048.3	1,360.7	8,662.1	2,464.1	6,015.9	908.4
1931–35	1,307.3	33.2	17,912.8	1,433.3	11,056.7	2,982.0	20,540.3	6,450.0
1936–40	1,325.4	52.9	10,136.2	804.9	12,945.1	5,695.9	17,157.0	9,498.1
1941–45	448.0	18.1	4,688.4	730.8	7,682.7	4,616.9	7,917.5	5,129.1
1946–50	276.0	25.6	5,716.8	1,537.8	10,623.5	9,072.5	13,882.1	12,203.4
1951–52	74.4	45.7	1,940.5	1,375.9	4,193.9	4,078.6	6,394.8	6,302.1
Total	5,797.7	187.2	97,650.0	7,676.4	61,693.5	30,402.8	72,289.3	40,541.2

Construction-year Grouping	Bituminous Penetration		Bituminous Concrete		Portland Cement Concrete		Brick or Block	
	Miles constructed	Miles remaining in service	Miles constructed	Miles remaining in service	Miles constructed	Miles remaining in service	Miles constructed	Miles remaining in service
1920 and prior	533.9	118.5	814.7	115.5	2,826.1	489.6	728.5	87.3
1921–25	2,454.8	517.8	1,510.6	295.9	12,169.1	5,119.9	598.1	59.1
1926–30	2,251.6	663.2	2,035.9	444.3	16,909.5	11,425.9	183.0	46.5
1931–35	3,366 9	1,864.2	2,011.5	790.5	12,938.0	10,691.3	183.8	54.9
1936–40	2,726 2	2,142.9	4,256.9	2,574.7	6,962.5	6,114.5	49.6	27.5
1941–45	1,967.6	1,516.5	4,543.6	3,537.0	2,489.5	2,299.5	14.5	7.9
1946–50	959.6	815.3	10,081.8	9,685.3	2,982.0	2,963.4	6.1	1.7
1951–52	300.9	296.4	6,639.0	6,622.9	1,180.0	1,168.1	1.4	1.4
Total	14,561.5	7,934.8	31,894.0	24,066.1	58,456.7	40,272.2	1,765.0	286.3

* Compiled from data submitted by 25 states and Puerto Rico for rural state or federal-aid primary systems.

COMPARISON OF THREE STUDIES

There are certain differences in the average lives presented in the 1940 report, the 1948 report, and the present report. Table 3 shows a comparison of the average lives for various types for the most recent 5-year periods for which data were listed in the 1940 report. No particular significance should be attributed to the differences in average lives shown in Table 3. Variations in average lives of this magnitude

TABLE 2
WEIGHTED PROBABLE AVERAGE SERVICE LIVES FOR VARIOUS CONSTRUCTION YEAR PERIODS FOR EACH SURFACE TYPE*

Construction-year Period	Soil Surfaced	Gravel or Stone	Bituminous Surface Treated	Mixed Bituminous	Bituminous Penetration	Bituminous Concrete	Portland Cement Concrete	Brick or Block
	years	*years*	*years*	*years*	*years*	*years*	*years*	*years*
1905 and prior	—	15.6	34.1	—	26.4	23.5	—	40.0
1906–10	10.5	9.2	38.8	—	24.7	27.8	41.3	25.1
1911–15	5.6	15.3	19.5	16.4	24.7	21.8	18.4	21.0
1916–20	12.7	11.5	19.0	18.4	17.9	19.8	23.3	20.7
1921–25	9.1	10.0	19.1	14.2	19.0	20.3	27.0	19.6
1926–30	6.0	8.8	16.1	12.5	18.5	17.8	26.8	20.5
1931–35	4.0	7.5	11.7	13.3	18.8	16.4	25.7	16.8
1936–40	3.2	5.6	12.0	14.7	19.6	16.1	23.1	15.6
1941–45	2.3	5.6	11.1	12.2	15.4	*14.1*	*21.1*	*10.5*†
1946–50	1.5	3.1	9.5	*11.7*	*12.0*	*16.8*	*24.0*	—
1951 & 52	2.1	2.8	*9.3*	*13.0*	*14.7*	*17.5*	*24.3*	—
Average	5.2	8.3	12.6	13.1	18.0	16.8	25.5	19.9

* Based on analysis of data submitted by 25 states and Puerto Rico for rural state or federal-aid primary systems. Average lives shown in this table are to the nearest 0.1 year, but they should not be presumed accurate to this extent. The averages would be affected by excluding certain states or by including additional states.

† Entries in Roman type represent averages obtained from an analysis of construction and retirements where the mileages involved were sufficient to give a supportable estimate. The entries in italic type represent composite averages developed from the projection of trends for each state.

TABLE 3
COMPARISON OF AVERAGE LIVES PRESENTED IN THE 1940 AND 1948 REPORT WITH THOSE LISTED IN THE PRESENT REPORT

Surface Type	Comparison Period*	1940 Report (26 States)		1948 Report (16 States)		Present Report (25 States and Puerto Rico)	
		Miles constructed	Average life	Miles constructed	Average life	Miles constructed	Average life
		miles	*years*	*miles*	*years*	*miles*	*years*
Soil surfaced	1931–35	2,542†	5.4†	668	4.5	1,307	4.0
Gravel or stone	1931–35	22,793	6.0	18,999	5.9	17,913	7.5
Bituminous surface treated	1931–35	10,286†	11.4†	9,301	7.4‡	11,056	11.7
Mixed bituminous	1926–30	5,610	14.3	5,801	12.3	6,016	12.5
Bituminous penetration	1926–30	3,725	17.0	1,851	16.0	2,252	18.5
Bituminous concrete	1921–25	2,362	17.9	822	18.1	1,511	20.3
Portland cement concrete	1921–25	6,737	24.4	8,855	26.1	12,169	27.0
Brick or block	1921–25	980	18.2	331	20.2	598	19.6

* The most recent period for which data were presented in Table 18 in the 1940 report.
† 1931 to 1934.
‡ Wisconsin data had a great influence on the average life for miles constructed in the 16 states. If Wisconsin data were excluded, the average life would be 10.2 years.

are not uncommon when the analyses are based upon different groupings and numbers of states. Further, unusual construction practices in one state may have considerable effect upon the average for a group of states.

There are nine states included in the present report that are likewise included in the 1940 report and the 1948 report. Based upon average lives developed in these two earlier studies, the 1940 report shows that of the mileage of all types in service on January 1, 1937, only 5 percent would probably still be in service on January 1, 1953; the actual amount was 8 percent. Similarly the 1948 report shows that of the mileage of all road types in service on January 1, 1946, 32 percent would probably still be in service on January 1, 1953; the actual amount was 34 percent. There are, of course, greater variations within the individual surface types, but in total the results of these forecasts are sufficiently in agreement with actuality as to warrant considerable confidence in the analysis procedures and the average lives developed. Any differences from actuality can be readily explained. In the case of the 1940 report, the influence of the World War II period could not be anticipated; and in the case of both the 1940 and 1948 reports there was no expectation that many surfaces would be kept in service beyond their normal life even though subjected, in most cases, to greater wear than in any previous period. In the 1948 report, it was assumed that the backlog of deferred work during the war would be overcome and normal trend resumed within a maximum of 10 years after the war and corresponding adjustments of the service life computations were made. This assumption is proving correct although a somewhat longer period than 10 years for the "catch-up" should have been used.

CLASSIFICATION BY RETIREMENT METHOD

In all but one of the states included in the average life analysis, the retired mileages for various years were reported and classified in accordance with the method by which the retirement was made. The total mileage involved was 183,976.

The methods of retirement into which these mileages were classified are (1) resurfaced, (2) reconstructed, (3) abandoned, and (4) transferred. These retirement classifications are general in character and should be so interpreted. Definitions will be found in the appendix.

Reversion in type, in which a surface reverts to a lower type through lack of adequate maintenance, also represents a distinct method of retirement. No retirements of this classification were reported in these data.

In Table 4 are shown the total mileages retired and the percentage distribution by methods of retirement. With the exception of soil-surfaced, and brick or block, more than half of all the retirements have been by resurfacing.

Table 5 shows the percentage distribution of miles retired by various methods for 5-year periods. Since the war there has been a downward trend in resurfacing and an upward trend in reconstruction.

TABLE 4
RETIRED MILEAGES FOR EACH SURFACE TYPE, AND PERCENTAGE DISTRIBUTION ACCORDING TO METHOD OF RETIREMENT (TOTAL FOR 1952 AND PRIOR)*

Surface Type	Total Retired	Methods of Retirement				
		Resurfaced	Reconstructed	Abandoned	Transferred	Total
	miles	*percent*	*percent*	*percent*	*percent*	*percent*
Soil surfaced	5,644.1	37.5	58.1	1.2	3.2	100.0
Gravel or stone	84,051.5	58.0	30.4	2.5	9.1	100.0
Bituminous surface treated	30,518.0	53.3	36.7	2.6	7.4	100.0
Mixed bituminous	30,821.8	57.1	29.8	3.8	9.3	100.0
Bituminous penetration	6,559.0	51.8	31.4	3.6	13.2	100.0
Bituminous concrete	7,485.8	60.9	26.0	2.4	10.7	100.0
Portland cement concrete	17,427.3	66.4	21.3	2.1	10.2	100.0
Brick or block	1,468.1	45.3	44.1	1.3	9.3	100.0
Total	183,975.6	57.0	31.3	2.7	9.0	100.0

* Computed from data submitted by 24 states and Puerto Rico for rural state or federal-aid primary systems.

TABLE 5
PERCENTAGE RETIRED BY VARIOUS METHODS FOR ALL SURFACE TYPES COMBINED FOR VARIOUS PERIODS*

Method of Retirement	Retirement Period								
	1920 and prior	1921–25	1926–30	1931–35	1936–40	1941–45	1946–50	1951 and 1952	Total 1952 and prior
	percent	*percent*	*percent*	*percent*	*percent*	*percent*	*percent*	*percent*	*percent*
Resurfaced	63.5	45.3	53.0	59.7	55.5	59.5	58.6	54.1	57.0
Reconstructed	35.7	49.0	34.9	26.6	30.9	28.8	31.5	36.4	31.3
Abandoned	0.4	0.6	2.3	3.8	3.4	2.7	2.0	1.6	2.7
Transferred	0.4	5.1	9.8	9.9	10.2	9.0	7.9	7.9	9.0
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

* Computed from data submitted by 24 states and Puerto Rico for rural state or federal-aid primary systems.

ANALYSIS BY MAJOR TYPE GROUPS

Figures 2, 3, and 4 show, in graphical form, some of the results of the analyses presented in the preceding pages. For purposes of simplifying these charts, the surface types have been combined into three major groups—low, intermediate, and high—as follows:

Low Type

Includes soil-surfaced and gravel or stone roads.

Intermediate Type

Includes bituminous surface-treated, mixed bituminous (thickness of surface and base less than 7 inches), and bituminous penetration (thickness of surface and base less than 7 inches) roads.

High Type

Includes mixed bituminous (thickness of surface and base 7 inches or more), bituminous penetration (thickness of surface and base 7 inches or more), bituminous concrete, portland cement concrete, and brick or block roads.

Accumulated mileages constructed and remaining in service on January 1, 1953 are shown by these groupings in Figure 2. These are graphic portrayals of the fact that construction programs must necessarily continue after mileage has been initially improved.

Estimates of service lives based upon actual retirement experience, were shown in Table 2. In general, the average lives for the more recent years were assumed to remain about the same or increase slightly in relation to the most recent years having retirement experience. These assumptions will no doubt vary somewhat from the actual future experience, but since the bulk of the retirements within the next few years will come from the older construction, any minor differences from the assumed average lives for the more recent construction will not have any major effect upon the over-all trends which are shown.

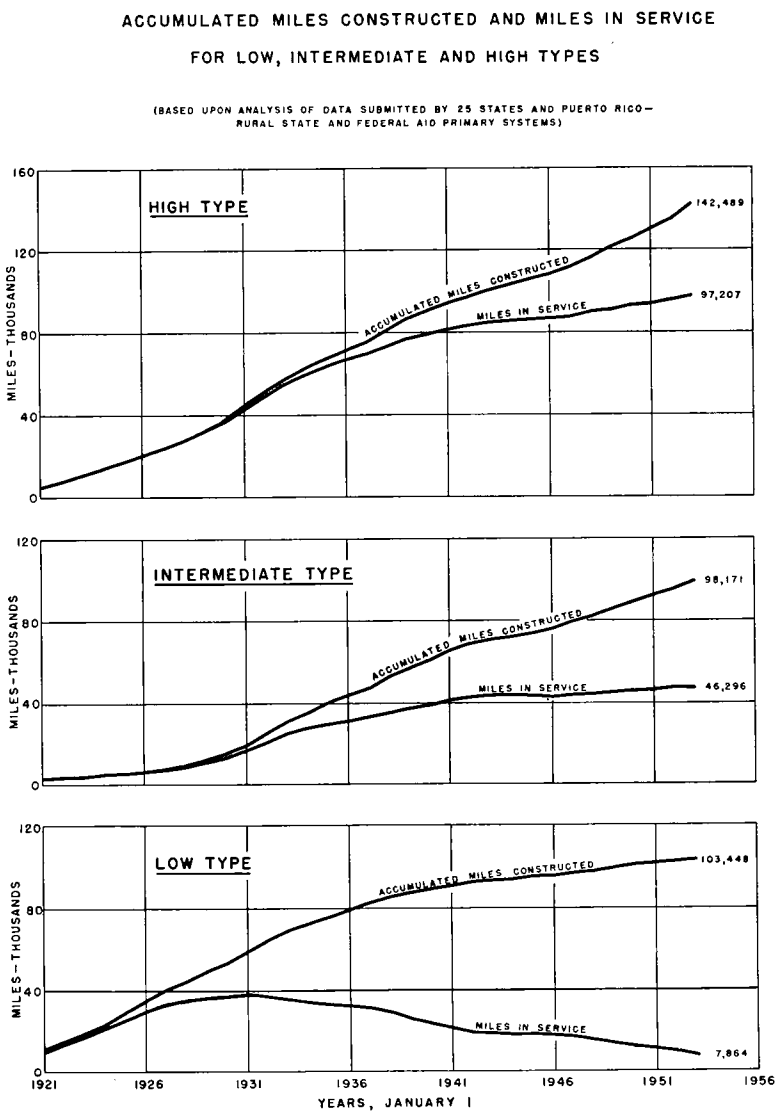

Figure 2. Accumulated miles constructed and miles in service for low, intermediate, and high types. (Based upon analysis of data submitted by 25 states and Puerto Rico; rural state and federal-aid primary systems.)

TRENDS IN SERVICE LIFE

Figure 3 shows, for each 5-year construction period, the mileages of low, intermediate, and high types in service up to January 1, 1953, for the 25 states and Puerto Rico included in this report, and the probable rates at which these mileages will go out of service. Table 6 shows the total mileages in service on January 1, 1953, and the probable amounts which will still remain in service for 5, 10, 15, and 20 years in the future.

Table 2 shows the probable average lives for various construction-year periods. The average lives are the expectancies at the time of construction or at age zero. As the road system develops and becomes older, the average age of the surface increases and the remaining life expectancy becomes less. Also,

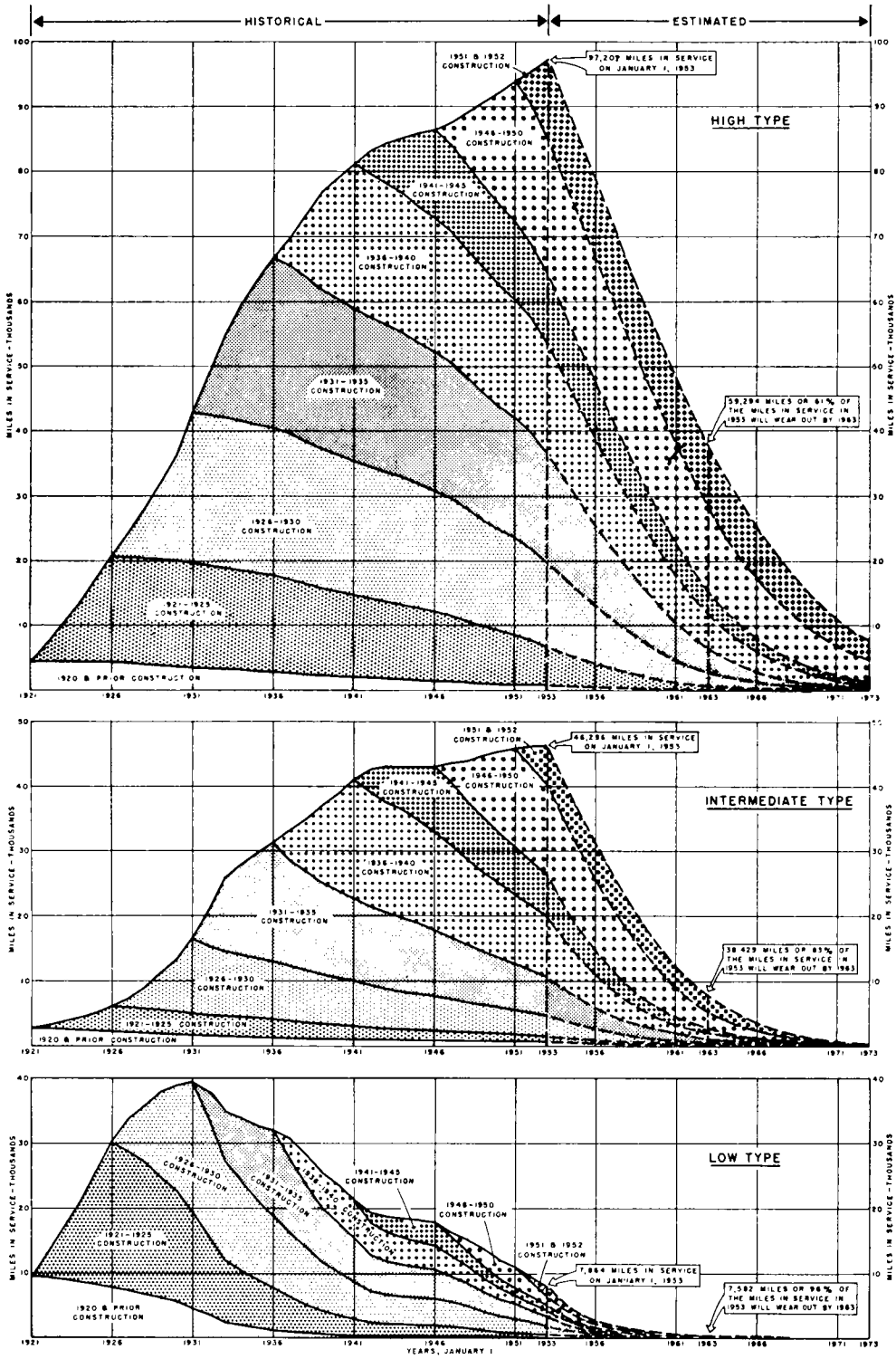

Figure 3. Seventy percent of the surface mileage on primary rural highways will wear out within the next 10 years. (Based upon analysis of data submitted by 25 states and Puerto Rico; rural state and federal-aid primary systems.)

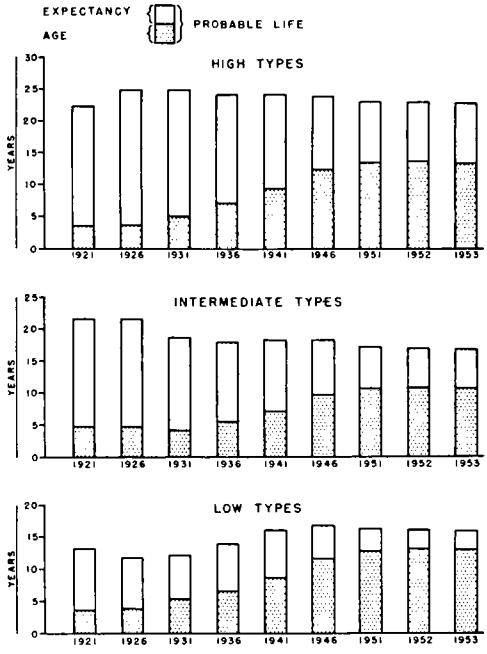

Figure 4. Trends in average age, expectancy, and probable life—1921 to 1953.

as the system becomes older, mileages of earlier retirements are taken out of service, thus leaving in service a preponderance of those mileages whose lives exceed the average life of the total original construction.

LIFE EXPECTANCY

The probable life of the mileage in service is equivalent to the age plus the expectancy. Under certain conditions it is possible for the average age of mileage in service to exceed the average lives shown in Table 2. This is true for low-type surfaced mileage, from which the miles in service have gradually been diminishing since 1931 (see Figure 3). Low types, when retired, tend to be replaced by intermediate or high types. Thus, there has not been sufficient construction of new low types to keep the average age of all low types in service from increasing from year to year. As a result, the low types now in service are quite old and have a short expectancy.

In Table 7 are shown the average age, remaining life expectancy, and total probable life of the mileages of low, intermediate, and high types in service, at 5-year intervals from January 1, 1921, to January 1, 1951, and a 2-year interval from January 1, 1952, and January 1, 1953. This information is also presented graphically in Figure 4, and shows increasing age and decreasing expectancy of mileages in service.

TABLE 6
MILEAGE IN SERVICE ON JANUARY 1, 1953, AND ESTIMATED PERCENTAGES WHICH WILL REMAIN IN VARIOUS FUTURE YEARS*

Surface Type	In Service on January 1, 1953	Remaining in Service on:			
		Jan. 1, 1958	Jan 1, 1963	Jan. 1, 1968	Jan. 1, 1973
	miles	*percent*	*percent*	*percent*	*percent*
Low	7,863.6	16.3	3.6	0.3	†
Intermediate	46,295.9	48.6	17.0	4.4	0.9
High	97,207.5	67.5	39.0	19.1	8.0
Total	151,367.0	59.0	30.4	13.7	5.4

* Based on analyses of data submitted by 25 states and Puerto Rico for rural state or federal-aid primary systems.
† Less than 0.05 percent.

TABLE 7
AVERAGE AGE, LIFE EXPECTANCY, AND PROBABLE LIFE OF MILEAGES IN SERVICE AT 5-YEAR INTERVALS*

Date: January 1,	Low			Intermediate			High		
	Age	Expectancy	Probable life	Age	Expectancy	Probable life	Age	Expectancy	Probable life
	years	*years*	*years*	*years*	*years*	*years*	*years*	*years*	*years*
1921	3.6	9.6	13.2	4.7	16.8	21.5	3.5	18.7	22.2
1926	3.8	7.9	11.7	4.7	16.8	21.5	3.5	21.3	24.8
1931	5.3	6.7	12.0	4.2	14.5	18.7	4.9	19.9	24.8
1936	6.6	7.2	13.8	5.5	12.3	17.8	7.0	17.0	24.0
1941	8.7	7.3	16.0	7.0	11.2	18.2	9.3	14.7	24.0
1946	11.7	5.0	16.7	9.7	8.5	18.2	12.3	11.4	23.7
1951	12.9	3.3	16.2	10.6	6.6	17.2	13.4	9.5	22.9
1952	13.1	2.9	16.0	10.8	6.1	16.9	13.6	9.2	22.8
1953	13.0	2.9	15.9	10.9	5.9	16.8	13.3	9.3	22.6

* Based on analyses of data submitted by 25 states and Puerto Rico for rural state or federal-aid primary systems.

The age of the three major type groups, as shown in Table 7 has been increasing from 1921 to 1951. Similarly the expectancy has been decreasing. Since 1951, there has been a leveling off which suggests that a period of stability has been reached. One means by which a more favorable condition with respect to expectancy can be obtained is by replacing worn out roads with new ones having a higher service life. This, of course, means greater construction expenditures to build the new roads to the higher standards necessary to obtain these higher lives.

ROAD-LIFE STUDIES ESSENTIAL

The data presented in this report relate only to the mileage of road surfaces constructed and retired. The road-life studies also embrace research in construction costs, maintenance costs, and salvage values for elements of the highway, including grading and structures. Knowledge on these subjects will be extended as additional states bring their basic studies up to date and as these studies are continued and extended. The objective of efficient and economical management of the highway program is to provide facilities at such locations and to such standards that they can absorb the inevitable and continuing changes in traffic requirements with the least effect upon the ability of the highway plant to provide the maximum service at minimum cost. The data obtained periodically from the road-life studies are among the essential facts that contribute to the attainment of this objective.

APPENDIX

Surface Type Definitions

Soil-surfaced road. A road of natural soil, the surface of which has been improved to provide more adequate traffic service by the addition of (1) a course of mixed soil having A-1 or A-2 characteristics, such as sand-clay, soft shale or topsoil, or (2) an admixture such as bituminous material, portland cement, calcium chloride, sodium chloride, or fine granular material (sand or similar material).

Gravel or stone road. A road the surface of which consists of gravel, broken stone, slag, chert, caliche, iron ore, shale, chat, disintegrated rock or granite, or other similar fragmental material (coarser than sand) with or without sand-clay, bituminous, chemical, or portland cement stabilizing admixture or light penetrations of oil or chemical to serve as a dust palliative.

Bituminous surface-treated road. An earth road, a soil-surfaced road, or a gravel or stone road to which has been added by any process a bituminous surface course, with or without a seal coat, the total compacted thickness of which is less than 1 inch. Seal coats include those known as chip seals, drag seals, plantmix seals, and rock-asphalt seals.

Mixed bituminous road. A road the surface 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.

Bituminous penetration road. A road the surface 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.

Bituminous concrete, sheet asphalt, or rock asphalt road. A road on which has been constructed a surface course 1 inch or more in compacted thickness consisting of bituminous concrete or sheet asphalt, prepared in accordance with precise specifications controlling gradation, proportions, and consistency of composition, or of rock asphalt. The surface course may consist of combinations of two or more layers, such as a bottom and a top course or a binder and a wearing course.

Portland cement concrete road. A road consisting of portland cement concrete with or without a bituminous wearing surface less than 1 inch in compacted thickness.

Brick[2] *or block road.* A road consisting of paving brick, stone block, wood block, asphalt block, or other form of block, with or without a bituminous wearing surface less than 1 inch in compacted thickness.

Methods of Retirement

Resurfacing. 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 re-working 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. For surfaces which are retired by this method, it is obvious that the new or replacement construction must necessarily be along the same alinement and practically the same grade.

[2] Vitrified paving-brick roads were reported by the states separately from other types of brick or block roads. Because of the small mileages involved, these two types are combined in this report. Approximately 99 percent of the construction of these two types included in the report is vitrified paving brick.

Reconstruction. When surfaces are retired by reconstruction, there is little or no salvage of the old surface and base into the new type constructed. 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 (generally within the limits of the existing right-of-way) involving only minor improvements in horizontal curvature. Substantial improvements are usually made with respect to grades, however.

Abandonment. When the new construction is on new location, the old road is classified as abandoned when it is no longer maintained or kept in service at public expense. The abandoned road may revert to a private road, be barricaded to public travel, or torn up and removed. Sometimes, because of changes in land usage, such as abandonment of factories, and removal or construction of railroad facilities, roads may be abandoned without involving new construction that may be considered as replacing the mileage abandoned.

Transfer. A retirement by transfer is similar to an abandonment except that the old road is continued in service after being dropped from the state or federal-aid system and is maintained by county or other authority responsible for the upkeep of the roads not on the state or federal-aid system. A transfer is not a retirement in the sense that the road has rendered its total service to the public, but merely that it has rendered its complete service as a primary 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 will no longer desire to continue responsibility for further upkeep of the old road, and the county or other local authority generally takes over this responsibility. If the road is entirely discontinued from service it is considered an abandonment.