Pavement Age and the Future Need for Road Reconstruction

Occasional Paper

Decisions on road reconstruction and rehabilitation are based on a combination of engineering, economic, financial and social considerations. Rigorous analysis in support of such decisions is necessarily extremely complex. At an aggregate level, however, it is clear that the possession of an asset (such as a road network) whose components are subject to deterioration and have finite lives imposes a maintenance requirement if the quality and value of the asset is to be preserved.

bureau of transport and communications economics

Occasional Paper 89

Pavement Age and the Future Need for Road Reconstruction

AUSTRALIAN GOVERNMENT PUBLISHING SERVICE, CANBERRA 1988

ISSN 0157-7085
ISBN 0 644 07390 X

Printed in Australia by Union Offset Co. Pty Ltd, Canberra

FOREWORD

Decisions on road reconstruction and rehabilitation are based on a combination of engineering, economic, financial and social considerations. Rigorous analysis in support of such decisions is necessarily extremely complex. At an aggregate level, however, it is clear that the possession of an asset (such as a road network) whose components are subject to deterioration and have finite lives imposes a maintenance requirement if the quality and value of the asset is to be preserved.

In this Paper, the scope for using the age of roads as an indicator of the aggregate need for reconstruction and rehabilitation is explored. The age distributions of Australia's rural road networks are estimated and the consequences for these age distributions, of alternative reconstruction strategies are examined.

The work was initiated by Dr G. W. King and was conducted by Mr T. G. Mikosza, assisted by Mr K. Lawson. The preparation of this Paper was overseen by Dr F. Poldy.

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January 1988

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SUMMARY

The decision to reconstruct or rehabilitate a section of road is based on a combination of engineering, economic, financial and social considerations and *not* on the age of the road. Nevertheless, for road networks as a whole, the agents of deterioration of the physical condition or level of service (weather and the passage and growth of traffic) are such that the age distribution of the roads *is* an indicator of the aggregate need for reconstruction and rehabilitation.

This Paper examines the evolution of the age distribution of the roads in the National Highway and rural arterial networks in each of the States and Territories. The 1985 age distributions were estimated from the best available data and a simple ageing model was then employed to determine the age distribution in the years 1990, 1995 and 2000 under a range of assumptions about the rates of reconstruction and rehabilitation.

The main results are (excluding ACT):

- the mean ages of the networks in 1985 were in the range 10 to 20 years;
- rates of reconstruction in 1985 ranged from 0.6 to 3.0 per cent of total network length;
- continuation of the 1985 rates of reconstruction would lead to mean network ages in 1995 in the range 16 to 27 years; and
- in all but two cases the 1985 rate of reconstruction would have to be at least doubled in order to maintain the current mean age.

These results alone do not lead to any necessary conclusions about the appropriateness of current (1985) rates of reconstruction. The increase in the mean age of the newer networks is likely to be entirely appropriate. However, the rate at which some of the older networks are ageing may well be a cause for concern.

CHAPTER 1 INTRODUCTION

The Australian network of sealed rural roads has been established largely since the Second World War with peak growth rates occurring during the early 1960s. As a consequence most of the network is still relatively new and has not, so far, imposed major burdens of reconstruction and rehabilitation. However, sealed roads have finite lives, of the order of 30 years, which leads to the expectation that current rates of reconstruction and rehabilitation may have to be dramatically increased if the assets represented by the road networks are to be maintained.

It is necessary, at the outset, to deal with a matter of terminology. In order to avoid repetition of the phrase 'reconstruction and rehabilitation', the single term 'reconstruction' will be used throughout this Paper. It is to be understood to include 'rehabilitation' and to refer to the process by which roads are restored to (at least) their original, new condition, but possibly including some degree of improvement over that condition (by way of widening, realignment or pavement strengthening).

In this Paper the future requirements for road reconstruction are examined using road ages as the sole indicator of the need for reconstruction. A road network is assumed to be characterised by the age distribution of its roads. If no reconstruction (or new construction) is undertaken the distribution simply shifts, the shift corresponding with the increasing age of the road network. If a program of road reconstruction is undertaken, it will generally be found that the older roads are those most in need of attention. In a given year, the effect on the age distribution is that, while the unreconstructed roads become a year older the reconstructed roads have their age effectively reduced to zero. Depending upon the annual rate of reconstruction the average age of the road network would remain unchanged, reduce or increase.

A simple model of road ageing has been developed and is described in Chapter 2. The model follows the changing age distribution of the

roads in a network as it evolves under the influence of new construction and alternative reconstruction programs. The model can be used to examine the consequences of current reconstruction programs for a network's age distribution in the future. Alternatively, the reconstruction program necessary to achieve desired age characteristics may be determined.

AGE AS AN INDICATOR OF ROAD QUALITY

There is a certain inevitability about age and time which places some aspects of the model described in Chapter 2 beyond question. Given adequate data on the initial age distribution (not a trivial requirement), the future distribution follows automatically from the assumed construction and reconstruction programs. What is much more open to question is the adequacy of age as an indicator of the need for reconstruction.

The very notion of a 'need for reconstruction' begs a number of questions. Ideally, proposals for road reconstruction (or for any other project) would be evaluated in a benefit-cost framework, both to ensure that the costs of the projects do not exceed their benefits and to enable them to be compared with alternative competing projects. In practice, it is not usually feasible (or perhaps even desirable) to conduct lengthy analyses to justify routine road-works and the need for reconstruction is generally determined by comparing road conditions with more or less formally specified 'standards' for such measures as roughness, alignment and level of service. Such standards constitute, at any time, the norm for roads of a certain type. They are arrived at by a process which takes some account of economic efficiency, but which also owes a lot to evolving social and political expectations.

It is not the purpose of this Paper to enquire into the origin or justification of these standards. It is sufficient to note their existence and that they play a part in determining the need for reconstruction. Whether the roads 'in need of reconstruction' are actually reconstructed is, of course, another question which depends on the availability of funds.

If the reconstruction decision is based on a comparison of road conditions with a set of standards, the question for this work becomes: to what extent can age be used as an indicator of road condition and hence of the need for reconstruction?

The question is an empirical one, to be answered by an examination of the distribution of the ages of roads at reconstruction. If age were

largely irrelevant to the condition of roads and the need for reconstruction one would expect the distribution to be approximately uniform. On the other hand, if age were a significant explanatory variable, one would expect the distribution to be more or less sharply peaked. The distribution would fall away for lesser ages because of the decreasing need to reconstruct younger roads, and for greater ages because of the decreasing lengths of road reaching the higher ages without being reconstructed.

Unfortunately, reliable data on the ages of roads at reconstruction do not appear to be available. However, anecdotal evidence strongly suggests that the distribution approximates a broad triangle with a peak (the most probable age at reconstruction) in the range 25 to 35 years and the large majority of roads occupying the range 15 to 45 years (which is not to say that reconstruction outside this range is unknown). This supports the premise of this work that age is relevant to the need for reconstruction. Further support is provided by a consideration of the concept of the 'design life' of a road which is embodied in the road construction process itself.

The design life of a road

Roads are not designed to last for ever. Forecasts of the type and volume of traffic are taken into account, and roads are designed to provide at least adequate service for a specified period, designated as the design life - typically 15 to 20 years. Implicit in this concept is the idea that, as the current and cumulative effects of traffic increase, there will be a steady decline in the measures of road quality but that these will not fall below predetermined levels (the standards) during the design life.

In practice, of course, forecasts of traffic growth and rates of deterioration are subject to large errors and, as has been noted, the setting of the standards may be somewhat arbitrary. The result is that the actual lives of roads cover a wide range, from as little as one-quarter to three or four times the design life. Nevertheless, the concept does embody the important idea that roads deteriorate and will eventually require reconstruction. In order to understand the time dependence of this process it is instructive to note how the separate measures of road quality are incorporated in the design life.

Roughness and road maintenance

Roughness is the surface manifestation of deterioration in pavement structure. Up to a point, increasing roughness may be made good by maintenance measures short of reconstruction but, as damage to the pavement structure accumulates with the passage of traffic, continued

reliance on these lesser measures becomes increasingly costly. The decision to reconstruct is, therefore, based partly on the increasing roughness of the road and partly on the increasing cost of containing this roughness.

The time scale for the process is set by the choice of the design life. The direct cause of structural damage to pavements is the passage of loaded axles. Forecasts of traffic growth, coupled with the appropriate weighting for axle load allow the cumulative impact of traffic over the life of the road to be estimated and the road is designed to withstand this impact.

Alignment
Road alignments determine safe maximum speeds. Unlike roughness, alignments do not change during the life of the road but their adequacy in relation to vehicle performance and driver expectations might well change. To some extent these factors can be foreseen and alignments are provided on the expectation that they will remain adequate for the design life of the road.

Level of service (width)
Much of the same can be said about level of service. The underlying physical characteristic of the road, the width, does not change, but the level of service provided declines with increasing traffic volume. Road widths are, therefore, set to provide an adequate level of service throughout the design life of the road.

This account of the design life of a road is enormously simplified. For the purposes of the work reported in this Paper, two points should be noted. First, the notion of a steady decline in the adequacy of a road towards a state where reconstruction may be required is central to the road design process. Second, the design life is set conservatively. Therefore, it would be expected to correspond approximately with the minimum age of the age at reconstruction distribution. This distribution and its relation to the design life is discussed in greater detail in Chapter 2.

SCOPE AND DEFINITIONS

Road networks

The analysis is based primarily on the Commonwealth road classification of National Highways and rural arterials. The National Highways and rural arterials correspond to the functional classification of primary and secondary rural arterials respectively. Strict adherence to this classification would have made possible a

consistent nationwide presentation of the results. Unfortunately, in New South Wales and Victoria, data under the Commonwealth classification were not available and so, in these States, the analysis was based on State road classifications. The details are discussed in Chapters 3 and 4.

Definitions and data

Initially, it was expected that most of the data for the study would be obtained from the National Association of Australian State Road Authorities (NAASRA) data base. Unfortunately this was found to have large gaps in its data on pavement ages. Other sources were then investigated, including State Road Authorities' (SRA) annual reports, information from SRA studies and SRA planning branch inventory information. These sources were often used in conjunction and, where possible, compared to validate data.

In the case of Queensland, no adequate road age data were available. In the interests of completeness, therefore, an attempt was made to estimate road age distributions from pavement roughness data using NAASRA roughness-age relationships (National Association of Australian State Road Authorities 1982). The procedure cannot be considered satisfactory, but is interesting because the distortions it introduces lend support to the use of road age as an indicator of the need for reconstruction.

Every effort has been made to ensure a consistent presentation of reconstruction data among the States but, as the study has had to rely on SRA definitions going back over a period of 40 years, there can be no guarantee that this has been achieved. Early data on road lengths obtained from SRA Reports and State Year Books reflect each State's road classification system and any reclassifications which have occurred over time.

The classification of roadworks as maintenance or reconstruction is often unclear. A profusion of terms is used in different ways according to State and circumstance. For the purposes of this study, reconstruction involves the complete rebuilding of the structure of a sealed road, including the surface and base materials. It resets the age of the road to zero and, apart from any design changes, leaves the road in as good a condition as when newly constructed.

The terms 'new construction' and 'initial sealing' are used synonymously to describe additions to the sealed road network. In almost all cases such additions are not new links where there were previously no roads, but rather involve the sealing of previously

unsealed roads (possibly with extensive realignment). It is assumed that any such initial sealing is accompanied by the (re)construction of the pavement to the new standards appropriate to the sealed road.

STRUCTURE OF THIS PAPER

The simple road ageing model used for this analysis is described in Chapter 2. Chapters 3 to 10 deal with the ageing characteristics of road networks by each State and Territory. Chapter 11 examines the complete National Highway system. Chapter 12 provides a summary and discussion of the results.

CHAPTER 2 ROAD AGEING MODEL

This chapter describes a simple model of the ageing of a road network under the influence of new construction (extending the network) and reconstruction of older roads.

The age of a length of road is measured in years, from initial construction or from the most recent reconstruction.

The age distribution of the roads in the network in year t is described by $a_i(t)$, the length of road of age i. Each year a length n(t) of new road is added to the network and a length $r_i(t)$ of road of age i is reconstructed. The total length of road reconstructed in year t is

$$R(t) = \sum_{i=1}^{N} r_i(t)$$

where N is the age of the oldest road.

The age distribution in the following year, t+1, is given by the equations

$$a_{i+1}(t+1) = a_i(t) - r_i(t)$$

$$a_1(t+1) = n(t) + R(t)$$

Repeated application of these equations describes the changing age distribution of the network.

It will occasionally be convenient to express reconstruction as a proportion of the total length, A(t), of the network. The reconstruction rate p(t) is given by

$$p(t) = R(t)/A(t)$$

where

$$A(t) = \sum_{i=1}^{N} a_i(t)$$

RECONSTRUCTION STRATEGIES

The variables R(t) and the associated distribution $r_i(t)$ determine the allocation of reconstruction funds to roads of different ages. Note that it is *not* being claimed that there is a strategy to reconstruct roads according to their ages. As discussed in Chapter 1, the decision to reconstruct a section of road is based on its condition in relation to the traffic it carries. The distribution $r_i(t)$ is determined after the event, by observing the ages of the roads which actually were reconstructed. However, as was noted in Chapter 1, it has not been possible to determine this distribution empirically. There are, nevertheless, plausible reasons for believing it to be triangular.

In the model, $r_i(t)$ is determined through the interaction of R(t) with the age distribution, $a_i(t)$, of the roads. One further parameter is required, i_{min}, the minimum age for reconstruction. It is assumed that roads younger than i_{min} are not reconstructed. At and above i_{min} there is assumed to be a 'propensity' to reconstruct roads which increases linearly with age. The rate of increase is determined by the requirement that the total length of road reconstructed be R(t) kilometres.

This is illustrated in Figure 2.1. O'A'B'C represents the age distribution of the roads in a particular year. C is at the age of the oldest road and A is at the minimum age for reconstruction, i_{min}. Only roads with ages between A and C will be reconstructed, the actual shape of the age distribution being obtained by increasing the slope of the line AR until the shaded area AB'C is equal to R(t). The lines AR' and AR" show the age distributions of roads to be reconstructed for successively higher values of R(t). If the line AR becomes vertical before the area AB'C = R(t), that is, if the total road length older than (or equal to) i_{min} is less than R(t), then the model simply reconstructs R(t) of the oldest roads.

With the reconstruction of R(t) kilometres of roads the distribution of remaining roads older than i_{min} falls to the broken line A'B. The reconstructed roads appear in the following year at the left of the distribution with ages under one year and the rest of the distribution moves one year to the right.

The roughly triangular shape of the age at reconstruction distribution AB'C is as expected. The maximum age at C is determined by the age distribution $a_i(t)$, and the peak at B' is determined by $a_i(t)$ and the amount of reconstruction R(t). Only A, the minimum age for reconstruction is relatively fixed. Without putting too much weight

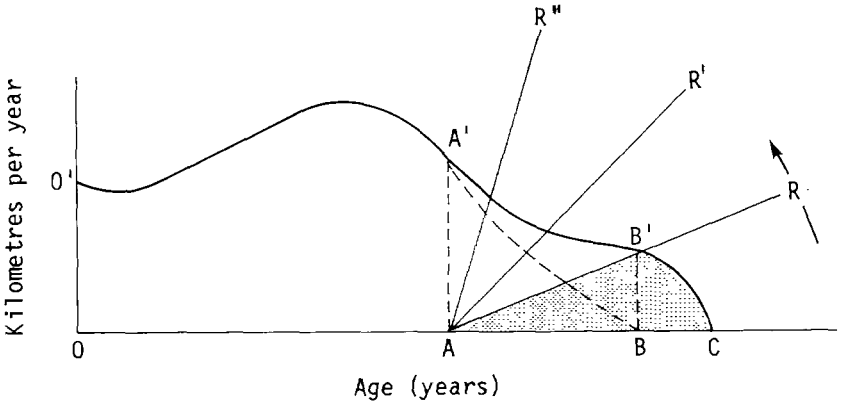


Figure 2.1 Age at reconstruction distribution

on its significance, it may be thought of as approximately the design life of the roads in the network.

THE STEADY STATE

None of the road networks analysed in this work are in a steady state, nor are any of them ever likely to be. Nevertheless, it is worth reviewing the nature and approach to the steady state as an aid to interpreting the results in the following chapters and to understanding the implications of different reconstruction strategies.

Consider a road network of fixed total length A (no new construction). For simplicity, assume a constant strategy which results in the reconstruction of a length R of the oldest roads each year.

Figure 2.2 shows the age distribution of the roads in the first three years of the strategy. In each year a length R of roads is moved from the high to the low end of the age distribution. After A/R years all roads will have been reconstructed and the age distribution will be flat from zero to A/R years and the average age of the roads will be A/2R. From then on, there will be no further change to the shape of the age distribution - and the system will be said to be in a steady state.

Note that A/R is the reciprocal of the reconstruction rate p.

If the reconstruction strategy results, as is more likely, in an increasing propensity to reconstruct roads older than i_{min} the steady state age distribution is essentially the same except that it does not

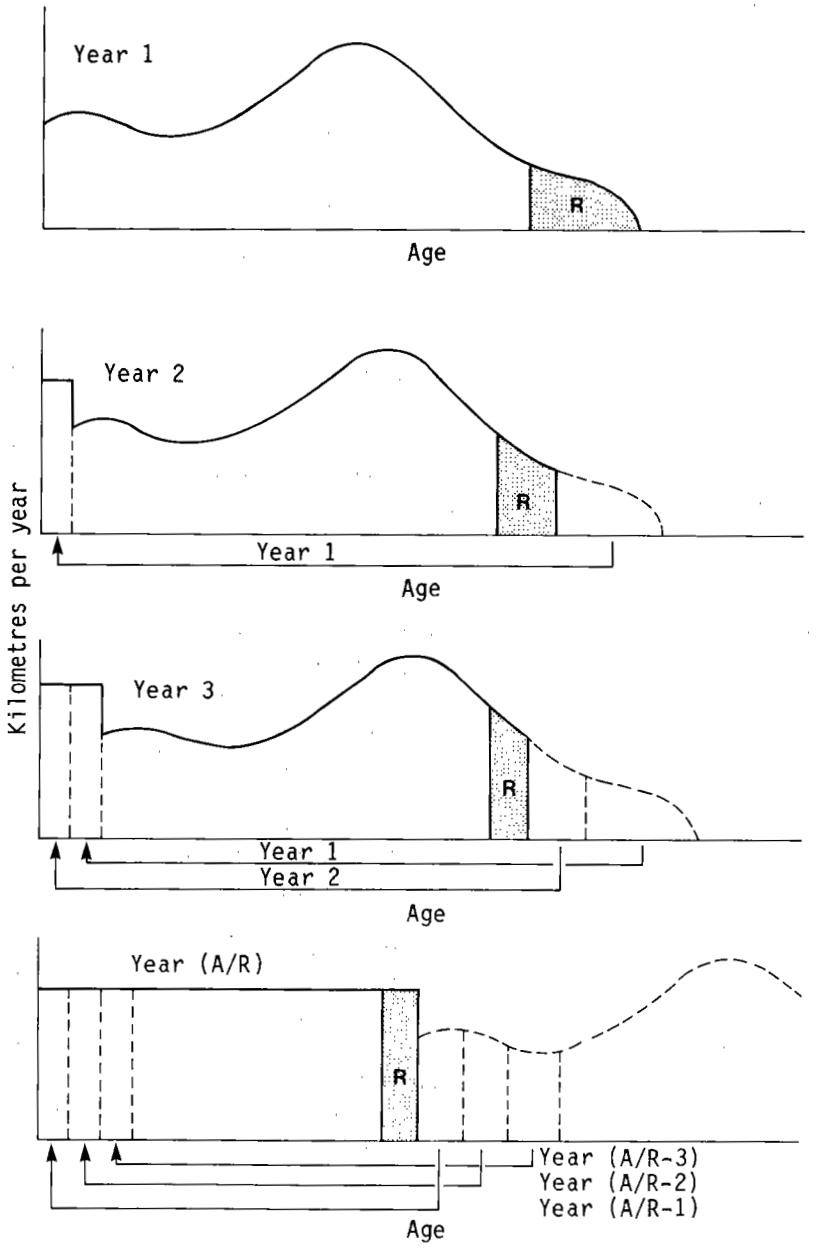


Figure 2.2 Road age distribution: approach to steady state

end abruptly at A/R but falls off more gradually from age i_{min} to a maximum age of $\frac{1}{2}(3A/R-i_{min})$.

STANDARD ANALYSIS

The object of the analysis in this Paper is to determine the implications for road ageing of the current and alternative reconstruction programs. The starting point for the standard analysis for each road network was the age distribution of its roads in a base year (1985 in most cases). The ageing model was then used to obtain projections of the age distribution for the years 1990, 1995 and 2000 under varying assumptions about future rates of new construction and reconstruction. Rates of new construction for each network were held constant and based on immediate past rates and on any additional information from the State Road Authorities.

A number of alternative reconstruction rates were chosen to span the range between two rates of particular interest:

- the current reconstruction rate; and
- the reconstruction rate necessary to maintain the current average age for the network.

The interest in the latter reconstruction rate does *not*, of course, imply that maintaining the current average rate is necessarily a sensible policy.

The parameter i_{min}, the minimum age for reconstruction, was set to 15 years. Tests with a value of 20 years reduced the computed average ages by, at most, 0.5 years.

For each road network, the standard results are presented in two figures and a table. The figures show, respectively, the age distribution in the base year and the projected distribution for 1995 assuming a continuation of the current rate of reconstruction. The table gives summary information, including the average age for all the projected distributions.

The starting point of the standard analysis was the 1985 age distribution - which was not always available. In such cases an estimate of the distribution was made using whatever data were available and making whatever assumptions were necessary. In two cases (New South Wales and Victoria), the distribution was obtained with the aid of the model itself. Roughness data were used to obtain the Queensland distribution. A history of road widening complicated

the interpretation in Victoria and Western Australia. In every case the standard analysis was undertaken using the best available base year age distribution and any special features of its derivation are described.

CHAPTER 3 NEW SOUTH WALES

The New South Wales analysis differs from the standard analysis, described in Chapter 2, in two respects:

- Data were not available by Commonwealth classification, and recourse had to be made to using aggregates of State road classes.
- Details of road ages were not available, and the 1985 age distribution had to be estimated by applying the ageing model to historical new construction and reconstruction data.

DATA SOURCES

The relevant data were available from Department of Main Roads (DMR) Annual Reports for the State classifications of State highways, trunk roads and main roads (Department of Main Roads 1985). Supplementary Papers to the Annual Reports provide data on State highways as a separate functional class, but a continuous series is only available up to 1977-78. Data for more recent years were obtained directly from DMR.

The main information acquired for each year described the length of road that received its initial seal, the length reconstructed and the total length of the sealed part.

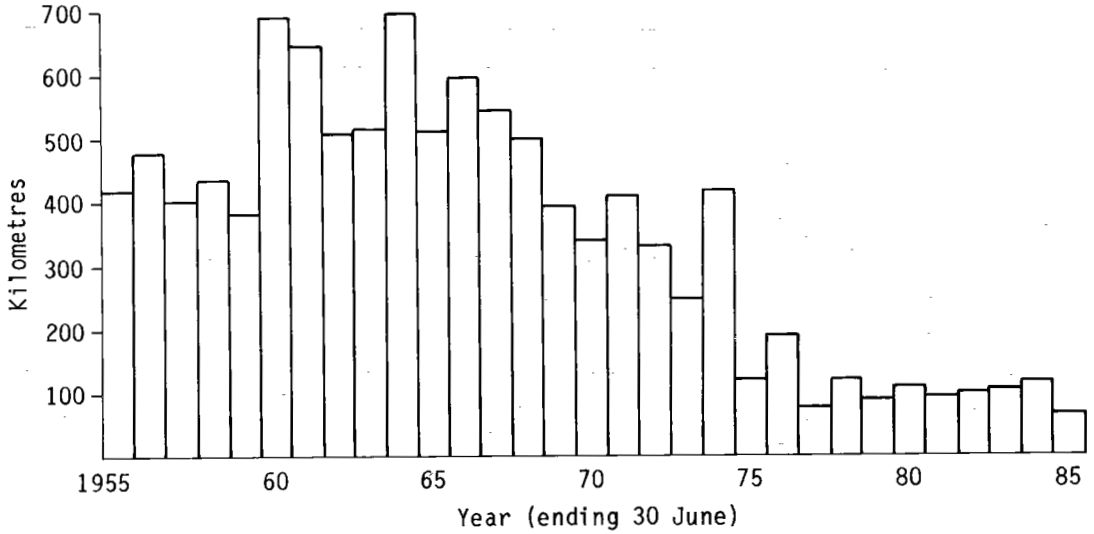
MAIN ROADS

This section discusses 'main roads' as the aggregate of trunk roads and main roads in New South Wales.

Derivation of the 1985 age distribution

Figure 3.1 shows the length of the main road system sealed for the first time in each year. Prior to 1954-55 the length of main roads sealed in New South Wales was 4900 kilometres. By the end of 1984-85 this had increased to 15 500 kilometres.

The length of road reconstructed in each year is shown in Figure 3.2. This shows that reconstruction has increased with time but the length reconstructed did not exceed newly constructed road (see Figure 3.1)



Note Main roads comprise State classifications 'Trunk Roads' and 'Main Roads'.

Source Department of Main Roads, NSW (1985 and pers. comm. 1986).

Figure 3.1 New South Wales main roads: length of initial sealed surface, 1954-55 to 1984-85

until the mid-1970s. An increase would be expected as a result of the growth of the road system, but this would have a time lag equal to the expected life of the roads. Figure 3.2 shows that the rate of reconstruction, the proportion of the total length reconstructed, has averaged only 1 per cent over the last five years.

The 1985 age distribution was estimated by running the road ageing model from 1955 to 1985 using the historical rates of new construction and reconstruction shown in Figures 3.1 and 3.2. This required an assumption about the age distribution of the 4900 kilometres of road which existed before 1955. The distribution was arbitrarily chosen to be uniform between 1943 and 1954; in fact, as much of the pre-existing road was reconstructed by 1985, the initial age distribution has little influence on the estimated 1985 distribution.

The standard analysis

The 1985 age distribution of the New South Wales main road system is shown in Figure 3.3. The main feature of the ages of New South Wales main roads in 1985 is that they are quite smoothly distributed over 40 years, with a mean age of 20 years. The resulting road system in 1995, if the present length of road reconstructed (150 kilometres per year) and initially sealed (90 kilometres per year) continues, is shown in Figure 3.4. The major feature is a rapid ageing of the road system, with 43 per cent of roads at least 30 years old, compared to 18 per cent in 1985. The average age of the road system will have increased from some 20 years in 1985 to over 25 years in 1995.

The effect of various reconstruction rates on the age distribution of New South Wales main roads is shown in Table 3.1. The results are based on a new construction of 90 kilometres per year, being close to the average for the years 1980-81 to 1984-85. It is apparent that the road system will age quite quickly if the present reconstruction rates are maintained.

The analysis shows that, if the average age of the New South Wales main roads is to be kept near its current value of 20 years, a reconstruction rate of about 425 kilometres per year will have to be maintained. This is nearly three times the current rate.

STATE HIGHWAYS

In New South Wales the State highway classification includes National Highways. Figures 3.5 and 3.6 show the lengths of road which were initially sealed and reconstructed each year since 1955. These data were used with the road ageing model to estimate the 1985 age distribution for State highways shown in Figure 3.7.

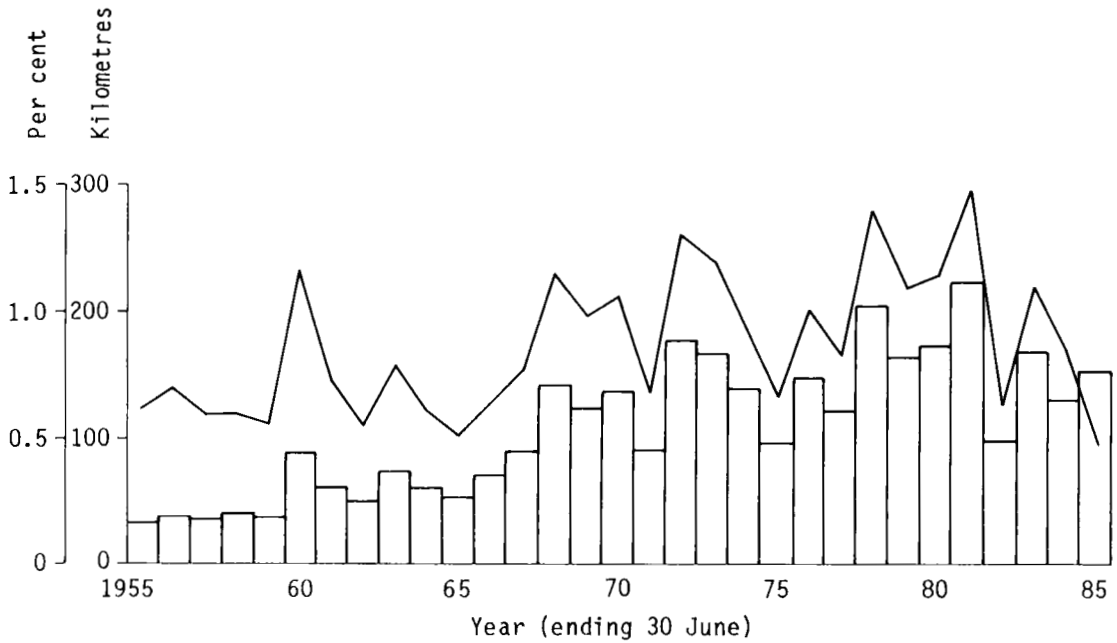
TABLE 3.1 AGE OF NEW SOUTH WALES SEALED MAIN ROAD SYSTEM FOR VARIOUS RECONSTRUCTION RATES, 1985 TO 2000

Year	Length of road reconstructed (km per year)		Length of road of age[a] (km) ≥20 years		≥30 years		≥35 years		≥40 years		Mean age (years)
1985	150	(1.0)[b]	8 400	(54)	2 800	(18)	1 100	(7)	200	(1)	19.8
1990	150	(0.9)[b]	10 500	(66)	4 800	(30)	2 300	(14)	800	(5)	22.6
	200	(1.3)	10 200	(64)	4 600	(29)	2 200	(14)	700	(4)	22.1
	300	(1.9)	9 700	(61)	4 200	(26)	1 800	(11)	500	(3)	21.0
	400	(2.5)	9 200	(58)	3 800	(24)	1 500	(9)	400	(3)	20.0
	500	(3.1)	8 700	(55)	3 400	(21)	1 300	(8)	200	(1)	19.0
1995	150	(0.9)[b]	11 700	(71)	7 100	(43)	4 200	(26)	1 900	(12)	25.2
	200	(1.2)	11 200	(68)	6 600	(40)	3 800	(23)	1 600	(10)	24.2
	300	(1.8)	10 200	(62)	5 800	(35)	3 100	(19)	1 100	(7)	22.2
	400	(2.4)	9 200	(56)	4 900	(30)	2 400	(15)	600	(4)	20.2
	500	(3.0)	8 200	(50)	4 100	(25)	1 800	(11)	300	(2)	18.4
2000	150	(0.9)[b]	12 300	(73)	9 100	(54)	6 500	(39)	3 700	(22)	27.7
	200	(1.2)	11 600	(69)	8 400	(50)	5 900	(35)	3 200	(19)	26.2
	300	(1.8)	10 100	(60)	7 000	(42)	4 700	(28)	2 300	(14)	23.2
	400	(2.4)	8 600	(51)	5 700	(34)	3 500	(21)	1 500	(9)	20.5
	500	(3.0)	7 100	(42)	4 400	(26)	2 500	(15)	800	(5)	17.9

a. Based on a minimum age of reconstruction of 15 years and new construction of 90 kilometres per year.
b. The present rate of reconstruction.

Note Figures in parentheses are percentages of the total sealed length of 15 504 kilometres in 1984-85.

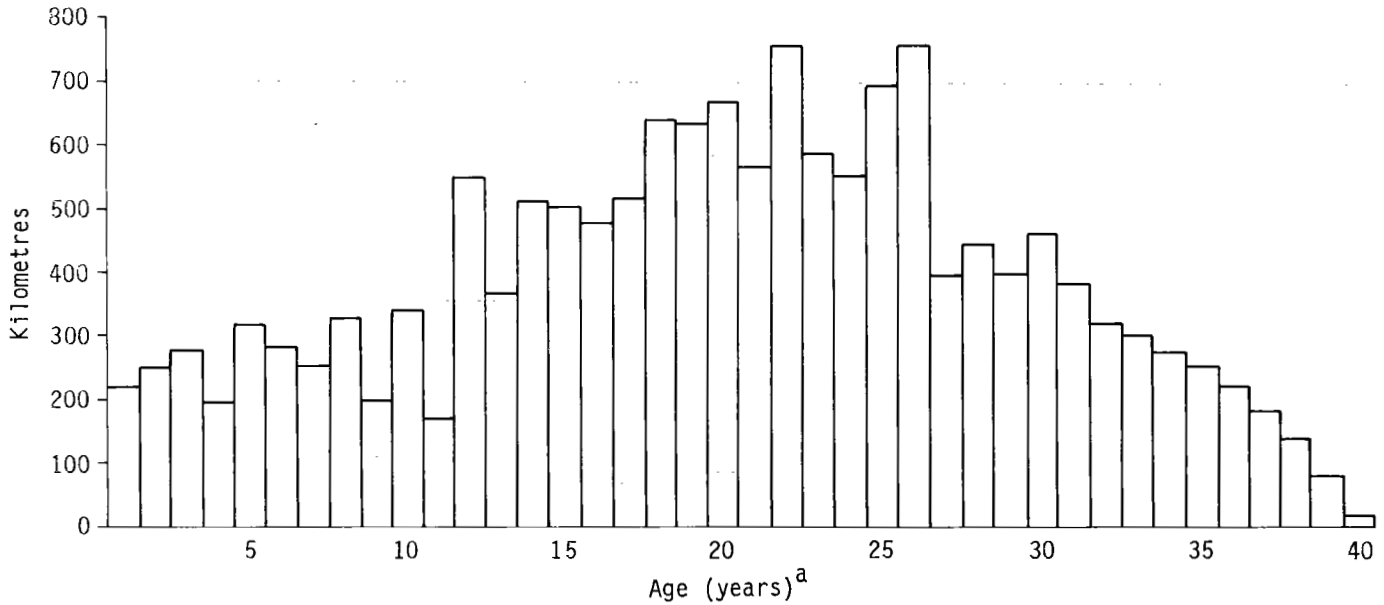
Source BTCE estimates.



Note Main roads comprise State classifications 'Trunk Roads' and 'Main Roads'.

Source Department of Main Roads, NSW (1985 and pers. comm. 1987).

Figure 3.2 New South Wales sealed main roads: length and percentage of road reconstructed, 1954-55 to 1984-85

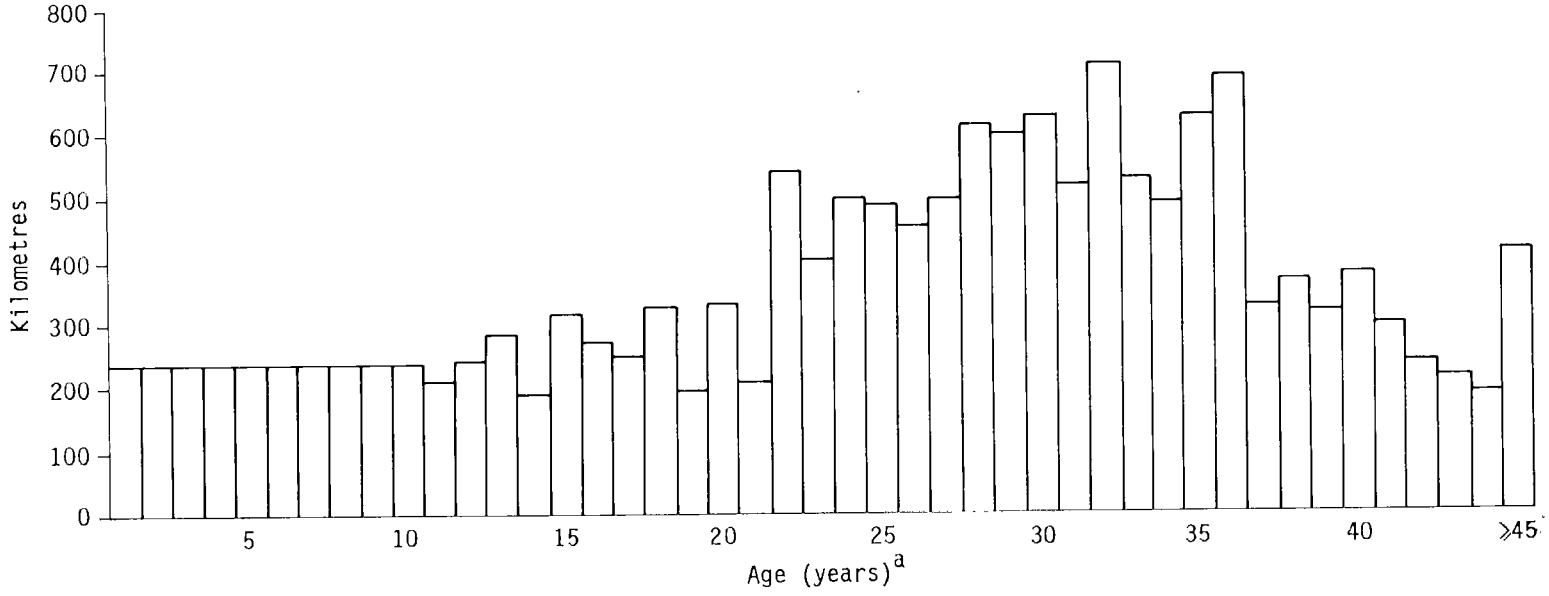


a. Average age = 19.8 years.

Note Main roads comprise State classifications 'Trunk Roads' and 'Main Roads'.

Source BTCE estimates.

Figure 3.3 New South Wales sealed main roads: estimated age of road system, 1985

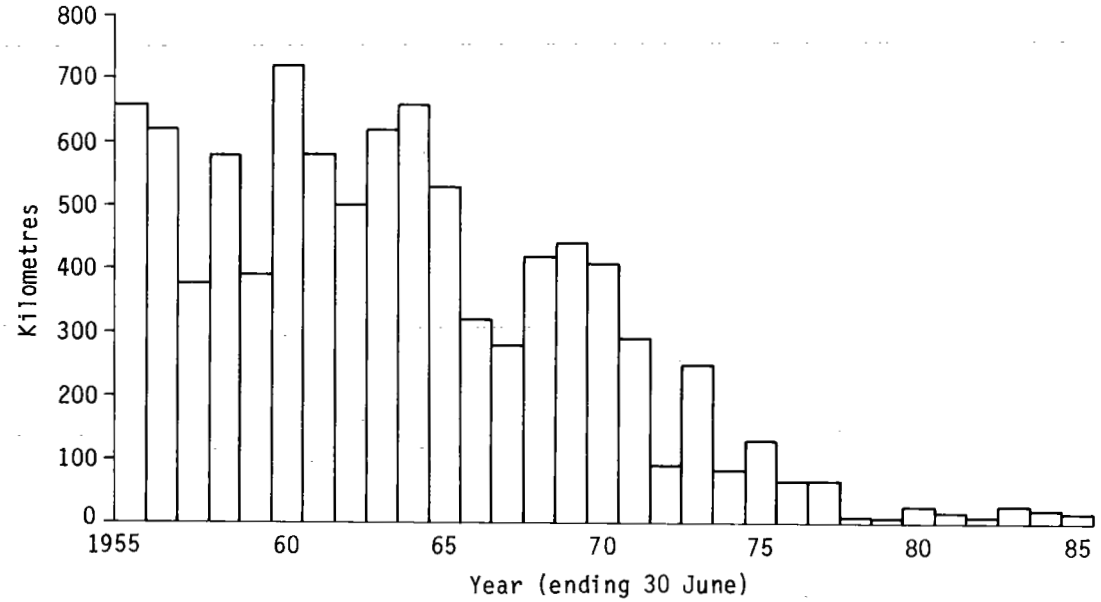


a. Average age = 25.2 years { new construction = 90 kilometres p.a.
reconstruction = 150 kilometres p.a.

Note Main roads comprise State classifications 'Trunk Roads' and 'Main Roads'.

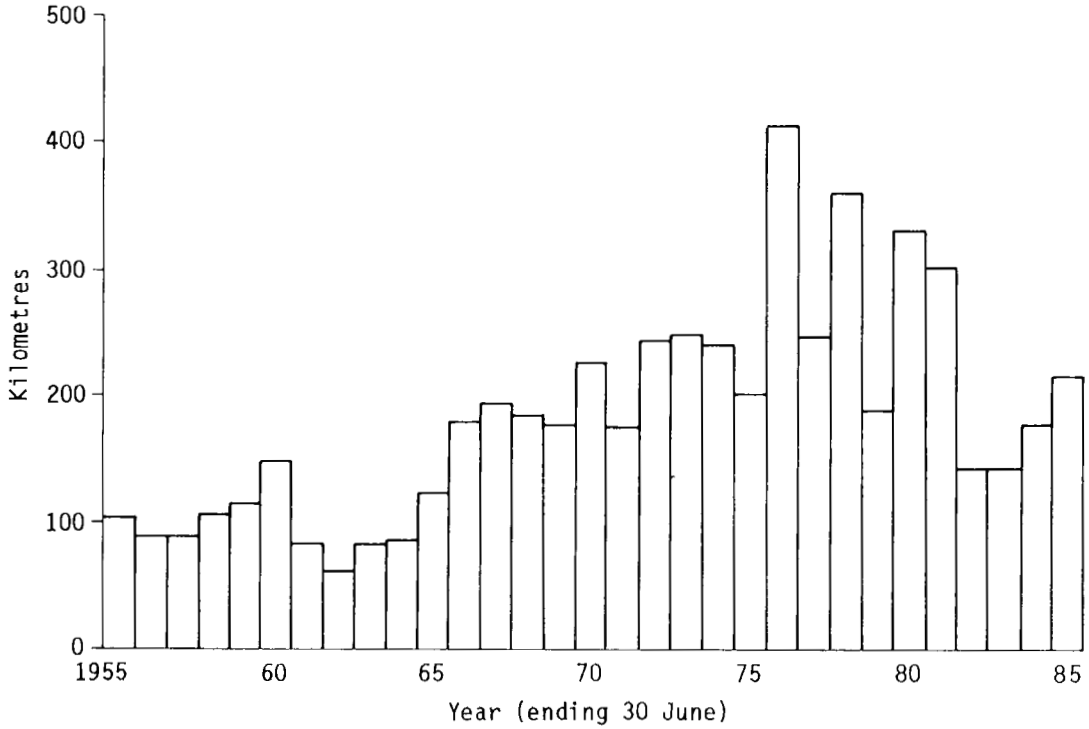
Source BTCE estimates.

Figure 3.4 New South Wales sealed main roads: estimated age of road system, 1995



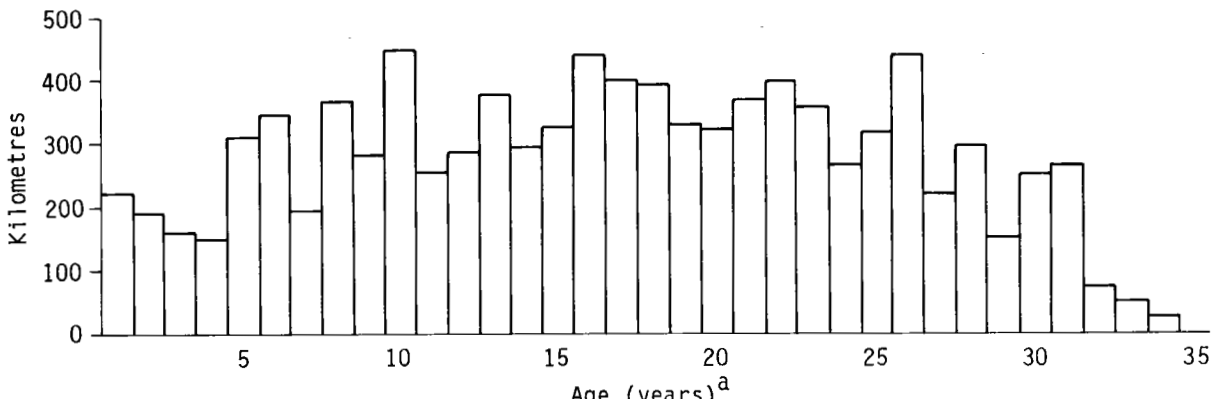
Source Department of Main Roads, NSW (1985 and pers. comm. 1986).

Figure 3.5 New South Wales State highways: length of initial sealed surface, 1954-55 to 1984-85



Source Department of Main Roads, NSW (1985 and pers. comm. 1986).

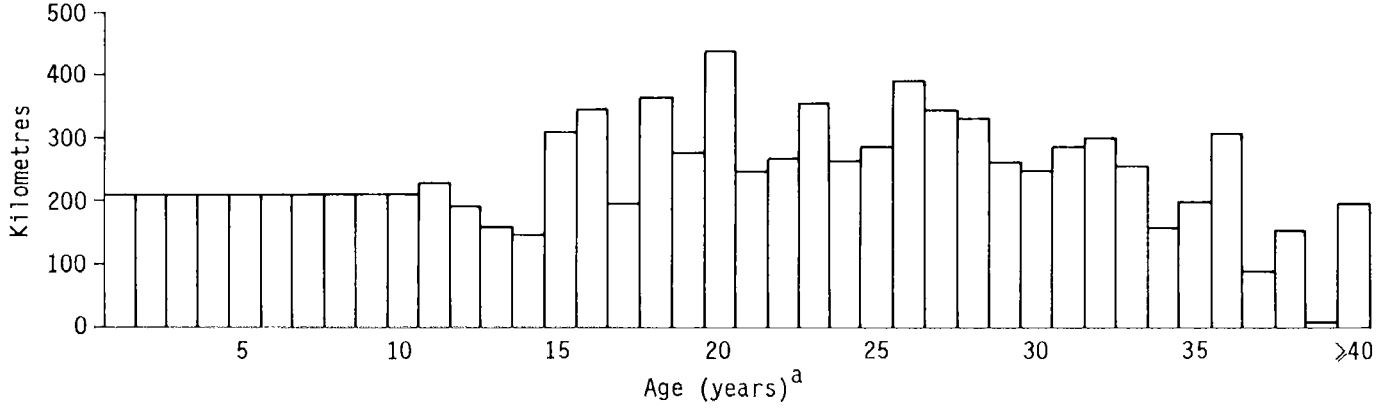
Figure 3.6 New South Wales sealed State highways: length of road reconstructed, 1954-55 to 1984-85



a. Average age = 16.2 years.

Source BTCE estimates.

Figure 3.7 New South Wales sealed State highways: estimated age of road system, 1985



a. Average age = 20.0 years { new construction = 5 kilometres p.a.
reconstruction = 200 kilometres p.a.

Source BTCE estimates.

Figure 3.8 New South Wales sealed State highways: estimated age of road system, 1995

TABLE 3.2 AGE OF NEW SOUTH WALES SEALED STATE HIGHWAYS FOR VARIOUS RECONSTRUCTION RATES, 1985 TO 2000

Year	Length of road reconstructed (km per year)		Length of road of age[a] (km) ≥20 years		≥30 years		≥35 years		≥40 years		Mean age (years)
1985	200	(2.1)[b]	3 800	(40)	700	(7)	0	(0)	0	(0)	16.2
1990	150	(1.6)	4 900	(51)	1 600	(17)	400	(4)	0	(0)	19.0
	200	(2.1)[b]	4 700	(49)	1 400	(15)	300	(3)	0	(0)	18.2
	250	(2.6)	4 400	(46)	1 300	(14)	300	(3)	0	(0)	17.5
	300	(3.1)	4 200	(44)	1 100	(12)	300	(3)	0	(0)	16.8
	350	(3.7)	3 900	(41)	1 000	(10)	200	(2)	0	(0)	16.1
1995	150	(1.6)	5 800	(61)	2 600	(27)	1 200	(13)	300	(3)	21.5
	200	(2.1)[b]	5 300	(55)	2 200	(23)	900	(9)	200	(2)	20.0
	250	(2.6)	4 800	(50)	1 800	(19)	700	(7)	100	(1)	18.5
	300	(3.1)	4 300	(45)	1 400	(15)	400	(4)	-		17.1
	350	(3.7)	3 800	(40)	1 100	(12)	300	(3)	0	(0)	15.7
2000	150	(1.6)	6 500	(68)	3 600	(38)	2 100	(22)	900	(9)	23.8
	200	(2.1)[b]	5 800	(61)	3 000	(31)	1 500	(16)	600	(6)	21.5
	250	(2.6)	5 100	(53)	2 300	(24)	1 100	(11)	300	(3)	19.3
	300	(3.1)	4 300	(45)	1 700	(18)	600	(6)	100	(1)	17.2
	350	(3.7)	3 600	(38)	1 100	(11)	300	(3)	-		15.2

a. Based on a minimum age of reconstruction of 15 years and new construction of 5 kilometres per year.
b. The present rate of reconstruction.
- Rounded to zero.

Note Figures in parentheses are percentages of the total sealed length of 9504 kilometres in 1984-85

Source BTCE estimates.

The effect of various reconstruction rates on the ageing of the State highways are shown in Table 3.2.

The analysis shows that the average age of the State highways will have risen from about 16 years in 1985 to 20 years in 1995, if current new sealing and reconstruction rates are maintained. The estimated 1995 age distribution is shown in Figure 3.8. Currently, 5 kilometres per year of new sealing and 200 kilometres per year of reconstruction are carried out. A long term reconstruction rate of 320 kilometres per year would be necessary to prevent any ageing of the road system, some 60 per cent above the current rate.

CHAPTER 4 VICTORIA

The same problems were encountered with roads data for Victoria as with New South Wales. First, classification of data was by State road types only. Second, the age distribution for the base year 1985 had to be estimated, using the ageing model.

A further consideration in Victoria is the prevalence of road widening, which raises the question whether the age of a road section should be based on the oldest remaining pavement or on the more recent additions; that is, whether widening should be classed as reconstruction. Widening has not been classed as reconstruction in the standard analysis, but the consequences of doing so are briefly discussed.

DATA SOURCES

Annual Reports

The following analysis makes use of information contained in the annual reports of the Engineer in Chief of the Country Roads Board of Victoria; more recently known as the Road Construction Authority (Country Roads Board, Victoria 1983; Road Construction Authority, Victoria 1985). The analysis covers the period 1952-53 to 1984-85.

Annual reports information of specific interest to this work includes:

- the length of extensions to the sealed system of declared roads; and
- the length of previously sealed sections which were reconstructed during the year.

The declared roads referred to include State highways, main roads, tourist roads and forest roads. The information used is available for each of these State classifications. The State highways component and the remaining declared roads, which are called 'main roads' in this chapter, are discussed separately.

NAASRA data base

Age data for some 80 per cent of Victorian State highways are available in the NAASRA data bank. As described in the section on State highways, this provides a test of the procedures used to estimate the 1985 age distributions (in New South Wales and Victoria).

MAIN ROADS

Derivation of the 1985 age distribution

Figure 4.1 shows the length of main roads (comprising the State main, tourist and forest road classes) sealed for the first time in each of the years 1952-53 to 1984-85. Prior to 1952-53 the length of sealed main roads in Victoria was approximately 6000 kilometres. By the end of 1984-85 this had increased to approximately 15 000 kilometres.

The length and percentage of road reconstructed each year is shown in Figure 4.2. This shows an increase from approximately 1 per cent or 60 kilometres per year in 1952-53 to 2.7 per cent or 380 kilometres per year in the period from 1963-64 to 1972-73. This increase occurred during the peak in the initial sealing rate (see Figure 4.1) and the length reconstructed has been greater than the length initially sealed since 1963-64. The total length of reconstruction during the 33 years was 8600 kilometres (which would include almost all the sealed main roads existing in 1953).

The low rate of reconstruction in recent years, far below the total constructed lengths in the mid-1950s to mid-1960s, will mean that a significant ageing of the road system will occur if the current reconstruction effort is not increased.

As in the case of New South Wales, the model of road ageing was used with the above data to estimate the present age distribution of the Victorian main roads.

The standard analysis

The estimated age distribution of Victorian main roads in June 1985 is shown in Figure 4.3. The main feature is that more than half (51 per cent) of the roads are older than 20 years, although there are few roads over 30 years old. The resulting road system in 1995, if the recent reconstruction effort is maintained, is shown in Figure 4.4. The main feature is that the road system will have aged markedly, with 38 per cent of roads older than 30 years.

The effects of alternative reconstruction rates on the age distribution are shown in Table 4.1. It is apparent that the road

TABLE 4.1 AGE OF VICTORIAN SEALED MAIN ROAD SYSTEM FOR VARIOUS RECONSTRUCTION RATES, 1985 TO 2000

Year	Length of road reconstructed (km per year)	Length of road of age[a] (km) ≥20 years	≥30 years	≥35 years	≥40 years	Mean age (years)
1985	250 (1.6)[b]	7 900 (51)	800 (5)	0 (0)	0 (0)	17.8
1990	250 (1.6)[b]	9 400 (61)	3 500 (23)	500 (3)	0 (0)	20.6
	300 (1.9)	9 200 (60)	3 300 (21)	500 (3)	0 (0)	20.2
	400 (2.6)	8 700 (56)	3 000 (19)	400 (3)	0 (0)	19.3
	500 (3.2)	8 200 (53)	2 700 (18)	200 (1)	0 (0)	18.5
	600 (3.9)	7 700 (50)	2 500 (16)	200 (1)	0 (0)	17.6
1995	250 (1.6)[b]	10 300 (67)	5 900 (38)	2 900 (19)	300 (2)	23.2
	300 (1.9)	9 800 (64)	5 500 (36)	2 600 (17)	200 (1)	22.3
	400 (2.6)	8 900 (58)	4 700 (31)	2 200 (14)	100 (1)	20.5
	500 (3.2)	7 900 (51)	4 000 (26)	1 700 (11)	0 (0)	18.7
	600 (3.9)	6 900 (45)	3 300 (21)	1 400 (9)	0 (0)	17.0

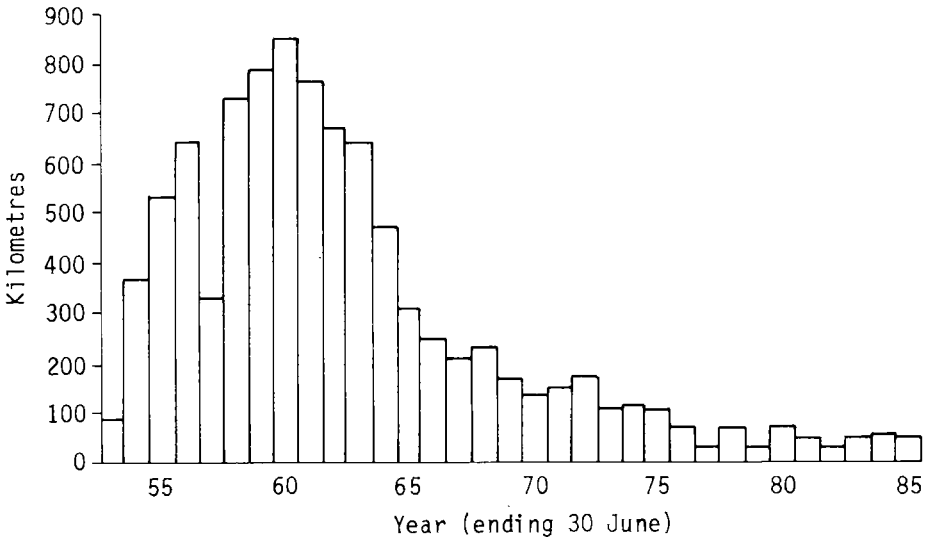
TABLE 4.1 (Cont.) AGE OF VICTORIAN SEALED MAIN ROAD SYSTEM FOR VARIOUS RECONSTRUCTION RATES, 1985 TO 2000

Year	Length of road reconstructed (km per year)	Length of road of age[a] (km) ≥20 years	≥30 years	≥35 years	≥40 years	Mean age (years)
2000	250 (1.6)[b]	10 500 (68)	7 300 (47)	5 100 (33)	2 400 (16)	25.5
	300 (1.9)	9 700 (63)	6 600 (43)	4 600 (30)	2 100 (14)	24.1
	400 (2.6)	8 200 (53)	5 300 (34)	3 600 (23)	1 500 (10)	21.3
	500 (3.2)	6 700 (44)	4 000 (26)	2 600 (17)	1 000 (6)	18.6
	600 (3.9)	5 200 (34)	2 700 (18)	1 600 (10)	500 (3)	15.9

a. Based on a minimum age of reconstruction of 15 years, and no new construction.
b. The present reconstruction rate.

Note Figures in parentheses are percentages of the total sealed length of the Victorian rural arterial roads, estimated as 15 400 kilometres in 1984-85.

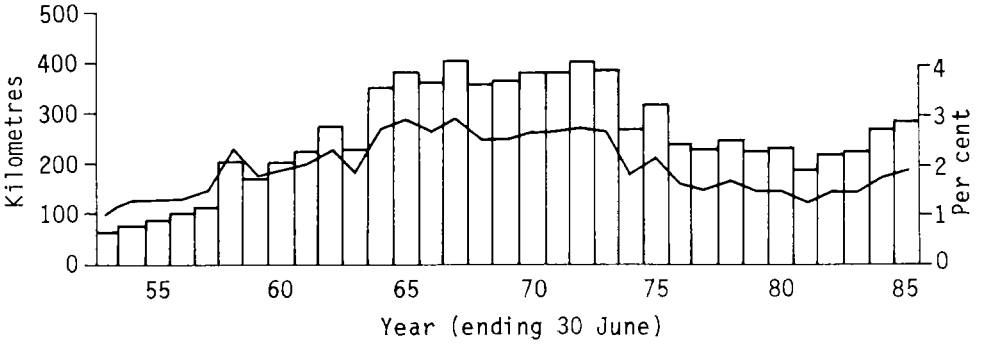
Source BTCE estimates.



Note Roads include main roads, tourist roads and forest roads.

Source CRB and RCA Annual Reports (various years).

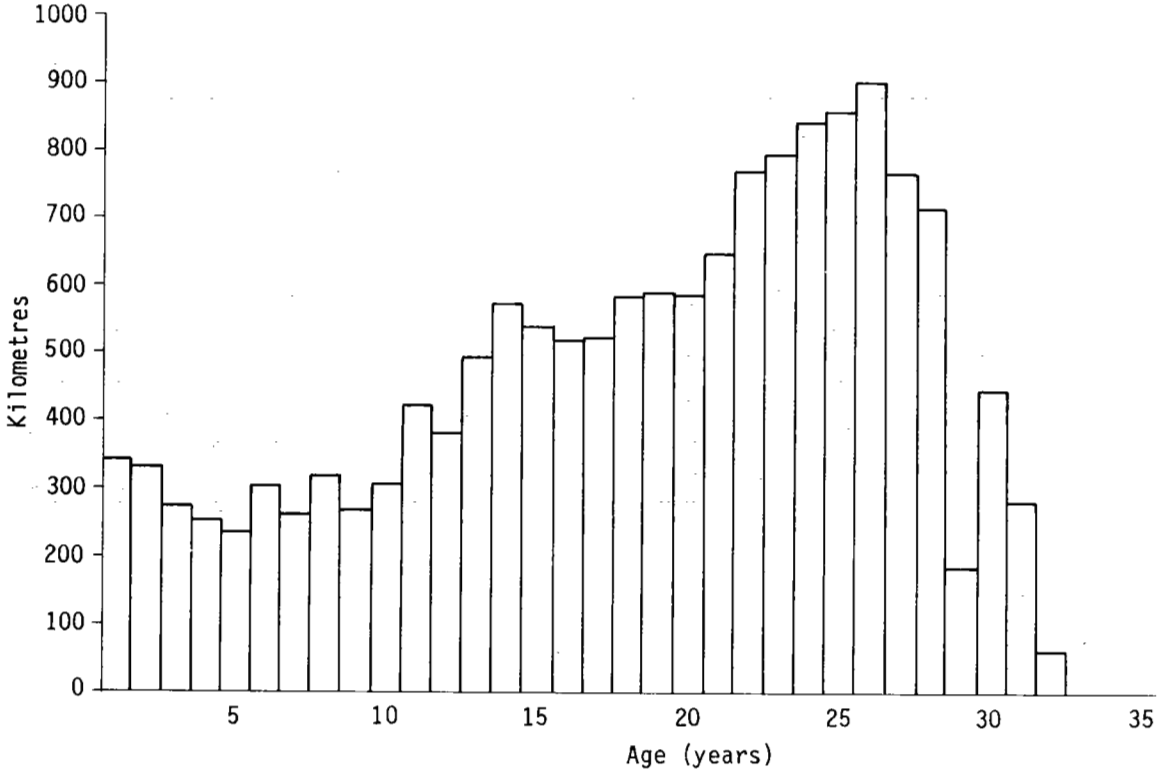
Figure 4.1 Victorian main roads: length of initial sealed surface, 1952-53 to 1984-85



Note Roads include main roads, tourist roads and forest roads.

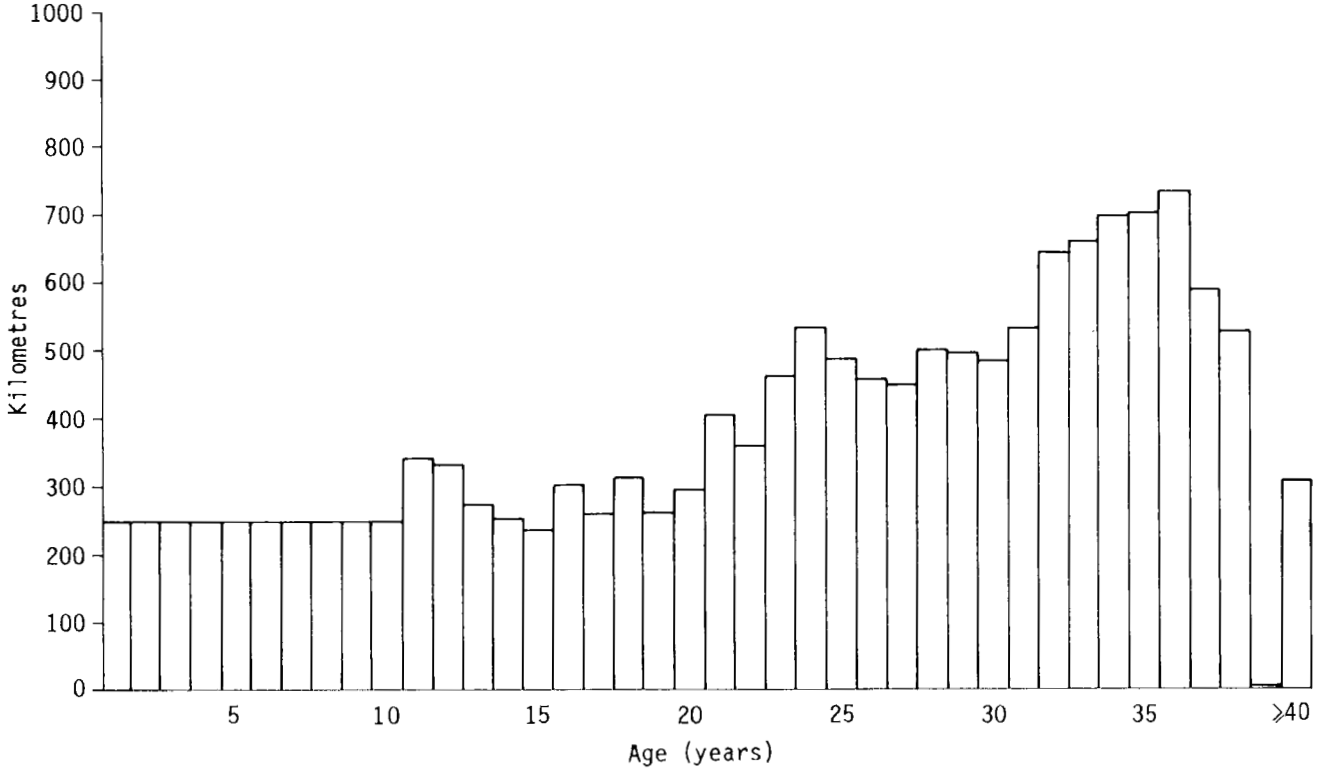
Source CRB and RCA Annual Reports (various years).

Figure 4.2 Victorian sealed main roads: length and percentage of system reconstructed, 1952-53 to 1984-85



Source BTCE estimates.

Figure 4.3 Victorian sealed main roads: estimated age of road system, 1985



Source BTCE estimates.

Figure 4.4 Victorian sealed main roads: estimated age of road system, 1995

system will age quickly unless reconstruction is greatly increased. A doubling of the reconstruction effort would be required to maintain the current average road age.

Widening

Figure 4.5 shows the length of road over which widening was completed in each of the financial years from 1955-56 to 1984-85. This information is relevant to the extent that widening increases pavement life. Although this proposition is not necessarily true in general, it almost certainly holds in some cases. It is worth noting that the incorporation of these data does not alter the general picture. If all widening work is identified with reconstruction, then the estimated mean road age in 1985 is reduced by approximately two years. Nonetheless, if the recent reconstruction effort is maintained, the forecast mean road age in 1995 will have increased by some five years whether or not widening is identified with reconstruction.

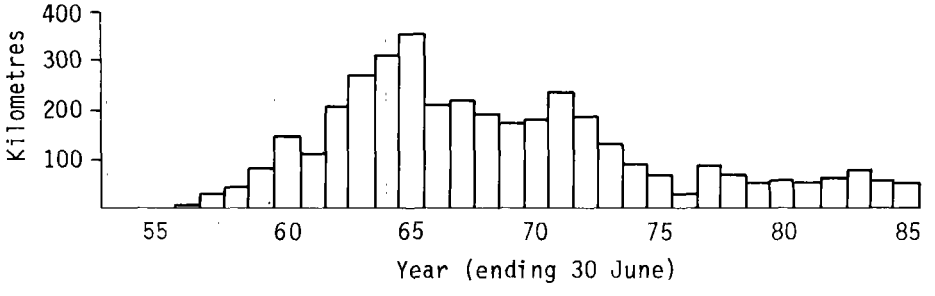
STATE HIGHWAYS

The data

In this section the State highway component (about 31 per cent by length) of the Victorian declared road system is discussed.

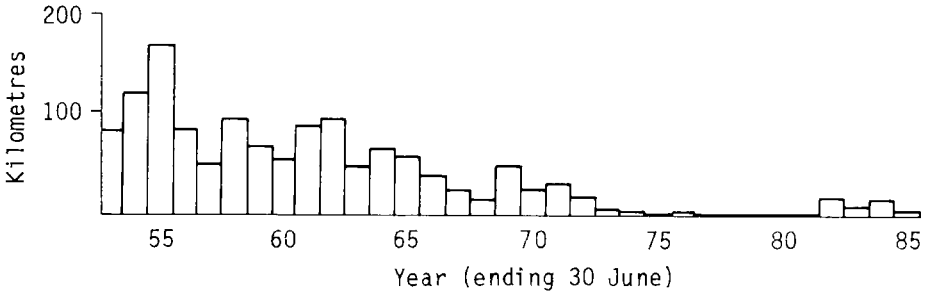
Figure 4.6 shows the length of new sealed State highways completed each year since 1952-53. As for the 'main roads' (Figure 4.1) an overall downward trend is shown.

Figure 4.7 shows the length and percentage of sealed Victorian State highways reconstructed each year. During the period 1957-58 to 1969-70 it is notable that the reconstruction rate averaged over 4 per cent.



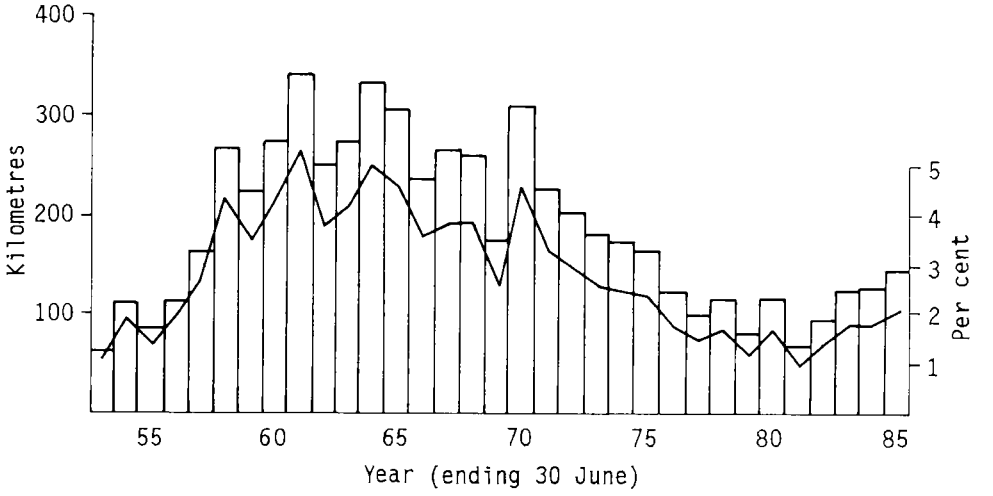
Source Road Construction Authority.

Figure 4.5 Widening on sealed main roads in Victoria



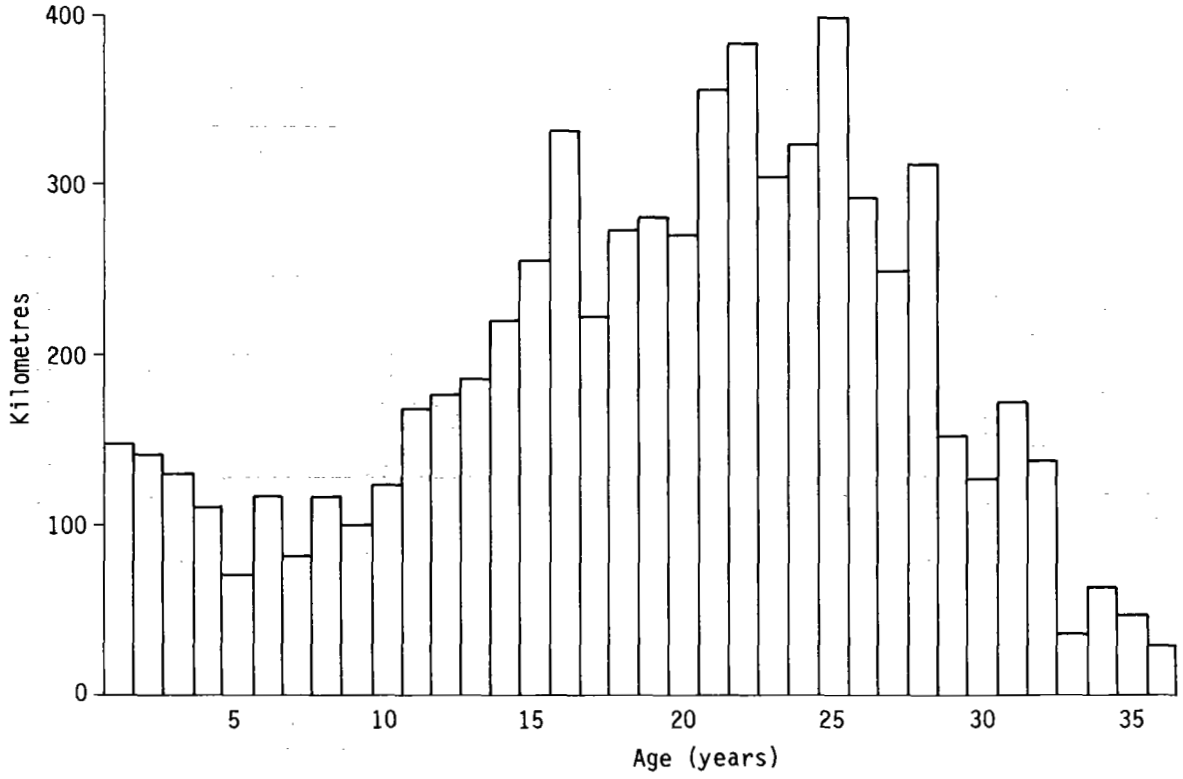
Source CRB and RCA Annual Reports (various years).

Figure 4.6 Victorian State highways: new sealed lengths, 1952-53 to 1984-85



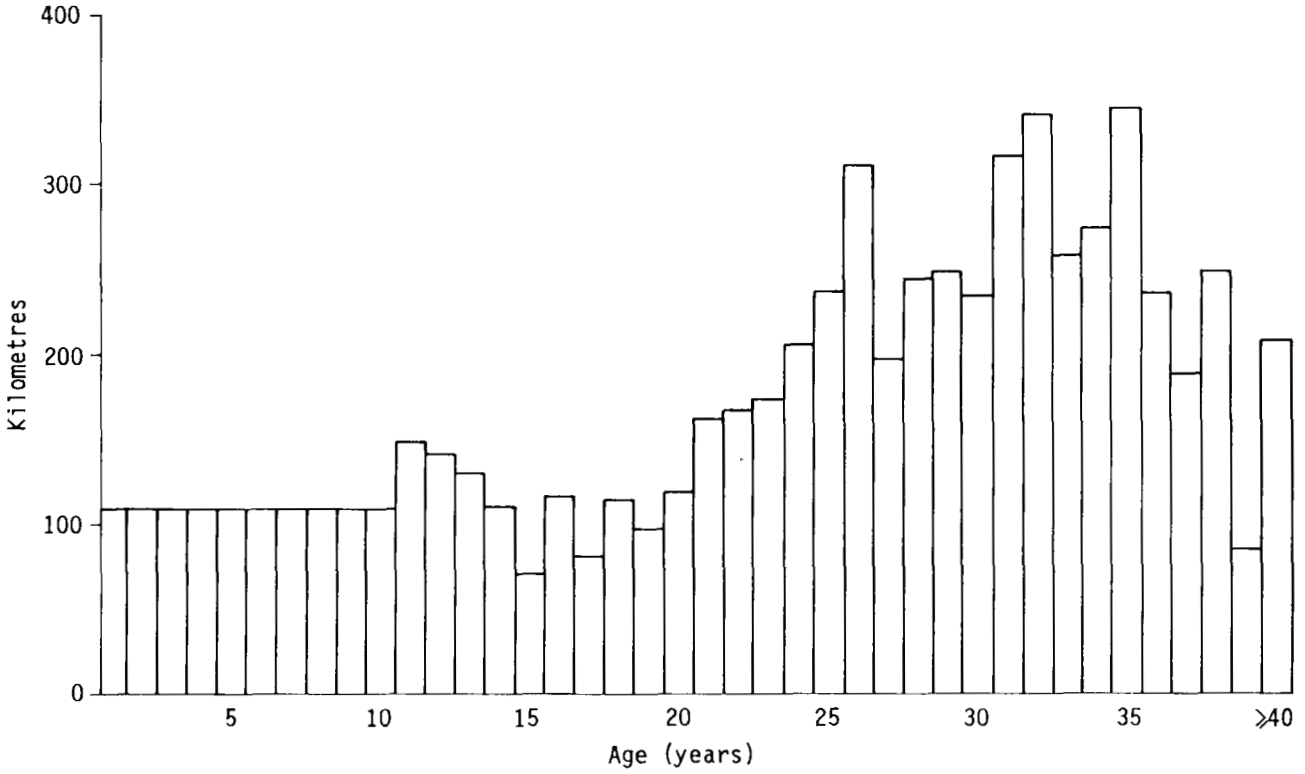
Source CRB and RCA Annual Reports (various years).

Figure 4.7 Victorian sealed State highways: reconstructed lengths and percentages, 1952-53 to 1984-85



Source BTCE estimates.

Figure 4.8 Victorian sealed State highways: estimated age of road system, 1985



Source BTCE estimates.

Figure 4.9 Victorian sealed State highways: estimated age of road system, 1995

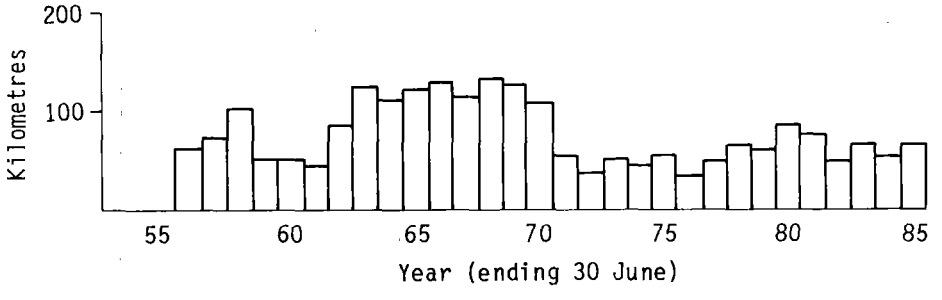
The age distribution

These data were used to estimate the age distribution of Victorian State highways in 1985 (shown in Figure 4.8). An estimate of the distribution of State highways by age in 1995, assuming that the recent reconstruction effort is maintained, is shown in Figure 4.9.

Table 4.2 summarises the forecast effects of increasing the reconstruction effort. As for the main roads a doubling of the reconstruction effort would be required if the average age of the system were to be maintained at its present level.

Figure 4.10 shows the widening effort for the years 1952-53 to 1984-85. If all of this work is identified as reconstruction, the mean age of State highways is reduced by some three years. Nonetheless the above forecast remains, in general terms, unaltered.

In the case of the Victorian State highways age data for about 80 per cent of the network are available from the NAASRA data bank. The corresponding age profile (scaled to represent the complete network) is shown in Figure 4.11 where it is compared with that deduced with the aid of the model from annual reports data. The agreement is good and lends support to the starting (1985) age distributions which have had to be estimated (for New South Wales and Victorian roads) with the aid of the model.



Source Road Construction Authority (1986).

Figure 4.10 Widening on Victorian sealed State highways

TABLE 4.2 AGE OF VICTORIAN SEALED STATE HIGHWAYS FOR VARIOUS RECONSTRUCTION RATES, 1985 TO 2000

Year	Length of road reconstructed (km per year)	Length of road of age[a] (km) ≥20 years	≥30 years	≥35 years	≥40 years	Mean age (years)
1985	110 (1.6)[b]	3 700 (54)	600 (9)	100 (1)	0 (0)	18.6
1990	110 (1.6)[b]	4 500 (65)	1 600 (23)	400 (6)	-	21.2
	125 (1.8)	4 400 (64)	1 600 (23)	300 (4)	0 (0)	20.9
	150 (2.2)	4 300 (62)	1 500 (22)	300 (4)	0 (0)	20.4
	200 (2.9)	4 000 (58)	1 300 (19)	200 (3)	0 (0)	19.4
	250 (3.6)	3 800 (55)	1 200 (17)	200 (3)	0 (0)	18.4
1995	110 (1.6)[b]	4 800 (70)	2 700 (39)	1 300 (19)	200 (3)	23.7
	125 (1.8)	4 700 (68)	2 600 (38)	1 200 (17)	200 (3)	23.1
	150 (2.2)	4 400 (64)	2 400 (35)	1 100 (16)	100 (1)	22.0
	200 (2.9)	3 900 (57)	2 000 (29)	800 (12)	-	19.9
	250 (3.6)	3 400 (49)	1 700 (25)	600 (9)	0 (0)	18.0

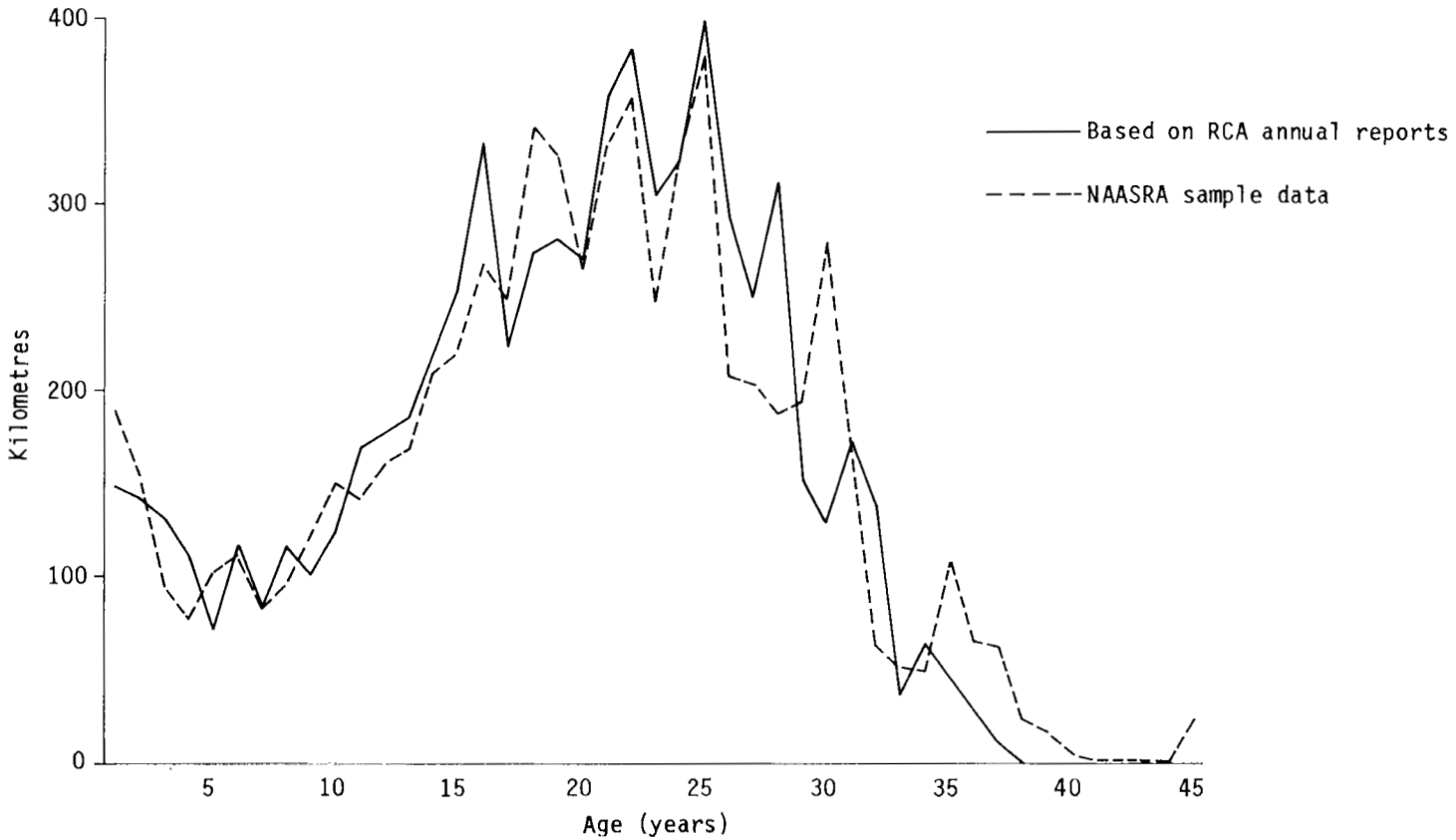
TABLE 4.2 (Cont.) AGE OF VICTORIAN SEALED STATE HIGHWAYS FOR VARIOUS RECONSTRUCTION RATES, 1985 TO 2000

Year	Length of road reconstructed (km per year)	Length of road of age[a] (km) ≥20 years	≥30 years	≥35 years	≥40 years	Mean age (years)
2000	110 (1.6)[b]	4 800 (70)	3 500 (51)	2 400 (35)	1 100 (16)	26.0
	125 (1.8)	4 500 (65)	3 300 (48)	2 200 (32)	900 (13)	25.0
	150 (2.2)	4 200 (61)	3 000 (43)	1 900 (28)	800 (12)	23.3
	200 (2.9)	3 400 (49)	2 400 (35)	1 400 (20)	500 (7)	20.3
	250 (3.6)	2 700 (39)	1 700 (25)	1 000 (14)	300 (4)	17.3

a. Assumes a minimum age at reconstruction of 15 years, and no new construction.
b. Average of 1981 to 1985 reconstruction.
- Rounded to zero.

Note Figures in parentheses are percentages of the length of sealed highways, estimated at 6900 kilometres in 1984-85.

Source BTCE estimates.



Source NAASRA (1985) data, BTCE estimates.

Figure 4.11 Victorian sealed State highways: age profiles based on annual reports data and NAASRA sample data

CHAPTER 5 QUEENSLAND

Age information is not generally available for Queensland roads and ages have therefore been estimated from pavement roughness data. Roughness measurements, taken between 1980 and 1983, are available in the NAASRA data base and have been used to estimate ages with the aid of the NAASRA roughness-age relationships.

Use of roughness data to estimate ages is a questionable process which has only been taken in the interests of providing an equivalent analysis for each State of the Commonwealth.

DATA SOURCES

Annual reports of the Queensland Main Roads Department (MRD), information contained in the NAASRA data base and an MRD overview of the National Highways in the South-West Division of Queensland were used. Although the actual pavement ages of National Highways were available for the South-West Division, this information was unavailable for Queensland as a whole.

The procedure adopted in this chapter is to estimate pavement age from the road roughness data contained in the NAASRA data base. This measure of roughness is given by the NAASRA roughness meter, and is available for each section of road included in the data base.

The relationship between pavement age and roughness is assumed to take the form of a quadratic, viz,

$$CNRM = A \times (age)^2 + B \times age + C \qquad \text{(Equation 5.1)}$$

where 'CNRM' denotes current roughness in counts per kilometre
'age' is the time in years since last (re)construction
'A,B,C' are constants specific to the functional class of the road section being considered.

The actual period over which deterioration to a particular level of roughness takes place is influenced by the following:

- subgrade strength
- climate
- traffic loading
- maintenance effort
- quality of construction.

Equation (5.1) will only give a crude estimate of the actual distribution of pavement ages. Two different quadratics are used. These are taken directly from NAASRA Technical Report No. 7 (National Association of Australian State Road Authority 1984a), were used in the 1984 NAASRA Roads Study (National Association of Australian State Road Authorities 1984b), and are as follows:

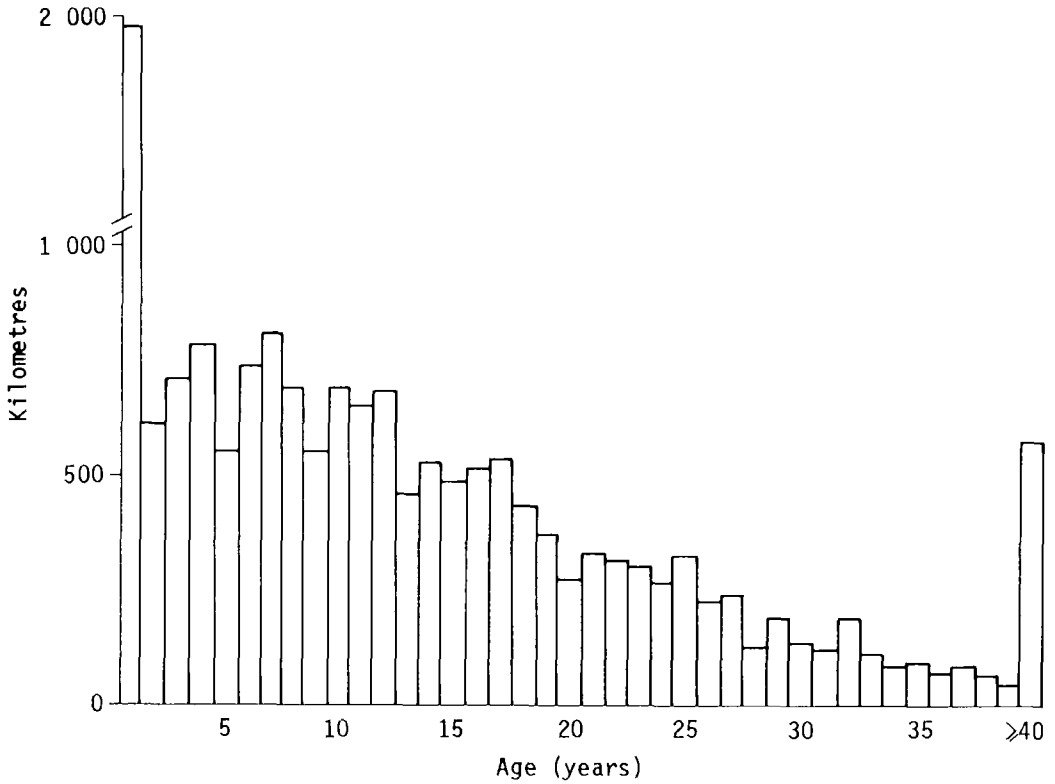
- primary arterials: $CNRM = 0.089 \times (age)^2 + 1.19 \times age + 66$
- secondary arterials: $CNRM = 3.741 \times age + 60$.

RURAL ARTERIALS

The (sealed) rural arterial road system in Queensland comprises State highways which are not classified as National Highways, together with main, developmental and secondary roads. The total length of sealed rural arterial roads in 1980 was 17 000 kilometres. Roughness counts for 13 700 kilometres were determined in 1980, and for 200 kilometres in 1981.

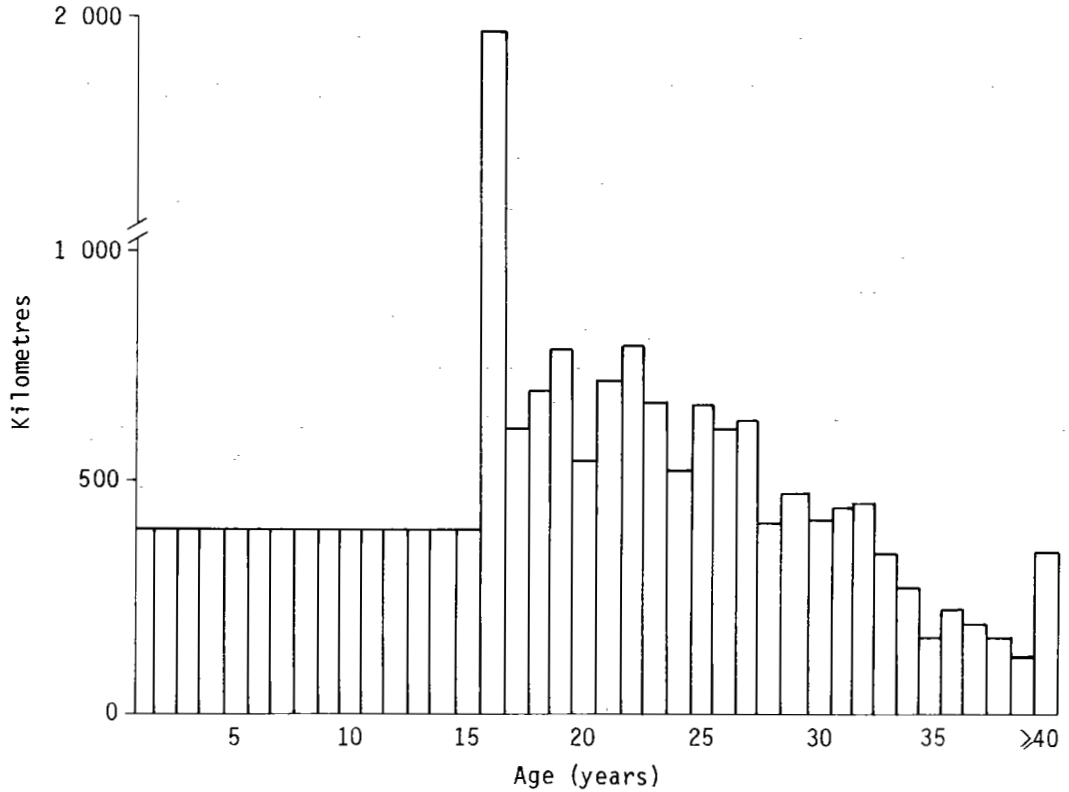
Figure 5.1 shows the estimated age distribution of this sample (82 per cent by length) in 1980. The lengths have been scaled to a total of 17 000 kilometres. Figure 5.2 illustrates the estimated age profile in 1995 if reconstruction continues at the estimated 250 kilometres (1.4 per cent) each year.

The estimated 1980 age profile is relatively young with an average age of 13.2 years and only 25 per cent of roads over 20 years old. The validity of this result rests with the NAASRA equations from which it was derived. More than 10 per cent of all the roads are shown to be under one year of age. This age corresponds, for the equations used, to roughness counts of up to 64 or 67 depending on functional class. This length probably includes many roads up to five years old, since newly constructed or reconstructed roads often have counts of 50 or lower. This error is not so much the consequence of the equations used (although they could perhaps be improved) as the method, since the range of roughness counts observed on roads of any given age is quite high. Another problem is the effect of maintenance, in particular resealing, to reduce roughness even though the underlying



Source BTCE estimates.

Figure 5.1 Queensland sealed rural arterials: estimated age of road system, 1980



Note Result assumes new sealing rate of 150 km p.a. and reconstruction rate of 250 km p.a.

Source BTCE estimates.

Figure 5.2 Queensland sealed rural arterials: estimated age of road system, 1995

pavement remains unimproved. As a result, the age profile shown is probably much younger than is actually the case.

The estimated age distribution in 1985 and the effects of a range of reconstruction rates in the years 1990, 1995 and 2000, are summarised in Table 5.1. The figures indicate that over 500 kilometres per year need to be reconstructed to keep the mean age constant. The lengths in Table 5.1, based on the 82 per cent sample in 1980, have been scaled up to correspond to the actual total length. A new construction rate of 150 kilometres per year has been assumed throughout the analysis.

NATIONAL HIGHWAYS

The Queensland National Highway network includes the Warrego, Landsborough and Barkly Highways, between Brisbane and the Northern Territory border, the Bruce Highway from Brisbane to Cairns, and part of the Cunningham and New England Highways linking Brisbane and the New South Wales border. All except for a small part of the Landsborough Highway are sealed and the total sealed length is approximately 4100 kilometres.

As for rural arterial roads, the ages of the National Highways were computed from a roughness-age relationship. The roughness counts of 3100 kilometres were determined in 1983 while 550 and 450 kilometres had their roughness measured in 1980 and 1982 respectively.

Figure 5.3 shows the resulting age distribution of Queensland National Highways. As before, an unrealistic proportion of the network is assigned an age of less than one year. This certainly includes roads aged up to 5 years or more. Figure 5.4 shows the age distribution for 1995 under a reconstruction rate of 80 kilometres or 2.0 per cent (by length) per year. The effects of various reconstruction rates over the next 15 years are further illustrated in Table 5.2. Reconstruction rates would have to be almost doubled if the mean age of the network is to remain constant.

TABLE 5.1 AGE OF QUEENSLAND SEALED RURAL ARTERIALS FOR VARIOUS RECONSTRUCTION RATES, 1980 TO 2000

Year	Length of road reconstructed (km per year)	Length of road of age[a] (km) ≥20 years	≥30 years	≥35 years	≥40 years	Mean age (years)
1980	na	4 200 (25)	1 600 (9)	900 (5)	600 (4)	13.2
1985	250 (1.4)[b]	5 300 (30)	1 600 (9)	600 (3)	200 (1)	14.7
1990	250 (1.4)[b]	7 100 (38)	2 000 (11)	800 (4)	100 (1)	16.7
	375 (2.0)	5 900 (32)	1 100 (6)	300 (2)	0 (0)	14.8
	500 (2.7)	4 600 (25)	300 (2)	-	0 (0)	13.2
	625 (3.4)	3 400 (18)	0 (0)	0 (0)	0 (0)	11.7
	750 (4.1)	2 300 (12)	0 (0)	0 (0)	0 (0)	10.4
1995	250 (1.3)[b]	9 200 (48)	3 100 (16)	1 200 (6)	300 (2)	18.8
	375 (1.9)	7 300 (38)	1 700 (9)	200 (1)	-	16.2
	500 (2.6)	5 500 (29)	600 (3)	0 (0)	0 (0)	14.1
	625 (3.2)	3 700 (19)	0 (0)	0 (0)	0 (0)	12.2
	750 (3.9)	1 900 (10)	0 (0)	0 (0)	0 (0)	10.7

TABLE 5.1 (Cont.) AGE OF QUEENSLAND SEALED RURAL ARTERIALS FOR VARIOUS RECONSTRUCTION RATES, 1980 TO 2000

Year	Length of road reconstructed (km per year)	Length of road of age[a] (km) ≥20 years	≥30 years	≥35 years	≥40 years	Mean age (years)
2000	250 (1.2)[b]	12 400 (62)	4 900 (24)	2 300 (12)	600 (3)	20.8
	375 (1.9)	10 100 (50)	2 800 (14)	800 (4)	0 (0)	17.7
	500 (2.5)	7 700 (38)	1 000 (5)	0 (0)	0 (0)	15.1
	625 (3.1)	5 400 (27)	100 (0)	0 (0)	0 (0)	12.9
	750 (3.8)	3 200 (16)	0 (0)	0 (0)	0 (0)	11.2

a. Assumes a minimum age at reconstruction of 15 years and new construction of 150 kilometres per year.
b. The present estimated reconstruction rate.
na Not available.
- Rounded to zero.

Note Figures in parentheses are percentages of the total sealed length, 17 750 kilometres in 1985.

Source BTCE estimates.

TABLE 5.2 AGE OF QUEENSLAND SEALED NATIONAL HIGHWAYS FOR VARIOUS RECONSTRUCTION RATES, 1983 TO 2000

Year	Length of road reconstructed (km per year)	Length of road of age[a] (km) ≥20 years	≥30 years	≥35 years	≥40 years	Mean age (years)
1983	na	1 100 (27)	200 (5)	100 (2)	0 (0)	12.4
1985	80 (2.0)[b]	1 100 (27)	100 (2)	-	0 (0)	13.1
1990	40 (1.0)	1 800 (44)	500 (12)	100 (2)	-	17.1
	80 (2.0)[b]	1 500 (37)	300 (7)	-	0 (0)	15.2
	100 (2.4)	1 400 (3.4)	200 (5)	0 (0)	0 (0)	14.4
	120 (2.9)	1 300 (32)	200 (5)	0 (0)	0 (0)	13.5
	160 (3.9)	1 000 (24)	100 (2)	0 (0)	0 (0)	12.0
1995	40 (1.0)	2 200 (54)	900 (22)	400 (10)	-	20.5
	80 (2.0)[b]	1 700 (41)	600 (15)	100 (2)	0 (0)	17.4
	100 (2.4)	1 500 (37)	400 (10)	100 (2)	0 (0)	16.0
	120 (2.9)	1 200 (29)	300 (7)	-	0 (0)	14.6
	160 (3.9)	800 (20)	-	0 (0)	0 (0)	12.0

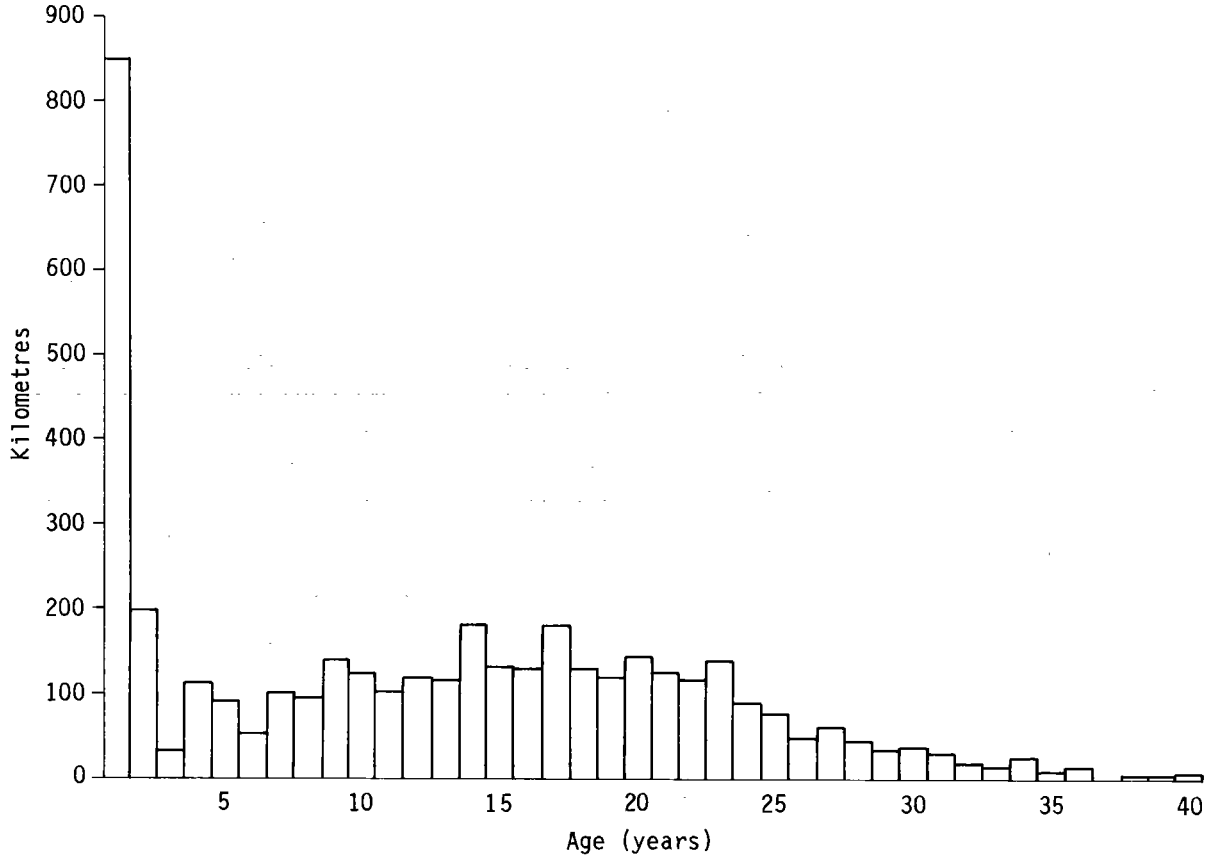
TABLE 5.2 (Cont.) AGE OF QUEENSLAND SEALED NATIONAL HIGHWAYS FOR VARIOUS RECONSTRUCTION RATES, 1983 TO 2000

Year	Length of road reconstructed (km per year)	Length of road of age[a] (km) ≥20 years	≥30 years	≥35 years	≥40 years	Mean age (years)
2000	40 (1.0)	2 400 (59)	1 500 (36)	800 (20)	300 (7)	23.9
	80 (2.0)[b]	1 700 (41)	900 (21)	400 (10)	100 (2)	19.4
	100 (2.4)	1 400 (34)	600 (15)	200 (5)	-	17.3
	120 (2.9)	1 000 (24)	300 (8)	-	0 (0)	15.4
	160 (3.9)	400 (10)	-	0 (0)	0 (0)	12.1

a. Assumes a minimum age at reconstruction of 15 years and no new construction.
b. The present estimated reconstruction rate.
na Not available.
- Rounded to zero.

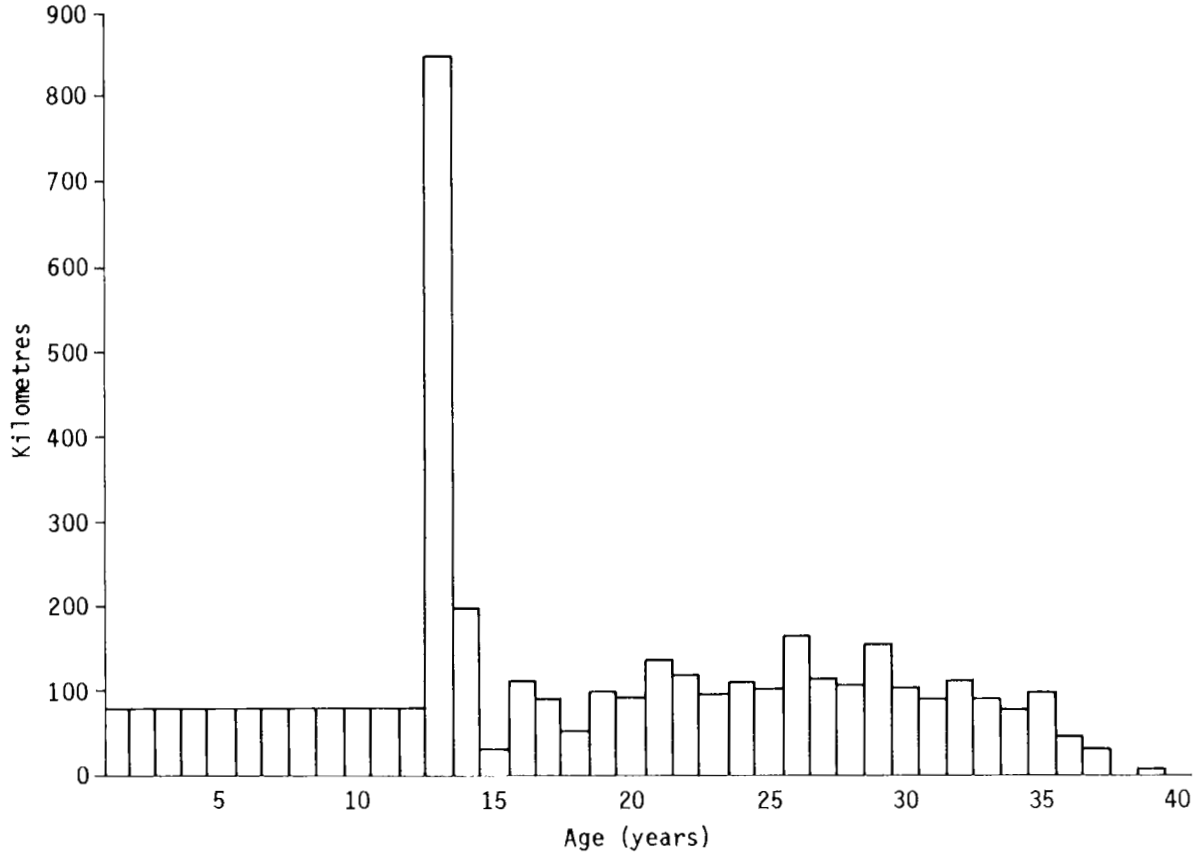
Note Figures in parentheses are percentages of a total sealed length of 4100 kilometres.

Source BTCE estimates.



Source BTCE estimates.

Figure 5.3 Queensland sealed National Highways: estimated age of road system, 1983



Source BTCE estimates.

Figure 5.4 Queensland sealed National Highways: estimated age of road system, 1995

CHAPTER 6 WESTERN AUSTRALIA

Analysis of the ageing of Western Australian roads is complicated by the amount of road widening which has recently taken place. Prior to the 1960s the desire for rapid expansion of what was then seen as a basic but adequate level of road access for rural communities led to the construction of considerable lengths of sealed single lane roads. More recently, these have been seen as less than adequate and the emphasis has shifted to widening these roads to meet normal standards for sealed two lane roads.

The problem for this analysis is whether the age of a widened road should be based on the age of the retained pavement or on the more recently constructed additions. Ideally, an analysis would need to consider the widenings and retained pavements separately. Unfortunately, the necessary data are not available, nor is it known whether widening actually extends the life of the retained pavements.

As in the case of Victoria, the analysis has been conducted on the assumption that the age of the road is given by the age of the oldest remaining pavement. However, an indication of the effect of the alternative assumption is also given.

DATA SOURCES

Road inventory information as at 1985 (based on both the above assumptions) was provided by the Western Australian Main Roads Department. Supplementary information was obtained from MRD Annual Reports (Main Roads Department pers. comm., 1986; Main Roads Department 1985).

RURAL ARTERIALS

The rural arterial road system in Western Australia comprises State highways which are not classified as National Highways, together with main roads and some secondary roads. In 1985 sealed rural arterial roads totalled 11 940 kilometres and it is estimated that in recent years the system was being extended by between 100 and 150 kilometres

per year. In the analysis to follow, a new sealing rate of 100 kilometres per year is assumed throughout for the years after 1985. The reconstruction rate (excluding widening) for rural arterial roads is estimated to be of the order of 75 kilometres per year.

The 1985 age distribution of the rural arterial road system is shown in Figure 6.1. The ageing model was used to derive the likely effects in the year 1995 of maintaining the current rates of new sealing and reconstruction (Figure 6.2). An estimated current reconstruction rate of 75 kilometres per year would result in some 3600 kilometres of pavements equal or greater than 35 years of age (27.6 per cent of the system in 1995). If the reconstruction rate was raised to 150 kilometres per year, 3000 kilometres (or 23.0 per cent) of pavements would be aged 35 years and over in 1995.

Table 6.1 shows the results for a range of reconstruction rates. At least 300 kilometres of pavement would need to be reconstructed each year to maintain the present average age of the road system through the 1990s, that is, over four times the present reconstruction rate. It is noted from the table that while the average age of the rural arterial road system would marginally increase if reconstructed at a rate of 300 kilometres per year, the age profile tends to become 'flatter' with more roads in the less than 20 years and greater than 30 years groups.

Road widening

Road widening activity from single lane sealed arterials to two lanes wide has recently approached 200 kilometres per year. Road widening encompasses work done on both sides of the road equally or unequally or on one side only. Usually, the widenings are constructed to higher standards than the original pavement. The MRD inventory data include overtaking lanes and deceleration lanes as widening.

Figure 6.3 shows the age distribution of Western Australian rural arterial roads based on the age of the newest pavement (that is, considering widening as reconstruction). The average age of the road is 16.2 years as compared with 19.6 years where road age is based on the oldest pavement. If current levels of new construction (100 kilometres per year), reconstruction (75 kilometres per year) and widening (110 kilometres per year - considered as reconstruction) are continued the average age of the roads would increase from 16 years to 20 years by 1995. The impact of widening does not, therefore, change the basic picture.

TABLE 6.1 AGE OF WESTERN AUSTRALIAN SEALED RURAL ARTERIALS FOR VARIOUS RECONSTRUCTION RATES, 1985 TO 2000

Year	Length of road reconstructed (km per year)		Length of road of age[a] (km) ≥20 years		≥30 years		≥35 years		≥40 years		Mean age (years)
1985	75	(0.6)[b]	6 800	(56)	1 750	(15)	450	(4)	150	(1)	19.6
1988	75	(0.6)[b]	7 800	(63)	2 950	(24)	950	(8)	200	(2)	21.5
1990	75	(0.6)[b]	8 400	(67)	3 850	(31)	1 500	(12)	250	(2)	22.7
	150	(1.2)	7 950	(63)	3 500	(28)	1 200	(10)	100	(1)	21.5
	300	(2.4)	7 050	(56)	2 850	(23)	800	(6)	0	(0)	19.4
	350	(2.8)	6 750	(54)	2 650	(21)	700	(6)	0	(0)	18.7
	400	(3.2)	6 450	(51)	2 450	(20)	550	(4)	0	(0)	18.0
1995	75	(0.6)[b]	9 500	(73)	6 100	(47)	3 600	(28)	1 300	(10)	25.6
	150	(1.2)	8 700	(67)	5 400	(41)	3 000	(23)	900	(7)	23.6
	300	(2.3)	7 050	(54)	4 050	(31)	2 000	(15)	350	(3)	19.9
	350	(2.7)	6 500	(50)	3 600	(28)	1 650	(13)	200	(2)	18.6
	400	(3.1)	5 950	(46)	3 150	(24)	1 350	(10)	100	(1)	17.4

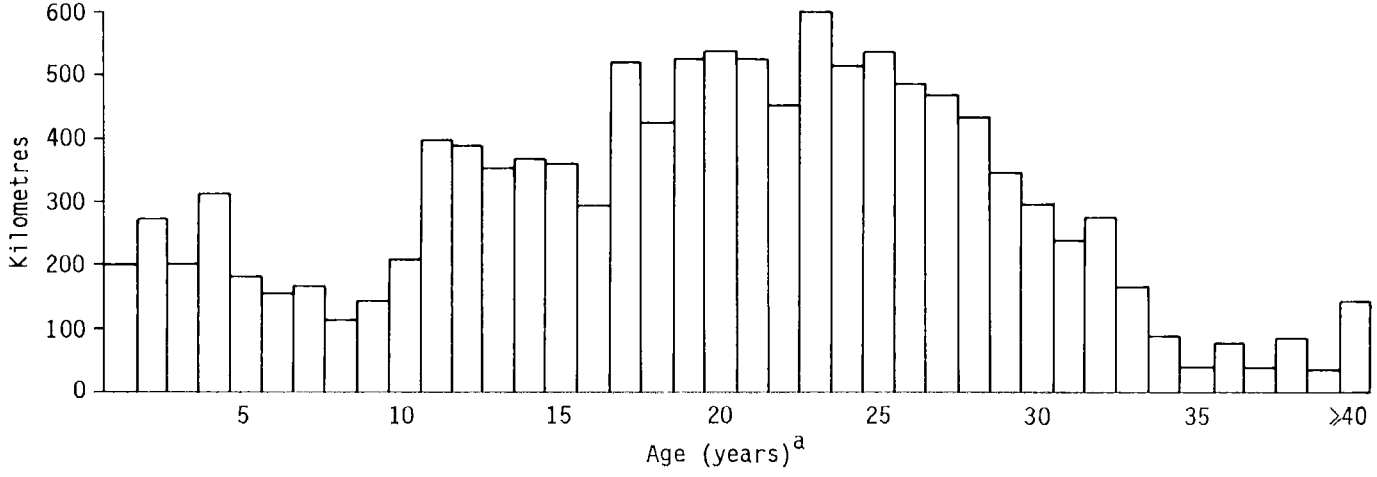
TABLE 6.1 (Cont.) AGE OF WESTERN AUSTRALIAN SEALED RURAL ARTERIALS FOR VARIOUS RECONSTRUCTION RATES, 1985 TO 2000

Year	Length of road reconstructed (km per year)	Length of road of age[a] (km) ≥20 years	≥30 years	≥35 years	≥40 years	Mean age (years)
2000	75 (0.6)[b]	10 050 (74)	7 700 (57)	5 850 (43)	3 350 (25)	28.5
	150 (1.1)	8 850 (65)	6 600 (49)	4 900 (36)	2 600 (19)	25.7
	300 (2.2)	6 450 (48)	4 450 (33)	3 050 (23)	1 300 (10)	20.2
	350 (2.6)	5 650 (42)	3 750 (28)	2 450 (18)	950 (7)	18.5
	400 (3.0)	4 900 (36)	3 050 (23)	1 950 (14)	650 (5)	16.9

a. Based on a minimum age at reconstruction of 15 years and a new sealing rate of 100 kilometres per year.
b. The present estimated rate of reconstruction.

Note Figures in parentheses are percentages of sealed length of rural arterial roads, estimated length of 11 939 kilometres in 1984.

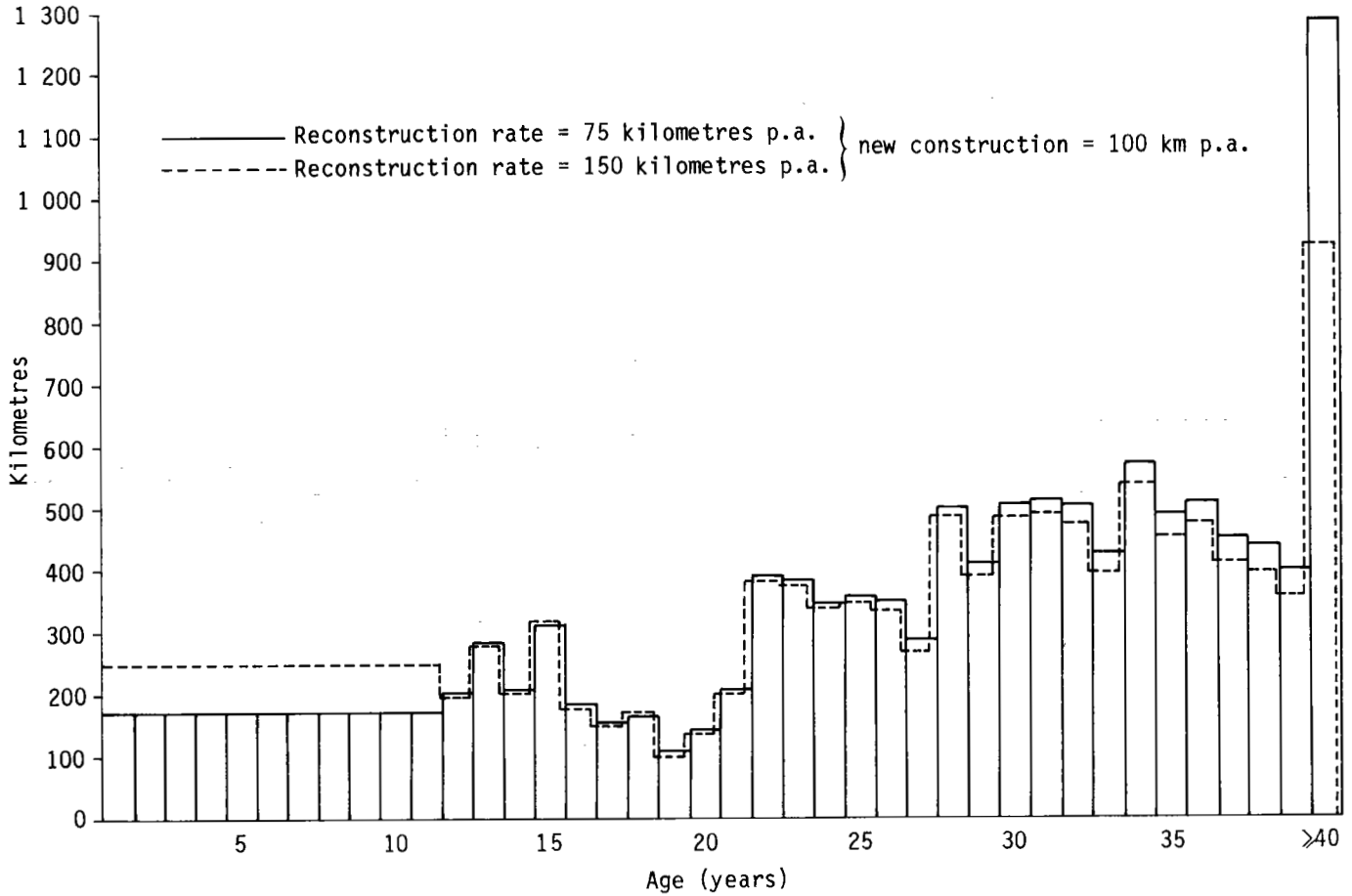
Source BTCE estimates.



a. Average age = 19.6 years

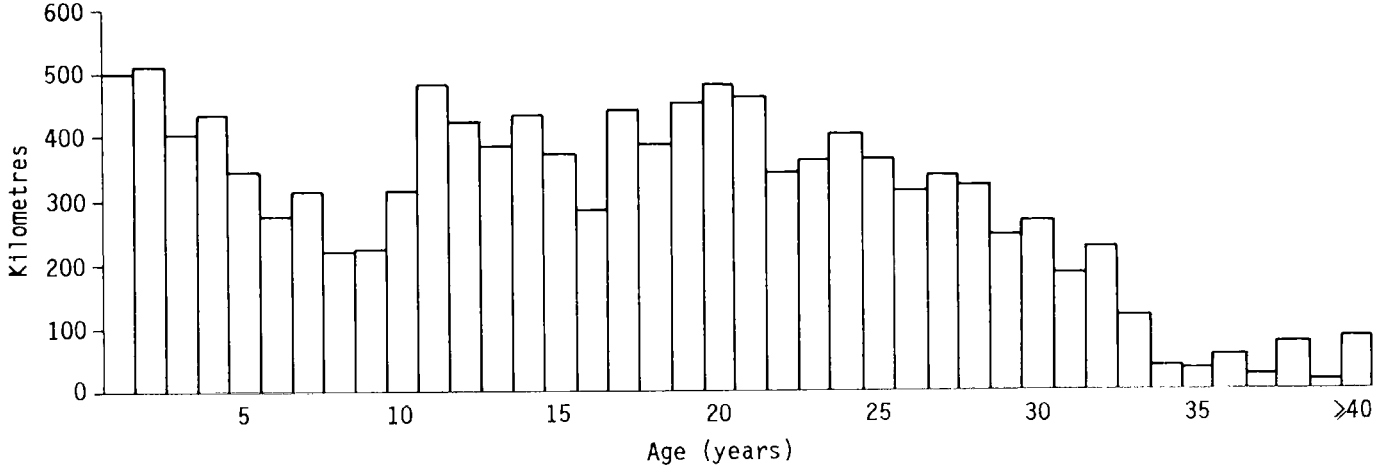
Source Main Roads Department (1986).

Figure 6.1 Western Australian sealed rural arterials: estimated age of road system, 1985



Source BTCE estimates.

Figure 6.2 Western Australian sealed rural arterials: estimated age of road system, 1995



Source Main Roads Department (1986).

Figure 6.3 Western Australian rural arterials: age distribution based on year of original seal or widening, 1985

NATIONAL HIGHWAYS

The Western Australian National Highways comprise the Great Eastern Highway-Eyre Highway link from Perth to the South Australian border near Eucla and the Great Northern Highway from Perth to the Northern Territory border near Kununurra, a combined distance of 4429 kilometres. MRD inventory data show that at the end of 1985, 4144 kilometres of National Highways were sealed. It is expected that the National Highway system will be completely sealed by 1988, following the conclusion of two major projects on the Great Northern Highway. They are the Fitzroy Crossing-Halls Creek project involving realignment and sealing of 275 kilometres of highway in the Kimberleys and the Newman-Port Hedland project which involves construction of a new 416 kilometres all weather sealed route crossing the Hamersley Range.

This remaining 285 kilometres of new sealing work was assumed to be distributed thus: 75 kilometres in 1985 and 70 kilometres per year in 1986 to 1988. Figure 6.4 highlights an uneven distribution of pavements by year of construction. Peak construction periods occurred in the late 1960s when the sealing of the Eyre Highway was completed, then during 1976 to 1977 and 1980 to 1981 when activity was concentrated on the Great Northern Highway.

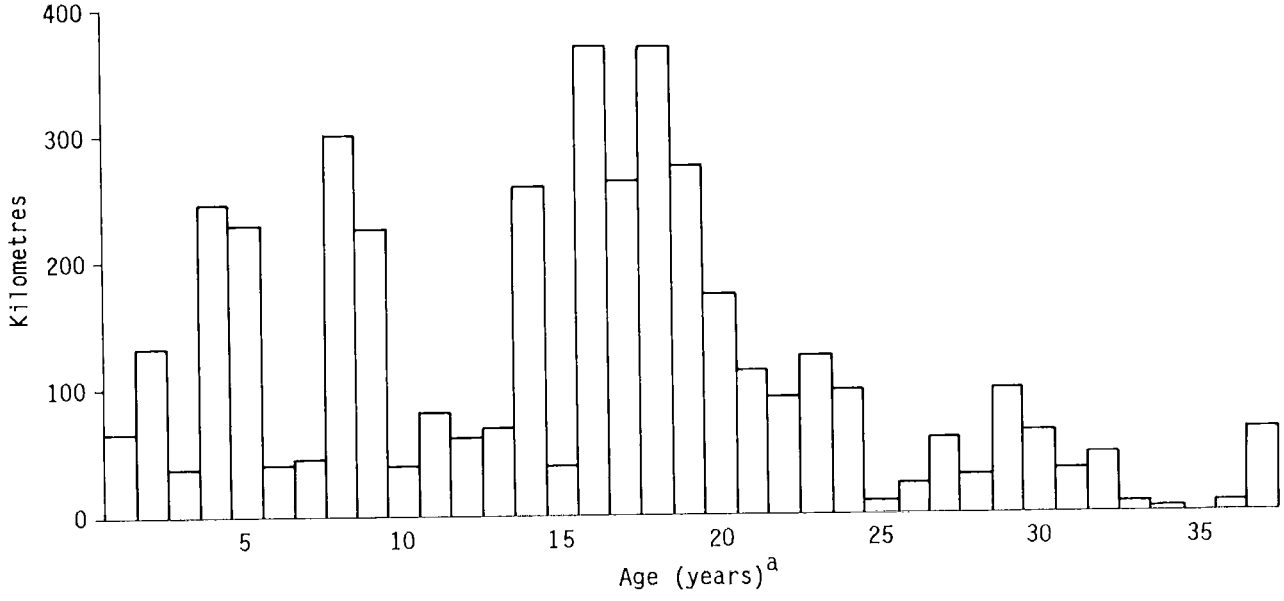
The average pavement age of Western Australian National Highways in 1985 was 15 years. Given that reconstruction continues at approximately the present rate of about 50 kilometres per year, the highways system would have an average pavement age of 21 years in 1995, and would have an age distribution similar to that in Figure 6.5. In order to arrest this process of ageing, it is estimated that the National Highways would need to be reconstructed at a considerably higher rate of 175 kilometres per year.

The effects of various reconstruction rates are shown in Table 6.2.

National Highways widening

In contrast to rural arterial roads, widening has not featured as prominently for National Highways. Major widening projects were undertaken on the Great Eastern Highway-Eyre Highway to Norseman in the late 1960s and are currently being undertaken on sections of the Eyre Highway farther east which were first sealed during the late 1960s and have since fallen below acceptable standards of road width.

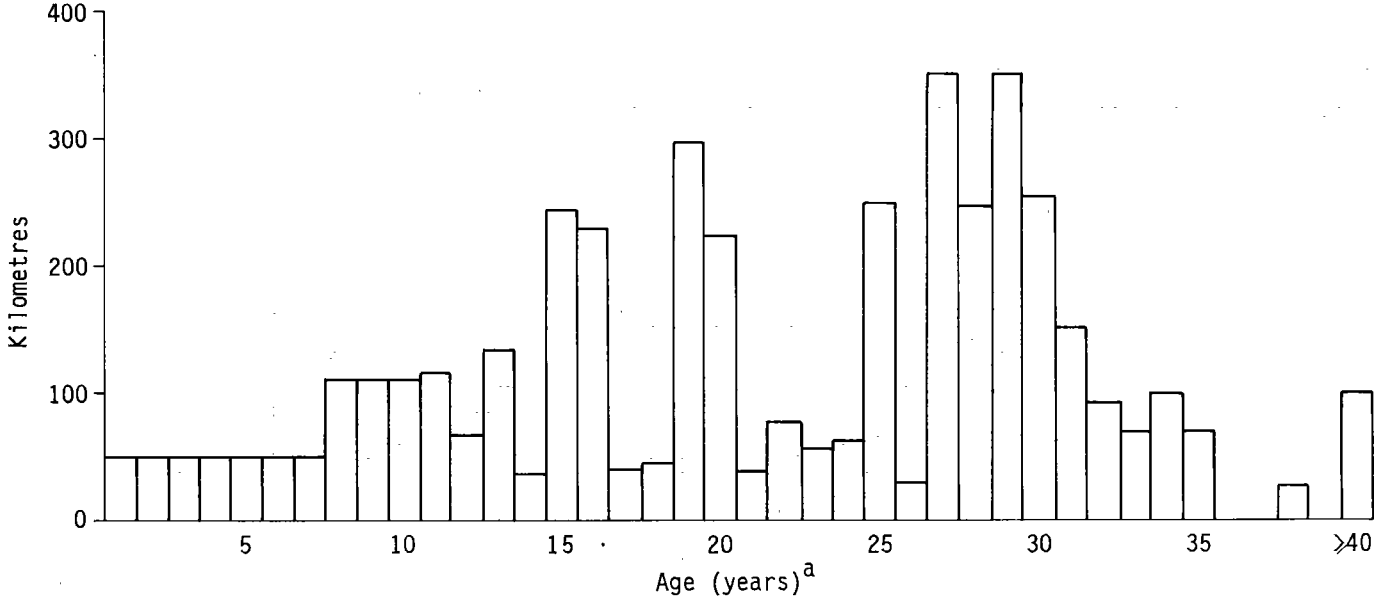
The pavement age profile based on main pavement construction and widening, including acceleration and deceleration lanes, is shown in Figure 6.6. The average age in this case is of the order of 14 years, marginally less than the age of main pavement only.



a. Average age = 15.0 years.

Source Main Roads Department (1986).

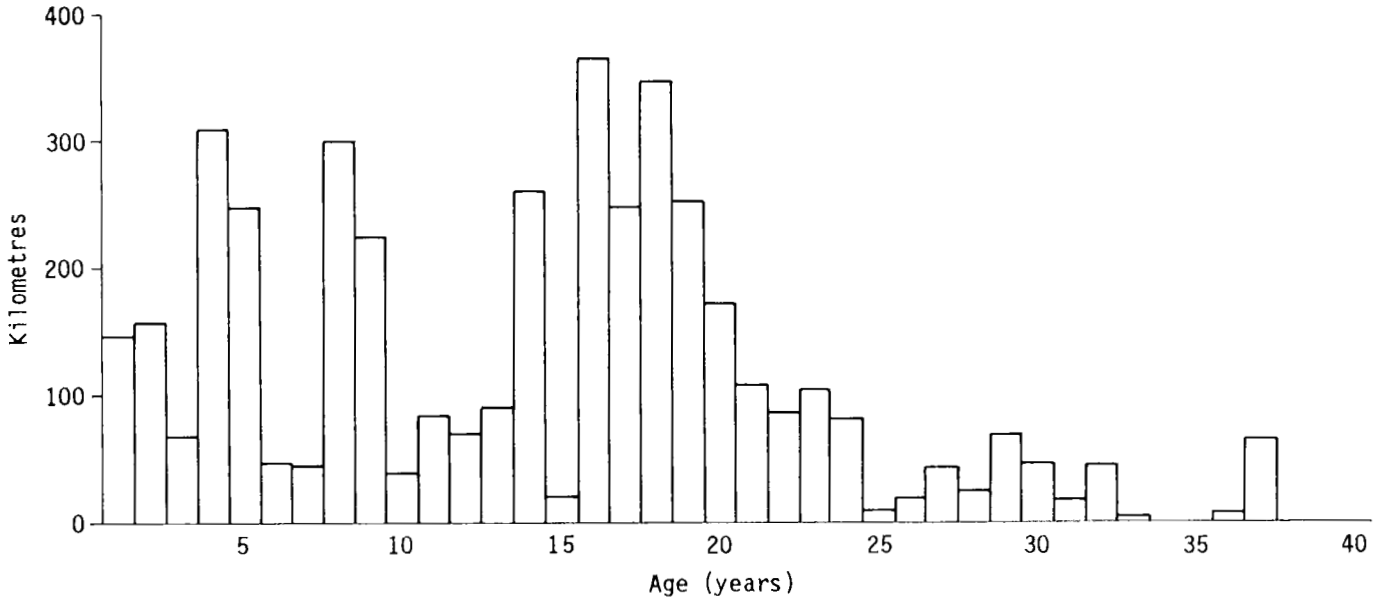
Figure 6.4 Western Australian sealed National Highways: estimated age of road system, 1985



a. Average age = 20.9 years.

Source BTCE estimates.

Figure 6.5 Western Australian sealed National Highways: estimated age of road system, 1995



Source Main Roads Department (1986).

Figure 6.6 Western Australian National Highways: age distribution based on year of original seal or widening, 1985

TABLE 6.2 AGE OF WESTERN AUSTRALIAN SEALED NATIONAL HIGHWAYS FOR VARIOUS RECONSTRUCTION RATES, 1985 TO 2000

Year	Length of road reconstructed (km per year)		Length of road of age[a] (km) ≥20 yrs		≥30 yrs		≥35 yrs		Mean age (years)
1985	40	(0.9)	1 250	(30)	300	(7)	50	(1)	15.0
1988	40	(0.9)	2 150	(49)	300	(7)	100	(2)	16.5
1990	50	(1.1)[b]	2 300	(52)	350	(8)	200	(5)	17.8
	100	(2.3)	2 250	(51)	250	(6)	150	(3)	17.1
	150	(3.4)	2 150	(49)	200	(5)	100	(2)	16.4
	175	(4.0)	2 100	(47)	200	(5)	100	(2)	16.1
	200	(4.5)	2 000	(45)	150	(3)	50	(1)	15.7
1995	50	(1.1)[b]	2 550	(58)	850	(19)	200	(5)	20.9
	100	(2.3)	2 200	(50)	650	(15)	50	(1)	18.7
	150	(3.4)	1 850	(42)	400	(9)	-		16.6
	175	(4.0)	1 700	(38)	350	(8)	0	(0)	15.6
	200	(4.5)	1 500	(34)	250	(6)	0	(0)	14.6
2000	50	(1.1)[b]	3 150	(71)	1 900	(43)	700	(16)	24.0
	100	(2.3)	2 550	(58)	1 400	(32)	400	(9)	20.2
	150	(3.4)	1 950	(44)	1 000	(23)	200	(5)	16.8
	175	(4.0)	1 650	(37)	800	(18)	100	(2)	15.2
	200	(4.5)	1 400	(32)	550	(12)	50	(1)	13.6

a. Based on a minimum age at reconstruction of 15 years.
b. The present estimated rate of reconstruction.
\- Rounded to zero.

Notes 1. Figures in parentheses are percentages of the sealed length of National Highways, estimated to have been 4144 kilometres in 1984.
2. It is expected that the Western Australian National Highway system will be completely sealed by 1988, reaching a length of 4429 kilometres.

Source BTCE estimates.

CHAPTER 7 SOUTH AUSTRALIA

The analysis of South Australian roads conforms with the standard approach.

DATA SOURCES

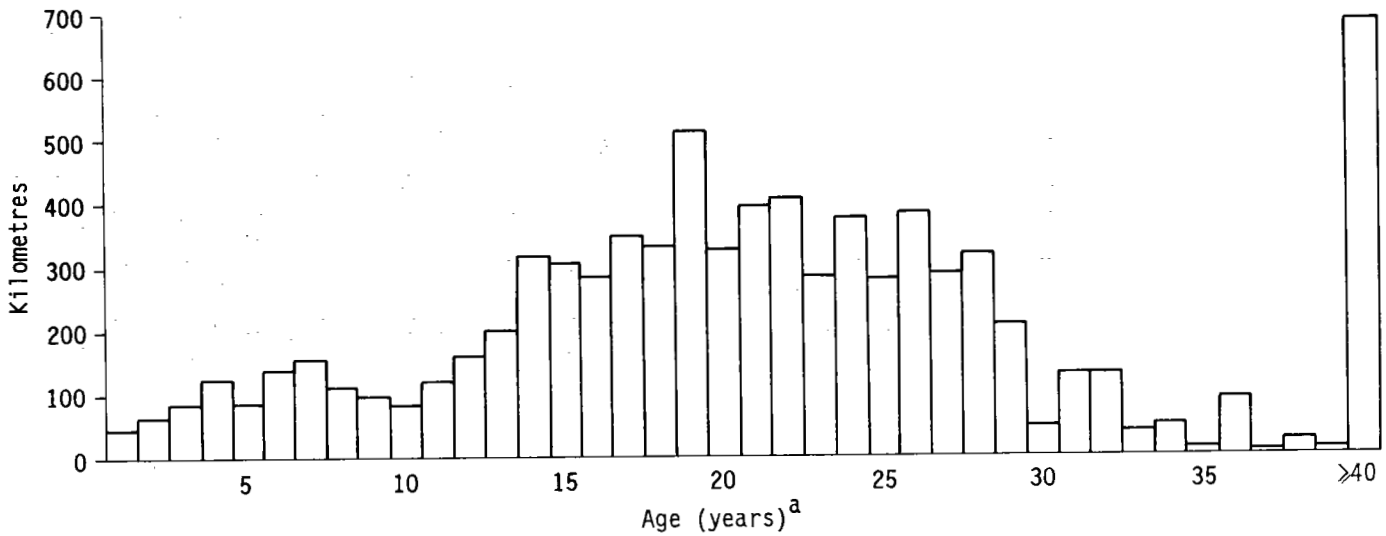
Information on the ages of South Australian rural arterial roads and National Highways was provided by the Advance Planning Branch of the SA Highways Department (pers. comm. 1986). Supplementary information was obtained from Annual and other reports of the Highways Department (Highways Department 1985).

RURAL ARTERIALS

The rural arterial roads considered in this section comprise NAASRA functional classes (FC) 1, 2 and 3; FC1 being the balance of arterial roads which are not classified as National Highways.

Figure 7.1 illustrates the distribution of the rural arterial road system by pavement age in 1985. The system, with a weighted average pavement age of 20.2 years, includes 8.6 per cent of roads which are at least 40 years old, although the large majority of roads (73.3 per cent) are 10 to 30 years old.

The ages of roads at reconstruction were discussed in Chapter 1 and 2 where it was observed that little is known about their distribution. However, a single datum is available from South Australia where there is evidence that, for roads of FC3 (which form the majority of the sealed rural arterial system), the Highways Department '... has tended to reconstruct at an age of approximately 37 years ...' (Highways Department 1984). This may be compared with mean ages at reconstruction, obtained from the model, of 33.3 or 35.1 years depending on the choice of i_{min} (15 or 20 years). This reasonable agreement lends support to the treatment of reconstruction in the model, the more so as the discrepancy may be partly explained by the inclusion in the model results of younger roads of FC1 and FC2.



a. Average age = 20.2 years.

Source SA Highways Department.

Figure 7.1 South Australian sealed rural arterials: estimated age of road system, 1985

The resulting road system in 1995, given that the present rates of reconstruction and new sealing continue, is shown in Figure 7.2. The estimated 1995 age distribution shows that significant ageing of the rural arterial roads will occur. The average age of the road system will have increased from 21 years in 1986 to almost 27 years in 1995.

The effect of an increased rate of new sealing and a decreased rate of reconstruction was examined. If the future new sealing rate was increased from 10 to 60 kilometres per year, and correspondingly, reconstruction was reduced from 80 to 30 kilometres per year, the average pavement age in 1995 would increase from 26.9 years to 27.4 years.

Even with the majority of effort on the South Australian rural arterials being concentrated on reconstruction, the reconstruction rates achieved are far too low to prevent the road system from ageing. This is demonstrated in Table 7.1 which shows estimated age profiles in the years 1990, 1995 and 2000 under various reconstruction rates. Based on a present reconstruction rate of 80 kilometres per year, it is seen that the reconstruction effort would need to be raised at least three-fold to 240 kilometres per year in order to hold the mean age of the road system close to its present level.

NATIONAL HIGHWAYS

National Highways in South Australia comprise the Dukes Highway from Adelaide to the Victorian border, the Princes Highway from Adelaide to Port Augusta, the Eyre Highway to the Western Australian border and the Stuart Highway to the Northern Territory border.

The age data on National Highways included short lengths of urban arterial (FC6) roads, the continuation of National Highways into urban areas. No attempt was made to exclude these from the analysis.

Figure 7.3 shows that the lengths of South Australian National Highways initially sealed or reconstructed varied considerably in length from year to year. However, the Highways Department does stress that these yearly variations in the distribution should not be interpreted as variations in rates of construction effort expended during these years. This is because 'year of pavement construction' recorded the year a road was actually sealed, but did not take account of the often considerable construction effort in the years before. For example, the peak at ages 8 and 9 years (1976 and 1977) reflects the completion of sealing of the Eyre Highway, yet most of the construction and expenditure on this project took place in the years 1971 to 1975.

TABLE 7.1 AGE OF SOUTH AUSTRALIAN SEALED RURAL ARTERIALS FOR VARIOUS RECONSTRUCTION RATES, 1985 TO 2000

Year	Length of road reconstructed (km per year)		Length of road of age[a] (km) ≥20 years		≥30 years		≥35 years		≥40 years		Mean age (years)
1985	80	(1.0)[b]	4 150	(52)	1 150	(14)	800	(10)	700	(9)	20.2
1986	80	(1.0)[b]	4 450	(55)	1 200	(15)	800	(10)	700	(9)	21.1
1990	80	(1.0)[b]	5 700	(70)	2 200	(27)	1 000	(12)	700	(9)	23.8
	120	(1.5)	5 600	(69)	2 100	(26)	950	(12)	700	(9)	23.3
	160	(2.0)	5 500	(67)	2 050	(25)	900	(11)	650	(8)	22.8
	200	(2.5)	5 350	(66)	1 950	(24)	850	(10)	650	(8)	22.3
	240	(2.9)	5 250	(64)	1 850	(23)	800	(10)	600	(7)	21.9
1995	80	(1.0)[b]	6 400	(78)	3 600	(44)	1 950	(24)	850	(10)	26.9
	120	(1.5)	6 100	(74)	3 250	(40)	1 750	(21)	650	(8)	25.7
	160	(1.9)	5 800	(71)	3 100	(38)	1 550	(19)	600	(7)	24.4
	200	(2.4)	5 450	(66)	2 850	(35)	1 400	(17)	550	(7)	23.2
	240	(2.9)	5 150	(63)	2 600	(32)	1 250	(15)	450	(5)	22.0

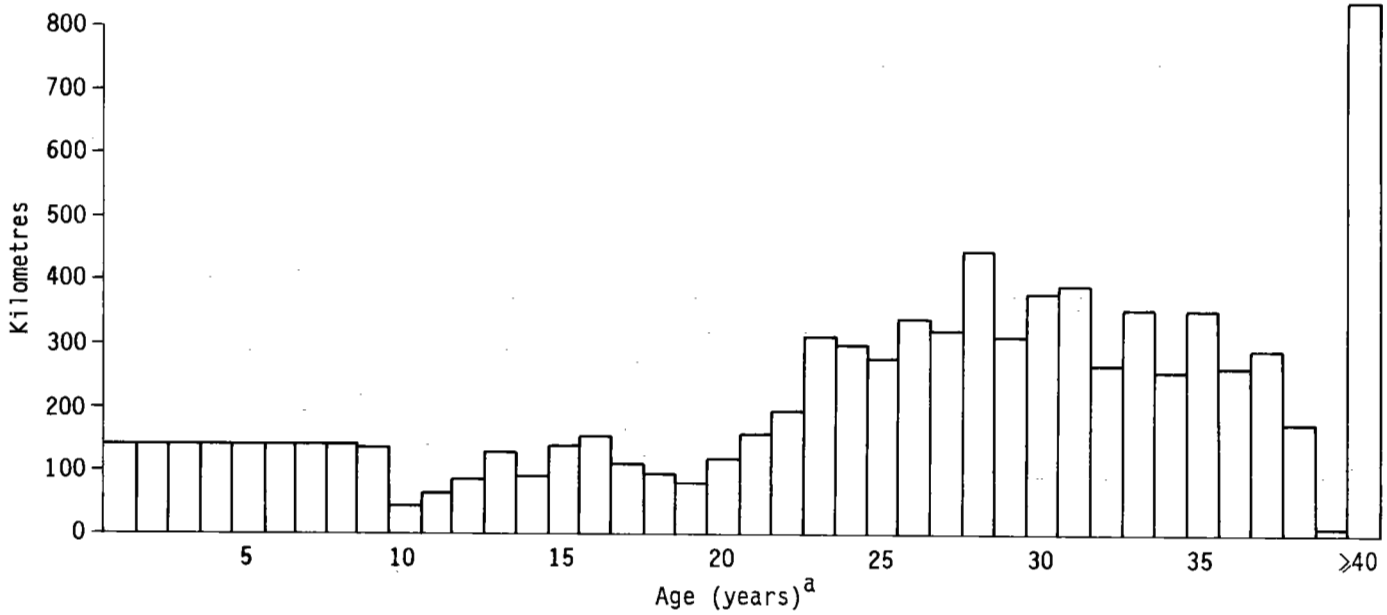
TABLE 7.1 (Cont.) AGE OF SOUTH AUSTRALIAN SEALED RURAL ARTERIALS FOR VARIOUS RECONSTRUCTION RATES, 1985 TO 2000

Year	Length of road reconstructed (km per year)	Length of road of age[a] (km) ≥20 years	≥30 years	≥35 years	≥40 years	Mean age (years)
2000	80 (1.0)[b]	6 600 (80)	5 000 (60)	3 300 (40)	1 750 (21)	30.0
	120 (1.5)	6 100 (74)	4 550 (55)	2 950 (36)	1 500 (18)	27.9
	160 (1.9)	5 550 (67)	4 100 (50)	2 550 (31)	1 200 (15)	25.8
	200 (2.4)	5 050 (61)	3 650 (44)	2 200 (27)	1 000 (12)	23.8
	240 (2.9)	4 550 (55)	3 200 (39)	1 850 (22)	800 (10)	21.8

a. Based on a minimum age for reconstruction of 15 years and a new sealing rate of 10 kilometres per year.
b. Estimated present rate of reconstruction.

Note Figures in parentheses are percentages of the length of the sealed part of rural arterial roads, estimated to have been 8052 kilometres in 1986.

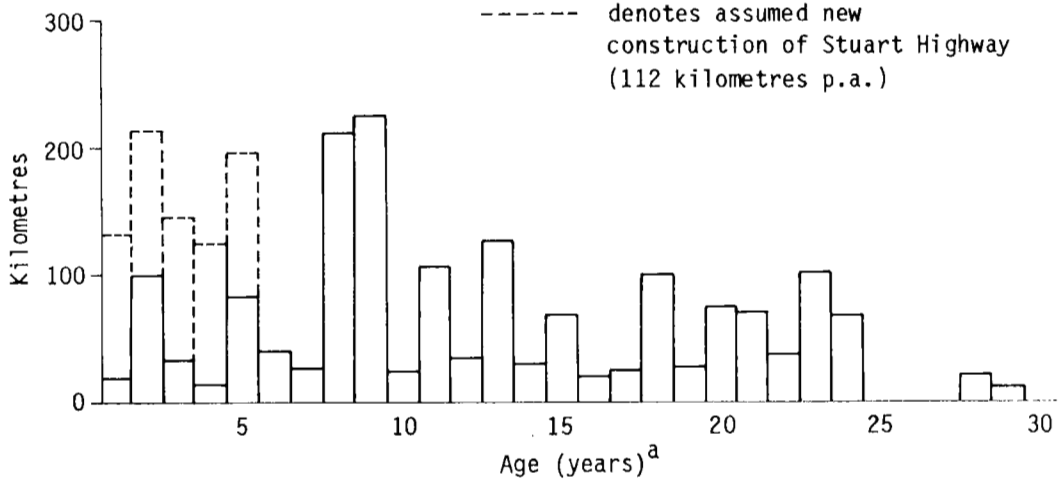
Source BTCE estimates.



a. Average age = 26.9 years.

Source BTCE estimates.

Figure 7.2 South Australian sealed rural arterials: estimated age of road system, 1995



a. Average age = 10.3 years.

Source SA Highways Department (1986), BTCE estimates.

Figure 7.3 South Australian sealed National Highways: estimated age of road system, 1985

A similar National Highway construction project is under way on the Stuart Highway, in order to completely seal the highway and the South Australian National Highway network by early 1987. Work on this project has proceeded rapidly since 1980, although the data set obtained from the Highways Department shows that 898 kilometres are yet to be sealed. The Highways Department has advised that once the field completion reports on this work are received, the 'year paved' figures will be adjusted retrospectively to the year 1980. In the absence of more precise information, the analysis to follow assumed that the outstanding 898 kilometres of seal were evenly distributed in eight portions of 112.25 kilometres over the years 1980 to 1987.

Unlike the rural arterial road system, the South Australian National Highways have a young age profile, with an average pavement age in 1985 of some 10 to 11 years and just 17 per cent of pavements aged 20 years or more (see Figure 7.3). This is mainly due to the recent emphasis on sealing of the Eyre and Stuart Highways. As such, the South Australian National Highways do not pose a reconstruction problem in the short term. Presently, the highways are being reconstructed at between 30 and 60 kilometres per year. Figure 7.4 shows the effect in 1995 of reconstructing at 60 kilometres per year. Under these conditions, the average pavement age would increase to 14.6 years, with 27 per cent of pavements aged 20 years or more.

Table 7.2 shows the effects of various reconstruction rates, presenting the estimated South Australian National Highway age profiles in the years 1990, 1995 and 2000. The analysis shows that in order to prevent ageing of the road system, a reconstruction rate of 120 kilometres per year is needed, two to four times the estimated present rate. It is possible that higher reconstruction rates than currently used would not need to be applied in the short-term (five to ten years) as existing pavement ages are generally much less than typical design life.

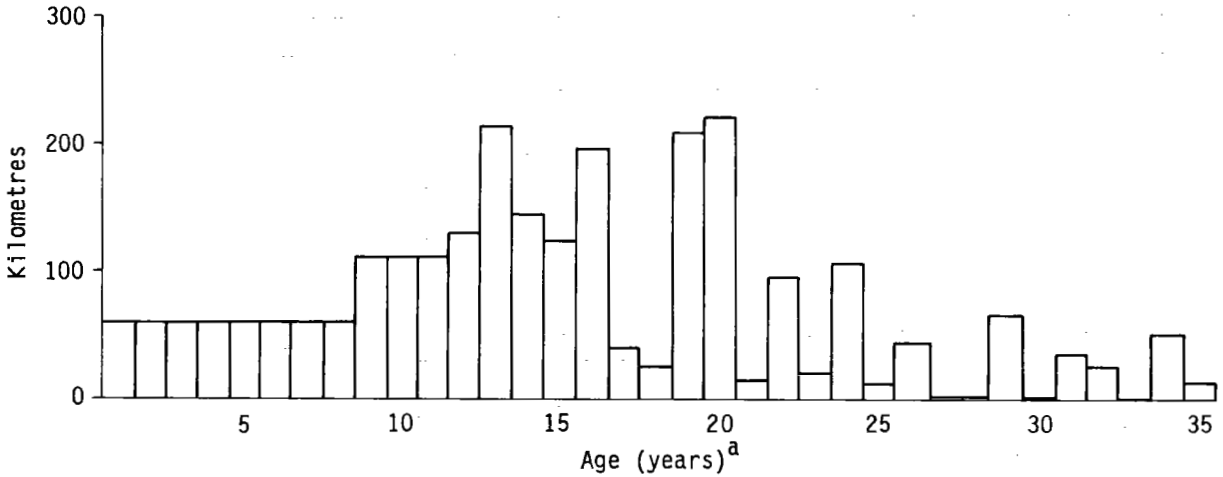
TABLE 7.2 AGE OF SOUTH AUSTRALIAN SEALED NATIONAL HIGHWAYS FOR VARIOUS RECONSTRUCTION RATES, 1985 TO 2000

Year	Length of road reconstructed (km per year)		Length of road of age[a] (km) ≥20 yrs		≥30 yrs		≥35 yrs		Mean age (years)
1985	40	(1.5)	400	(17)	-		0	(0)	10.3
1986	40	(1.5)	500	(20)	50	(2)	0	(0)	10.8
1990	40	(1.5)	550	(21)	50	(2)	0	(0)	13.2
	60	(2.3)	500	(19)	50	(2)	0	(0)	12.6
	80	(3.1)	450	(17)	50	(2)	0	(0)	12.1
	100	(3.8)	400	(15)	50	(2)	0	(0)	11.5
	120	(4.6)	300	(12)	-		0	(0)	11.0
1995	40	(1.5)	850	(33)	200	(8)	50	(2)	16.1
	60	(2.3)	700	(27)	150	(6)	-		14.6
	80	(3.1)	550	(21)	50	(2)	0	(0)	13.1
	100	(3.8)	400	(15)	0	(0)	0	(0)	11.7
	120	(4.6)	300	(12)	0	(0)	0	(0)	10.6
2000	40	(1.5)	1 250	(48)	250	(10)	150	(6)	18.9
	60	(2.3)	1 000	(38)	100	(4)	-		16.4
	80	(3.1)	750	(29)	0	(0)	0	(0)	14.3
	100	(3.8)	500	(19)	0	(0)	0	(0)	12.5
	120	(4.6)	300	(12)	0	(0)	0	(0)	11.0

a. Based on a minimum age for reconstruction of 15 years.
- Rounded to zero.

Notes 1. Figures in parentheses are percentages of sealed National Highways, reaching a length of 2606 kilometres in 1987.
2. Estimated present reconstruction rate is 30 to 60 kilometres per year.

Source BTCE estimates.



a. Average age = 14.6 years.

Source BTCE estimates.

Figure 7.4 South Australian sealed National Highways: estimated age of road system, 1995

CHAPTER 8 TASMANIA

DATA SOURCE

Pavement age information for Tasmanian roads was provided by the Department of Main Roads, Tasmania (pers. comm. 1986). Data for the Tasmanian rural arterials were complete and for the year 1984-85. For the National Highways, some 88 per cent of road length was classified by age and was given for the year 1980-81. Therefore, an estimate had to be made of the age distribution in 1984-85, as the starting point for the analysis.

RURAL ARTERIALS

The sealed length of Tasmanian rural arterials is estimated to have been 2550 kilometres in 1984-85. The rural arterials consist of primary and secondary rural arterial roads (FC2 and FC3) and include a number of State highways. The 1985 age distribution on which the analysis is based is presented in Figure 8.1; its computed weighted average age is 19.6 years. Based on recent roadwork trends, the analysis has assumed new sealing at a rate of six kilometres per year and reconstruction of 45 kilometres per year. The age distribution for 1995 (see Figure 8.2) shows that if roadwork is maintained at present rates, the rural arterials would age to 23.1 years. Over 1000 kilometres (38 per cent) of the roads would be aged 30 years or more and 280 kilometres at least 40 years.

The effects of the various reconstruction rates on the age distribution of Tasmanian rural arterial roads are illustrated in Table 8.1. The table shows that the annual reconstructed lengths would need to be increased from 45 kilometres to 75 kilometres in order to prevent ageing of the road system.

NATIONAL HIGHWAY

The Tasmanian National Highway extends from Hobart to Launceston (Midland Highway) then to Burnie (Bass Highway), totalling 336 kilometres. Age data for 295 kilometres of the highway were scaled to 336 kilometres for the base year of 1980-81, prior to analysis.

Figure 8.3 shows the estimated 1985 age distribution derived by the ageing model, using annual reconstruction lengths of 10 kilometres per year. The National Highway has been completely sealed for some considerable time. Features of the age distribution are an average age of 14.4 years, a relatively flat distribution dating back to 1960 and some 43 kilometres of pavements constructed in 1951-52. The corresponding 1995 age distribution (Figure 8.4) represents the situation if the present reconstruction effort of 10 kilometres per year continued.

The effects of various reconstruction rates on National Highways age distributions in future years are illustrated in Table 8.2. The figures show that the reconstruction effort would need to be marginally increased from 10 to 12 kilometres per year to keep the average age of the road system constant.

TABLE 8.1 AGE OF TASMANIAN SEALED RURAL ARTERIALS FOR VARIOUS RECONSTRUCTION RATES, 1985 TO 2000

Year	Length of road reconstructed (km per year)	Length of road of age[a] (km) ≥20 years	≥30 years	≥35 years	≥40 years	Mean age (years)
1985	45 (1.7)[b]	1 400 (55)	550 (22)	300 (12)	-	19.6
1990	45 (1.7)[b]	1 600 (62)	650 (25)	400 (16)	200 (8)	21.5
	55 (2.1)	1 550 (60)	600 (23)	350 (14)	200 (8)	20.9
	65 (2.5)	1 500 (58)	550 (21)	350 (14)	200 (8)	20.2
	75 (2.9)	1 450 (56)	500 (19)	300 (12)	150 (6)	19.6
	85 (3.3)	1 400 (54)	500 (19)	300 (12)	150 (6)	19.0
1995	45 (1.7)[b]	1 600 (61)	1 000 (38)	500 (19)	300 (11)	23.1
	55 (2.1)	1 500 (57)	950 (36)	400 (15)	250 (10)	21.9
	65 (2.5)	1 400 (54)	850 (33)	350 (13)	200 (8)	20.6
	75 (2.9)	1 300 (50)	750 (29)	250 (10)	150 (6)	19.4
	85 (3.3)	1 200 (46)	700 (27)	200 (8)	100 (4)	18.1

TABLE 8.1 (Cont.) AGE OF TASMANIAN SEALED RURAL ARTERIALS FOR VARIOUS RECONSTRUCTION RATES, 1985 TO 2000

Year	Length of road reconstructed (km per year)	Length of road of age[a] (km) ≥20 years	≥30 years	≥35 years	≥40 years	Mean age (years)
2000	45 (1.7)[b]	1 550 (59)	1 200 (45)	850 (32)	350 (13)	24.6
	55 (2.1)	1 400 (53)	1 050 (40)	750 (28)	250 (9)	22.7
	65 (2.5)	1 250 (47)	900 (34)	600 (23)	150 (6)	20.8
	75 (2.8)	1 100 (42)	800 (30)	500 (19)	100 (4)	19.1
	85 (3.2)	950 (36)	650 (25)	400 (15)	50 (2)	17.4

a. Assuming a minimum age at reconstruction of 15 years and new constrution of 6 kilometres per year.
b. The estimated present reconstruction rate.
\- Rounded to zero.

Note Figures in parentheses are percentages of total sealed length, estimated to be 2550 kilometres in 1984-85.

Source BTCE estimates.

TABLE 8.2 AGE OF TASMANIAN NATIONAL HIGHWAY FOR VARIOUS RECONSTRUCTION RATES, 1981 TO 2000

Year	Length of road reconstructed (km per year)	Length of road of age[a] (km) ≥20 years	≥30 years	≥35 years	≥40 years	Mean age (years)
1981	10 (3.0)[b]	90 (27)	55 (16)	0 (0)	0 (0)	13.4
1985	10 (3.0)[b]	80 (24)	45 (13)	0 (0)	0 (0)	14.4
1990	8 (2.4)	125 (37)	35 (10)	35 (10)	0 (0)	16.9
	10 (3.0)[b]	110 (33)	25 (7)	25 (7)	0 (0)	15.5
	12 (3.6)	90 (27)	20 (6)	20 (6)	0 (0)	14.2
	14 (4.2)	75 (22)	10 (3)	10 (3)	0 (0)	12.8
	16 (4.8)	60 (18)	5 (1)	5 (1)	0 (0)	11.4
1995	8 (2.4)	150 (45)	40 (12)	25 (7)	25 (7)	18.6
	10 (3.0)[b]	125 (37)	25 (7)	15 (4)	15 (4)	16.4
	12 (3.6)	95 (28)	15 (4)	5 (1)	5 (1)	14.3
	14 (4.2)	70 (21)	-	0 (0)	0 (0)	12.4
	16 (4.8)	45 (13)	0 (0)	0 (0)	0 (0)	10.9

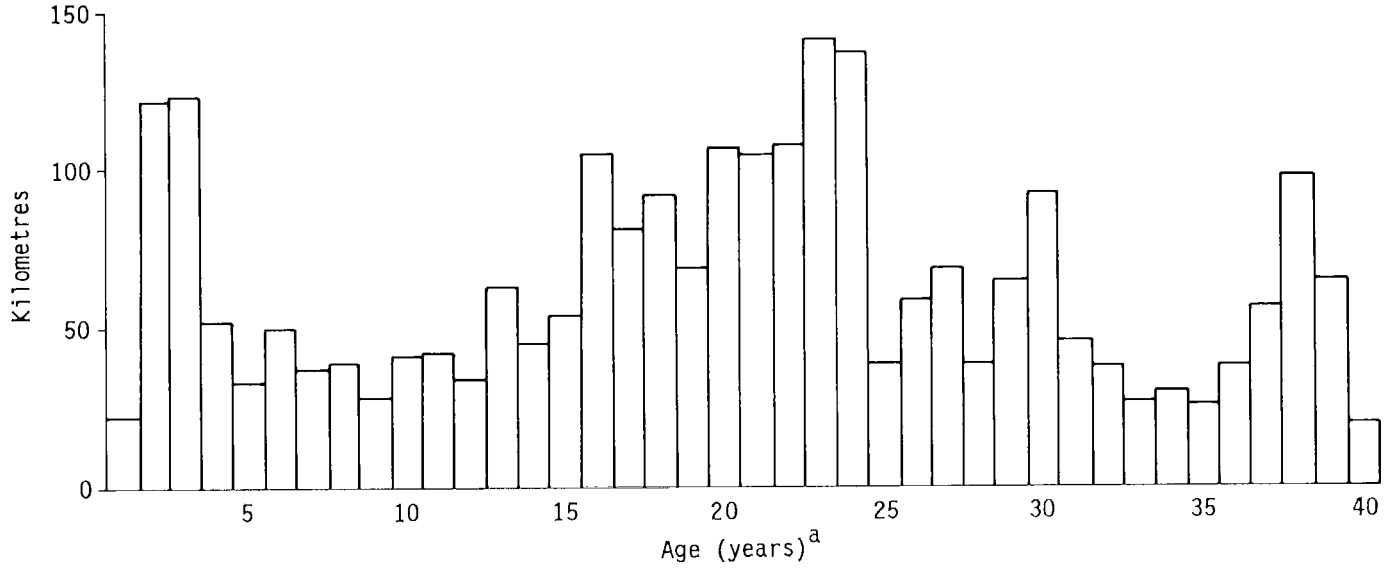
TABLE 8.2 (Cont.) AGE OF TASMANIAN NATIONAL HIGHWAY FOR VARIOUS RECONSTRUCTION RATES, 1981 TO 2000

Year	Length of road reconstructed (km per year)	Length of road of age[a] (km) ≥20 years	≥30 years	≥35 years	≥40 years	Mean age (years)
2000	8 (2.4)	185 (55)	70 (21)	30 (9)	20 (6)	20.0
	10 (3.0)[b]	145 (43)	40 (12)	15 (4)	10 (3)	17.0
	12 (3.6)	110 (33)	15 (4)	0 (0)	0 (0)	14.3
	14 (4.2)	75 (22)	5 (1)	0 (0)	0 (0)	12.4
	16 (4.8)	35 (10)	0 (0)	0 (0)	0 (0)	10.7

a. Assuming a minimum age at reconstruction of 15 years.
b. The estimated present reconstruction rate.
- Rounded to zero.

Note Figures in parentheses are percentages of total length, estimated to be 336 kilometres (all sealed).

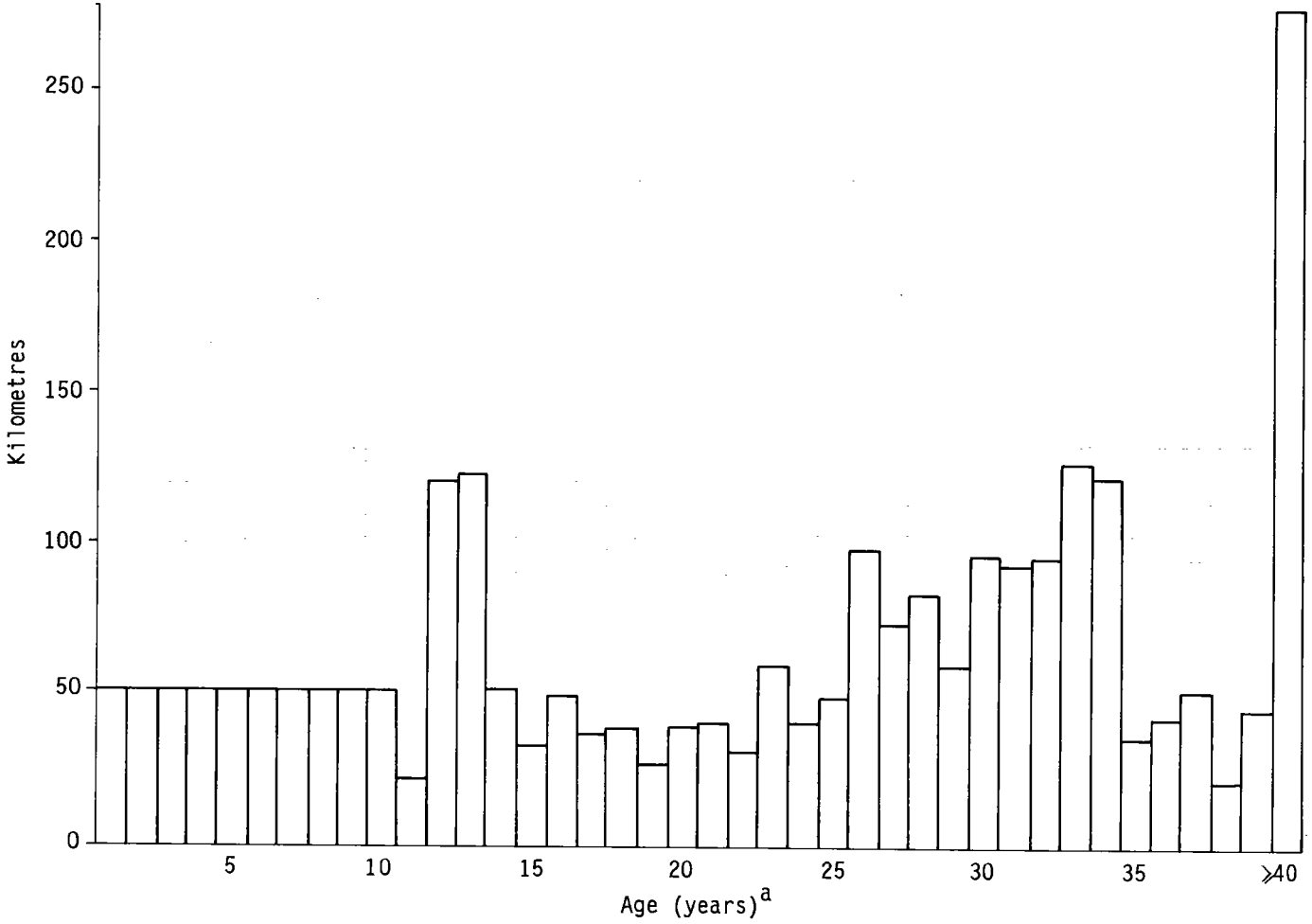
Source BTCE estimates.



a. Average age = 19.6 years.

Source Department of Main Roads, Tasmania.

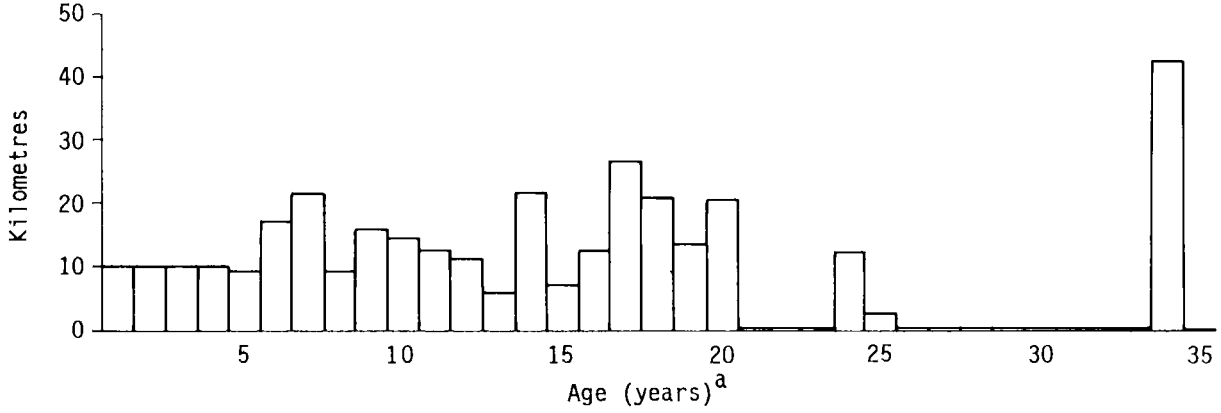
Figure 8.1 Tasmanian sealed rural arterials: estimated age of road system, 1985



a. Average age = 23.1 years.

Source BTCE estimates.

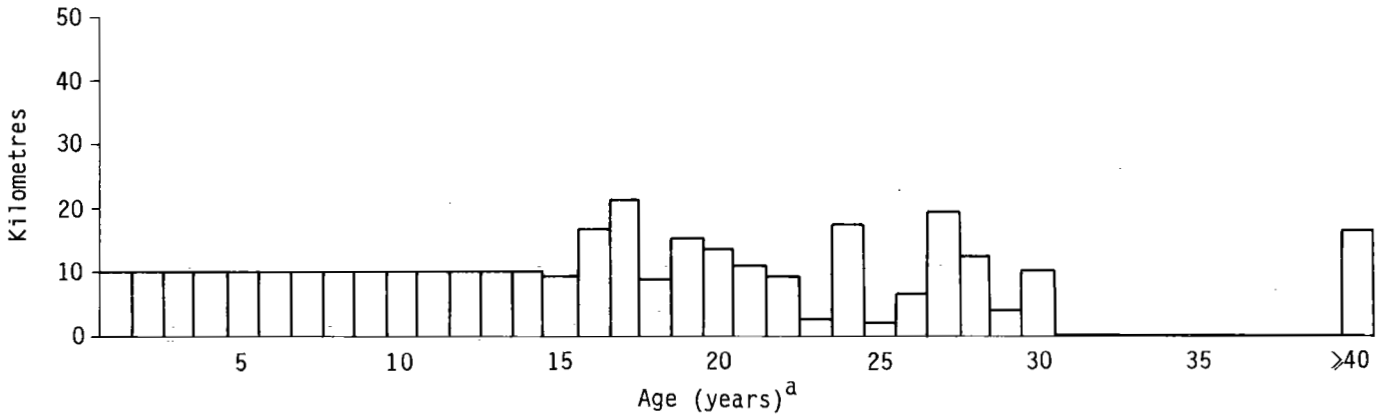
Figure 8.2 Tasmanian sealed rural arterials: estimated age of road system, 1995



a. Average age = 14.4 years.

Source BTCE estimates.

Figure 8.3 Tasmanian National Highway: estimated age of road system, 1985



a. Average age = 16.4 years.

Source BTCE estimates.

Figure 8.4 Tasmanian National Highway: estimated age of road system, 1995

CHAPTER 9 NORTHERN TERRITORY

DATA SOURCE

Pavement age information for roads of the Northern Territory was provided by the Territory's Department of Transport and Works (pers. comm. 1986).

RURAL ARTERIALS

Rural arterial roads in the Northern Territory include the following highways and roads: Arnhem, Buchanan, Carpentaria, Delamere, Kakadu, Plenty, Tablelands and Tanami. These are mainly narrow pavements and the total sealed length is approximately 1600 kilometres.

Figure 9.1 presents the age profile of these roads. Almost all the roads are under 20 years of age and the average age is 14.9 years. With 20 kilometres or 1.2 per cent reconstructed each year, the average age would increase to 21.8 years by 1995 resulting in an age profile shown in Figure 9.2. The effects of higher reconstruction rates over the next 15 years are illustrated in Table 9.1. Extrapolation of the results in the table shows that reconstruction would have to be increased to 60 kilometres per year in order to maintain the average age at 15 years.

NATIONAL HIGHWAYS

The Northern Territory's National Highway network includes the Stuart Highway between Darwin and the South Australian border, the Barkly Highway from the Queensland border to the Stuart Highway at Threeways and the Victoria Highway from Katherine on the Stuart Highway to the Western Australian border. All the highways are sealed and the total length is around 2700 kilometres.

Figure 9.3 shows the age distribution of these National Highways. The most prominent feature is the 290 kilometres (11 per cent) of road over 40 years of age. These pavements were built during the Second World War and are only 4.9 metres in width. Otherwise the roads are relatively young and the average age overall is 13 years.

Figure 9.4 illustrates the age profile for 1995 under the assumption that 25 kilometres of roads (0.9 per cent by length) are reconstructed each year. This leads to an average age of 20 years with the prospect of much higher reconstruction rates becoming necessary in the succeeding years if ageing of the National Highway is to be arrested.

Table 9.2 illustrates, for the years 1990 and 1995 and 2000, the effects of a range of reconstruction rates. A four-fold increase would be required to maintain the current average age.

TABLE 9.1 AGE OF NORTHERN TERRITORY SEALED RURAL ARTERIALS FOR VARIOUS RECONSTRUCTION RATES, 1985 TO 2000

			Length of road of age[a] *(km)*						
Year	*Length of road reconstructed (km per year)*		*≥20 yrs*		*≥30 yrs*		*≥35 yrs*		*Mean age (years)*
1985	20	(1.2)[b]	340	(21)	20	(1)	0	(0)	14.9
1990	10	(0.6)	1 060	(66)	-		-		19.1
	20	(1.2)[b]	1 020	(64)	0	(0)	0	(0)	18.4
	30	(1.9)	980	(61)	0	(0)	0	(0)	17.7
	40	(2.5)	920	(58)	0	(0)	0	(0)	17.0
	50	(3.1)	880	(55)	0	(0)	0	(0)	16.3
1995	10	(0.6)	1 160	(72)	246	(16)	0	(0)	23.3
	20	(1.2)[b]	1 060	(66)	200	(13)	0	(0)	21.8
	30	(1.9)	960	(60)	60	(10)	0	(0)	20.3
	40	(2.5)	860	(54)	140	(9)	0	(0)	18.9
	50	(3.1)	760	(48)	120	(7)	0	(0)	17.5
2000	10	(0.6)	1 280	(80)	980	(61)	240	(15)	27.4
	20	(1.2)[b]	1 140	(71)	860	(54)	180	(11)	25.0
	30	(1.9)	980	(61)	740	(46)	140	(9)	22.7
	40	(2.5)	840	(52)	620	(39)	100	(6)	20.5
	50	(3.1)	680	(43)	500	(31)	80	(5)	18.2

a. Assumes a minimum age at reconstruction of 15 years and no new construction.
b. The present rate of reconstruction.
\- Rounded to zero.

Note Figures in parentheses are percentages of a total sealed length of 1600 kilometres.

Source BTCE estimates.

TABLE 9.2 AGE OF NORTHERN TERRITORY NATIONAL HIGHWAYS FOR VARIOUS RECONSTRUCTION RATES, 1985 TO 2000

Year	Length of road reconstructed (km per year)	Length of road of age[a] (km) ≥20 years	≥30 years	≥35 years	≥40 years	Mean age (years)
1985	25 (0.9)[b]	300 (11)	300 (11)	300 (11)	300 (11)	13.0
1990	10 (0.4)	650 (24)	250 (9)	250 (9)	250 (9)	17.3
	25 (0.9)[b]	550 (20)	200 (7)	200 (7)	200 (7)	16.4
	50 (1.9)	450 (17)	150 (6)	150 (6)	150 (6)	15.0
	75 (2.8)	350 (13)	100 (4)	100 (4)	100 (4)	13.4
	100 (3.7)	200 (7)	-	-	-	11.8
1995	10 (0.4)	1 420 (52)	250 (9)	250 (9)	250 (9)	21.7
	25 (0.9)[b]	1 250 (46)	200 (7)	200 (7)	200 (7)	20.0
	50 (1.9)	1 000 (37)	100 (4)	100 (4)	100 (4)	17.0
	75 (2.8)	800 (30)	0 (0)	0 (0)	0 (0)	14.4
	100 (3.7)	550 (20)	0 (0)	0 (0)	0 (0)	12.7

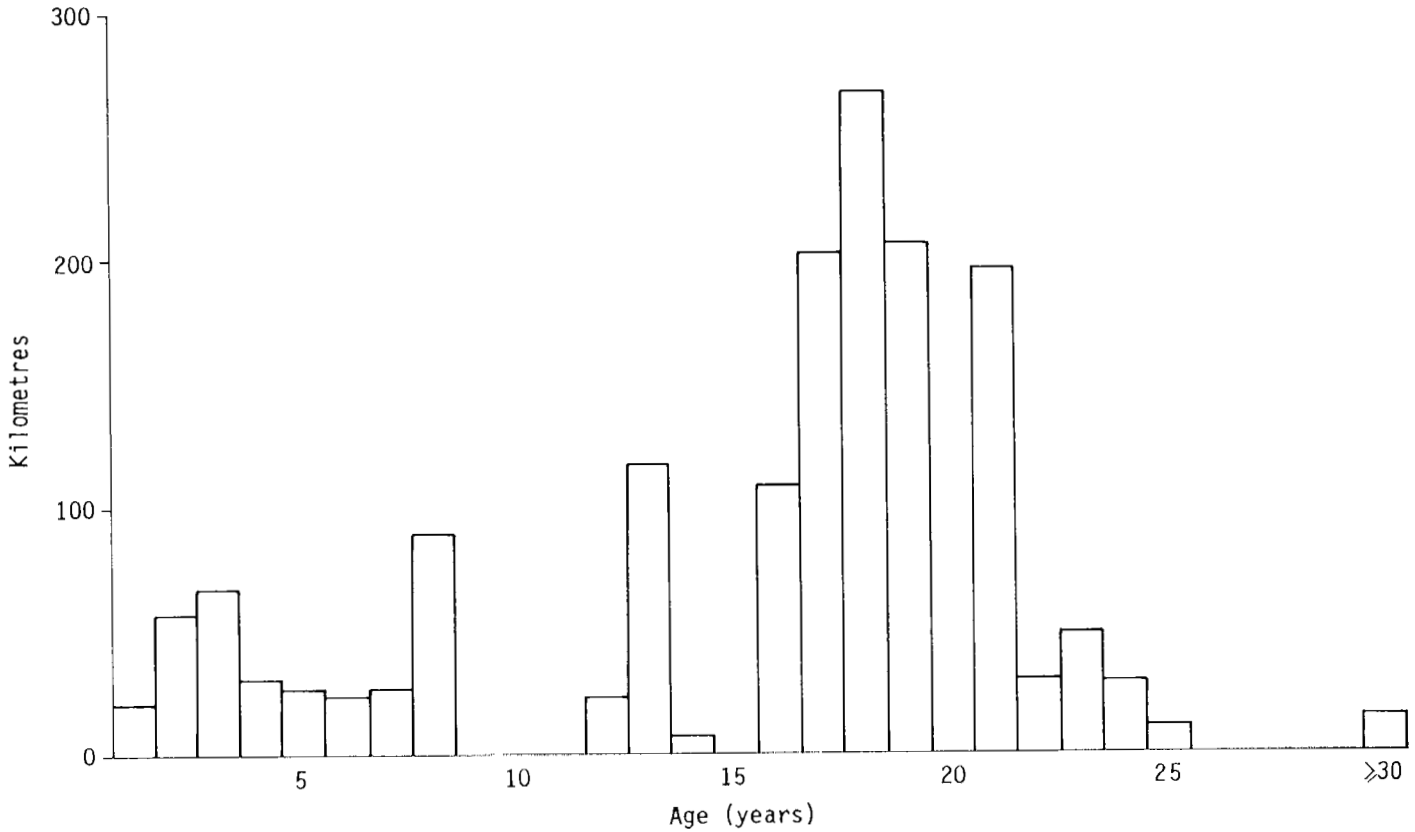
TABLE 9.2 (Cont.) AGE OF NORTHERN TERRITORY NATIONAL HIGHWAYS FOR VARIOUS RECONSTRUCTION RATES, 1985 TO 2000

Year	Length of road reconstructed (km per year)	Length of road of age[a] (km) ≥20 years	≥30 years	≥35 years	≥40 years	Mean age (years)
2000	10 (0.4)	1 900 (70)	550 (20)	250 (9)	250 (9)	26.1
	25 (0.9)[b]	1 700 (63)	400 (15)	150 (6)	150 (6)	23.5
	50 (1.9)	1 300 (48)	150 (6)	-	-	18.9
	75 (2.8)	950 (35)	-	0 (0)	0 (0)	16.1
	100 (3.7)	600 (22)	0 (0)	0 (0)	0 (0)	13.5

a. Assumes a minimum age at reconstruction of 15 years and no new construction.
b. The present rate of reconstruction.
- Rounded to zero.

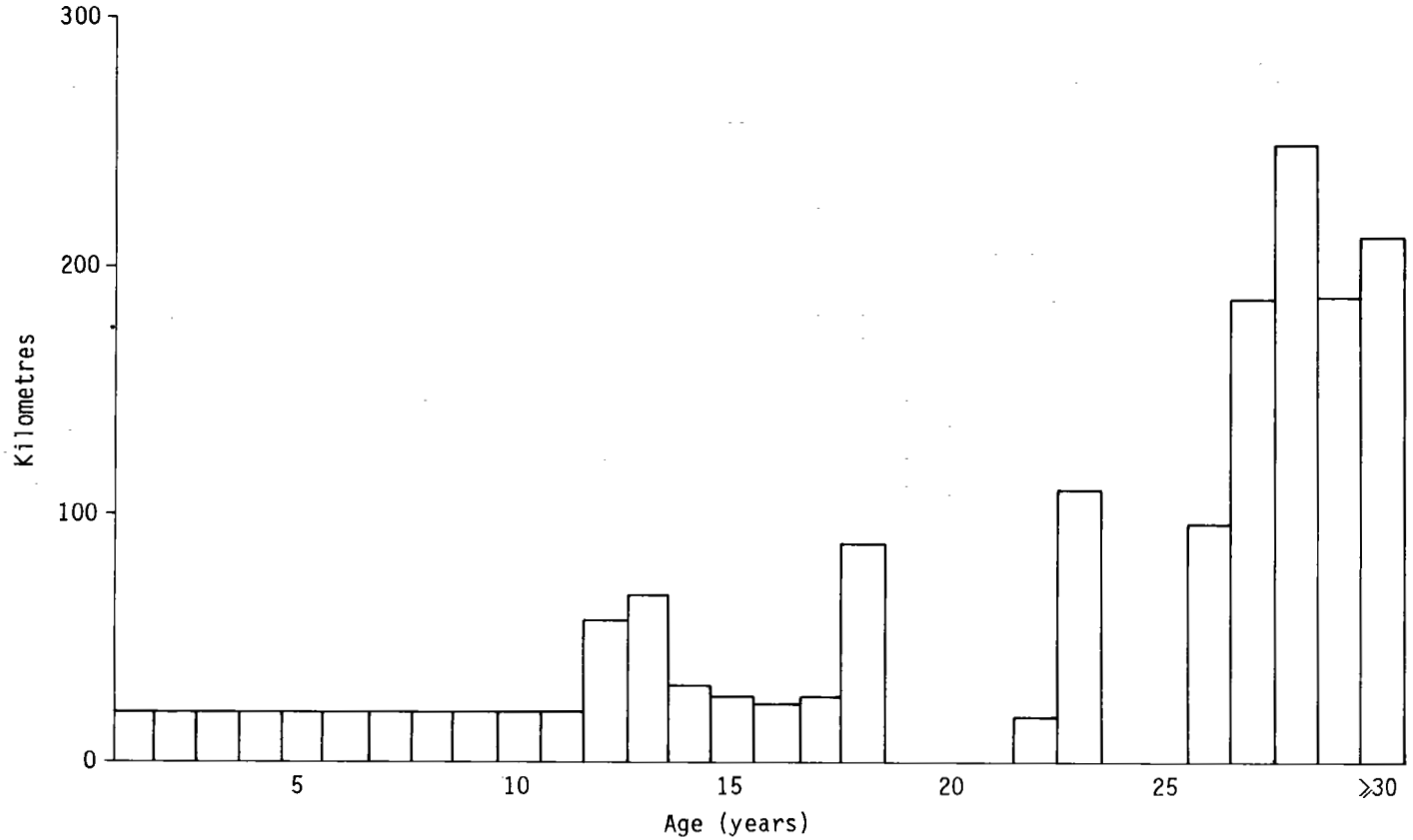
Note Figures in parentheses are percentages of a total sealed length of 2700 kilometres.

Source BTCE estimates.



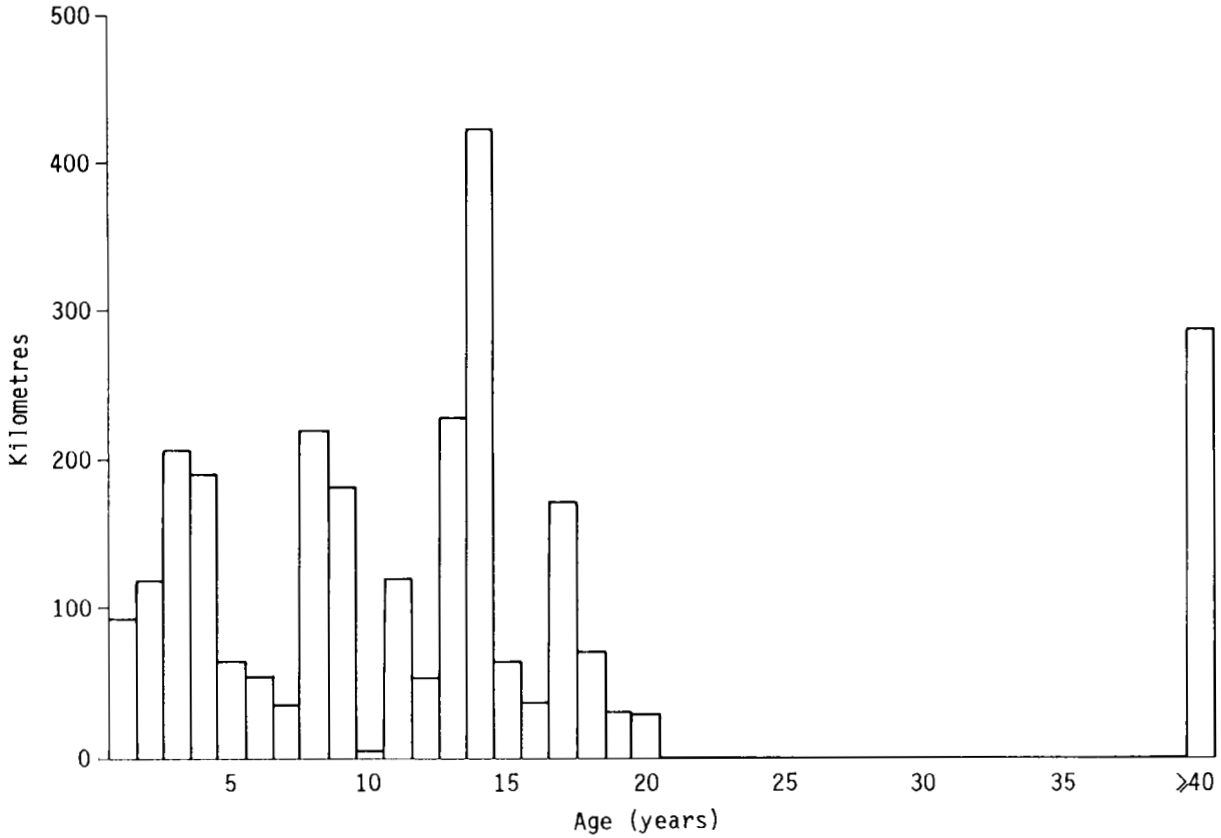
Source NT Department of Transport and Works (1986).

Figure 9.1 Northern Territory sealed rural arterials: estimated age of road system, 1985



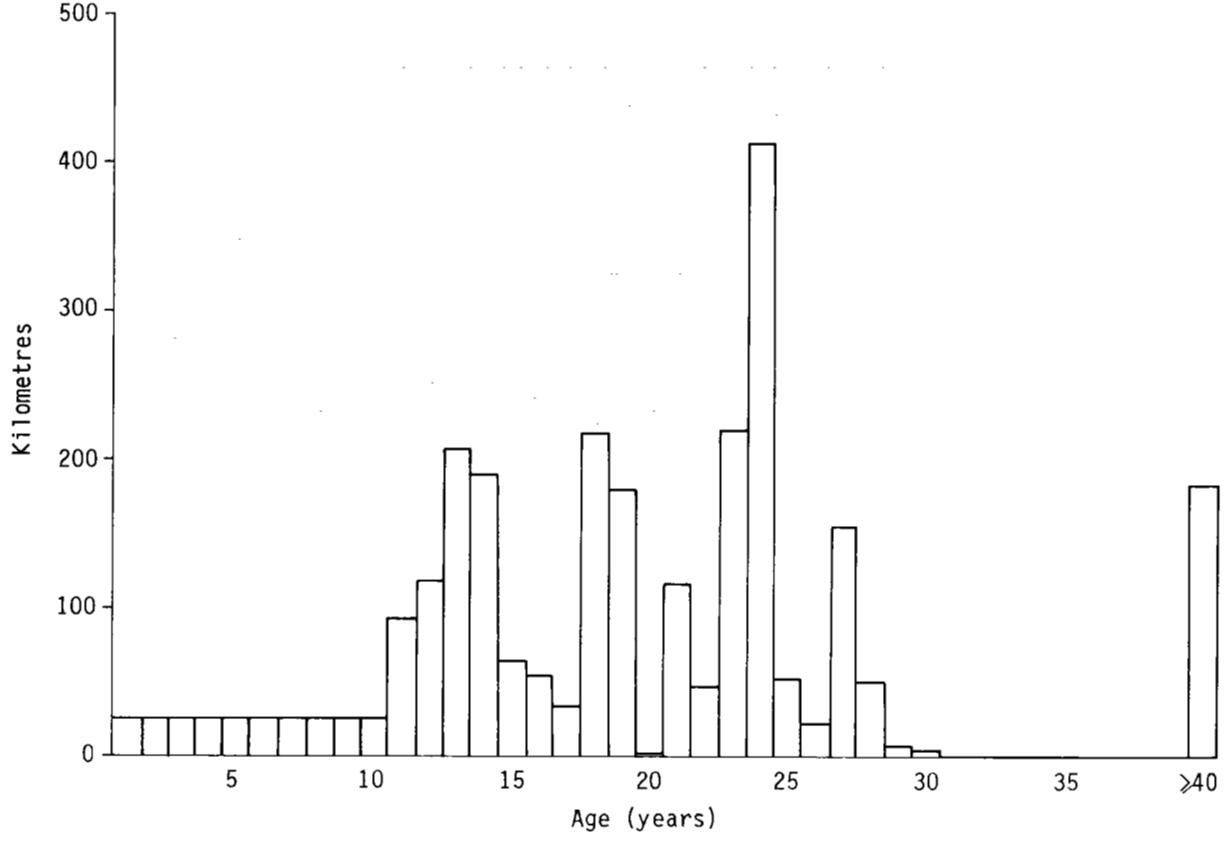
Source BTCE estimates.

Figure 9.2 Northern Territory sealed rural arterials: estimated age of road system, 1995



Source NT Department of Transport and Works (1986).

Figure 9.3 Northern Territory National Highways: estimated age of road system, 1985



Source NT Department of Transport and Works (1986).

Figure 9.4 Northern Territory National Highways, estimated age of road system, 1995

CHAPTER 10 AUSTRALIAN CAPITAL TERRITORY

There has not been any legislative declaration of National Highways or rural arterial roads in the Australian Capital Territory. Nevertheless, roads in the Australian Capital Territory are identified by Functional Classes and Commonwealth Legal Classes (CLC). This permits an analysis to be made of roads in the Territory which are directly comparable to National Highways and rural arterials in the States and the Northern Territory. For consistency, roads of FC1 (CLC1) will be termed as 'National Highways' in the analysis to follow. Those of FC2 and FC3 (CLC2) will be referred to as 'rural arterials'.

DATA SOURCE

Age information of sealed rural roads in the Territory was obtained from a Department of Housing and Construction (DHC) road inventory file (DHC, pers. comm. 1986).

ACT RURAL ROADS

National Highways

The total length of Australian Capital Territory National Highways is only 10.6 kilometres, consisting of some 3.3 kilometres of the Barton Highway and 7.3 kilometres of the Federal Highway.

DHC records show that 6.7 kilometres of National Highways were constructed in 1981 and 1.9 kilometres in 1985. Another 2.0 kilometres of National Highways are at least 15 years old.

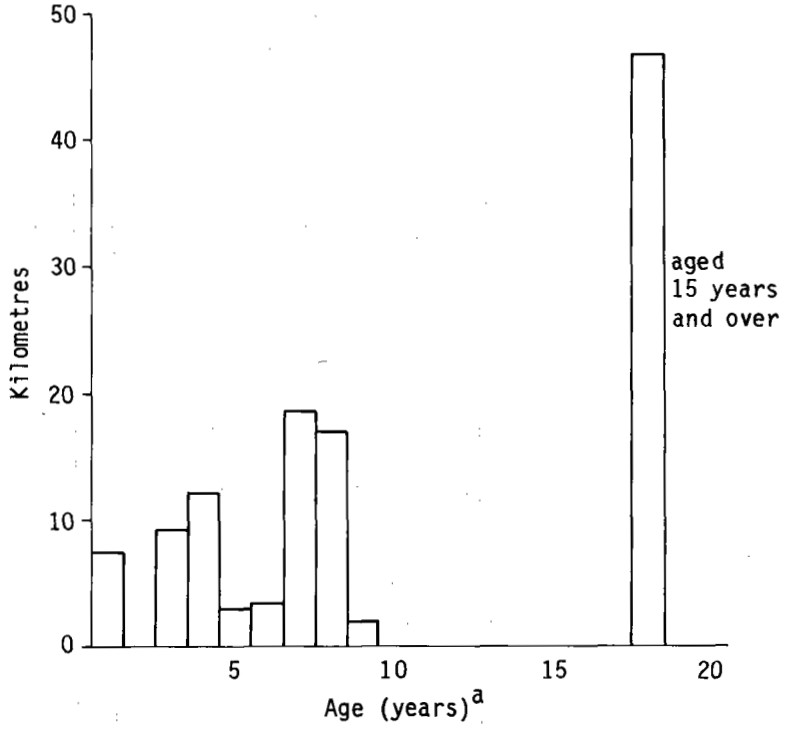
Average age for Australian Capital Territory National Highway pavements is low, estimated to be some seven years old. A contributing factor to this young age has been the recent upgrading of the Barton Highway to service increasing suburban traffic.

Rural arterial roads

The total length of sealed rural arterial roads in the Australian Capital Territory is 119.2 kilometres. The pavement ages are known

precisely for 72.4 kilometres of these roads, while the remaining 46.8 kilometres are known only to be at least 15 years old. On advice from DHC this analysis has proceeded on the assumption that the mean age of the older roads is 17 years. The road system may be somewhat older than presented, as sections of road exist which have not been reconstructed for some 30 years.

Figure 10.1 presents the age profile of the Australian Capital Territory rural arterial roads in 1985. The figure shows that no reconstruction was undertaken in the early and mid-1970s, followed by relatively high reconstruction rates (for a road system of 119 kilometres) which have gradually tapered off to an average of about six kilometres per year.



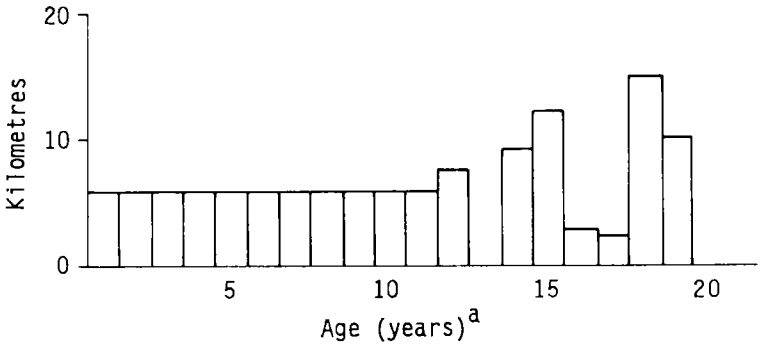
a. Average age (1986) = 9.7 years.

Source Department of Housing and Construction.

Figure 10.1 Australian Capital Territory rural arterials: estimated age of road system, 1986

The rate of six kilometres (5 per cent of road system) per year is sufficient to maintain the mean age of the road system at 10 years. Figure 10.2 shows the estimated 1995 age distribution of the roads if the present reconstruction rate is maintained. The distribution is 'smoother' than that of 1985.

In reality, the road system is expected age by 1995, given that the high reconstruction rates in recent years reflected changing traffic patterns in a period of high growth of Canberra. Table 10.1 shows the effects of various reconstruction rates of the Australian Capital Territory rural arterial roads for the years 1990, 1995 and 2000.



a. Average age = 9.7 years.

Source BTCE estimates.

Figure 10.2 Australian Capital Territory rural arterials: estimated age of road system, 1995

TABLE 10.1 AGE OF AUSTRALIAN CAPITAL TERRITORY RURAL ARTERIALS FOR VARIOUS RECONSTRUCTION RATES, 1985 TO 2000

Year	*Length of road reconstructed* (km per year)	*Length of road of age*[a] *(km)* ≥20 yrs		≥30 yrs		*Mean age* (years)
1985	6 (5.0)[b]	0	(0)	0	(0)	9.9
1990	2 (1.7)	37	(31)	0	(0)	13.2
	3 (2.5)	32	(27)	0	(0)	12.4
	4 (3.4)	27	(23)	0	(0)	11.6
	6 (5.0)[b]	17	(14)	0	(0)	9.9
	8 (6.7)	7	(6)	0	(0)	8.2
1995	2 (1.7)	29	(24)	0	(0)	16.3
	3 (2.5)	20	(17)	0	(0)	14.5
	4 (3.4)	11	(9)	0	(0)	12.7
	6 (5.0)[b]	0	(0)	0	(0)	9.7
	8 (6.7)	0	(0)	0	(0)	7.7
2000	2 (1.7)	61	(51)	25	(21)	19.3
	3 (2.5)	46	(39)	13	(11)	16.5
	4 (3.4)	32	(27)	-		13.7
	6 (5.0)[b]	6	(5)	0	(0)	10.1
	8 (6.7)	0	(0)	0	(0)	7.5

a. Based on a minimum age for reconstruction of 15 years.
b. The present rate of reconstruction. Assumes no new construction to the year 2000.
\- Rounded to zero.

Note Figures in parentheses are percentages of sealed length of rural arterial roads, which totalled 119.2 kilometres in 1985.

Source BTCE estimates.

CHAPTER 11 THE COMPLETE NATIONAL HIGHWAY NETWORK

This concluding analysis deals with the total Australian National Highway network, whose sealed length in 1985 is estimated to have been 15 750 kilometres. By 1988 the sealed length is expected to increase to some 16 200 kilometres, at which stage the entire length of the network will be sealed.

A number of approximations and input assumptions which underpin this analysis affect the accuracy of the results. For this reason, the estimated 1985 road age distribution, and the anticipated road ageing to the year 2000, are considered to be broadly representative of the National Highway network but are not accurate in detail. The main shortcomings arise from specific data deficiencies of some State segments of the National Highway:

- For New South Wales and Victoria (see Chapters 3 and 4) data were available only for State highways. As National Highways are a subset of State highways and functionally are alike, the same age profiles were assumed, that is, estimated 1985 State highways age distributions were scaled down to the State totals of the National Highways; 1328 kilometres in New South Wales and 707 kilometres in Victoria.
- As mentioned in Chapter 5, the Queensland age distribution has been derived from roughness measurements. Before the data were input to this analysis, the unrealistically high peak of road length for 1983 (see Figure 5.3) was distributed over the period 1980 to 1983.

The New South Wales, Victoria and Queensland segments of the National Highway together amounted to some 39 per cent of the network in 1985.

ANALYSIS

Some of the data on State components of National Highways pertained to the financial year 1984-85 (New South Wales, Victoria and Tasmania), other data pertained to the calendar year 1985 (Queensland, Western

Australia, South Australia, Northern Territory and Australian Capital Territory). The data were added without adjustment being made for the six-month time discrepancy.

Figure 11.1 shows the estimated age distribution of the complete National Highway system in 1985. The average age of the system is 13.6 years. The oldest National Highways, dating to 1942 and 1943, are found in the Northern Territory, followed by those of 1948 found in Western Australia.

The estimated 1995 distribution is shown in Figure 11.2. It has been derived by projection with the ageing model, using remaining new construction of some 450 kilometres to 1988, and an annual reconstruction rate of 300 kilometres, estimated to be the present rate of rebuilding of the National Highways. The National Highway will have aged by some four years by 1995, to an average age of 17.6 years. With these assumptions, pavements built before 1960 will all have been reconstructed.

The analysis has been repeated for a range of annual reconstruction lengths, with a summary of effects on the age distribution of the National Highway provided in Table 11.1. Annual reconstruction rates would have to be doubled in order to maintain the current average age.

TABLE 11.1 AGE OF THE COMPLETE NATIONAL HIGHWAY FOR VARIOUS RECONSTRUCTION RATES, 1985 TO 2000

Year	Length of road reconstructed (km per year)	Length of road of age[a] (km) ≥20 years	≥30 years	≥35 years	≥40 years	Mean age (years)
1985	300 (1.9)[b]	4 100 (26)	900 (6)	400 (3)	300 (2)	13.6
1988	300 (1.9)[b]	5 400 (33)	800 (5)	200 (1)	200 (1)	14.5
1990	300 (1.9)[b]	5 800 (36)	900 (6)	200 (1)	100 (1)	15.4
	400 (2.5)	5 600 (35)	800 (5)	200 (1)	100 (1)	15.0
	500 (3.1)	5 400 (33)	600 (4)	100 (1)	100 (1)	14.7
	600 (3.7)	5 200 (32)	500 (3)	100 (1)	-	14.3
	700 (4.3)	5 000 (31)	400 (3)	-	-	13.9
1995	300 (1.9)[b]	7 100 (44)	1 700 (10)	200 (1)	0 (0)	17.6
	400 (2.5)	6 400 (40)	1 300 (8)	100 (1)	0 (0)	16.5
	500 (3.1)	5 700 (35)	1 000 (6)	100 (1)	0 (0)	15.4
	600 (3.7)	5 000 (31)	600 (4)	0 (0)	0 (0)	14.3
	700 (4.3)	4 300 (27)	300 (2)	0 (0)	0 (0)	13.2

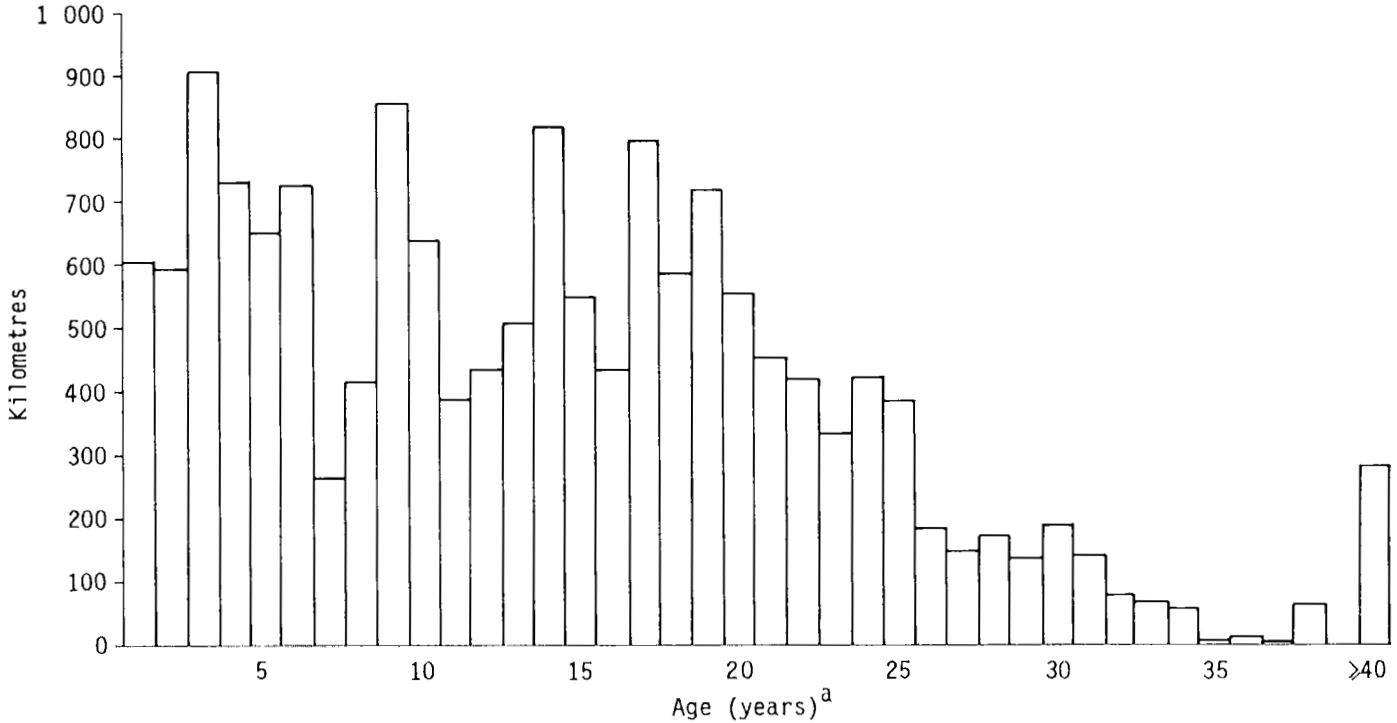
TABLE 11.1 (Cont.) AGE OF THE COMPLETE NATIONAL HIGHWAY FOR VARIOUS RECONSTRUCTION RATES, 1985 TO 2000

Year	Length of road reconstructed (km per year)	Length of road of age[a] (km) ≥20 years	≥30 years	≥35 years	≥40 years	Mean age (years)
2000	300 (1.9)[b]	8 500 (52)	3 400 (21)	1 100 (7)	100 (1)	19.8
	400 (2.5)	7 300 (45)	2 400 (15)	500 (3)	0 (0)	17.8
	500 (3.1)	6 100 (38)	1 600 (10)	100 (1)	0 (0)	16.0
	600 (3.7)	4 900 (30)	900 (6)	0 (0)	0 (0)	14.3
	700 (4.3)	3 700 (23)	300 (2)	0 (0)	0 (0)	12.6

a. Based on a minimum reconstruction age of 15 years and no new construction beyond 1988.
b. The present estimated reconstruction rate.
- Rounded to zero.

Note Figures in parentheses are percentages of a total sealed length, which was 15 763 kilometres in 1985.

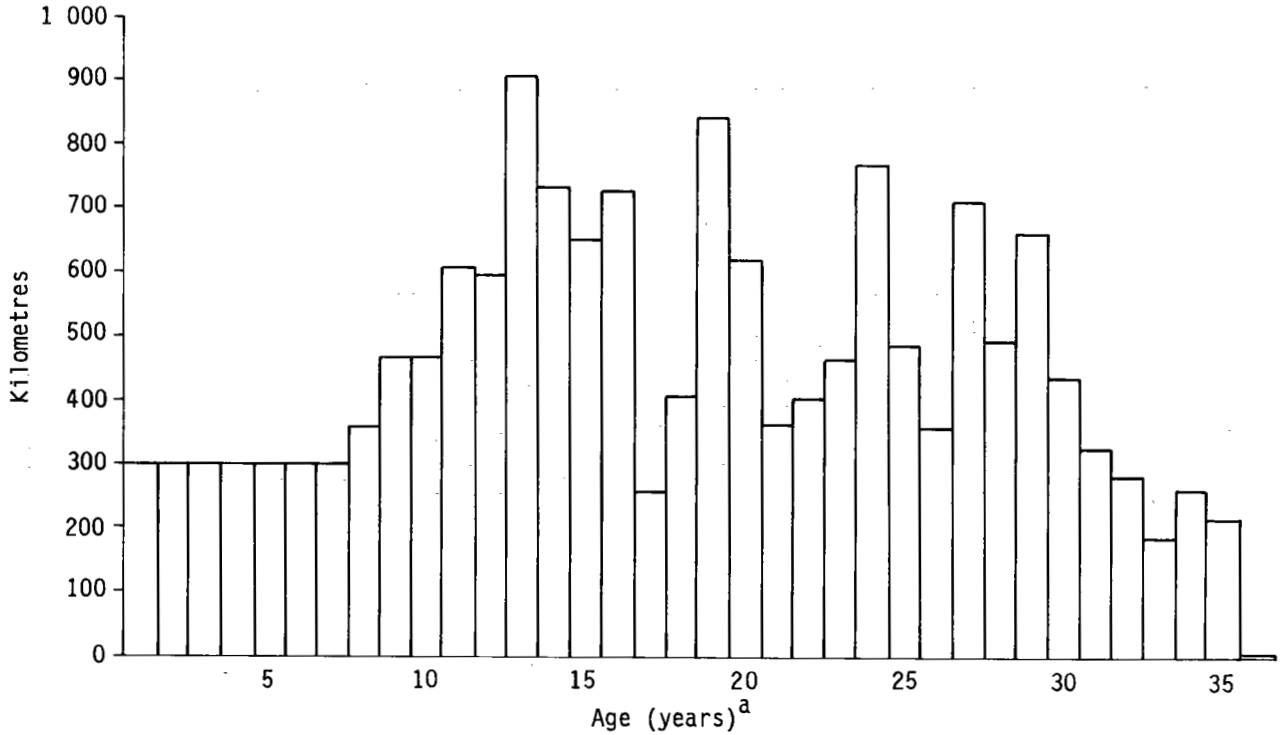
Source BTCE estimates.



a. Average age = 13.6 years.

Source BTCE estimates.

Figure 11.1 The complete National Highway: estimated age distribution of pavements, 1985



a. Average age = 17.6 years.

Source BTCE estimates.

Figure 11.2 The complete National Highway: estimated age distribution of pavements, 1995

CHAPTER 12 SUMMARY AND CONCLUDING REMARKS

This Paper has attempted to present, in a consistent way, the ageing characteristics of the National Highway and rural arterial road systems in the States and Territories. As noted, data for these road classifications were not available for New South Wales and Victoria, and the results for these States had to be presented according to State highways and so-called 'main roads' (aggregates of several State classifications).

The ageing characteristics of the complete National Highway were determined from data of the State components (except for the above States where State highway data were used as a proxy). A similar Australia-wide analysis of rural arterials was not possible because New South Wales and Victorian 'main roads' differed too greatly from the rural arterials. Queensland presented a special case in that road age data were absent, and age profiles for National Highways and rural arterials for that State were estimated from pavement roughness measurements, using NAASRA roughness-age relationships. The accuracy of the Queensland results is unknown, nevertheless the results are presented for completeness.

The starting point for each analysis was a 1985 (or 1984-85) road age distribution, details of which were either provided by a State road authority or had to be estimated with the ageing model from a history of new sealing and reconstruction. The subsequent evolution of these age distributions was examined for a range of alternative rates of reconstruction. Analyses set out mainly to:

- estimate the effects of the current reconstruction rate on future road age profiles; and
- determine the reconstruction rate necessary to maintain a constant average age of the road system.

The results are presented in summary form in Table 12.1.

TABLE 12.1 AUSTRALIAN ROADS: SUMMARY OF EFFECTS OF ROAD RECONSTRUCTION ON THE AGEING OF SEALED ROAD SYSTEMS

State/ Territory	Road classification	Road status in 1985		1995 status based on current roadwork rates				Reconstruction rate to prevent ageing		
		Sealed length (km)	Mean age of system (yrs)	Reconstruction (km/yr)	Reconstruction (per cent)	New constr. (km/yr)	Mean age of system (yr)	Reconstruction (km/yr)	Reconstruction (per cent)	Per cent increase (approx.)
New South Wales	SH	9 500	16.2	200	(2.1)	5	20.0	320	(3.4)	60
	MR[a]	15 500	19.8	150	(0.9)	90	25.2	425	(2.7)	180
Victoria	SH	6 900	18.6	110	(1.6)	0	24.0	220	(3.2)	100
	MR[b]	15 400	17.8	250	(1.6)	0	23.2	500	(3.2)	100
Queensland	NH	4 100	13.1	80	(2.0)	0	17.4	160	(3.9)	100
	RA	17 800	14.7	250	(1.4)	150	18.8	500	(2.7)	100
Western Australia	NH	4 200	15.0	50	(1.1)	0[c]	20.9	175	(4.0)	250
	RA	12 000	19.6	75	(0.6)	100	25.6	300	(2.3)	300
South Australia	NH	2 300	10.3	40	(1.5)	0[d]	16.1	120	(4.6)	200
	RA	8 000	20.2	80	(1.0)	10	26.9	240	(2.9)	200
Tasmania	NH	330	14.4	10	(3.0)	0	16.4	12	(3.6)	20
	RA	2 500	17.8	45	(1.8)	6	22.1	90	(3.5)	100

TABLE 12.1 (Cont.) AUSTRALIAN ROADS: SUMMARY OF EFFECTS OF ROAD RECONSTRUCTION ON THE AGEING OF SEALED ROAD SYSTEMS

State/ Territory	Road classification	Road status in 1985		1995 status based on current roadwork rates				Reconstruction rate to prevent ageing		
		Sealed length (km)	Mean age of system (yrs)	Reconstruction (km/yr)	Reconstruction (per cent)	New constr. (km/yr)	Mean age of system (yr)	Reconstruction (km/yr)	Reconstruction (per cent)	Per cent increase (approx.)
Northern Territory	NH	2 700	13.0	25	(0.9)	0	20.0	100	(3.7)	300
	RA	1 600	14.9	20	(1.2)	0	21.8	60	(3.8)	200
Australian Capital Territory	NH	10	7.0	-	-	0	-	na	na	na
	RA	120	9.9	6	(5.0)	0	9.7	6	(5.0)	0
Australia	NH	15 800	13.6	300	(1.9)	0[c]	17.6	650	(4.1)	120

a. Includes trunk roads and main roads.
b. Includes main, tourist and forest roads.
c. Beyond 1988.
d. Beyond 1987.
na Not available.
- Rounded to zero.
SH State highways
MR Main roads
NH National Highways
RA Rural arterials

Source BTCE estimates.

FINDINGS

The table indicates that the road systems are expected to age quite considerably if the current new construction and reconstruction rates are maintained. By 1995, weighted average ages for the road systems are expected to increase as follows:

- for National Highways, from 13.6 years in 1985 to 17.6 years in 1995; and
- for rural arterials[1], from some 18.0 years in 1985 to 23.3 years in 1995.

Typically, two or three times the reconstruction rates are necessary to ensure that the average age of the road systems is kept constant (see Table 12.1). There are some atypical results of relatively high reconstruction rates (Tasmanian National Highways and Australian Capital Territory rural arterials), or where considerable recent new construction or reconstruction caused the average age of the road systems to be low (South Australian and Australian Capital Territory National Highways). National Highway reconstruction rates are relatively low at present in Western Australia and in the Northern Territory.

FUTURE DEMAND FOR RECONSTRUCTION

The future demand for road reconstruction will be determined by the state of the roads in relation to a combination of engineering, economic and social considerations. This study is based on the premise that, for whole networks, the distribution of pavement ages is an indicator of the overall need for reconstruction. It must be emphasised again that it is not being claimed that roads are or should be reconstructed according to age criteria; only that the state of the roads evolves in such a way that the decision to reconstruct (according to engineering, economic and social criteria) results in an increasing propensity to reconstruct the older roads.

With this firmly in mind we can, nevertheless, ask what ages for roads or mean ages for networks are relevant to reconstruction policy. Two facts are relevant. Limited information, supported by the results of this work, suggests that the mean age at reconstruction on the older networks is in the range 35 to 40 years; and concern is currently being expressed about reconstruction rates on networks with mean ages approaching 20 years.

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1. Or main roads, as defined in Chapers 3 and 4, New South Wales and Victoria.

The latter concern may be either for the short or medium term. If the network has a significant proportion of roads with ages near 40 years, their condition is likely to give rise to a need for reconstruction in the immediate future.

Alternatively, a mean age approaching 20 years may result, as in the case of Victorian main roads (Figure 4.3), from a peak in the age distribution in the 25 to 30 year range. While the condition of these roads might be adequate in the short term, it might still be advisable to increase reconstruction rates if a major burden of reconstruction is to be avoided in the following decade.

The suggestion is, therefore, that road ages of 35 years and mean network ages approaching 20 years are cause for concern. This study has highlighted the fact that the road systems are ageing significantly. With two minor exceptions, mean ages are increasing by 4 to 7 years per decade. The increased rates of reconstruction required to arrest this ageing have been estimated. These rates, of course, partly reflect the current ages of the network, and would only be appropriate for the older systems. The younger networks can reasonably be allowed to age somewhat, although advantage should be taken of the time available to plan the introduction of the higher reconstruction rates which will eventually be necessary.

An assumption implicit in this work is that the road systems analysed are statistically homogeneous; in other words, that the reconstruction decision criteria apply equally to all parts of the network and do not change over time. An example where this assumption is violated is provided by the New South Wales main roads. There, a peak in the age distribution of 20-25 years (Figure 3.3) results from the high rate of initial sealing in the early 1960s (Figure 3.1). This sealing concentrated on western New South Wales at a time when road funding was expanding rapidly and social expectations prevailed to develop the inland. In fact, the main growth areas for population and traffic in more recent years have been near the coast, with the result that the more limited funds currently available have been channelled towards more heavily trafficked coastal roads. A question therefore arises as to whether it will be appropriate, in the long term, to maintain the more remote roads to the standards established in the 1960s. For the current work it suggests that the two classes of roads are inherently different and should really be analysed separately.

CONCLUDING REMARKS

Analysis of road ages cannot substitute for detailed planning of reconstruction programs. It can, however, contribute to an estimation

of road 'needs' for the purposes of fund allocation and serve as an indicator of the likely consequences of inadequate reconstruction rates.

The work has highlighted the generally poor state of information about the age of Australia's roads. The generally favourable response to the work by the State road authorities suggests that a priority for any further effort should be to improve data holdings on pavement ages.

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ABBREVIATIONS

CLC	Commonwealth Legal Class
CRB	Country Roads Board (Victoria - to 1983)
DHC	Department of Housing and Construction
DMR	Department of Main Roads (NSW, Tasmania)
DTW	Department of Transport and Works (NT)
FC	Functional Class
HD	Highways Department (SA)
MRD	Main Roads Department (Qld, WA)
NAASRA	National Association of Australian State Road Authorities
RCA	Road Construction Authority (Victoria)
SRA	State Road Authority