MAIN ROADS

SEPTEMBER 1978

Aerial view of Epping Road Interchange at North Ryde (see article commencing on page 18).

SOME NEW SOUTH WALES STATISTICS
AS AT 30 JUNE 1978

The lengths of roads in various classifications.

Freeways	127 km
State Highways	10 471 km
Trunk Roads	7 103 km
Main Roads	18 400 km
Secondary Roads	287 km
Tourist Roads	426 km
Developmental Roads	3 486 km
Unclassified Roads (in the unincorporated area of the Western Division)	2 398 km
Unclassified Roads (in the incorporated area of New South Wales)	83 km
Total	42 781 km
Total length of Public Roads including those listed above	208 804 km
Area	801 428 km²
Registered Motor Vehicles	2,768,699
Population	5,110,600.

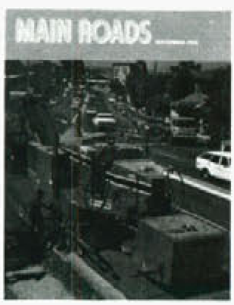
MAIN ROADS

JOURNAL OF THE DEPARTMENT OF MAIN ROADS, NEW SOUTH WALES

SEPTEMBER 1978 VOLUME 44 No. 1

ISSN 0025-0597

CONTENTS



Front cover: The introduction of the Department's new Roto-mill Pavement Profiler brings new technology into the field of road maintenance (see article commencing on page 7).

Back cover: The Department's unusual pyramid-shaped exhibit at the 1978 Royal Easter Show attracted a great deal of interest, especially among young people.

THE NEW AND THE NOSTALGIC

Cold is the heart that is not fired with interest and excitement at the sight of a grand old veteran car. In the elderly, they stir memories of the almost forgotten challenges of early motoring and raise in young minds the mystery of how such fragile vehicles went so far and survived so long.

Often retrieved from obscurity in long-locked garages or derelict farm sheds, most veteran vehicles have been lovingly restored over many months by their new owners. Countless hours of study and hard work — tracking down missing parts, re-assembling chassis, engine and body, painting and polishing — inevitably precede the pleasures of the occasional rally with like-minded enthusiasts. Our photographer recently recorded some scenes from just such a rally and we have included some of these views on pp. 14-15.

The term "veteran" is, of course, not restricted to either cars or people. On pp. 10-11 we provide some fresh research into the origins of a "veteran" bridge near Tamworth, which is, in fact, a little older than the cars we've shown in the rally photos. With no brass to polish and no horns to toot, old bridges don't have the same impact as old cars but, nevertheless, they can be just as interesting and valuable — as reminders of yesterday's styles and techniques.

While constant care and repair are essential in keeping any car (new or old) on the road, the same degree of concern and maintenance are needed to keep roads "on the road". It is no longer (if it ever was) a matter of simply *"slicing the tops off the bumps and throwing them into the potholes"*. Cutting back old road pavements before resurfacing has invariably been a troublesome task — however, the Department's new Pavement Profiler (see article on pp. 7-9) will make the job easier. The Department is the first State Road Authority in Australia to purchase one of these machines and to introduce this new method of road maintenance.

So you see, our love for old things doesn't stop us from using new equipment and introducing new techniques. ●

PRICE Fifty cents

ANNUAL SUBSCRIPTION
Two Dollars Post Free

Issued quarterly by the
Commissioner for Main Roads
B. J. Sexton

Editors may use information contained in this Journal unless specially indicated to the contrary, provided the exact reference thereto is quoted

Additional copies of this Journal may be obtained from
Department of Main Roads,
309 Castlereagh Street,
Sydney, New South Wales, Australia

Typeset by Keyset Phototype Pty. Ltd.
Printed by Superfine Printing Co. Pty. Ltd.

NOW and in the FUTURE

. . . A Look at Departmental Finance and Planning

In such a large commercial and community-oriented organisation as the Department of Main Roads, planning for NOW is a matter of tailoring yesterday's plans for the future to meet *present-day* requirements. It is also essential that plans be made for the *future* in an endeavour to steer an appropriate course which will effectively provide for the better financing, construction and maintenance of tomorrow's main roads.

THE NOW

Men and money

The Commissioner for Main Roads is responsible for financing the construction and maintenance of 42 781 km of roads in New South Wales, of which 37 000 km form the proclaimed main roads system. To present these roads to the public to an adequate standard requires the services of a workforce of some 15,470 persons made up of the Department's personnel, council employees engaged on subsidised works, and contractors and their employees.

To finance this workforce and to provide it with materials for its operations, the Department of Main Roads obtains funds from two principal sources — State motor vehicle taxation and grants from the Australian Government. In the 1977/78 financial year the total receipts from all sources amounted to $370 million.

Motor vehicle registration in New South Wales now totals almost 2.4 million vehicles. This is an increase of about 18% since 1972/73, bringing another 367,000 vehicles onto the State's road system in that time.

In spite of this increase in vehicle numbers, receipts from motor vehicle taxation have dwindled in real terms by some 21% since 1972/73 and amounted to only $122.9 million or 33.2% of the total income in 1977/78.

This inflationary spiral is doubly apparent when it is considered that, even though there was a 33⅓% increase in motor vehicle taxation rates in 1976, the average receipt per vehicle from this source has fallen in the same period by 33%, when expressed in 1977/78 values.

Old roads

There is a need to reconstruct many thousands of kilometres of road and many hundreds of timber bridges which were built by councils and other authorities prior to the formation of the Main Roads Board in 1925.

Many of these roads have never been adequately realigned and many of the bridges (particularly in the more remote rural areas of the State) are still in service. These bridges are rapidly approaching the end of their economic and structural life and will need replacement very soon.

There is increasing difficulty in "maintaining the asset" of our older roads and bridges. Obviously, with the passage of time, considerably more lengths of road throughout the State will reach the stage of requiring either major reconstruction or an ever increasing investment in maintenance costs — and many more bridges will require either replacement or much more money being spent on them than at present to keep them safe and serviceable.

With continuing inflation having a drastic and detrimental impact on the real value of the finance available for road and bridge works, it is imperative that increased funds be found to "maintain the asset" which has been established for the community over past years.

Roads and bridges are not PERMANENT assets. As soon as they are constructed they commence to wear out through usage, as does every other commodity we use.

Local Government is also concerned about road issues and road finance. As an echo of this concern, an address by Mr. A.L. Morse, O.B.E. to the 1978 Annual Conference of the Shires Association of New South Wales, highlighted the point that there is serious concern in Local Government with the deteriorating position of the rural roads and bridges in this State. He stated that, because of the inadequacy of the bridge subsidy and the fact that grants for works on rural roads have not kept pace with the loss of value in money terms, some councils were unable to maintain the standards of existing roads — let alone make any impact in new areas.

He emphasised that a day of crisis was not far away. He said *"Governments in their desire to meet the legitimate needs of the community, are perhaps directing a too large portion of the national resources to what might loosely be called human, cultural or welfare needs. This is at the expense of the more basic programmes. As a nation, it is obvious that we cannot do all the things that we would like to do. There are simply not enough resources to go around.*

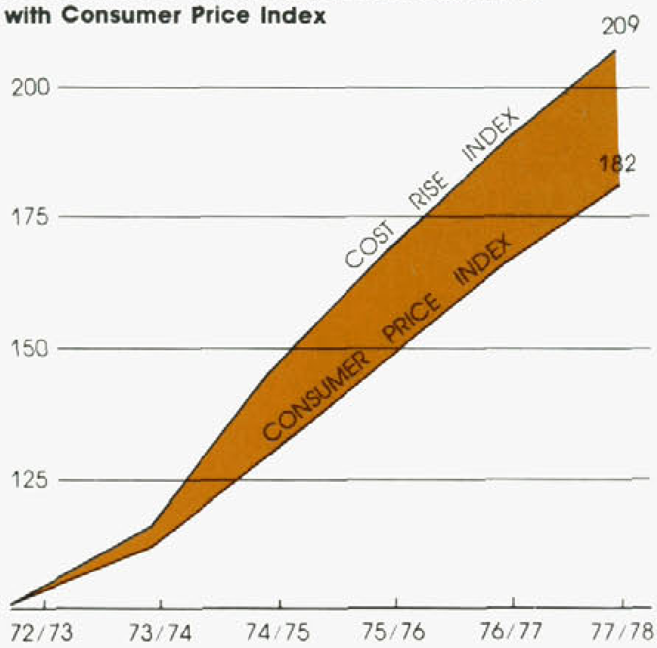
"It is a matter then for our governments to decide which things are the most

urgent, to constantly review priorities and to do things first which will benefit the nation most.

"The economic cost to the community of roads and bridges that are not allocated enough funds to permit reasonable standards to be maintained is great in this land of long distances. Improvements to them must advance our ability to do the other things which contribute to the fuller life that we all desire."

He also made reference to the revenue sharing scheme introduced by the Australian Government in 1976 as part of its policy for a new federalism. This revenue sharing on a percentage share of personal income tax collections of the preceding year provided some $60.3 million distributed to Local Government during 1977/78. This has all the elements of a growth sharing source of funds for Local Government.

Comparison of Department's Cost Rise Index with Consumer Price Index



The Department's Road Cost Index takes into account movement with cost of labour, materials for roads and bridges, haulage and road machinery. The Index shows that road construction and maintenance costs have increased by 109% over the five year period since 1972/73, whereas the Consumer Price Index has recorded an increase of 82% in that same period.

The Department's main sources of income for classified main roads, when expressed in 1977/78 values, have progressively declined by 18%; from $321 million in 1972/73 to $263 million in 1977/78.

Commonwealth Roads Grants

The Department of Main Roads, along with other Australian State Road Authorities, is dependent to a large degree on Commonwealth grants, which currently are a fixed amount over each of three years. The present legislation for the source of Commonwealth major funds to the State Road Authorities is through the States Grants (Roads) Act, 1977 which covers the three year period to 30 June 1980.

Although not built into the legislation, a promise was made by the Commonwealth Minister for Transport in introducing the Bill for Roads Grants that the value of the previously announced grants would be maintained in *"real terms"*.

A scheme based on an implicit price deflator index tied to particular expenditures in the national accounts (although not particularly applicable to the road construction industry), provided an increase of 10.1% for the 1978/79 grants. The Commonwealth Treasury, however, provided only a 6.95% increase to the States, thus further eroding the grants which the States receive to carry out many of their construction and maintenance projects.

Both State and Commonwealth Governments have recently rejected a form of alternative funding based on road usage and in-built to a degree to inflation. This alternative was proposed by the Heads of the various State Road Authorities in an attempt to solve the present, and future, difficulty. The proposal involved the Australian Government in imposing a special fuel tax levy of 1.2 cents a litre which, it was estimated, would provide a national total of $180 million each year to be earmarked for roads.

At this stage, there is no reason to doubt that funds at least at the same level in real terms will be provided specifically for roads in future legislation. It is extremely likely that either in the next Act in 1980 or the following one in 1983, the Australian Government will be dealing with land transport grants. Competition for available funds will depend on cost/benefit analysis of various projects which will ensure the "best" use of available resources.

Australian Government budget outlay for transport and communication throughout Australia for 1978/79 provides for $769.3 million or 2.7% in a total budget outlay of $28,869.5 million. In contrast, the budget outlay for transport and communication for Australia for 1976/77 was $988 million or 4.1% of a total budget outlay of $24,122.7 million.

Road transport's share of this $769.3 million is $508 million or 1.759% of total budget. While providing an approximate 7% increase in Commonwealth funds over the 1977/78 figure, this share is still a decreasing percentage of the total budget outlay from 1.978% in 1976/77 to 1.759% in 1978/79.

As an indication of the priorities set by the Australian Government, an amount of $35.5 million (forming part of the total appropriation to the National Capital Development Commission for all works in the Australian Capital Territory) is being provided for construction, improvement and maintenance of urban, arterial and rural roads, highways and bridges in the Australian Capital Territory, including parking facilities and public transport. In comparison, an amount of $30.7 million has been provided by the Commonwealth for urban arterial roads in Sydney, Newcastle and Wollongong.

Furthermore, the National Capital Development Commission has no acquisition or public utility adjustment costs. These "hidden" costs can be up to 50% of the cost of urban road construction in New South Wales.

Road maintenance tax

Road maintenance tax revenue contributed just over $19 million to the Department's funds in 1977/78. All of this revenue, as required by the Road Maintenance (Contribution) Act 1958, is expended on maintenance of roads and bridges.

The charge at 0.17 cents per tonne/kilometre for the additional wear these vehicles cause to public streets was introduced in 1958. Since 1972/73 the receipts from this source have declined in real terms by 50%. When expressed in 1977/78 values, they have declined from $38.2 million to $19 million in 1977/78.

Loans

In 1977/78, $10 million was borrowed under Semi-Government loan allocations for construction works. A further $3 million was borrowed in June 1977 for use in 1977/78. An additional amount of $9 million was provided from repayable State Government Loan Funds.

The increase in the total loan borrowings from $8.5 million in 1972/73 to $22 million in 1977/78 has thus partly offset the loss in real value of receipts from motor vehicle registration tax and road maintenance charges.

While increases in loan funds have enabled some road projects to be completed, the continued use of high loan allocations is undesirable. As debt charges on loan funds must be met from motor vehicle registration tax (because Commonwealth grants and road maintenance charges are not available for this purpose), new capital works have to be deferred each year in order to meet the charges due on loans already raised.

THE FUTURE

Funds

What then of the *future* for a road authority such as this Department?

For 1977/78, expenditure on construction and reconstruction, including land acquisition, accounted for $189 million or 49% of the Department's total expenditure of $387 million.

Expenditure on maintenance and minor improvements on the other hand, excluding traffic facilities, accounted for $91 million or 23.6% of the total expenditure. This also included approximately $9 million which had to be provided for restoration of flood damage resulting from natural disasters.

For 1978/79 funds up to a total of $465 million are available for roadworks. Of this amount, $40 million is from special loan raisings over a period of two years to allow major works, principally in the urban areas of Sydney, Newcastle and Wollongong to be commenced.

Included in the total of $465 million are a Treasury loan of $38 million together with $167 million from the Commonwealth and $220 million from normal State source revenues. After providing about $36 million for rural and urban local roads, about $429 million is available for spending on almost 37 000 km of proclaimed main roads.

Total loan funds for 1978/79 amount to some 26% of the total State source revenue and some 18% of the total Departmental expenditure. Until the last few years, loan funds were used for specific works such as tollworks which are revenue producing works able to repay the loans. Now they are provided to make up any shortfalls in revenue.

Works programme

A programme of major works for 1978/81 has been developed and it incorporates the $40 million special loan raisings referred to earlier.

In addition, proposals for the Sydney region for inclusion in the review of the 1976 URTAC (Urban Transport Advisory Committee) Report have been submitted to the Government recently to cover the period 1979/91.

Sydney

From 1978 to 1981, in the principal urban areas of the State, the Department will complete

- roadworks associated with the development of Port Botany (Foreshore Road) and associated works and the Eastern Suburbs Railway (Bondi Junction By-Pass and associated works) and continue with —
- the F4 — Western Freeway from Concord to Granville;
- the Parramatta By-Pass (to be completed from Rosehill to Northmead and then to the Great Western Highway at Wentworthville in 1983 but opened to traffic progressively); and
- the development of the major circumferential route, Ring Road No. 3, from Blakehurst to Mona Vale, including a new, duplicate bridge over the Parramatta River at Ryde.

The Department will commence —

- the construction of the first carriageway of section of the F5 — South Western Freeway between the Hume Highway at Casula and Moorebank Avenue, Moorebank. The first stage will be a new bridge over the Georges River at Liverpool (to commence in 1979);
- the construction of section of the F4 — Western Freeway from Church Street, Parramatta near Woodville Road to Mays Hill — to commence 1979. This work will provide a southern by-pass of the commercial centre of Parramatta; and
- the construction of a new, duplicate, bridge over the Georges River at Tom Uglys Point — to commence in 1981.

Newcastle

In Newcastle, the broad objectives are to provide for an effective by-pass of the city by constructing the National Route (in the form of the F3 — Sydney-Newcastle Freeway) west of Lake Macquarie and to further develop the arterial road system within that city. Within Newcastle it is proposed to construct a by-pass of the regional centre of Charlestown, to complete the construction of a divided carriageway on the Pacific Highway between Swansea and Newcastle and to assist council to complete the construction of the Donald Street route in 1979/80.

Wollongong

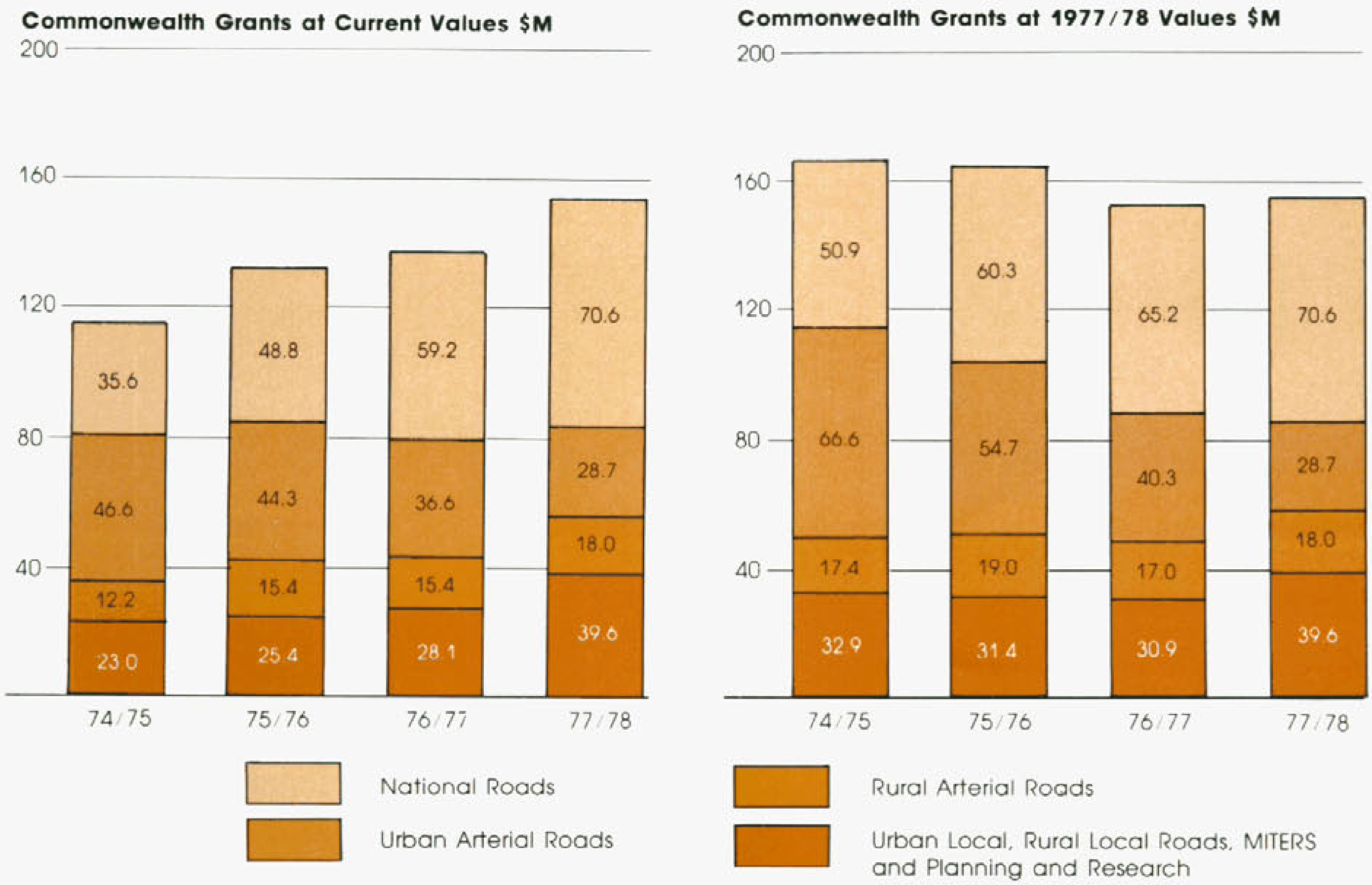
In the Wollongong area, the Department has been concentrating on the completion of the F6 — Southern Freeway. The Freeway has been opened to traffic in stages and now extends as far south as Kanahooka Road, Kanahooka. It is proposed to complete it to Yallah in 1980/81. It is also intended to commence construction of a four lane arterial road through North Wollongong to provide a distributor road to the northern suburbs connecting to the F6 — Southern Freeway at Gwynneville. It is proposed to complete, in 1979/80, the reconstruction of Mount Ousley Road to provide a four lane arterial road from the top of Bulli Pass to connect to the F6 — Southern Freeway at Gwynneville.

Rural works

In the rural areas two major works are in progress on the construction of **National Highways** to the north and south west of Sydney.

The extension of the F3 — Sydney-Newcastle Freeway from Ourimbah to near Wyee with a link to the Pacific Highway at Doyalson is in hand and planned to be completed by 1982.

The construction of the F5 — South Western Freeway between Kenny Hill near Campbelltown and Yanderra is planned to be completed by 1981. By this



The Commonwealth Grants for roads in New South Wales in 1977/78 were increased from $139.3 million in 1976/77 to $156.9 million. This increase of $17.6 million was offset by cost rises of 12.2% in 1976/77 and consequently did not provide for any increase in the work effort.

While the total Commonwealth Grants when expressed in 1977/78 values, have been reduced from $167.8 million in 1974/75 to $156.9 million in 1977/78, the amounts granted for Urban Arterial Roads have been dramatically reduced. When expressed in 1977/78 values these Urban Arterial road grants have fallen by 57%; from $66.6 million in 1974/75 to $28.7 million in 1977/78.

time the National Highway route between Sydney and Goulburn will be constructed to dual carriageway standard except for lengths at Mittagong and Marulan.

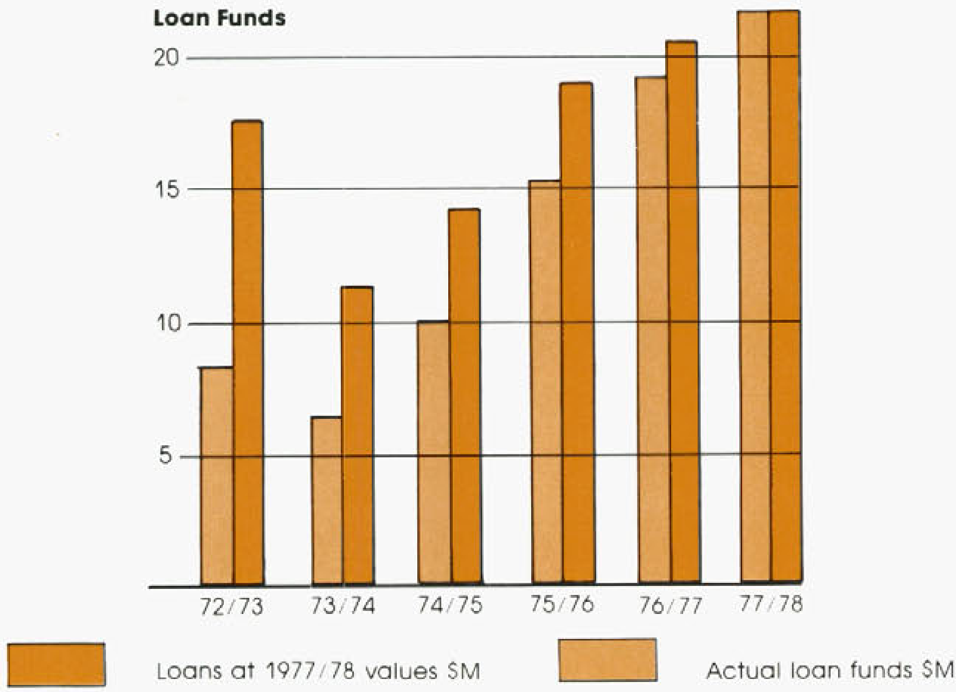
On the **State Highways** network, the total length of 10 471 km, combined with the general deficiency in funding results in a need to concentrate on maintaining the present network, restoring it by pavement strengthening and reconstruction and, wherever funds permit, undertaking new construction to replace particularly poor lengths.

As part of the Department's programme of major works it is proposed to —

- develop a deviation of the Princes Highway at Nowra (including a new bridge over the Shoalhaven River) and to complete it by 1981;
- substantially improve the Great Western Highway over its whole length within the City of Blue Mountains; and
- construct a deviation of the Pacific Highway around Nambucca Heads. Tenders for bridges on this deviation have already been called.

Less spectacular but certainly substantial fund absorbing roadworks are in progress throughout the State as part of the continuing development and improvements to the State's road system. Such roadworks and the anticipated expenditure on them in the 1978/79 financial year are as follows.

- Construction of a second carriageway to form dual two-lane divided carriageways on the existing Pacific Highway between Doyalson and Swansea. This improvement will provide for the "local" traffic between Wyong and Newcastle south (despite construction of the National Highway route—F3—Sydney-Newcastle Freeway—west of Lake Macquarie). This work will absorb approximately $1 million in this financial year.
- Provision of a climbing lane on the Pacific Highway south of Taree at an estimated cost of $250,000.
- Work in the Grafton area and reconstruction on the Pacific Highway north of Bangalow between Ballina and Tweed Heads will account for about $1.2 million before it is finished.
- A second carriageway on the Hume Highway between Uringalla Creek and Marulan will absorb $1.8 million in this year.
- The continuing construction of the deviation of the Hume Highway around Gundagai—$1.3 million.
- Work on the Hume Highway between Jugiong and Tarcutta Range—about $1 million.
- The construction of 8 km of northbound carriageway to form dual carriageways on the Hume Highway south of Tarcutta will absorb an expenditure of nearly $2 million this year.



The increase in the total loan borrowings from $8.5 million in 1972/73 to $22 million in 1977/78 has partly offset the loss in real value of receipts from motor vehicle registration tax and road maintenance charges.

These are just further examples of the spread of capital works and the list does not include any repairs to lengths of distressed highway pavement which require reconstruction because they can no longer be held by maintenance measures.

Separate tenders will be accepted for construction of a number of **bridgeworks**—large and small in both urban and rural areas. These structures include:

- Bridges over Rickabys Creek and South Creek on the Richmond-Blacktown Road
- A bridge over Duck River on the F4—Western Freeway at Auburn
- A bridge over the Bell River on the Mitchell Highway near Wellington
- A bridge over Bomaderry Creek on the Princes Highway to coincide with completion of the new Shoalhaven River Bridge at Nowra, and
- A bridge over Eathers Creek on the Newell Highway at Narrabri.

Such bridgeworks are an integral part of the Department's programme for the continuing development and improvement of the State's road system.

On **Trunk and Ordinary Main Roads** in the rural area, the Department is in partnership with Local Government. The partnership has the broad aims of extending the bitumen surfacing, largely in accordance with Council's priorities, as well as reconstruction and improvement projects. This is particularly relevant to the more heavily trafficked trunk roads, which were originally constructed and sealed many years ago.

A FORWARD PLAN

The road needs of the community are apparent and so are the funds required and the problems which will be faced. There will, no doubt, be constant amendments to the planning to accord with the realities of existing finance and likely available finance.

In preparing a plan for the future, many difficulties were overcome but there was one facet encountered in the compilation of a plan which requires special mention to illustrate the problems of establishing priorities.

A survey and study of the rural highway system for the broad plan development to the year 2000 was completed in 1970 (see article in March 1976 issue of "Main Roads", Vol. 41, No. 3, p. 74).

A subsequent survey and study during 1977 brought this earlier survey up to date, but did not attempt to project beyond the year 2000.

A standard of service (known as Level C) which provides stable traffic flow, but in which most drivers are restricted in their freedom to select their own speeds or change lanes, overtake etc., was selected, looking realistically at road capacity as well as known and projected traffic volumes.

The service volume at Level C was converted into an Annual Average Daily Traffic Figure (AADT) normally on the basis that the 30th highest hourly volume was 15% of the AADT and this AADT was then quoted as the service volume for the particular length or section of highway chosen.

A general growth factor of 3.4% per annum (calculated by the Commonwealth Bureau of Roads), was adopted as a general Statewide figure based on population projections, increases in motor vehicle ownership and increases in motor vehicle usage. Different growth rates were adopted for some of the State Highways where it was apparent that 3.4% was not appropriate.

In brief, the Report concluded that there are substantial sections of the Princes Highway, the Great Western Highway, the New England Highway, the Pacific Highway, the Bruxner Highway and the Illawarra Highway which are not providing a Level C standard of service *now*, let alone over the next twenty years.

The New England Highway, although it is a National Highway and construction is funded fully by the Commonwealth, was included in the survey and study to assess the magnitude of the construction task for this road.

There is a declining priority being given to financing roads which appears to be based on the grounds of economic restraint. Total funds are restricted and all costs are increasing.

The first call on available funds is for maintenance, but by making provision for additional funds for maintenance the amount which can be provided for capital construction improvements is reduced.

In spite of this, the Department of Main Roads, on behalf of the New South Wales Government, is proceeding with a massive road improvement programme.

To finance this programme, a huge financial commitment has been undertaken which is placing a severe strain on the limited financial resources of the State.

The continuation of the programme will provide a much needed stimulus to employment and to the development of industries. Its completion will bring many benefits to the whole community, including substantially lower transportation costs. All in all, it is vital to the economy and welfare of New South Wales. ●

DEPARTMENT'S NEW PAVEMENT PROFILER

"Precision made" — the term usually brings to mind a picture of something shiny and commonly metallic, machined or cast to mirror smoothness, perfection and accuracy.

Having travelled over rough roads so often in the past, few people would associate the term "precision made" with roadbuilding. Nevertheless, modern highway engineering is increasingly concerned with the development of greater accuracy using intricate technology and equipment.

For modern traffic, a road has to be accurate to level and grade in the interests of safety, comfort and economy. At today's normal road speeds, a small bump or a section which is only slightly uneven can make its presence felt. Not only does an uneven road surface wear out vehicles and sometimes endanger the people in them, but it tends to wear out faster than an even one.

Road surface deterioration may occur in the form of deformation in the wheel tracks or polishing of the surface lowering the skid resistance and leading to the possibility of aquaplaning at high speeds in wet conditions.

Adding layers is not the answer

Simply laying a new surface on top of the worn pavement to bring it back to level is seldom an adequate solution. Compacted by traffic, the thick—and very expensive—new topping will soon take on the contours of the old deformed base. Its surface will then just repeat the old undulations with the same bumps and thumps.

Another problem and one that is critical in metropolitan areas is that, over the years, added layers will seriously alter the designed cross-section profile. This can cause serious problems with drainage, guttering and kerbs. Manholes and other access points to public utility services can be affected. Tunnel and bridge clearances can be significantly reduced.

Back to basics

Where a simple overlay cannot be used for these reasons, the best solution is to cut the road surface back to the original designed profile and construct a new pavement course on the corrected base.

With asphalt surfaces, in the past, this has generally meant heating, burning and physically ripping away the old topping, then carrying out expensive re-grading and compaction of the disturbed base course before resurfacing. The work is slow, noisy and heavy on fuel and it is particularly unpleasant and potentially dangerous in tunnels.

The removal of cement concrete is an even more difficult operation especially where only minor lowering of the grade line is necessary. This often means having to resort to massive attacks with pneumatic drills, with all the attendant noise and dust pollution.

A new approach

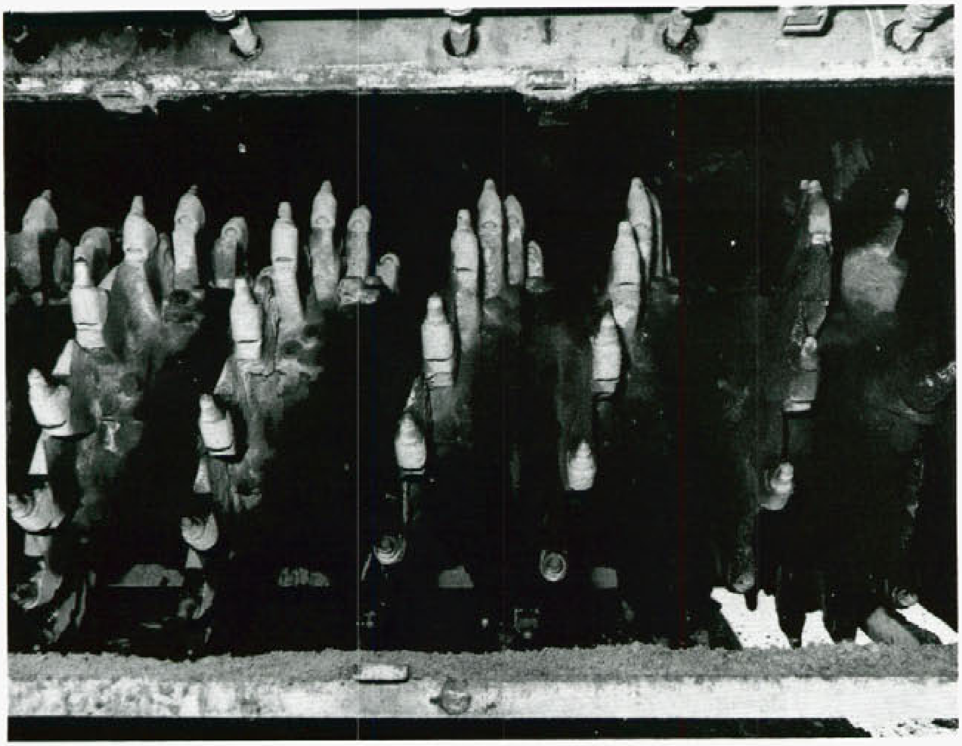
To carry out this work in a much faster, cleaner, more efficient and more economical manner, the Department recently put into commission a Model PR-375 *Roto-Mill Pavement Profiler* built by the CMI Corporation of the United States of America. Some readers may have already seen this *"cold milling"* machine working its way along some of our Main Roads.

A huge unfamiliar machine to the casual observer, the machine's function is screened from view. As someone once said—"It's like a duck on the water—calm on the surface, but paddling like mad underneath". As far as the passing road user is concerned, the 30 tonne machine (about the mass of a medium tank in World War II) may not seem to be achieving much in its 1 km/h travel, on its hydraulically driven tracks. But, underneath, out of sight, a great deal is happening.

Getting our teeth into it

Behind the shelter of its side skirts, there is a rotating cutter, spinning against the direction of the machine's travel. On its whirling drum are mounted 178 cutter

The "back-end" of the pavement profiler showing the conveyor belt which carries machined material to waiting trucks.



Some of the 178 cutter bits which are tungsten carbide tipped and form part of the rotary cutter assembly.

"teeth" or bits, each tipped with a tungsten carbide point. These bits are arranged in helical patterns from the outside ends to the centreline and span 2.82 m across the pavement.

As the Pavement Profiler tracks along, the spinning tungsten carbide cutter bits chew at the old road surface, machining it down to a textured but level surface fit for refinishing. This happens comparatively cleanly and quietly, damped down by a water spray that keeps dust and disturbance to a minimum.

The cutting "teeth" are keyed in place to resist the tremendous forces they encounter. They cannot loosen accidentally, but the system allows them to be readily changed as they wear or to suit various paving materials. The machine includes among its fittings a powered kit for making such changes.

It may look slow, but . . .

On asphalt, this new machine can profile up to 2 500 m^2 in each hour. Cement concrete is tougher, and the progress rate is approximately halved. However, most of our surfaced roads are "black-top" and the former figure is generally true.

Slow as its progress along the road may appear to the passer-by, the Pavement Profiler's work output is much greater than is possible with other methods. In an eight-hour shift, it can complete a couple of hectares of accurately profiled road, ready for re-surfacing. As the milled surface is immediately trafficable, even before retopping, the profiling can stop at any time to allow for peak hour traffic to pass.

As shown in the diagrams on page 9, the serrated surface also gives greater "grip" to the re-surfacing material.

What to do with the "left-overs"

In the past, the "spoil" from pavement reclamation processes has been so irregular and heterogeneous in size and content that it was usable only for rough filling. The Pavement Profiler's output of "waste" is fairly constant in dimensions. On an average asphalt pavement, the maximum sized particles are about 20 mm in diameter.

Although it may be a by-product of the process of lowering a pavement surface to new levels, the material produced by the Pavement Profiler is not waste. The aggregates produced are similar in grading to the original asphalt although usually with a small excess of fine particles. They are particularly suitable as shoulder or sub-grade material, being comparatively easy to level and compact. Indeed the reclaimed material may be re-cycled and used as a surface layer, too.

The machine itself retrieves the milled material. The helically arranged rows of cutters on the cutting barrel move the material to the centre of the machine. There it is picked up by a conveyor belt system which extends towards the rear. The conveyor has a 180° traverse, with a reach of approximately 7 m. It can feed the removed particles directly onto the road shoulders or into the tray of a following truck for stockpiling or use in some other locality.

Waste not, want not

While none of the material saved by the Pavement Profiler is wasted at present, the Department is working on plans for making even better use of it in the future.

Bitumen, the binder material in asphalt, is by far the most expensive component. As a product of crude oil refining, it represents a considerable investment in a diminishing energy source. In the long term, recycling the material reclaimed by the Pavement Profiler will be a more economic use of a valuable resource than using it simply as fill.

At the present time, none of the Department's asphalt plants are equipped to recycle this material. However, experiments are being conducted to discover the most efficient manner of handling the reclaimed materials in the existing asphalt plants and investigations are being carried out, into designing a special recycling plant.

Texturing for pavement surface

In road surfacings, one of the problems which may develop, depending upon such factors as the nature of the surfacing materials, the *macro texture* of the surface, the speed, volume and type of traffic, the road alignment and the climate, is the gradual "polishing" or loss of texture which affects the skid resistance.

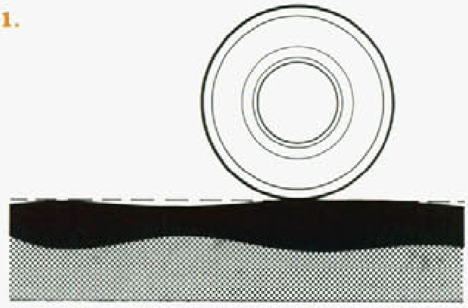
Usually, when this occurs, the skid resistance is restored by resurfacing.

In some circumstances, however, provided that the pavement strength and shape are satisfactory, it may be more economical to use the Pavement Profiler to re-create the coarse or *macro texture* required for moderate to high speed skid resistance.

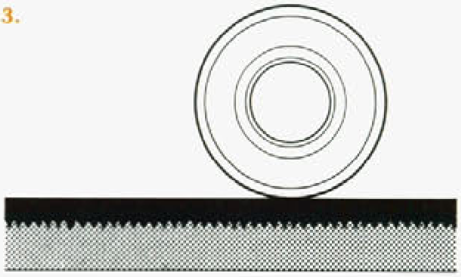
The patterns produced depend upon the machine's speed of travel, the cutter speed and the type of bit used.

Power and control

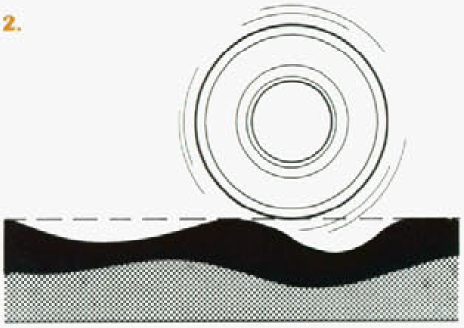
The prime power plant of the Model PR-375 Roto-Mill Pavement Profiler is a 6-cylinder Caterpillar diesel engine, 1.



3.



2.



1. When a hot mix is placed directly on a rough, unlevel surface, the overlay thickness varies and so does its density.
2. As time passes, the new layer is consolidated and compacted by traffic to the same profile as the original rough surface.
3. Profiling creates a serrated interlocking texture which provides for an increased binding area. The new surface interlocks with the old to form a monolithic pavement.

producing 283 kW at a governed speed of 2 100 rpm. This engine in turn drives a number of hydraulic pumps. From there on, the various power trains are hydrostatic, using oil under pressure, with one pneumatic link in the quick-change cutting tip kit.

One advantage of this type of power system is its clean operation. Ordinary vehicle engines run the gamut from idle to top "revs" depending on traffic conditions, but this machine runs at a near-constant rate and its engine can be tuned to give maximum power with minimum harmful emission.

All three tracks are powered through the hydrostatic system, as is the steering system. Most directional changes are made by pivoting the entire front track assembly. Sharper turns can be made by also varying the speeds of the side tracks in crawler tractor fashion.

Other items powered by hydrostatic drive include the conveyor belt system and its positioning, a mouldboard with hydraulic down-pressure for clean-up and, of course, the cutter drum itself and its adjustments.

The cutter's speed is variable to suit the nature of the surface and the texture desired. The whole cutter can be raised or lowered as a unit, or the ends differentially controlled. These operations can be either under the operator's direct manual control, or, alternatively, the milling action can be set in a completely automatic mode.

In the latter case, the Roto-Mill Pavement Profiler can be set to follow a taut stringline between datum points. However, the most common control method is to have a "ski", on either the left or right side, follow a predetermined contour. The sensed movements of this contour-follower are processed through a transducer system to control the positioning of the cutter system. It is claimed that these controls can maintain an accuracy of within 4 mm on successive passes. With this joint-matching accuracy, a near-perfect profile can, where necessary, be carried across the entire width of a road.

A good investment

Despite its somewhat cumbersome appearance, the Roto-Mill Pavement Profiler is a highly developed and intricate piece of equipment. The Department is the first State Road Authority in Australia to purchase this type of machine and it is one of the first two of its kind to be seen in this country. (A smaller machine is owned and operated by the commercial company Bitupav Ltd.)

With a purchase price of $327,000—which would buy 30 to 40 average family-sized cars—the value of the Pavement Profiler lies in its tremendous capacity to profile accurately to levels and reclaim the cut material. Within its rugged exterior is concealed a mass of sophisticated and sensitive control mechanisms, which provide it with its capacity for "precision" work.

For those with engineering interests, who know what it does and how it does it, this machine has a functional attraction of its own. For the whole community too, the Department's purchase of the Pavement Profiler is a worth-while investment. It will mean better roads sooner because it provides a faster and more efficient method of pavement rehabilitation. It also introduces the important potential for recycling old road pavements.

Colour photographs of the Pavement Profiler appear on pp. 16-17. •

. . .

For readers wishing to compare methods, an article entitled "Mechanical Removal of Asphalt Surfacing" which appeared in the June 1974 issue of "Main Roads" (Vol. 39, No. 4, pp. 120-1) may be of interest.

Journal articles on other unusual items of Departmental machinery include:
"Linemarking Machines — Their Design, Development and Duties" December 1970 (Vol. 36, No. 2, pp. 50-4).
"New Dual Lane Autograde Trimmer Spreader" — December 1970 (Vol. 36, No. 2, pp. 34-5).
"Moving a Mobile Marvel" — December 1975 (Vol. 41, No. 2, pp. 48-9).
"The Department's Deflectograph" — March 1976 (Vol. 41, No. 3, pp. 66-8).
"Flying a Whirly Bird" — June 1976 (Vol. 41, No. 4, pp. 112-3, 118-120).
"Rotary Snow Plough" — September 1977 (Vol. 43, No. 1, pp. 15-17).
"Department's New SCRIM" — June 1978 (Vol. 43, No. 4, pp. 98-101).

PS.
OLD "MONIER" BRIDGE NEAR TAMWORTH

Research reveals interesting details

"Monier" Arch Bridge over Read's Gully on the Main Northern Road near Tamworth in 1900. Reproduced from the Journal and Abstract of Proceedings of the Sydney University Engineering Society for 1900, Vol. 9, page 65 by courtesy of the Fisher Library, University of Sydney.

On the front cover of our March 1978 issue we featured a colour photograph of the "Monier" Bridge, which still stands on an earlier route of the New England Highway through the Moonbi Ranges north of Tamworth. It was then thought that it was built about 1914 (see reference on Page 85 of that issue). Subsequent research, by the Department's Public Relations Section, to accurately trace its origins has shown that the bridge is much older than was previously believed and, apparently was the first road bridge in this State to be built on the "Monier" principle.

In the Annual Report of the Department of Public Works for the year ended 30 June 1900 (p. 77) there is the following entry.

"Monier Arch, at Read's Gully, Tamworth District — The unqualified success attending the use of the Monier system in the arches of sewerage aqueducts near Sydney has not, as yet, been followed by any extensive use of the system for traffic bridges. That this is not due to any defect in the system itself is shown by the graceful and economical bridges erected on this principle in Victoria, viz., the three spans of 95 feet each across the Yarra at Melbourne, and two spans of 60 feet and one of 100 feet in the bridge at Ryan's Ford, Geelong. The fact is that sites suitable for arched bridges are comparatively rare in this Colony, as the rivers for the greater part run through flat country, where the banks are subject to inundation. Under these circumstances, a foundation suitable for a bridge of the arch type, coupled with banks sufficiently high to admit of the springing of arches clearing the flood, without, at the same time, unduly raising the road level, are comparatively rare; hence the general adoption of timber structures on pile foundations in which the superstructure is so designed as to reduce the vertical distance between the highest flood level and the deck level to a minimum. At Read's Gully, however, the site presents no obstacles to the use of an arch, and, for purposes of comparison, estimates were prepared for three different types of structures. It was found that a timber bridge on concrete abutments would cost £500; an iron buckled plate bridge, with tarred metal deck, also on concrete abutments, £620, while the Monier arch of 28 ft. 6 in. span (which was erected) actually cost £406 8s 6d. It will be seen, therefore that while leaving nothing to be desired in point of durability, the Monier arch was considerably cheaper than the iron bridge, and even less costly than the perishable timber one, and while this comparison would not hold good in a district where timber is readily obtainable, it is probable that Monier arches will be found very economical where suitable sites exist. The economy attending the use of Monier cylinders in lieu of cast-iron (to which reference was made in last report in connection with Cockle Creek Bridge), has led to considerable contracts being let which will provide for their extensive use during the coming year."

In the same year (1900) the eminent engineer Dr. J. J. C. Bradfield, of later Sydney Harbour Bridge fame, wrote about this structure in his paper "Some Notes on Monier Construction", which was published in the Journal and Abstract of Proceedings of the Sydney University Engineering Society for 1900, Vol. V, pp. 55-65.

"A road bridge on the Monier principle has just been completed over Read's Gully, Main Northern Road, by the Bridges Branch of the Public Works Department, at a cost of £480. "The arch is about thirty feet span, six inches thick at crown and ten inches at abutments. The carrying bars are three-eighths of an inch diameter, spaced three inches centres, and distributing bars a quarter of an inch diameter, spaced four inches centres, and the grill is tied at each point of intersection with No. 22 B.W.G. black wire, the overlap of the bars is twelve inches, tied in three places with double wire. The bridge is shown by the accompanying Plate.

"The scaffolding consisted of gauged timber, planed on one side with sufficient space between the planks to allow them to swell freely when wetted, templates cut to the exact thickness of the arch were then nailed on either side of the scaffolding.

"The grill was supported on small pats of cement mortar placed irregularly on the surface of the scaffolding to keep the grill in its proper position. The cement mortar (3 to 1) was spread in two layers, the lower one about one and a quarter inches thick, was rammed between and completely covered the grill, the upper layer was of the requisite thickness to bring the mortar to the top of the templates. It is essential to keep the lower layer about one foot in advance of the upper one, so that the unfinished ends form steps for jointing, and the work must be finished between the supports without any intermission.

"The arch was tested with a one sided load of eighty seven pounds per square foot, consisting of wet sand, and did not give the slightest deflection."

Earlier in his paper, Dr. Bradfield gave details about both the principles and practice of "Monier" construction and a few more extracts in his own words will help to complete our story.

"About twenty years ago, a novel system of construction was invented by one Jean Monier, and is now known by his name. The system, viz: a combination of cement mortar

and iron, was perfected by two German engineers, Wayss and Koenen, and thoroughly tested by the "Austrian Society of Engineers and Architects". These tests proved its great strength, durability and fire resisting properties . . .

"Cement mortar is cheap, durable and readily moulded to any required shape; its compressive strength, however, is at least ten times as great as its tensile strength, and when subject to bending moments, it is impracticable to develop the full compressive strength, and at the same time provide the necessary area to resist the tensile stresses. In order therefore, to develop the full compressive strength of the mortar, it has been found necessary to augment its tensile strength, and thus decrease the total area of section, which would otherwise be required . . .

"The Monier system consists in embedding a rectangular grill or mesh of bars in cement mortar at the proper position to augment its tensile strength; the object of the grill is to take up and transmit the tensile stresses — primary and secondary — bind the mass together and give elasticity to the whole.

"The rods forming the grill are wrought iron or steel round bars, consisting of longitudinal or carrying bars to augment the tensile strength of the mortar, and transverse or distributing bars, to hold the longitudinal bars together, and distribute the stresses over the whole grill. The bars are tied at each point of intersection with black iron wire about No. 22 gauge.

"The spacing of the carrying bars depends on the amount of tension which they have to take up, but the distribution bars are usually spaced four inches centres, i.e. three bars to the foot.

"The longitudinal or carrying bars vary from about one inch to three-eighths of an inch in diameter, whilst the distributing bars are three-eighths or a quarter of an inch diameter. These sizes are easily handled and form a flexible grill. Ordinary trade lengths of iron are used, and . . . the rods and wire must be clean and free from paint, oil or varnish . . .

"Neat cement and cement mortar, when setting in air diminish, and in water increase their volume, but the mortar on account of the sand it contains, is subject to much less change in volume than the neat cement. This change in volume occurs chiefly during the first twenty-eight days, when the neat cement and cement mortar are most rapidly increasing in strength.

"The change in volume when setting, causes the mortar to adhere to the iron, but the adhesion is also due to the chemical action of the cement on the iron, forming an insoluble double silicate of lime and iron, which binds the two materials together, excludes air and moisture from the iron, and acts as a preservative, preventing any deterioration of the iron. The adhesion is not destroyed by vibration or varying temperature, and is at least equal to the cohesive strength of the mortar . . .

PILE PROTECTION

"Pipes eighteen inches internal diameter for hewn piles, and twenty-one inch diameter for round piles, are used for protecting piles in tidal waters from the ravages of the teredo, the protection extends from one foot above High Water Mark to six or eight feet below bed of river. The pipes are not cut by the drifting sand, or acted on by the sea water, and form a strong durable and efficient protection. The pipes are threaded around the piles, jointed up in one length, and then sunk to the requisite depth by the water jet, assisted in some cases with jacks. The joints are made with wire netting and cement mortar (2 of sand to 1 of cement), and the space between pile and pipe filled in with sand, except the top nine inches, which is filled in with fine concrete, and finished off with a concrete cap.

"Some seventeen hundred lineal feet of twenty-one inch diameter pipes, and one hundred and thirty lineal feet of eighteen inch diameter pipes have been used up till February, 1901, in protecting the piles of bridges built in tidal waters.

CYLINDERS

"Monier cylinders are made from three feet six inches to six feet in diameter, about three feet seven inches long, and have proved to be an efficient substitute for cast iron at about one half the cost.

"They are used for foundations of moderate depth, and may be sunk by open excavation, or under air pressure, the connections between the cylinders have been designed to withstand a head water of forty feet. Each cylinder has several pairs of connecting strips built in, the number of which depend on the diameter of the cylinder; between these connecting strips in two adjacent cylinders a fish plate fits, and is secured to the connecting strips by steel wedges . . .

"Each bottom length of cylinder has a cast iron cutting edge bolted to it, and the cylinders in each pier are braced together with wrought iron bracing.

"Monier cylinder piers have been sunk at Cockle Creek to thirty-six feet below water, and at the Wilson River at Telegraph Point, to a similar depth; contracts have also been let for three other bridges in which they will shortly be used — Mulwarrie Ponds at Goulburn, Wyong Creek at Wyong, and MacIntyre River at Inverell — and so far, four hundred and seventy seven lineal feet of three feet six inches diameter cylinders, one hundred and twenty lineal feet of four feet six inches in diameter, and seventy two lineal feet of six feet diameter, have been constructed, or are in course of construction in New South Wales.

AQUEDUCTS

"The first Monier structures erected in New South Wales were the Monier aqueducts across Johnstone and White Creeks at Annandale. They were erected in 1897 by Messrs. Carter, Gummow and Co., for the Sewerage Branch of the Public Works Department, under the direction of Mr. J. Davis, Engineer-in-Chief for Sewerage Construction.

"The aqueducts carry the main northern sewer for Annandale and Leichhardt, they are similar in design and connect with sewer tunnels at each end. There are seventeen arches in all, seventy-five feet clear span, and eighty-two feet ten inches from centre to centre of piers. The arches are twelve inches thick at crown . . .

"As these works were of a novel character, and the first of their kind in Australia, the Contractors were required to maintain them for three months, after erection, and further to guarantee to remove and replace them by suitable structures if any defects were found within a period of three years. This period has now expired and the structures have proved satisfactory.

BRIDGES

"An overhead bridge consisting of three forty-two feet spans, eight inches thick at crown, has been erected by the Railway Commissioners at Strathfield station, partly to carry the road traffic, and partly to support the new station buildings."

Mr. Bradfield also gave more extensive details about the bridge over the Yarra River in Melbourne and finished off with some notes about "Monier" reservoirs.

In conclusion, our research showed that on 2 February 1914 the New South Wales Government took over the Monier Pipe and Reinforced Concrete Works, previously conducted by Messrs. Gummow, Forrest and Company of Erskineville. After operating for 22 years in the manufacture of all classes of reinforced concrete items (including bridge cylinders), the State Monier Pipe and Reinforced Concrete works was sold back to private enterprise in 1936 to become Monier Industries Ltd.

One of their major undertakings while a State concern was the erection of the bridge over the Georges River at Tom Uglys Point. This work was carried out for Sutherland Shire Council but supervised by engineers from the Department of Public Works. The bridge was commenced in 1925 and completed in 1929. •

Statement of Receipts and Payments for the year ended 30 June 1978

Receipts

Motor vehicle registration tax
Charges on heavy commercial vehicles under the Road Maintenance (Contribution) Act, 1958
Levy upon Councils in accordance with Section II of the Main Roads Act, 1924
State Government Loans—Repayable
Loan Borrowings under Section 42A of the Main Roads Act, 1924
State Treasury Advance—Repayable
Councils for works carried out in conjunction with works on Main Roads
Other departments and bodies for works carried out in conjunction with works on Main Roads
State Government Grant for Relief of Unemployment
Commonwealth/State Government Grant for restoration of flood damage
State Government Grant for upgrading Cane Roads
State Government Grant for access road to Westmead Hospital
Sydney Harbour Bridge Account for freeway approaches
Transport (Planning and Research) Act, 1974
Transport Planning and Research (Financial Assistance) Act, 1977
National Roads Act, 1974
Roads Grants Act, 1974
States Grants (Roads) Act, 1977
Road Transport and Traffic Fund and Public Vehicles Fund
Ministry of Transport Vote
Other
Total Receipts

Payments

Construction and reconstruction of roads and bridges
Construction and maintenance of local roads
Property acquisition
Maintenance and minor improvements of roads and bridges
Restoration of flood damage (Proclaimed Natural Disasters)
Purchase of land and buildings for works operations
Administrative expenses
Purchase of land and buildings for administration
Planning and research
State Treasury Loans—
Sinking fund payments
Interest, exchange, management and flotation expenses
Loan Borrowings under Section 42A of the Main Roads Act, 1924—
Repayment of principal
Interest
Other
Transfers to reserve for loan repayments
Net transaction of operating and suspense accounts
Total Payments

(a) Credit

County of Cumberland Fund $	Country Fund $	Commonwealth Fund $	Traffic Facilities Fund $	Total 1977/78 $	1976/77 $
34,288,739	84,766,150		3,820,000	122,874,889	106,098,521
3,804,513	15,218,052			19,022,565	19,809,661
59,324				59,324	56,559
6,000,000	3,000,000			9,000,000	8,000,000
4,010,000	6,000,000			10,010,000	13,990,000
7,000,000				7,000,000	—
160,728	401,130			561,858	898,392
1,396,005	865,936			2,261,941	914,044
2,860,000	7,820,000			10,680,000	100,000
	8,725,600			8,725,600	11,806,380
				—	300,000
500,000				500,000	—
				—	354,230
		112,647	150	112,797	1,785,494
		1,613,285		1,613,285	—
		1,811,314		1,811,314	57,388,686
			228,051	228,051	78,191,778
		149,521,664	4,278,336	153,800,000	—
			13,618,078	13,618,078	7,229,609
			2,500,000	2,500,000	2,500,000
3,153,389	1,031,599		1,801,745	5,986,733	2,866,843
63,232,698	127,828,467	153,058,910	26,246,360	370,366,435	312,290,197
30,195,674	48,687,074	93,405,078	7,724,764	180,012,590	146,507,632
		34,065,615		34,065,615	21,875,700
3,264,617	2,064,503	11,494,995		16,824,115	16,309,516
17,921,239	57,243,204	6,948,170	16,378,141	98,490,754	83,957,456
	9,261,714			9,261,714	12,184,292
1,752,081	833,141	507[(a)]	323,746	2,908,461	1,016,666
2,273,387	6,776,232	4,821,328	1,519,559	15,390,506	15,973,551
576,090	221,620			797,710	599,985
664,630	1,044,280	1,779,433	150	3,488,493	3,193,884
50,000	291,172			341,172	243,313
531,640	3,239,193			3,770,833	2,102,997
403,550	719,291			1,122,841	758,495
2,114,479	2,549,763			4,664,242	3,222,539
426,339	1,340,883			1,767,222	793,672
60,173,726	134,272,070	152,514,112	25,946,360	372,906,268	308,739,698
303,787	320,363	—	—	624,150	480,150
7,626,409	5,932,099	—	300,000	13,858,508	644,453
68,103,922	140,524,532	152,514,112	26,246,360	387,388,926	309,864,301

Of Time and Distance

. . . a tale of lasting quality

During April 1978, more that 500 veteran and vintage cars and motorcycles assembled to undertake the 16 day Australian International Veteran and Vintage Motor Rally. Following the Pacific Highway to the Gold Coast for most of the route, they made an interesting and colourful addition to the more regular road users.

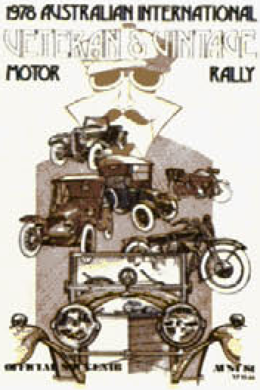
Whether travelling the Berowra-Calga Tollwork (illustrated here) or climbing the ranges further north, they took their place amidst long-distance hauliers, commercial travellers and holiday makers—showing once more that our roads are for the use of all.

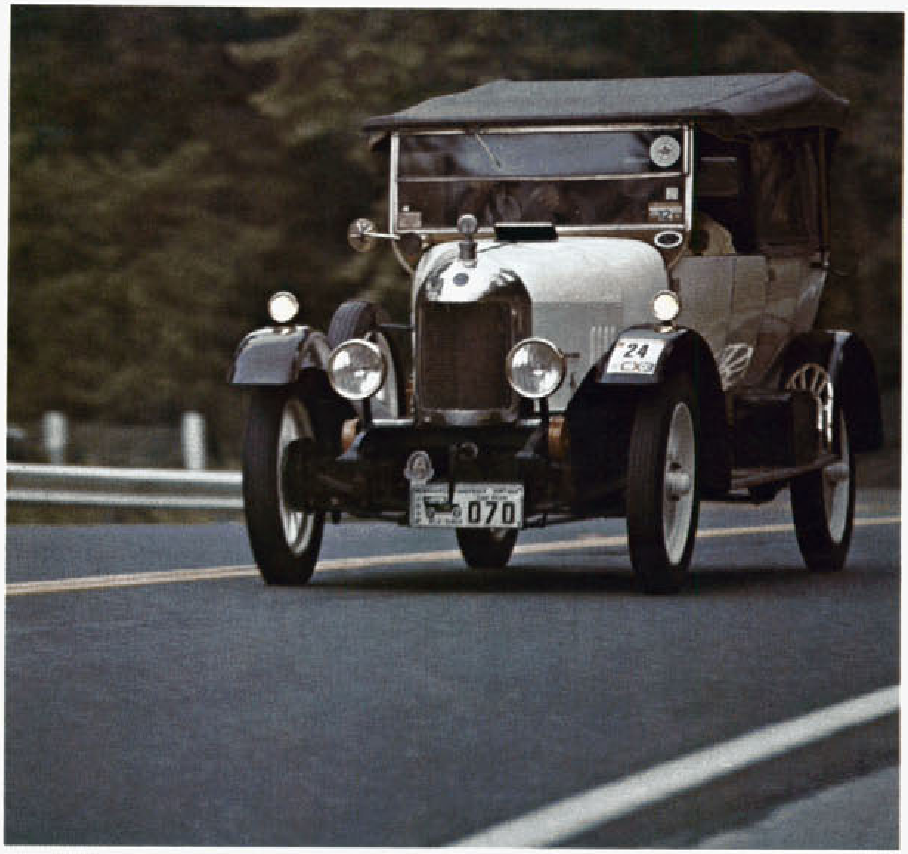
Above: *Automation* hasn't been limited to cars alone. This 1909 Clement Bayard contrasts with one of the automatic toll collection machines installed at Berowa, just over half ● century later, in December 1968.

Left: This single cylinder FN motorcycle of 1907 has pedals which are used to start the 'cycle, and to help it along on steep climbs. The easier grades, improved alignment and better surfaces of today's roads have shortened travelling times . . . and mean less peddling than in the past.

Below left: A 1909 Renault and a traditional cup of tea by the roadside . . . times haven't changed. The improvement of our roadways is pursued with the same enthusiasm which fires man to spend countless hours in restoring old vehicles to their former glory.

Below: The passenger in this 1924 Douglas motorcycle and sidecar reminds us that touring can still be a pleasure . . . especially on well *designed, and well made roadways.*





Above left: In 1927 when this Chevrolet was built, the Main Roads Board was re-establishing a direct road link from Sydney to Newcastle, via Peats Ferry. Further improvements were initiated in the 1960's when work began on construction of the F3—Sydney-Newcastle Freeway.

Above: A Morris Cowley, built in 1924, travels a section of the Pacific Highway, built in 1930, near Hawkesbury River. Both were designed to last, if treated with due respect and proper investment in maintenance.

Left: Another vintage car takes its place with the other traffic, on the Berowra-Calga Tollwork. The massive cuttings which ease the grades, and the new alignment along the route, represent an enormous advance in road building technology, when compared with the days when these vehicles were common-place.

Below: The seven decades, which have passed since the era of this Sizaire Naudin, have produced such new features as electric street lighting, safety fencing, divided carriageways, raised medians, improved road base construction and surfacing, "rumble" strips and breakdown lanes, reflectorised and raised lane markings and many more.


PR-375

GIVING ROADS A FACE LIFT

In July 1978, the Department took delivery of its first Roto-Mill Pavement Profiling Machine—to add yet another item of modern equipment to its already extensive fleet of specialist machinery.

More details about this fascinating machine, which introduces a new method of road maintenance and repair, are given in the article on pages 7-9.

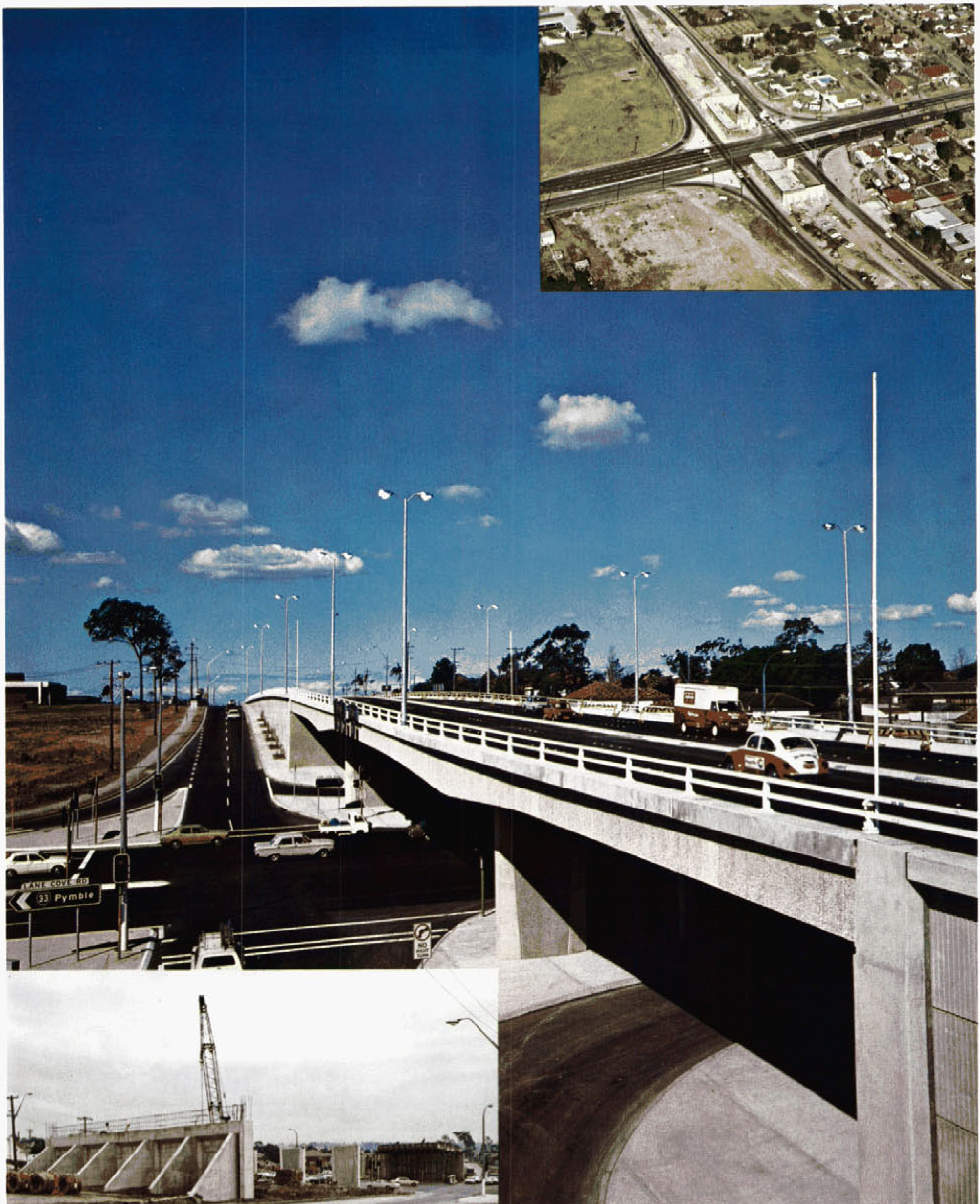
Below left: "Despite its somewhat cumbersome appearance, the Roto-Mill Pavement Profiler is a highly developed and intricate piece of equipment."

Left: ". . . the spinning tungsten carbide cutter bits chew at the old road surface . . . cleanly and quietly, damped down by a water spray that keeps dust and disturbance to a minimum."

Below: "The machine itself retrieves the milled material. It can feed the removed particles directly . . . into the tray of a following truck . . ."

Above right: "Within its rugged exterior is concealed a mass of sophisticated and sensitive control mechanisms . . ."

Right: The serrated surface gives greater 'grip' to the new surfacing material.


LANE COVE RD
33 Pymble
NO RIGHT TURN

EPPING ROAD INTERCHANGE OPENED

The interchange

Many major road works are planned well in advance of construction but their implementation is deferred while funds are provided for other more important works with a greater needs priority.

Plans for these deferred works are constantly being revised to incorporate improved methods of construction which will mean savings in costs, construction time and which will give a greater level of service to the road-using public.

Such a work was the construction of the interchange at the intersection of Epping Road and Lane Cove Road where savings were made in construction costs by the substitution of vertical reinforced earth walling for crib walling on piles in the bridge approach embankments (see article in September 1977 issue of "Main Roads", Vol. 43, No. 1, pp 10-13).

This interchange serves road users from a large number of Sydney suburbs. Both Epping Road and Lane Cove Road are major urban arterial roads carrying substantial volumes of traffic, a great deal of it being heavy commercial vehicles. The separation of the two major traffic flows—east/west and north/south has resulted in great benefits to road users. The separation of traffic flows has eliminated long queues at traffic signals, marked savings in time and fuel and has dramatically reduced accidents and noise and air pollution.

At the last traffic count Epping Road was carrying 35,000 vehicles each day and 30,000 vehicles were using Lane Cove Road, thus making it one of Sydney's busiest intersections.

Official opening

In officially opening the interchange to traffic on Friday, 28 July 1978, the Hon. N. K. Wran, Q.C. M.P., Premier of New South Wales, said that the overpass was being opened *"at a time when people concerned with transport, and particularly road transport, are endeavouring to appraise what the future is in respect of the construction of more road, more freeways in this State"*.

He went on to say that *"this is a magnificent bridge, we need more of this type of construction throughout the metropolitan area of Sydney"*.

Left: View of the Epping Road overbridge looking towards the City.

Upper right: Aerial view showing construction in August 1977.

Lower left: Construction scene in June 1977 showing bridge abutments (left), piers (centre), and girders on falsework (right).

The bridge

The core of the interchange is the three-span prestressed concrete bridge, 101.8 m long and 21.8 m wide. The length of the central span of the bridge is 45.7 m and the end spans are each 27.4 m. The bridge carries six lanes of traffic separated by a raised median.

The bridge is supported at the abutments on 685 mm diameter bored piles socketed 2 m into hard shale 6 m below ground level. The abutments are of the reinforced concrete counterfort type approximately 8 m high on the face. The exposed concrete panel work has been sand-blasted for textural effect.

The triple-column piers at the southern end are founded on separate spread footings and at the northern end on bored piles.

The superstructure of the bridge comprises broad-flanged prestressed concrete girders of varying depth, 21 in number, placed side-by-side. The 36.2 m long end girders cantilever 8.8 m into the central span to support suspended 28 m long lightweight-concrete girders.

The lower flanges of the girders are wider than the top flanges and are sealed with mortar. Reinforcement protrudes laterally and from the top flanges overlaps in the space between the girders. *In situ* concrete has been placed in the spaces to form a complete and economical deck system without need for any additional concrete overlay. 50 M pa concrete was used in the precast segments and in the *in situ* joint concrete.

The deck of the bridge was surfaced with asphaltic concrete 50 mm thick.

End-span girders were assembled into position (in three separate sections) on falsework and were post-tensioned by the PSC Monogroup system. The girders are haunched to a depth of 1.6 m at the piers.

Headstock cross girders are post-tensioned and cantilever sideways from the pier columns. They were effectively hidden by constructing the underside flush with the bottom of the main girders. Additional cross girders have been built into the structure.

The central 28 m suspended span girders were manufactured from lightweight concrete (using expanded shale aggregate), having a density of approximately 2000 kg/m^3 and a compressive strength of 42 M pa.

These girders were pre-tensioned and delivered to site and lifted into position by two mobile cranes. They are stiffened transversely by four post-tensioned cross girders.

Fascia panels to the outside of the outer girders were manufactured from 25 mm thick compressed asbestos cement board faced with carefully selected granite chips epoxied to the base board. The panels are attached by hidden fixings to the lower flanges of the girders and are held in a groove at the kerb soffit.

The lighting for the overpass is unusual in two regards. Firstly, the light poles themselves are situated on top of the kerb outside the bridge guardrail, to eliminate the possibility of impact by passing traffic. Secondly, the lights provide illumination for both the overpass itself, as well as the ramps and Lane Cove Road, beneath.

The approaches

Crash rails and kerbs have been continued in both directions along the elevated bridge approaches.

The approaches are about 2.1 km long extending from Delhi Road in the east to Shrimptons Creek in the west. These approaches have been constructed to a six lane divided road standard. Road users in Epping Road are now largely unaware of the fact they are crossing over a previously densely trafficked intersection.

In the design of these approaches, careful consideration was given to the many public utility services accommodated within the road reserve. As many of the services were major trunk arteries, especially the water service, any major adjustment would have been extremely costly and time consuming. The road was designed with rolling grades to minimise interference to these services.

A number of properties have access directly onto the ramps connecting with Lane Cove Road and so that residents of these properties do not have to make long and tedious detours to gain access to their homes, U-turn facilities have been introduced beneath the end spans of the bridge.

These facilities are named "Texas Turns" and their name implies their origin. Their cost is small but their benefits as a traffic management procedure for the easy movement of purely local traffic is great.

Pedestrian overbridge

Epping Road is flanked to the south by the well developed residential suburb of North Ryde and to the north by an industrial area.

Near Paul Street to the west of the bridge, the approaches are extremely wide because of the merging lanes on each side. These lanes lead to the southbound link which connects Epping Road to Lane Cove Road and from the northbound ramp which connects Lane Cove Road to Epping Road.

Consequently, it is proposed that a pedestrian overbridge will be constructed across Epping Road near Paul Street, to provide access to and from bus stops and the industrial centres established on the north side of Epping Road.

Growth of the area

Construction of Epping Road as we know it today began in February 1938 with the object of developing a large sparsely settled residential area. The initial work, including construction of three major bridges over Stringybark Creek, the Lane Cove River and Terrys Creek, was completed within two years and it was opened to traffic on 3 February 1940.

Much of North Ryde was then semi-rural and it is not so many years ago that extensive market gardens were supplying vegetables for the Sydney Markets.

Prior to the construction of Epping Road the principal access to the Sydney Markets was by boat along the Parramatta River. Lane Cove Road was the artery to the River for this trade.

The importance of Lane Cove Road increased when the Lane Cove River was crossed in 1901 by the original De Burghs Bridge (see article in June 1976 issue of "Main Roads", Vol. 41, No. 4, pp. 125-127).

Both Epping Road and Lane Cove Road have been extensively developed over the years and the traffic now using these two roads vindicates the early planners in identifying the need for them.

Costs and credits

The construction of this interchange and its associated approach road works cost slightly in excess of $5 million.

The bridge, which was constructed by contract, cost $1,025,744. The approaches from Delhi Road to Shrimptons Creek cost almost $4 million.

The bridge was designed in the Department's Bridge Section and was built for the Department by G. Abignano Pty Ltd of Pymble. The prestressed concrete girders were manufactured under sub-contract by E.P.M. Concrete Pty Ltd of Blacktown. The reinforced earth walls of the approaches were erected by the Department to designs prepared by Vidal Reinforced Earth Pty Ltd of Clyde. The precast wall panels, specially fluted to give a more attractive appearance, were manufactured by Humes Ltd. The contract bridge works and all associated roadworks were supervised by officers of the Department's Parramatta Division, under Divisional Engineer, Mr. B. H. Butcher. ●

• • •

An article in the December 1974 issue of "Main Roads" (Vol. 40, No. 2, p. 52) describes the design of the interchange.

In the September 1976 issue (Vol. 42, No. 1, p. 25), a brief article describes the calling of tenders for the construction of the interchange bridge. The cover photograph on this issue featured a scale model of the interchange.

Details of "Recent Reconstruction on Ring Road 3—Mona Vale to Top Ryde" appeared in the June 1976 issue (Vol. 41, No. 4, pp. 107-111).

An article entitled "The New Road from Epping towards St. Leonards" appeared in the November 1938 issue (Vol. 10, No. 1, pp. 14-18), with a follow-up article entitled "The Construction of the Epping—St. Leonards Road (Main Road No. 373)" in the February 1940 issue (Vol. 11, No. 2, pp. 57-60).

New Deputy Commissioner

New Deputy Commissioner, Mr. Bruce Loder

Mr. Bruce Norman Loder, B.E., Dip. T.C.P., M.I.E. (Aust), was appointed Deputy Commissioner for Main Roads on 1 September 1978.

Following advertisements placed in major newspapers in all State capital cities throughout Australia, applications for the position of Deputy Commissioner were received by the Ministry of Transport for consideration by the Government. The selection was made by Cabinet, approval by His Excellency, the Governor of New South Wales and announced by the Minister for Transport and Highways, Mr. Peter Cox, at the end of August 1978.

An honours graduate in Civil Engineering at the University of Sydney, Mr. Loder joined the Department on 5 February 1948. He served as an assistant engineer in the Bridge Section for a short time before being posted to the field as the assistant engineer at Bilpin, then briefly at Windsor and later at Bowenfels.

In March 1950, Mr. Loder left the Department to gain experience in overseas civil engineering practices. On rejoining the Department in October 1951 he spent some months in the Outer Metropolitan Division before becoming Works Engineer at Bega in January 1952.

After 3½ years service at Bega, he spent a similar period at Goulburn. In April 1959, Mr. Loder was seconded to the National Association of Australian State Road Authorities, where he served for the next 3½ years as Executive Engineer in charge of the Secretariat.

In November 1962, he returned to Departmental activities as Supervising Engineer in the Metropolitan Division, before being appointed Divisional Engineer of the Central Northern Division at Bourke from June 1967 to December 1968.

Mr. Loder came back to Head Office to take up the position of Assistant Urban Investigations Engineer in January 1969 and then Advance Planning Engineer in June 1975. A year later he became Divisional Engineer again, this time of the Department's Illawarra Division centred at Wollongong. In December 1977, he returned to Sydney to take up special duties in connection with the Department's Management and Strategy Review being undertaken in conjunction with the Management Consultants, W. D. Scott and Co.

In 1972 Mr. Loder visited European member countries of the Permanent International Association of Road Congresses (PIARC) on behalf of the Australian Government and spent some time inspecting road and bridge works in the United Kingdom.

In 1974 Mr. Loder attended the Australian Administrative Staff College at Mt. Eliza, Victoria.

In 1975 he attended the XVth World Congress of PIARC in Mexico City and at this Congress he was the co-ordinating reporter for the presentation of papers contributed by Australian members. At this time, he also made an extensive study of civil engineering works in the United States of America and Canada before returning to Australia.

Mr. Loder has been a keen participant in the activities of the Main Roads Social and Recreation Club and other staff associations. He has also served a term as Chairman of the Board of Directors of the Main Roads Staff Credit Union.

He has always been an active member of the Institution of Engineers and was a foundation member of the Institution's National Committee on Transportation. He was Chairman of the Transportation Branch of the Institution's Sydney Division during 1975.

He has written and presented a number of papers on planning and transportation matters to both the Institution of Engineers and the Royal Australian Planning Institute. His activities in civic matters have led him on many occasions to address citizen groups on the principles of transport and planning.

Mr. Loder brings to the position of Deputy Commissioner wide ranging engineering knowledge and experience, as well as an undoubted capacity for high level management and policy decision-making. He has a deep desire to derive the maximum value out of funds spent through the Department, for he believes that this is the way in which the Department best serves the Government, the road-users and the whole community. •

* * *

In the December 1975 issue of "Main Roads" (Vol. 41, No. 2, pp. 60-63) there is an article on metropolitan transport entitled "Who Goes Where—How, When and Why?". This article was originally prepared as a conference paper by Mr. Loder, then the Department's Advance Planning Engineer and Mr. K. M. Anderson, the Department's Urban Investigations Engineer.

Mr. Frank Hulscher (on the left) holding the ARRB Directors' Prize for 1978 which was presented to him at the 9th Biennial Conference held at Brisbane from 21-25 August 1978. Congratulating Mr. Hulscher is Mr. W. Hanson, who is Commissioner for Main Roads, Queensland and one of the seven Directors of the ARRB.

The Dependence of Traffic Engineering on Peripheral Technology

ARRB DIRECTORS' PRIZE

The Australian Road Research Board (ARRB) was established in 1960 by the National Association of Australian State Road Authorities (see article in December 1976 issue of "Main Roads", Vol. 42, No. 2, pp. 61-63).

One of the major activities of the Board is the organisation of a Biennial Conference which attracts delegates from throughout Australia and from overseas.

Commencing with the 8th Biennial Conference held at Perth, Western Australia in 1976, the Directors of ARRB decided to award a Prize to be known as the Directors' Prize for the paper which best translates research into practice.

The purpose of the Prize is to encourage papers describing the application of research into practice and to assist in raising the already high standard of papers presented. Papers concerned with research into all aspects of the planning, design, construction, maintenance, operation of roads and road transport (including economic, administrative and legislative matters) are open for consideration.

The Prize is an "objet d'art" presented at the Conference. The design of the Prize is one of three originally conceived within the ARRB and which were presented to the Board of Directors for selection and approval early in 1976. The work was done by Michael Mezaros, a young and talented Melbourne sculptor with several original works to his credit before he agreed to act as technician and produce the design.

In appearance, the silvery "objet d'art" is a hubless wheel, poised on a section of road and subtly scored to suggest movement according to the source of light and the viewer's position.

This combination of wheel and road symbolises the interdevelopment that exists in reality, where the function of one relies on the provision of the other.

As road and road transport research operates to attain the optimum relationship between road vehicles and road design, it is envisaged that The Directors' Prize will provide a simple but unique recognition of the most practical research contribution.

The first Directors' Prize was presented at the 8th Biennial Conference held at Perth in 1976. It was awarded to Mr. Bruce Phillips of the Country Roads Board, Victoria for his paper "Synthetic Aggregates for Road Surfacing".

The second Prize was presented in 1978 to Mr. Frank Hulscher, Supervising Engineer in the Traffic Section of the Department of Main Roads, New South Wales. It was awarded in recognition of the two papers he submitted (in conjunction with five other authors) to the 9th Biennial Conference and also because of the high calibre of the two papers presented by him at the 8th Biennial Conference.

During the session at which the Directors' Prize was presented, Mr. Hulscher gave the following special address in which he explained motivation for the areas of research covered in the four papers. Some slight editing of this address has been undertaken to adapt it for publication in this Journal.

In making this award the Directors specifically stated that the Prize has been awarded in respect of four papers to which I have contributed, two of which were submitted to the 8th Conference in Perth. The first two papers dealt with traffic signal facilities for blind pedestrians, and with failsafe requirements of traffic signal equipment. The other two papers are concerned with loop configurations for vehicle detectors and with the concluding phase of the work on failsafe requirements of traffic signal equipment.

At first sight the papers presented and yet to be presented, may not appear to have a great deal in common. But you must understand that Traffic Engineering is a lusty fledgling. Give a traffic engineer a text book on applied statistics and a handful of empirical formulae, and he will transform the world. My specific field of interest is traffic light signals, and as an electrical engineer I have been particularly concerned with the technological 'gap' which exists between the traffic engineer's sophisticated designs and the equipment I was able to place at his disposal. Not that that 'gap' has ever inhibited the traffic engineer in his search for perfection in traffic management . . . and that has concerned me even more. The road user has to adapt to a cold, hard world; he demands safety, efficiency, and above all, honesty. Esoteric traffic designs all too often fail to recognise the limitations of the equipment at hand, and the awesome responsibility to keep the monster going once it has been created.

But don't allow me to forget myself. *Noblesse oblige* and it does not behove me to issue admonishments to traffic engineers. The underlying theme I would propose for my address is THE DEPENDENCE OF TRAFFIC ENGINEERING ON PERIPHERAL TECHNOLOGY.

Signal Lanterns

In the early 1960s we started to make a critical examination of the most basic component of the traffic signal system: the lantern. We found an item which had been relatively unchanged since it was originally designed in Britain some 30 years previously. Lenses, such as they were, were made from glass in a bewildering variety of colours. I remember a consignment of yellow (amber) glass lenses which ranged from deep-brown to pale yellow and represented a range in internal transmittance from 0.5 to 0.8. Chrome-plated reflectors, inefficient vacuum lamps and glass lenses with low internal transmittance yielded red (on-axis) signal intensities in the order of only 50 cd. Research by Cole and Brown (1968) indicated that a four-fold increase in signal intensity would be needed to cater for the needs of motorists with *average* vision. The importance of adequate signal intensity, control of chromaticity limits and use of auxiliary devices such as target boards has been clearly described by Fisher and Cole (1974). The practical implementation of this research precipitated a multitude of problems (Hulscher 1974*a*), most of which have been solved; and as a result of which we can now pride ourselves on a good signal presentation without having resorted to exotic (and expensive) lamps. This work has culminated in the issue of Australian Standard 2144-1978 *(Traffic Signal Lanterns)* earlier this year.

Lest I have given you the impression that the problems of signalling our intentions to road users have been substantially overcome, I would list the following serious deficiencies which still await a satisfactory solution.

(a) The signals are still subject to excessive sun-phantom.

(b) There is no satisfactory method for restricting the signal range or coverage where different installations are in close proximity.

(c) There is no effective switchable restriction sign ('secret' sign) for use at traffic signal sites.

Non-visual signals

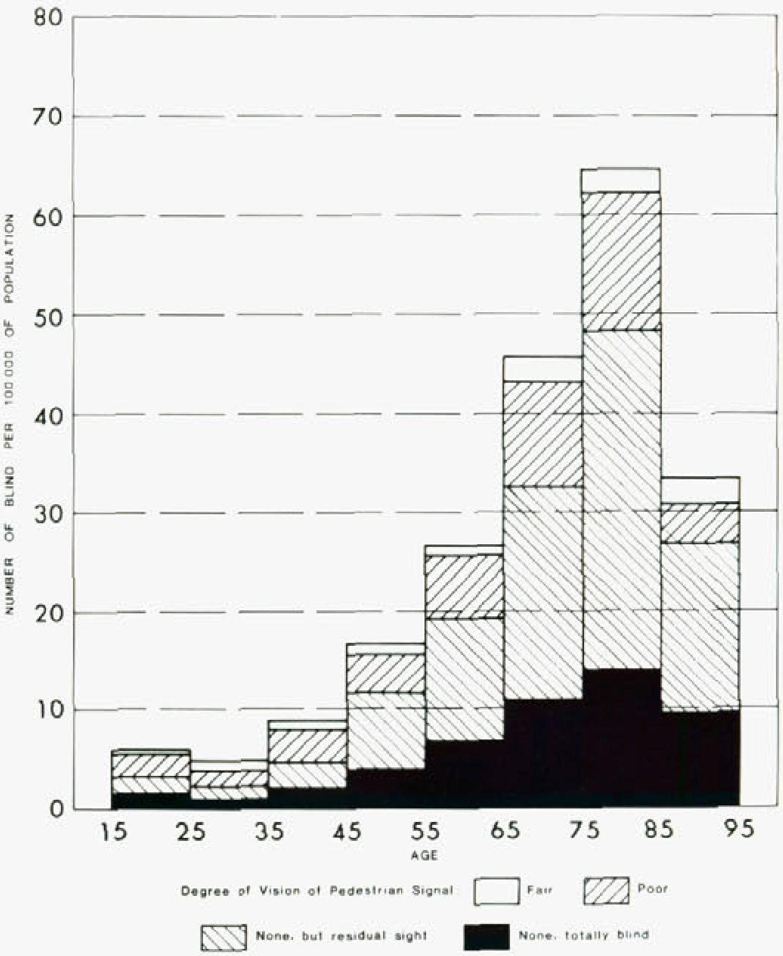
The signals I have been talking about so far rely on visual perception. But not all road users have adequate visual perception, and it has been estimated that up to 0.13 per cent of the population over the age of six cannot see the illuminated pedestrian signal and requires special assistance. It is important to explain at this point that only a small proportion of these visually handicapped people are *totally* blind. This is illustrated in the bar chart on page 23.

Because of the obvious difficulty in establishing sound economic arguments for expenditure of public funds on traffic facilities which benefit a statistically insignificant group, the whole question has become obscured by emotive contentions. On the one hand, the proponents of the special facilities argue that Society owes it to the unfortunate handicapped person to do everything possible to make life easier for him. On the other hand, the traffic authority is understandably reluctant to assume the responsibility for the safety features of a facility which might cause a blind pedestrian to relax some of his customary caution in traffic. Whilst it is difficult to sustain a logical argument favouring any one of these viewpoints, there is an undeniable world-wide trend to bias public facilities to provide special assistance to handicapped persons. Until realistic warrants for non-visual signals can be formulated, the application of such devices is likely to be restricted to a very small number of 'obvious' sites (Hulscher 1977*a*).

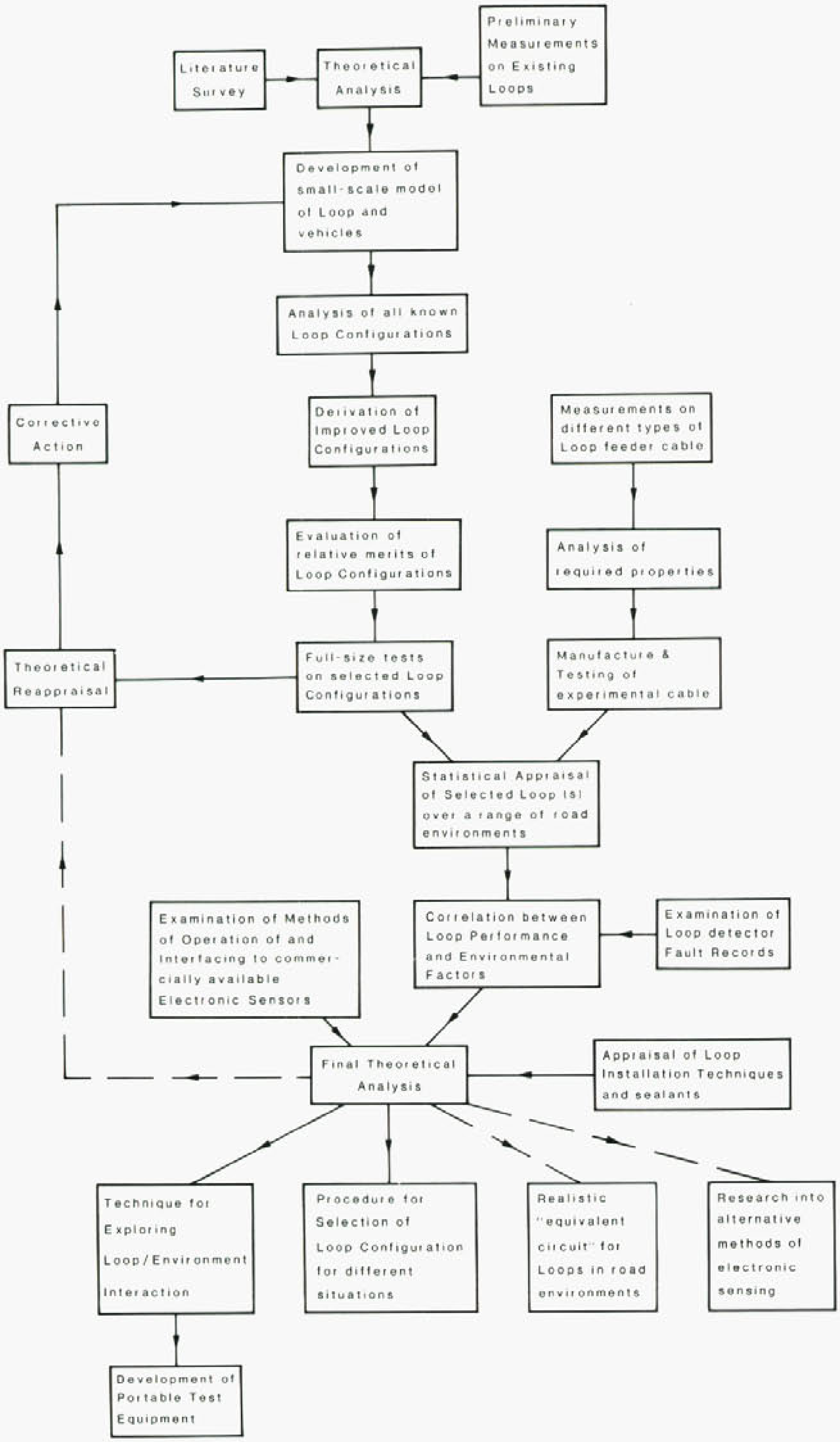
An early installation in Sydney used bells to indicate WALK across one street and buzzers to indicate WALK across the intersecting street. This set-up soon indicated severe limitations for general usage, not the least of which were complaints about the noise nuisance created by these devices. A subsequent installation based on the tactile sense only, avoided the noise problem, but was criticised by some members of the blind community for ergonomic reasons.

It was then realised that the old 'stopgap' approach was unsatisfactory, and the investigation which followed was described in a paper presented at the 8th Conference (Hulscher 1976). It was most gratifying when the Association of Consulting Engineers, Australia, subsequently presented Louis A. Challis and Associates with the *1976 Engineering Award* in recognition for their outstanding work on the practical development of an audio-tactile signal device (Challis and Associates 1976).

Preliminary trials with prototype audio-tactile signals, mounted inside the normal push-button boxes, elicited an encouraging response from the various Organisations for the Blind. Regrettably, the reliability of the prototype transducers left much to be desired and extensive redesign has had to be undertaken. At this stage we are proceeding cautiously and an expanded trial with the redesigned signal devices will enable us to



Age distribution and degree of blindness in N.S.W. population (estimated).



Flow chart of vehicle detector loop research.

make a better evaluation not only of the primary objectives, but also their effect on normal pedestrian traffic (which is often slow to respond to the WALK signal) and the noise abatement feature.

Vehicle detection

In the early 1930s the British Authorities adopted a policy of vehicle-actuation for traffic light signals. That is, vehicle detectors are used to determine the signal phase sequence and the duration of green times. The same policy prevails in Australia. In retrospect, was this a wise policy or have we committed the public to an expensive luxury? Vehicle detectors have always been a troublesome item and even today, notwithstanding the enormous technological advances in solid-state electronics, detectors are still the 'weak link' in our traffic control systems. Vehicle detection has provided a fertile ground for experimentation and development (Hulscher 1974*b*). The healthiest survivor currently is the inductive loop detector, but it nevertheless suffers from serious limitations:

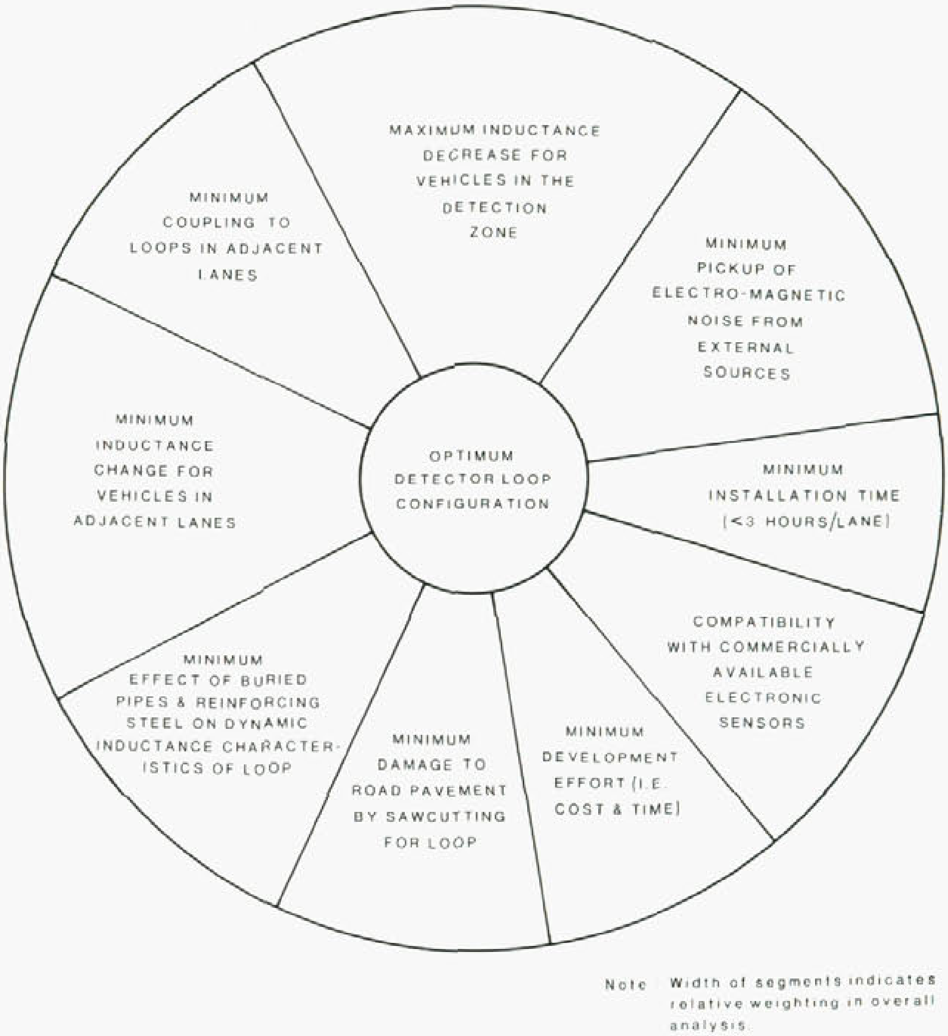
(a) it has a poor conversion efficiency and is extremely susceptible to induced interference;
(b) its low inherent sensitivity results in unreliable detection of some types of vehicles (e.g. small motor cycles and high-bed trucks);
(c) the dynamic characteristics of this type of detector limit presence time (memory) and minimum entry speed in relation to vehicle type; and
(d) its actual performance varies significantly from site to site depending on road construction, location of utility services and type of sub-soil.

In fact, if we examine what the electronic circuit 'sees' when it looks across the terminals of the loop transducer, it seems amazing that the device works as well as it does. But this is principally due to the advances in solid-state (IC) electronics in combination with vigorous competition amongst the manufacturers of electronic sensors. Although we have a basic understanding of the principles involved in the operation of the inductive loop detector, very little is known about the interaction of the loop transducer and its environment. Yet it appears axiomatic that improvements in the operational design of the detector rely primarily on the accuracy of the model of the input transducer. When one examines the 'fine print' of loop detector manufacturers' brochures, one realises that their claims are in terms of simulated laboratory conditions — they will not and cannot guarantee that the device will detect any vehicle in any road environment. And this is only for a simple binary system . . . we will have to do better than this if we aim to carry out vehicle classification using pattern recognition techniques, as some people have proposed.

Since the loop transducer and its lead-in cable are critical components in the detector system, and seem to have escaped rigorous study in the past, we started at that end. Because of their expertise in aerial systems, we sought the assistance of the AWA Research Laboratory to undertake some fundamental research. The scope of the project is shown in the flow chart on page 24.

It is difficult to forecast at this stage if we shall ever find the 'optimum' loop configuration *(Morris et al. 1978)*, or more correctly, if we will be able to determine that a certain configuration is the optimum (or close to it). Nor would I dare to predict that an accurate dynamic model of the loop transducer will emerge from the studies. My own feelings about the investigations so far suggest that we are only starting to 'scratch the surface', and as happens so frequently in research, new questions appear at a much faster rate than answers. I think that I can speak for all those who have participated in the work when I say that our understanding of the subject has increased beyond that at the start of the work . . . whatever that means.

Of course, to a major extent, the results of the investigations will be limited by the basic constraints placed on the project. The diagram on page 25 illustrates the main factors between which a compromise will need to be sought. It is obvious that if one relaxes the constraint imposed by application to commercially-available electronic sensors, for instance, the scope of the work would be considerably expanded. Perhaps this would be an appropriate point to invite further sponsors for this worthy project . . .



Compromise diagram for vehicle detector study.

System reliability

Have you ever been subpoenaed as an expert witness at a court case on an accident at a set of signals? And struck a defence lawyer whose only objective was to manoeuvre you into a position of admission that the signals *could* (and very likely *did*) show green both ways? He wanted a yes-no answer, and you were given no opportunity to explain about equipment reliability and probabilities of failure. I used to admire the people who had the faith and utter conviction on such occasions to state unequivocally that their lamp switching circuits were so interlocked that it was *impossible* for conflicting signal displays to be generated.

Away from the restrictive atmosphere of the court room, I can state, without fear of contradiction, that even the best-designed equipment is subject to failure. Of course, the probability of failure can be reduced to an acceptable level by proper design, and this provides a measure of the *reliability* of the equipment or the control system.

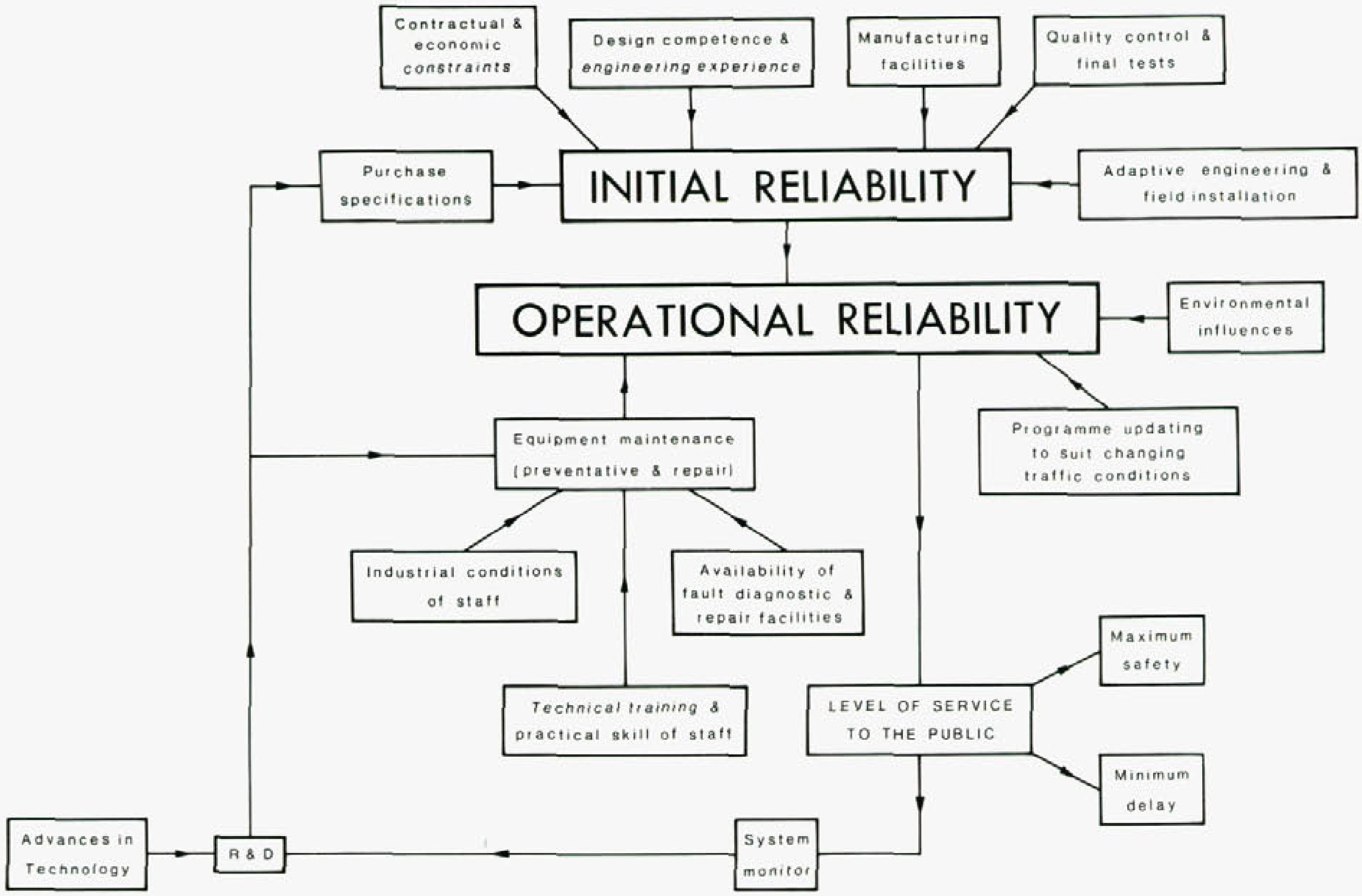
I should like to place traffic signal failures in three broad categories:

(a) failures which generate dangerous displays and therefore affect safety;
(b) failures which cause needless or excessive delay; and
(c) failures which do not directly affect safety or delay, but which reduce public confidence in the facility.

Traffic signal installations represent an enormous investment of public funds. Since that investment was justified by anticipated reductions in accidents and delay, it follows that inadequate reliability will reduce the level of service to the public who therefore will not obtain the full benefit from the facility. I regret to say that maintenance of traffic facilities in the past has not received the attention it deserved. In view of this lack of appreciation of reliability, the *mismatch* between the traffic engineer's design and the 'maintainability' of the installed facility is a matter of serious concern. The many factors influencing reliability of the system are shown diagrammatically on page 26.

I want to return now to the first of the 'level of service criteria: safety, which led to the research into *failsafe* requirements which is the subject of two of the papers referred to. In this context failsafe operation denotes a system condition which immediately removes a dangerous signal display and alerts drivers and pedestrians that the signals have failed. Equipment failures which generate unsafe (dangerous) signal displays are related to an increase in *risk*, which may be defined as the product of the probability of occurrence of a given failure mode at a random time and the probability of an accident resulting from that failure mode at a certain site. Given an efficient system of recording and processing signal failure data and accident statistics, and provided appropriate correlations between those two sets of data can be established, any particular failure mode can be equated to a definite increase in risk.

It may be surprising to find that an extensive search of the overseas literature did not reveal any evidence of previous research in this area. Although intuitively the public are



Factors influencing reliability of traffic control systems.

aware that a display of conflicting green signals (say) is more dangerous than a skipped yellow (amber) signal, it was not clear initially how we could quantify the public's perception of the risk levels involved. Moreover, accident statistics, in the format that they are normally collected, do not lend themselves to establishment of correlations between different types of signal failures and traffic accidents.

I am particularly pleased that the study which has been undertaken has succeeded, in devious ways, in quantifying the maximum incidence tolerated by the public of the various unsafe signal displays. This, in turn, has provided a measure of the minimum level of reliability required for the components of the system. Note that this also implies a *justifiable level of expenditure*. Raising the level of reliability substantially above that point would not be warranted, because it would merely reduce the risk further below the already acceptable levels. We must be careful not to incite an over-reaction in this area, as happened in the nuclear power industry. The risk of an accident in a nuclear power plant is currently below the risk of injury by meteorite impact, but it is difficult to see how the enormous cost of such levels of safety could have been justified.

Earlier in the piece I mentioned *honesty in engineering*. One of the favourite means for traffic engineers to justify provision of complex traffic control schemes is by quantifying reductions in delay and equating these to cost savings to the community as a whole. They have deduced that journeytime reductions in the order of a few minutes per motorist result in savings of millions of dollars in very few years. Let me put it to you that these arguments might impress your fellow traffic engineers and may be useful to keep the Treasury Officials at bay, but they are just so much hogwash to the average road user. He lives in the *real* world, and his ire is raised on each occasion when he is delayed by a red signal when there is no traffic on the conflicting phase.

This brings me to the second 'level of service' criterion: delay. This is an area which we have not researched in any depth. However, it is clear that drivers (and pedestrians) are fairly intolerant of delay, particularly if they cannot see any reason for it. Although traffic authorities in Australia have made every effort to shield the public from excessive amounts of information about traffic management schemes, I feel sure that the average motorist has acquired a reasonable concept of traffic-actuation. He is entitled to the extra efficiency which traffic-actuation implies. And why not: he has paid for all those detectors, including the 30 per cent or so which are inoperative, or which feed distorted data into the system. I suspect the number of equipment failures and maladjustments producing *unnecessary* delay is excessive, but until we can quantify the public's levels of tolerance for delay under defined failure conditions, we cannot know the minimum performance required of the system.

The diagram on page 27 illustrates the interaction of the two main classes of signal failure in the overall analysis. It is clear that our work on dangerous displays has revealed only one side of the picture, and until the delay criteria have been evaluated, we are not in a position to specify the overall system reliability.

The third type of failure, which principally affects the public's level of confidence in the system, will impose further demands on equipment performance, but I foresee that quantification of that criterion is going to be the most challenging of all. Yet it is not a factor we can ignore. It has been suggested for instance (Hulscher 1977*b*) that, provided a reasonable level of redundancy exists in the number of signals displayed, the permissible rate of premature lamp burnouts is defined by its effect on the public's level of confidence in the system. I don't know if I am letting the 'cat out of the bag' by admitting that the existing performance criterion of 0.22 per cent premature lamp failures per week was related to the critical level of disconcertion of a senior staff member!

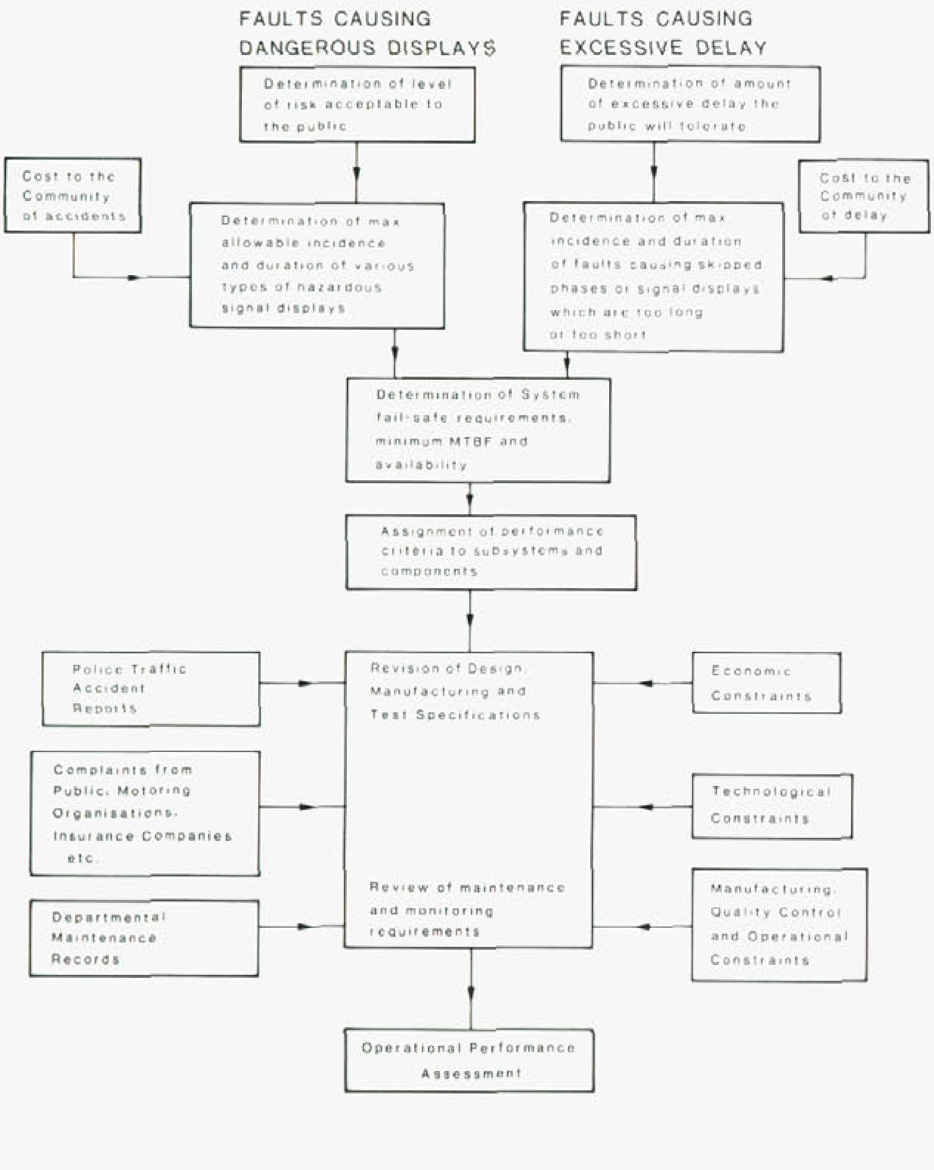
Conclusion

Lest I have left an overly pessimistic impression about the performance potential of traffic signal equipment, let me hasten to reassure you that there have also been enormous advances. Digital micro-processor technology has now developed to a point where on-line computers are small and cheap enough to carry out all the logic functions for the signals. Not only has this increased the scope for control sophistication, but the adaptive engineering can now be done much more conveniently and efficiently at the software level, while the reliability of the control equipment has more than trebled. Never has the traffic engineer had so much computing power at his disposal!

But now that the limitations imposed by the control equipment have been all but removed, the restrictions on our means of collecting input data (detectors) and communicating with the road user (signal displays) show up more clearly. Leaving aside the traffic engineer's programming skill, the computer is only as good as the data you can feed into it; and if you cannot get your message across to the road user, all your good intentions are to little avail.

For this reason I felt that I should make a special effort, firstly, to bring about a better understanding of the technological and ergonomic limitations inherent in some of the vital components of the traffic signal system.

Secondly, having defined the principal areas of research and the relative priorities involved, I had to convince my Superiors that funds should be allocated for this work. The papers which have been referred to indicate a measure of success, but much remains to be done. If it were not for the discernment and goodwill of my Superiors, and for the competence and dedication of Dr Davies and his staff at the AWA Research Laboratory I would not stand before you today. ●



Analysis of performance requirements for traffic signal installations.

REFERENCES

BLANKS, H.S., DAVIES, L.W., HULSCHER, F.R. and SYME, J.W. (1976). *Failsafe requirements of road traffic signal equipment — 1. Proc. 8th ARRB Conf. 8(5), Session 25, pp. 27-35.*

CHALLIS, L.A. AND ASSOCIATES PTY LTD (1976) *Development of an audio-tactile signal* to assist the blind at pedestrian crossings. Rep. No. 2413-1-76.

COLE, B.L. and BROWN, B. (1968). *Specification of road traffic signal light intensity.* Human Factors. *10(3).*

DAVIES, L.W., HULSCHER, F.R. and SYME, J.W. (1978). *Failsafe requirements of road traffic signal equipment — 2. Proc. 9th ARRB Conf. 9(5), Session 27.*

FISHER, A.J. and COLE, B.L. (1974). *The photometric requirements of vehicular traffic signal lanterns. Proc. 7th ARRB Conf. 7(5), pp. 246-65.*

HULSCHER, F.R. (1974a). *Practical implementation of performance objectives for traffic light signals. Proc. 7th ARRB Conf. 7(5), pp. 226-45.*

— (1974b). *Selection of vehicle detectors for traffic management.* Traffic Eng. Control. *15(20), pp. 915-25.*

— (1976). *Traffic signal facilities for blind pedestrians. Proc. 8th ARRB Conf. 8(5). Session 25, pp. 13-26.*

— (1977a). *Traffic signals for handicapped minorities — a right or a privilege?* Insight. *6(4), pp. 21-23.*

— (1977b). *Reliability aspects of road traffic control signals.* Traffic Eng. Control. *18(3), pp. 98-101.*

MORRIS, D.J., HULSHER, F.R., DEAN, K.G. and MACDONALD, D.E. (1978). Loop configurations for vehicle detectors. Proc. 9th ARRB Conf. 9(5), Session 16.

THE EFFECTS OF VEHICLE OVERLOADING ON PUBLIC ROADS

The following article is taken directly from the address given to the Stipendiary Magistrates of New South Wales, on 2 June 1978.

The address was given by Mr. J. A. Wilks, who is Technical Assistant to the Department's Engineer-in-Chief.

This is the first time that a representative from the Department of Main Roads has spoken to a group of magistrates about the damage to roads caused by overloading. This is a unique occasion and on behalf of the Commissioner for Main Roads, I would like to thank the Acting Chief Stipendiary Magistrate for the invitation to speak today.

The purpose of my talk is—

- To explain the cost of heavy vehicle overloading to the Department of Main Roads.
- To explain how overloading affects the life of road pavements.

The main interest in damage to roads due to overloading is the enormous cost and inconvenience that the damage causes. In the last financial year the Department spent $234 million on road and bridge maintenance and construction. This was the amount that the Department put into new roads and bridges and to maintain previously constructed facilities at a reasonable level of serviceability. This sum does not include money spent on such items as traffic facilities, the acquisition of property, administration and other items not directly related to constructing roads and maintaining them.

It can be shown that the life of the Department's roads is being reduced by 25% by the damage caused by overloading of heavy vehicles. Later on I will show you in some detail how we arrive at this, but at this point I want to emphasise that there is a very considerable financial burden placed on the community of this State of the order of $60 million per year as a result of overloading. This means that every year, at today's costs, roads and bridges which cost the community $60 million to put there, are being brought to a state of unserviceability in terms or road user expectations, or to put it another way, it means that, only for overloading, many additional new facilities could be brought into service every year.

There are some obvious effects of overloading which most people are aware of. These relate to the effect on the vehicle itself and on safety. Everyone knows that an overloaded vehicle is at risk because its brakes may become ineffective in some situations such as on steep grades. Structural components may fail because they have been subjected to stresses they were not designed for. These are the very obvious results of overloading and sometimes the overloading directly results in some catastrophe.

I am not going to dwell on these obvious effects but I will explain how vehicle overloading affects the life of road pavements.

As you know, when a vehicle makes one pass over a road pavement, it is not possible to observe the effect on it. There is an effect nevertheless, and the passing of many vehicles has a cumulative effect. It is a knowledge of the effects of axle loads on pavements which enables a road engineer to design a road pavement. Most people do not have a knowledge of those complex relationships. The relationships come from the laws of Physics, Mathematics and Soil Chemistry, governing the behaviour of road pavement materials under stress. I would be too tedious if I tried to explain in those terms how overloading affects the life of a road pavement so to avoid going into detail I am going to use a fairly simple analogy.

When anything is designed—whether it is a road pavement, an engine for a motor car, or a household appliance, or for that matter any device which is designed taking some account of economics, the concept of the *Design Life* of that device is a basic consideration. In other words, the device is designed to last for a certain period before it reaches an unserviceable condition.

For instance, road pavements are commonly designed for a life of 20 to 30 years—a household appliance such as a washing machine would have a design life of say 500 hours of operation. A large motor car engine, say 2,000 hours. There are of course many examples. Various devices have various design lives built into the article, depending on the expectations and requirements placed on that article.

If you take delivery of a new car, and you are that mythical average driver, you could expect to operate that car in your usual manner for 2,000 hours before something goes wrong. If you look at this particular design life you would see that you could expect about 100 000 km on the clock before some major trouble develops. However, as you are aware, various drivers put different demands on their cars and where that demand is heavier than usual, it will not last as long. The extreme example of this is the racing car. As you probably know, nowadays, the ordinary production motor car engine is often used in the racing car. Engines are modified to produce much more power than they would in their standard form—sometimes up to three times the power output is obtained for this purpose. In increasing the power by this amount, the engine is not expected to operate for anything like the life it would have had in an ordinary motor car. In fact only a few hours of operation is expected, and in many cases it lasts even less. So you can see in this case that an increase in the stresses of operation by a comparatively small factor reduces the life of the engine by a very large factor.

It is much the same with a designed road pavement. Overloading by a comparatively small amount can reduce the pavement life by a large amount.

The design of road pavements has been the subject of extensive research throughout the world. Most of the developed countries of the world have carried out road pavement research. The most comprehensive research into pavements ever carried out was done in the USA when the U.S. Highway Research Board undertook what is known as the AASHO Road Test. This work was completed in 1962 at a cost which ran into many millions of dollars. Briefly, it consisted of the testing to destruction of all types of road pavements and structures by actually running various vehicles over a test track.

Among the results, much was found out about the damaging effects of vehicular loadings. Today most road authorities incorporate some findings of the AASHO Road Test into their pavement designs.

One of the principles established by the AASHO Road Test was that the *damaging power* of an axle load increases as to the fourth power of the load. This is the principle incorporated in most pavement design methods. It allows the engineer to design a "life" into a road pavement in much the same way that an engine of a motor car is designed for a certain life.

Mathematically this principle is shown thus $D \propto L^4$. With this principle I can show you how the life of a pavement is reduced by overloading.

Most road authorities base their pavement designs on the number of vehicles that will pass over the road during its designed life.

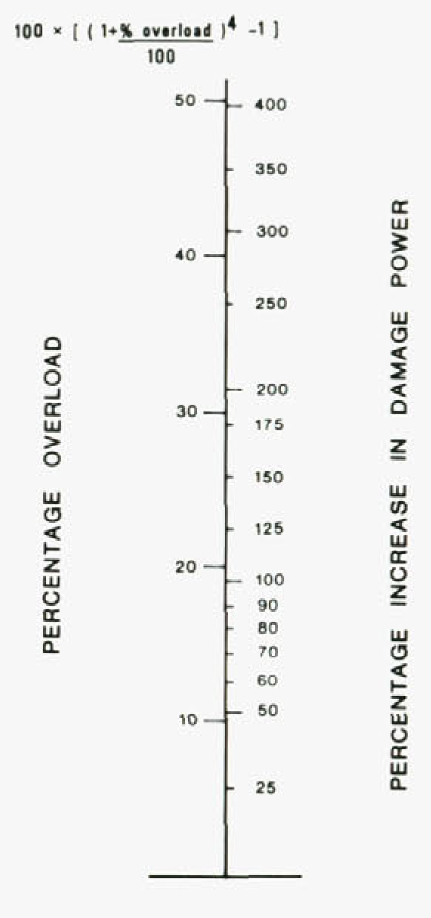
As different vehicles load the pavement in various ways all types of vehicles are brought down to a common denominator. The common denominator is called the *Standard Axle*. The Standard Axle is a single axle having dual wheels loaded to 8.2 tonnes. The passage of a single Standard Axle is rated as unity. Smaller and larger loads are rated as a fraction or as a multiple of the Standard Axle respectively. The rating system allows the designer to calculate the number of equivalent repetitions of the Standard Axle which will pass over the road in the designed life of the road. This rating system is directly related to the *damaging power* of various loads compared with the Standard Axle. For instance, the passage of a large car with an all up mass of 2 tonnes is considered to damage a pavement only 1/2250th as much as a Standard Axle whereas an axle loaded to 10 tonnes would damage the pavement 2.2 times that of the standard load. Using this rating system we can look at the effect of overloading and compare the damage caused by overloads with the damage caused by allowable loads. Some comparisons are as follows:

% overload	% increase in damage
10	45
20	105
30	185
40	285

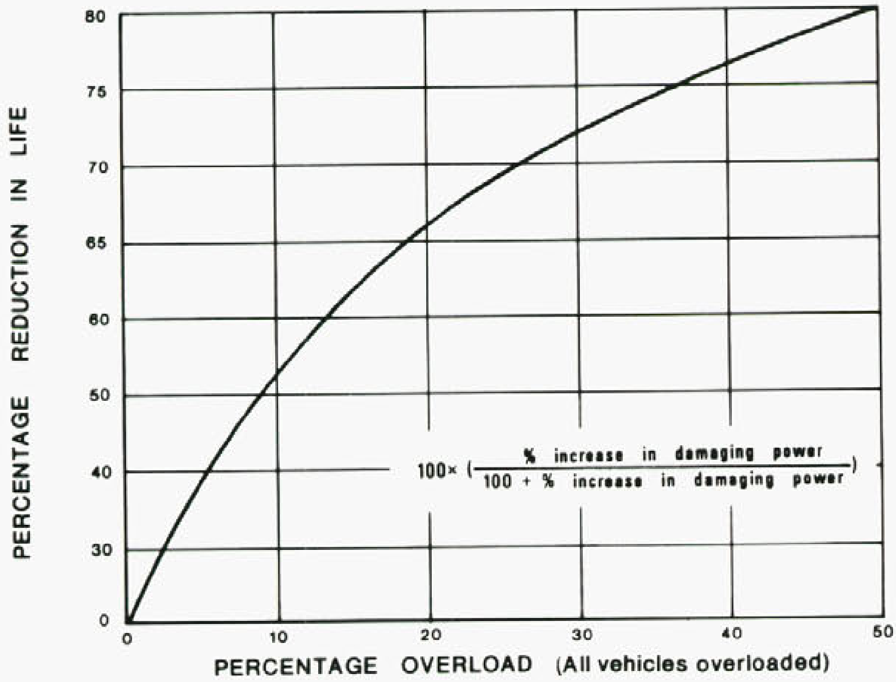
As you can see from the figures and the graphs, the overloaded vehicle places the road pavement in a somewhat analogous position to the motor car engine that is being overstressed by the heavy demands of car racing.

I want to mention that the deterioration of road pavements is not the only thing that worries the Department as far as overloading is concerned. Bridges receive their share of damage. You will of course appreciate that it would take a monumental overload to bring down a large bridge but, just the same, bridges suffer from the effects of repeated overloading the same way as pavements do. In the AASHO Road Test I have already mentioned, bridges of different types were built and subjected to repeated overloads. While there were no noticeable effects early in the testing programme, the ultimate result was the failure of the structures. The Department has records of many bridges which have been made unserviceable by the type of damage consistent with the effects of repeated overloading.

From a study carried out by the National



Damaging power of overloads.



REDUCTION IN PAVEMENT LIFE DUE TO OVERLOADS

Association of Australian State Road Authorities it was found that the extent of overloading was very significant. NAASRA, as the Association is known for short, found that one in every four laden tandems was overloaded above the effective limits. The effective limit is, of course, the allowable load plus a tolerance.

Furthermore, NAASRA found that the then current level of penalties was not high enough to act as any deterrent to overloading. Those operators who consistently overloaded simply regarded fines as part of their normal operating expenses.

I have analysed a sample of the Department's records on overloading prosecutions and I have found that the average overload involved in the sample was about 22%. Now, if this figure is applied to the NAASRA finding that 1 in 4 of all heavy vehicles was being overloaded, it can be shown from the damage factors mentioned before, that the Department's road pavements are having their effective lives reduced by about 25% by that minority of vehicle operators who overload.

During 1976/77 truck drivers in N.S.W. were fined a total of just over $1 million. This amounts to only about 1/220th of the Department's direct annual expenditure on roads and bridges of $234 million. This latter figure does not take into account other expenditure on roads not financed by the Department. There is in fact a very considerable expenditure by Local Government Councils which comes into this catergory.

Catering for the reduction in pavement life occasioned by the practice of overloading represents an enormous cost to everyone concerned. It means that the Department is involved in large maintenance expenditures which could otherwise be devoted to new construction. This, of course, is to the detriment of the road user in general but it also means that the operator who is prepared to abide by the rules is disadvantaged by those who do not. As the operator who overloads is in the minority, it means that a minority is gaining at the cost to the majority.

I would like to show you how critical the cost of overloading has become to the Department.

In 1975 the Commonwealth Bureau of Roads carried out a survey of the road needs of Australia and it was found that very large funds would need to be injected into the roads system if their deficiencies were to be overcome. The proposed allocations of funds covered all types of roads in all States and covered a five year period. In order to illustrate the position the Department is in with funds, I will relate the Bureau's findings to one category of road and to one year, that is the National Highways System, and the year 1976/77. The Bureau indicated that in that year, $116.6 million was warranted for National Highways in New South Wales. When the actual funds were allocated only $57.4 million was made available. This represents only 49.2% of the Bureau's figure.

The general public judges the Department of Main Roads on the quality of its road surfaces. I would like to emphasise that the Department is very conscious of the inadequacies of the road system and we recognise that it is our responsibility to provide as good a service as we can. The roads, nevertheless, are very sensitive to overloading, more so because of the inadequate funds that are available.

I hope that through this address I have managed to convey to you how vehicle overloading —

- damages road pavements,
- costs enormous sums to the Department and to the community, and
- reduces the level of service that the Department is able to provide. ●

REFERENCES

The AASHO Road Test by the Highway Research Board. Publication by the National Academy of Sciences 8 volumes 1961 and 1962.

A study of the Economics of Road Vehicle Limits. National Association of Australian State Road Authorities. August 1976.

Report on Roads in Australia — Commonwealth Bureau of Roads 1975.

. . .

Recent articles appearing in "Main Roads" on this subject include:

"New Road Vehicle Limits" — June 1978 (Vol. 43, No. 4, pp. 103-108).

"New Study of Road Transport Costs" — June 1975 (Vol. 40, No. 4, p. 127).

"Weight Watching — A Matter for Concern" — September 1972 (Vol. 38, No. 1, p. 8).

"Vehicle Load Limits on Australian Roads" — December 1971 (Vol. 37, No. 2, pp. 59-62).

Tenders Accepted by Councils

The following tenders (in excess of $20,000) for road and bridge works were accepted by Councils for the three months ended 30 June 1978.

Council	Road No.	Works or Service	Name of Successful Tenderer	Amount
Auburn	Main Road No. 190	Supply of 20 mm asphaltic concrete for reconstruction between Amy St. and Boundary with Bankstown Municipality.	Emoleum (Aust) Ltd	$34,300.00
Auburn	Main Road No. 190	Supply of 10 mm asphaltic concrete for reconstruction between Amy St. and Leila St.	Emoleum (Aust) Ltd	Up to $149,500.00
Auburn	Main Road No. 190	Supply of lime stabilised fine crushed rock for reconstruction between Amy St. and Leila St.	Pioneer (Aust) Pty Ltd	Up to $160,000.00
Boolooroo	Main Road No. 507	Reconstruction and bituminous surfacing between 5.2 and 10.2 km east of Boomi.	Shorncliffe Pty Ltd	$53,326.44
Boomi	Various	Bituminous surfacing at various locations.	Shorncliffe Pty Ltd	$31,281.69
Cessnock	Main Road No. 220	Construction of cast-in-place abutment piles for bridge over Bangalow Creek, 21.6 km south of Cessnock.	Civilbuild Pty Ltd	$27,499.00
Cessnock	Main Road No. 220	Construction of prestressed concrete girders for bridge over Bangalow Creek, 21.6 km south of Cessnock.	Hastings Pre-stressed Pty Ltd	$25,774.00
Coonabarabran	Trunk Road No. 55	Construction of 5 span prestressed concrete girder bridge at Bomera Creek, 49.7 km north of Coolah.	A. R. Dickinson Construction Company Pty Ltd	$269,101.65
Fairfield	Secondary Road No. 2088	Horsley Drive. Supply of 40 mm asphaltic concrete for reconstruction between Justin St. and Market St.	Bitupave Pty Ltd	$107,250.00
Hornsby	Main Road No. 332	Operation of Berowra Ferry for three years.	D. Cox	$57,451.00
Illabo	Trunk Road No. 78	Construction of T. C. Lord bridge over Houlaghans Creek at Wallacetown, 20.1 km north of Wagga Wagga.	Nelmac Pty Ltd	$194,399.60
Maitland	Main Road No. 101	Construction of twin cell 4.5 m × 4.0 m reinforced concrete box culvert over Mindaribba Creek, 9.1 km north of Maitland.	J. Parkinson	$65,269.00
Mumbulla	Main Road No. 272	Supply and driving of piles for new bridge over lagoon at Bermagui South.	N. J. McIntosh	$20,944.00
Yallaroi	State Highway No. 12	Supply and delivery of 2 348 m³ aggregate for bituminous surfacing works on Gwydir Highway.	Ron Johnstone Pty Ltd	$32,178.50
Yallaroi	State Highway No. 12	Bituminous surfacing and resurfacing works on Gwydir Highway.	Emoleum (Aust) Ltd	$91,226.87

Tenders Accepted by the Department of Main Roads

The following tenders (in excess of $20,000) for road and bridge works were accepted by the Department for the three months ended 30 June, 1978.

Road No.	Work or Service	Name of Successful Tenderer	Amount
F5—South Western Freeway	Shire of Wollondilly. Construction of twin bridges over Nepean River at Pheasants Nest.	White Industries Ltd	$4,599,650.00
State Highway No. 2	Hume Highway. Shire of Gundagai. Test boring at 12 sites from Tumblong to Snowy Mountains Highway approx. 13-27 km south of Gundagai.	Earthboring Services Pty Ltd	$47,750.00
State Highway No. 5	Great Western Highway. Cities of Blue Mountains and Greater Lithgow. Supply and delivery of 25 000 t of lime stabilised fine crushed rock to various locations.	Readymix Group (N.S.W.) Pty Ltd	$204,200.00
State Highway No. 5	Great Western Highway. Cities of Bathurst, Greater Lithgow, Blue Mountains and Shire of Evans. Supply of ready mixed concrete for kerb and gutters and various drainage structures at various locations.	Pioneer Concrete (N.S.W.) Pty Ltd	$34,080.40
State Highway No. 5	Great Western Highway. City of Blue Mountains. Supply of ready mixed concrete for kerb and gutters, and drainage structures at various locations.	J. & E. Thomas Pty Ltd	$24,750.00
State Highway No. 7	Mitchell Highway. Shire of Talbragar. Construction of two bridges over Sandy Creek at 6.6 and 6.8 km west of Dubbo.	Nelmac Pty Ltd	$135,565.00

Tenders Accepted by the Department of Main Roads

The following tenders (in excess of $20,000) for road and bridge works were accepted by the Department for the three months ended 30 June, 1978.

Road No.	Work or Service	Name of Successful Tenderer	Amount
State Highway No. 9	New England Highway. Shire of Denman. Supply and delivery of up to 8 000 m³ of lower base course gravel for strengthening and widening pavement west of Sandy Creek, 3.2-10.3 km north of Muswellbrook.	E.H. & P.H. Clifford	$31,600.00
State Highway No. 9	New England Highway. City of Maitland. Supply and delivery of up to 10 000 m³ of lower base course material for reconstruction between Verge St. and Anambah Road, Rutherford, 2.7-4.7 km west of Maitland.	K. & M. Haulage	$40,500.00
State Highway No. 9	New England Highway. City of Maitland. Supply and delivery of up to 10 000 m³ of selected sub-grade material for reconstruction between Verge St and Anambah Rd, Rutherford, 2.7-4.7 km west of Maitland.	Blue Metal and Gravel (North) Pty Ltd	$25,500.00
State Highway No. 9	New England Highway. City of Maitland. Supply and delivery of up to 10 000 m³ of upper base course material for reconstruction between Verge St and Anambah Rd, Rutherford, 2.7-4.7 km west of Maitland.	L.S. & W.R. Everett	$26,500.00
State Highway No. 9	New England Highway. City of Maitland. Supply and delivery of up to 7 000 m³ of base gravel from Dalwood Rd No. 1 Quarry to construction sites for strengthening and sealing of pavement through Lochinvar, 10.6-12.3 km west of Maitland.	D.J. & C.R. Barnes	$23,100.00
State Highway No. 9	New England Highway. City of Newcastle. Supply and lay up to 5 000 tonnes of 10 mm asphaltic concrete for pavement strenghtening and resheeting between Tarro Overbridge and Thornton Rd, 18.5-23.3 km north of Newcastle.	Bitupave Ltd	$169,500.00
State Highway No. 9	New England Highway. City of Newcastle. Supply and lay up to 1 450 t of 10 mm asphaltic concrete for pavement strengthening and resheeting, 4.7-6.9 km north of junction with Pacific Highway.	Bitupave Ltd	$48,212.00
State Highway No. 9	New England Highway. City of Newcastle. Supply and lay up to 1 450 t of 10 mm asphaltic concrete for pavement strengthening and resheeting between 5.2 and 6.9 km north of junction with Pacific Highway.	Bitupave Ltd	$48,212.00
State Highway No. 9	New England Highway. Shire of Singleton. Supply and lay up to 2 100 t of 10 mm dense graded asphaltic concrete for pavement resheeting between Mudies Creek and Kelso St, Singleton, 38.9-44.4 km north of Maitland.	Boral Road Services Pty Ltd	$76,440.00
State Highway No. 9	New England Highway. Shire of Uralla. Supply and delivery of 1 000 m³ of 10 mm and 400 m³ of 10 mm bituminous sealing aggregate for Uralla — Barleyfields Deviation.	Guyra Shire Council	$24,360.00
State Highway No. 9	New England Highway. Shire of Uralla. Supply and delivery of up to 450 m³ of ready mixed concrete for new structure over Brigstocks Brook, 2.6 km north of Uralla.	G.T. Cochrane and Co. Pty Ltd, Armidale	$21,600.00
State Highway No. 9	New England Highway. Supply and application of thermoplastic road marking materials at various locations within North Western Division.	Shorncliffe Pty Ltd	$73,708.15
State Highway No. 10	Pacific Highway. Municipality of Ku-ring-gai. Jacking of box units for pedestrian subway at Pymble.	Pipeline Boring Pty Ltd	$109,187.42
State Highway No. 10	Pacific Highway. Shire of Lake Macquarie. Supply and lay up to 930 t of 40 mm asphaltic concrete for reconstruction south of Violet Town Rd, North Belmont.	Bitupave Ltd	$28,458.00
State Highway No. 10	Pacific Highway. Shire of Lake Macquarie. Supply and lay up to 710 t of 10 mm and 20 mm asphaltic concrete for reconstruction south of Violet Town Rd, North Belmont.	Boral Road Resources Pty Ltd	$24,133.00
State Highway No. 10	Pacific Highway. Shire of Great Lakes. Supply and lay up to 5 500 t of 10 mm asphaltic concrete for pavement strengthening at O'Sullivans Gap, between 106.4 and 110.7 km north of Newcastle.	Boral Road Services Pty Ltd	$200,200.00
Main Road No. 111	Shires of Manning and Great Lakes. Strengthening of piers Nos. 30, 31, 32 and 33 on bridge over Wollomba River between Tuncurry and Forster.	McConnell Dowell Constructions Ltd	Rates as scheduled in tender
Main Road No. 172	Municipality of Woollahra. Bondi Junction By-Pass. Manufacture and delivery of a precast post-tensioned concrete girder for pedestrian bridge over By-Pass at Nelson Street.	Pearson Bridge (N.S.W.)	$31,078.00
Main Road No. 172	Municipality of Woollahra. Bondi Junction By-Pass. Manufacture, delivery and placing of 92 girders for four spans of viaduct.	E.P.M. Concrete Pty Ltd	$370,318.00
Main Road No. 504	Shire of Gosford. Avoca Drive. Reconstruction and widening from Main Road No. 336 to Kincumber.	Bitupave Pty Ltd	$58,140.00
Alpine Way.	Shire of Snowy River. Haulage of pavement material to various locations.	W.H. Knowles	$55,000.00
Various	Remarking of transverse lines with thermoplastic road marking material at traffic signal sites in the Ryde, Parramatta, Baulkham Hills and Hornsby areas.	Mercury Linemarking	$31,944.00
Various	Supply and application of sprayable thermoplastic road marking material on selected roads within the Parramatta, Strathfield, Blacktown and Penrith areas.	Linemarking Services	$39,190.00

Aerial view, from above Thompsons Corner Shopping Centre at West Pennant Hills showing the junction of Castle Hill Road and Pennant Hills Road (State Highway No. 13). The introduction of traffic signals, channelisation and pavement marking has greatly improved traffic conditions at this location (see article on reliability of traffic signals commencing on page 22).


DEPARTMENT OF MAIN ROA


GOOD ROADS COST YOU LESS
THAN BAD ROADS
SOUTH WALES