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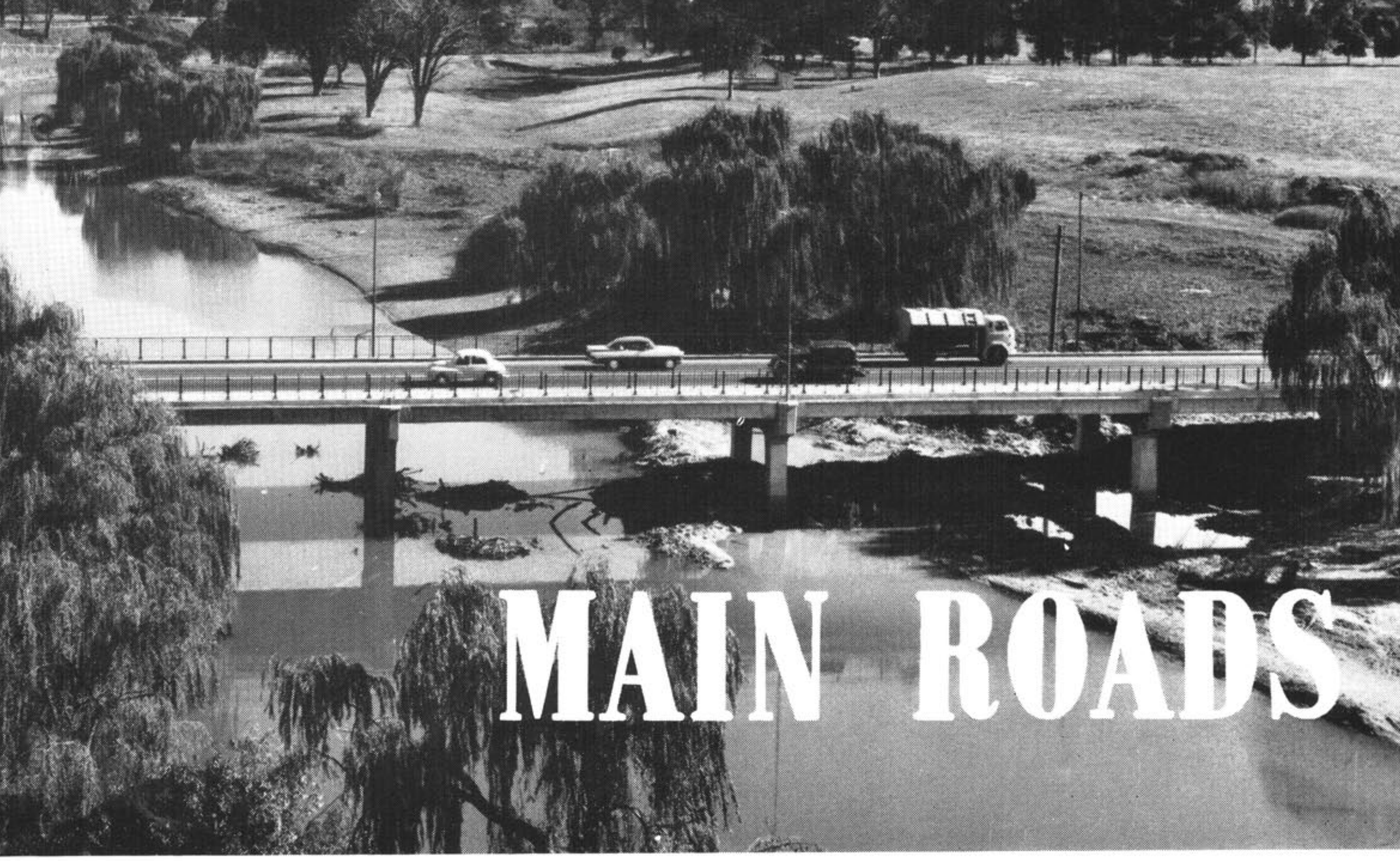
JOURNAL OF THE DEPARTMENT OF MAIN ROADS · NEW SOUTH WALES

JUNE, 1963

MAIN ROADS



JUNE, 1963 Volume 28 Number 4

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COVER SHEET

Obelisk at Mount York erected " by public subscription " in 1900 " In commemoration of the first crossing of the Blue Mountains in 1813 A.D. by Blaxland, Lawson and Wentworth ".

MAIN ROADS

JOURNAL OF THE
DEPARTMENT OF MAIN ROADS
NEW SOUTH WALES

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NEXT ISSUE
SEPTEMBER 1963

0346—1

Bridge Over Clarence River at Harwood on the Pacific Highway

The Department of Main Roads has accepted tenders for the construction of a steel and concrete bridge over the Clarence River at Harwood on the Pacific Highway near Maclean.

The work will be undertaken in two separate contracts; one for the manufacture of the steelwork and lift span machinery and the other for the construction of the piers, abutments and deck, and assembly of the superstructure.

The successful tenderer for the manufacture of the steelwork etc., is Arcos Industries Pty. Ltd., of Sydney in an amount of £359,662 6s. 9d. Reed and Mallik Ltd. of Salisbury, England, are the successful tenderers for the construction of the piers, etc., and the assembly of the falsework in an amount of £735,530 12s. 10d. Reed and Mallik Ltd., in partnership with the Sydney firm of Stuart Bros. Pty. Ltd., are at present constructing the new bridge over the Parramatta River at Gladesville.

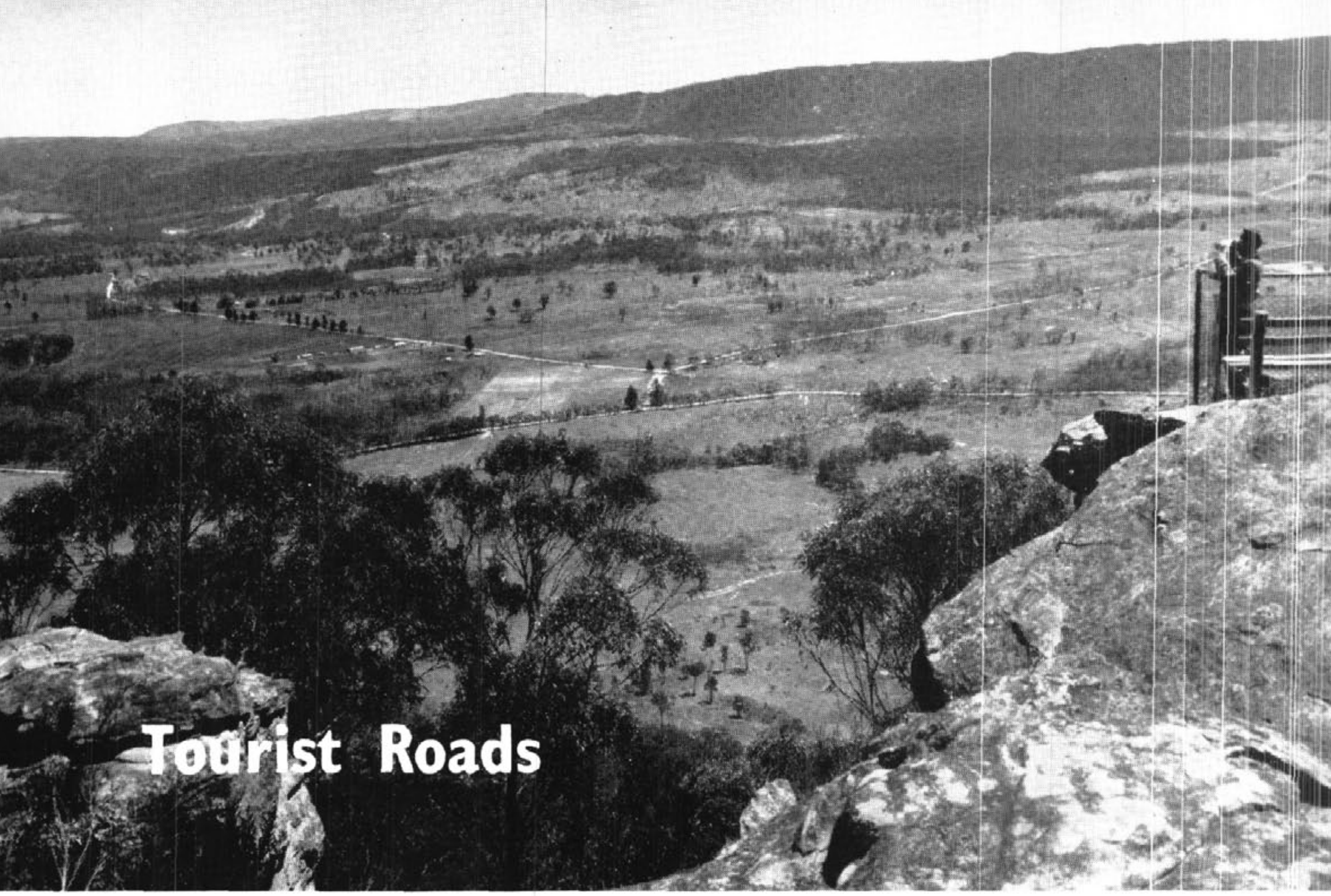
The contract time for the manufacture of the steelwork, etc., is 78 weeks and for the completion of the bridge 130 weeks.

The bridge designed by the Department of Main Roads, will be 2,915 feet long and will be the third longest road bridge in New South Wales. The two bridges of greater length are Sydney Harbour Bridge (3,770 feet) and the bridge over the Murrumbidgee River at Gundagai (3,025 feet).

The carriageway on the bridge will be 28 feet wide and there will be a footway on the upstream side.

A vertical lift opening span of 100 feet will be provided to allow shipping to pass through the bridge.

Completion of the Harwood Bridge and the bridge now being built over the Richmond River at Wardell will eliminate the last two ferries on the route of the Highway between Sydney and Brisbane and on the State Highway System of New South Wales.



View from the look-out at Mount York

MOUNT YORK ROAD

THE Main Roads Act was amended in December, 1960 to make provision for the proclamation of roads as Tourist Roads and to provide for the granting of assistance to Councils (and in the case of National Reserves to the Trustees of such Reserves) towards the maintenance and construction of these roads. The assistance given by the Department to Councils is usually half the cost.

A number of applications has been received from Councils for the proclamation of roads as Tourist Roads and 21 roads totalling about 70 miles in length have already been proclaimed or recommended by the Commissioner to the Governor of New South Wales for proclamation.

It is proposed to publish in " Main Roads " from time to time, an article dealing with one of the Tourist Roads. This is the first of these articles and it deals with Mount York Road, which was proclaimed as Tourist Road No. 4004 on the 3rd November, 1961.

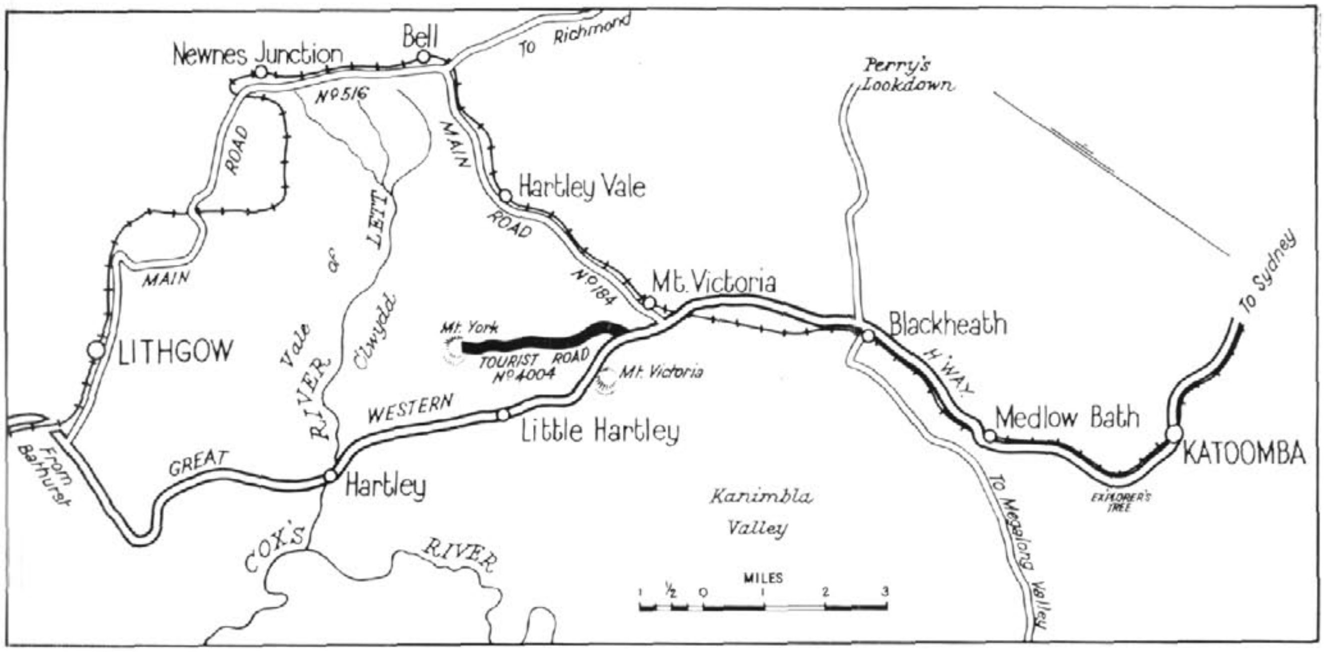
It might be mentioned that the Department's contribution towards works on Tourist Roads is provided from its normal funds, i.e. there is no special fund or additional source of revenue for works on these roads, and it has become apparent that the proposals of Councils for proclamation of roads as Tourist Roads are of such an order that the Department would not be able, over any reasonably short period to match the funds which Councils apparently have for expenditure on this class of road.

For this reason, the Department is at this stage restricting its recommendations for proclamation to those roads which provide access to important tourist areas or to isolated natural features of special tourist interest where access does not at present exist or is inadequate.

MOUNT YORK ROAD

Mount York Road commences from the Great Western Highway near Mount Victoria and runs generally north-westerly for approximately three miles to Mount York. It is situated within the City of Blue Mountains.

The mountain attracts many tourists owing to the outstanding views which may be obtained from its



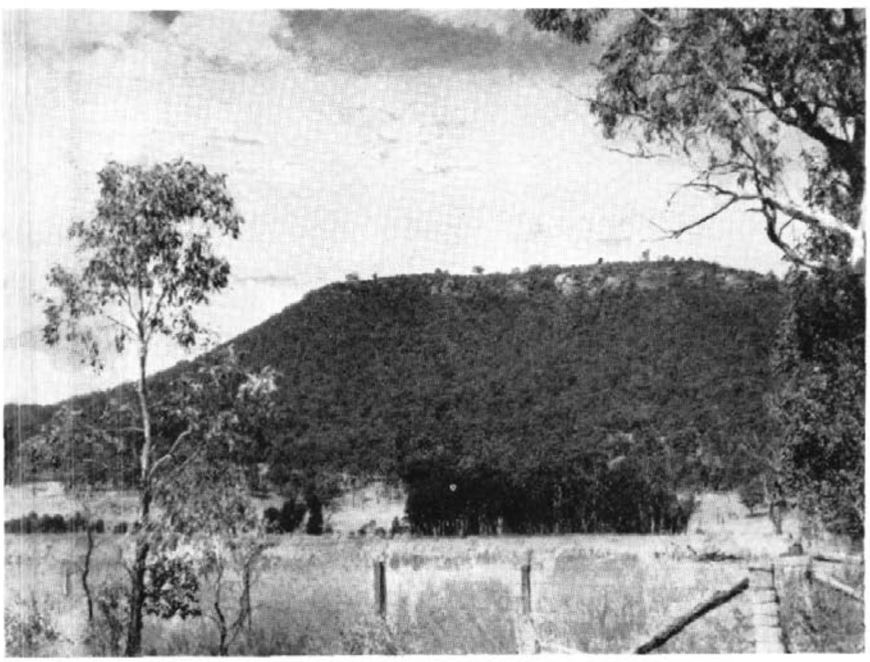
Locality sketch

summit, which overlooks Hartley and the Lett River Valley.

Mount York is rich in early Australian history. Its views were first experienced by white men on the 28th May, 1813, when Blaxland, Lawson and Wentworth reached the summit during their historic first crossing of the Blue Mountains. It was from here that they discovered that the land below, which had previously been considered as sandy and barren, was actually forest land covered with trees and good grass.

The three explorers were followed some six months later by George Evans, who was sent by Governor Macquarie to survey the route. Evans reached Mount York on the 24th November, 1813, his journal on that date stating that he "came to the end of the Range from which the Prospect is extensive and gives me sanguine hopes, the descent is rugged and steep . . . . . . we got into a valley of good feed and appears a fine part of the Country; I have no doubt but the points of Ridges or Bluffs to the N.W. and S. (the Country seems to be open in the form of this Angle) are the termination of what is called the Blue Mountains and that we are now over them . . . . ."

Construction of a road across the mountains was commenced by William Cox on the 18th July, 1814, and by the beginning of November that year the road had been extended to Mount York. Upon inspecting the descent of the mountain on the 3rd November, Cox



Mount York from the valley below

Monument to " The Pioneer Road Builders "—erected on Mount York Road by the Blue Mountains Historical Society, 1959

***The commencement of Cox's Road down Mount York.* The tablet on the rock at the left reads " These pick marks were made to allow Governor Macquarie's vehicle to pass over the Blue Mountains—*1815* "**

was appalled at the sheer drop of the cliffs and wrote " I have therefore made up my mind to make such a road as a cart can come down empty or with a very light load without a possibility of its being able to return with any sort of a load whatever, and such a road will also answer to drive stock down to the forest grounds. It is a very great drawback to the new country, as no produce can be brought from thence to head-quarters except fat bullocks or sheep. The sheep will also be able to bring their fleeces up and be shorn on the mountains ". Cox faced his tremendous task with characteristic resolve and ordered his men to " put up the forge for the blacksmith to repair all tools for the Herculean mountain. Issued to all hands a gill of spirits ". The road, when constructed, had in parts, a grade of 1 in 4.

Cox's road was first travelled by Governor Macquarie in 1815. Macquarie's journal entry of 29th April, 1815, records his impressions upon reaching Mount York. Macquarie wrote that he reached " the termination of the Blue Mountains ending in a very abrupt descent almost perpendicular. Here we halted for a little while to view this frightful tremendous Pass, as well as to feast our eyes with the grand and pleasing prospect of the fine low country below us . . . . . . this mountain being one of the most prominent and remarkable of the whole Range, I have named it ' Mount York ' . . . . " The " frightful tremendous Pass " he named Cox's Pass, and to the " beautiful extensive vale of Five Miles " beyond its foot he gave the name " The Vale of Clwydd " after a vale in Wales. The vale terminated at a river which Macquarie named Cox's River in honour of William Cox.

The descent of Mount York by early travellers was a rather terrifying experience. Logs were tied behind carts to steady them down the steep grade. At the bottom of the grade the logs were unhitched and left strewn over the road. These accumulations became so

The road—now Tourist Road No. 4004—leading to Mount York

bad at times that parties of convicts were sent to clear them. To bring a loaded cart up the pass was a laborious process. Heavy staples were fastened into the rocks at the steepest points with iron rings attached, which acted as anchors. With the aid of pulleys and ropes, bullocks driven down the hill could assist laden vehicles up the worst pinches.

Cox's descent of Mount York was later abandoned in favour of a route, the discovery of which is credited to Lieutenant Lawson, who had accompanied Blaxland and Wentworth on the first exploration. The date of construction is uncertain, but the route was in use in 1827 and carried traffic to the west until 1832. The road fell steeply to the valley, the grade being no better than Cox's line. It had the advantage, however, of getting stock to water and grass in the valley quickly.

Subsequent routes across the Blue Mountains were selected so as to avoid the steep descent of Mount York. However, the two earlier routes, although not trafficable by vehicles, can still be traversed on foot today.

As the result of the proclamation of Mount York Road as Tourist Road No. 4004, the Department of Main Roads will assist the Council of the City of Blue Mountains financially in maintaining the road to a standard which will encourage tourists to enjoy the "grand and pleasing prospect" and to remember the historic associations of the spot.

MAIN ROADS FUNDS

Receipts and Payments for the period from 1st July, 1962 to 31st March, 1963

General Purposes

Heading	County of Cumberland Main Roads Fund	Country Main Road Fund
	£	£
RECEIPTS—		
Motor Vehicle Taxation (State)	1,493,025	5,972,094
Charge on heavy commercial goods vehicles under Road Maintenance (Contribution) Act, 1958 (State)	597,455	2,389,819
Commonwealth Aid Roads Act, 1959	1,326,047	5,103,187
Commonwealth Aid Roads Act, 1959 for expenditure on Rural Roads	13,000	18,600
From Councils under Section 11 of Main Roads Act and for cost of works	1,076,888	7,471
Other	369,637	105,797
Total Receipts £	4,876,052	13,596,968
PAYMENTS—		
Maintenance and minor improvement of roads and bridges	669,034	4,541,279
Construction and reconstruction of roads and bridges	2,148,728	6,180,453
Land acquisition	696,371	147,368
Administrative expenses	256,723	653,403
Loan charges—		
Payment of interest, exchange, management and flotation expenses	35,910	218,210
*Miscellaneous	991,122	1,086,692
Total Payments £	4,797,888	12,827,405

* Includes transfers to Special Purposes Accounts in respect of finance for Operating Accounts, Suspense Accounts and Reserve Accounts.

ECONOMICS

Of Road Improvement

PLANNING the improvement of a section of road often entails consideration of the merits of a number of possible alternative proposals.

Cost of construction is generally the prime consideration in determining which of several alternatives is to be adopted. Selection of an alternative involving higher costs may be justified, however, if it results in considerably reduced costs to the road-user.

In this article, road-user costs are defined and a method of making a quantitative assessment of them is described. A second article, to be published in a later number of "Main Roads", will review methods of economic analysis and will describe how calculated benefits to road users, in addition to construction costs, may be taken into account in assessing the relative economic merits of alternative road improvement proposals.

ROAD-USER COSTS

The term "road-user" includes anyone who owns, operates, or uses any road vehicle, or who uses the road in any other capacity, *e.g.*, as a pedestrian. Due to the predominance of motor vehicles in the road transportation system, the term is applied particularly to owners, operators and users of motor vehicles and those pedestrians who may be involved in motor vehicle operation, *e.g.*, as victims of road accidents, or as a contributing factor in traffic congestion.

Except for the cost of road building and maintenance, all the direct costs of road transportation can be considered as "road-user costs". The term "cost" as used here covers not only the price paid for an article or a service but also any expenditure of time or labour by the road-user to his loss or detriment.

Elements of Road-user Cost

The many elements of road-user cost and the factors which affect those cost elements are too numerous to be discussed in full detail in a short article. Literature dealing with the subject is extensive. In New South Wales a report on the subject of Economics of Road Improvement was recently prepared by an officer of the Department of Main Roads, New South Wales, following a study at the School of Traffic Engineering, University of New South Wales.*

Main elements of road-user costs which will be discussed in this article can be grouped as follows:—

(*a*) Running cost of vehicles,

(*b*) Vehicle ownership cost,

(*c*) Time cost of freight and passengers,

(*d*) Cost of road accidents,

(*e*) Other road-user costs.

In this article these elements are considered, primarily, as they apply to "rural" road conditions.

Classification of Motor Vehicles

The cost of operating motor vehicles differs according to type, age, annual mileage, load carried and driver's experience. Since it is not practicable to take into consideration a great variety of vehicles the whole traffic is regarded as composed of a few typical vehicle classes for which the average operating costs are assessed.

Though passenger cars vary greatly in respect of their operating cost, it is common practice to treat them as units of one class represented by a typical, or a "representative", car.

Motor trucks can be subdivided into a few classes according to their weight, load-carrying capacity, and weight-power ratios. A subdivision into light, medium and heavy trucks has been used in many studies and operating costs for a typical vehicle in each class have been computed.

Buses, taxis and motor cycles are often dealt with separately in economic studies, or they are included in the nearest class (motor-cycles sometimes omitted), depending on the percentage of these vehicles in the traffic stream under consideration.

In this article, road-user costs are discussed in respect of two broad classes of vehicles only: cars and trucks.

The "cars" class includes all private and commercial cars, as well as other vehicles with similar characteristics, such as station wagons, taxis, utilities and light trucks (not more than four wheels).

The "truck" class is applied to all vehicles with two axles and dual tyres (medium trucks, buses), all

* *A report titled "Economics of Road Improvements" by E. Pelensky has been published by the Department of Main Roads, New South Wales, for limited distribution. A list of references is appended to the report.*

heavy trucks (more than two axles), and articulated vehicles (trucks with trailers and semi-trailer combinations).

It must be appreciated that even for rural traffic, the percentage of heavy and articulated vehicles varies from road to road and for any individual study this affects the average operating cost of trucks, taken as a single class. However, their running costs generally, and fuel costs in particular, are directly related to the gross weight. For this reason computations of road user cost not only take into consideration the volumes of traffic in two separate categories, *i.e.*, cars and trucks, but also the average GW (gross weight) of trucks.

Running Cost of Vehicles

Running cost *Cr* of vehicles of any class in any traffic stream and for any length of road is the product of the unit running cost, *i.e.*, cost for one vehicle per mile (U), the distance in miles (L), and the number of vehicles (N)

$$Cr = N \times L \times U$$

Unit running cost (U), apart from being different for each class of vehicles, is influenced by many other factors; the most significant being: average speed of vehicles and speed distribution, road type, arrangement of traffic lanes and their width, pavement surface and condition (dry, wet), gradient (longitudinal profile), horizontal alignment (curvature and super-elevation), available sight distance, traffic conditions (volume, types of vehicles) and human factors evidenced by drivers' behaviour.

The main elements of running cost are: cost of fuel and oil, tyre wear, cost of vehicle maintenance and repair, and that part of vehicle depreciation which is due to wear and tear and is proportional to the mileage run.

(*a*) *Basic Running Cost*

A conclusion of the recent New South Wales report was that an adequately accurate estimate of running cost can be obtained by adopting basic running costs for the two broad classes of vehicles, these basic costs being then adjusted to take account of different road and traffic conditions. The required adjustment can be made by multiplying the basic costs by several "adjusting factors". To simplify calculation of the effect of adjusting factors, use can be made of a composite adjusting factor which will be approximately equal to the product of all factors computed in respect of various aspects of road and traffic.

The basic cost should be related to the conditions under which running cost is at a minimum. This can be assumed to be the case with a near straight, near level, multilane divided highway with controlled access, good pavement and a small volume of traffic. In consequence, no adjusting factor will be less than unity.

For present Australian conditions, the basic running costs may be taken as:

Cars—5 pence per mile.

Trucks—$(4 + 2t)$ pence per mile, where "t" is the gross weight in tons.

(*b*) *Adjusting Factors for Running Cost*

Of the many factors influencing the running cost, speed of the vehicle affects the cost most markedly. Speed distribution has been the subject of many studies and its general pattern for rural traffic is well known. There are enough data available to enable an assessment to be made of what may be termed "the annual running speed", *i.e.*, the speed at which the running cost is equal to the average running cost computed from the costs for all vehicles passing over a specified length of road at various speeds over a whole year.

Studies of operating speeds have also shown that when drivers are free to choose their own speed, the average speed of a particular vehicle class is mainly affected by road design characteristics and by traffic volumes. In computing the adjusting factors for various road and traffic conditions, due allowance is made for the effect of variations in the operating speed.

Some less significant factors have been ignored in the simplified method for determination of running cost per vehicle mile.

The factors taken into account are:

(*i*) Pavement factor—(*Fp*)

An approximate relationship has been assessed between running cost and the type of road, number of lanes, and pavement surface (with allowance for prevailing weather conditions). The relative increase in running cost on a lower type of pavement is greater for trucks than for cars.

As a result of an investigation carried out by the Department and on the basis of information published by Research Organisations of the United States of America, the following values may be used for a few typical road types and pavement surfaces:

Pavement factor *Fp*	Cars	Trucks
Divided highways—good pavement	1·00	1·00
Two-lane roads—good concrete or good bitumen	1·02	1·05
Two-lane roads—poor bitumen pavement	1·05	1·10
Gravelled roads	1·20	1·30

(*ii*) Gradient factor (*Fg*)

Considerable information is available concerning the effect of grades on the running cost of vehicles. As shown by an extensive study on fuel consumption in the United States of America* and by fuel consumption tests carried out in New South Wales, the rate of fuel consumption can be related to the rate of rise and fall, called here "the gradient".

$$\text{Gradient (in \%)} = \frac{100 \times \text{arithmetic sum of rises \& falls (in ft.)}}{\text{length of section (in ft.)}}$$

Accordingly the total running cost can be related to the gradient "g". An approximate gradient factor,

* *Time and Gasoline Consumption in Motor Truck Operation, Highway Research Board, Research Report No. 9A, Washington,* 1950.

different for cars and for trucks, can be computed from the formulae

Cars $Fg = 1 + g^2/400$ (gin %)
Trucks $Fg = 1 + g^2/200$

It is not convenient to consider a large number of short sections; sections should be as long as practicable, but lengths with markedly different topography must be considered separately.

(*iii*) Curvature factor (*Fc*)

Tests conducted by the Iowa Engineering Experiment Station have shown that additional friction is developed requiring additional tractive effort when a vehicle travels around a horizontal curve. The resulting increase in running costs has been empirically related to the additional friction, and can be calculated as a function of speed, radius and super-elevation. For curves conforming to the standards of radius and super-elevation of the Department of Main Roads and for speeds within the ranges of speed observed on New South Wales roads during a study conducted by the Department in 1956, the approximate percentage increase in running cost can be taken as the horizontal deflection (in degrees per mile) divided by 75.

Thus the curvature factor is

$Fc = 1 + D/7500$, when D is the horizontal deflection (change in road direction) in degrees per mile.

(*iv*) Traffic factor (*Ft*)

The traffic factor should take account of any increase in the running cost due to interference from other traffic. The running cost will increase when the volume of traffic exceeds the practical capacity of the road. The practical capacity is affected by many factors, such as width of pavement and shoulders, steepness and length of grades, sight distance, operating speed, and nature of traffic, especially the proportion of slow moving vehicles. However, it is possible to make an estimate of practical capacity from knowledge of the salient road features and traffic volumes, by adapting overseas data to typical local conditions.

For rural roads in New South Wales the effect of traffic volumes on running cost may be ignored unless the average daily volume of traffic computed on an annual basis (AADT) exceeds seven times the practical capacity " P " (in vehicles per hour). Above this level of congestion the running cost will increase at a rate of approximately one per cent for each increase in the AADT of an additional amount equal to the practical capacity " P " until a level of AADT is reached, which is 15 times the practical capacity. In other words when the AADT amounts to $(7 + x)$P, and x is within the range 1 to 8, running cost is expected to be " x " per cent in excess of the cost at AADT equal to or less than 7P.

Thus the traffic factor for a rural road is

$Ft = 0{\cdot}93 + 0{\cdot}01$ AADT/P

for a range of AADT between 7P and 15P. For an AADT equal to or less than 7P the factor $Ft = 1$. If the AADT is more than about 15P there is no simple relationship between running cost and traffic volume.

Vehicle Ownership Cost

The cost of vehicle ownership is often referred to as time cost of vehicles, standing cost, fixed cost, or time-element cost. The cost is independent of the mileage run; it is borne by the vehicle owner on a time basis, and for convenience it is usually computed on an annual basis.

Cost elements taken into consideration are:

(i) depreciation of vehicles due to age,
(ii) comprehensive and third party insurance,
(iii) vehicle registration fees and other taxes,
(iv) licence or permit fees,
(v) cost of garaging,
(vi) interest on capital,

and in addition for trucks,

(vii) wages of drivers,
(viii) overhead costs.

For an average passenger car in New South Wales this ownership cost amounts to approximately £230 per annum, for medium/heavy trucks it varies between £1,000 and £2,000.

In order to determine the proportion of annual vehicle ownership cost which should be charged against any particular use of a vehicle such as the time spent on driving along a mile of road, or waiting for a truck being loaded or unloaded, or the time lost through delays in congested traffic, the average usage of vehicles in hours per annum has been estimated. Though, due to the lack of research data, this estimation can only be regarded as approximate, the effect of possible errors on the total road-user cost is not significant. Average vehicle usage has been assessed as approximately 450 hours per annum for cars and between 1,000 and 1,600 hours per annum for medium/heavy trucks. Consequently the approximate vehicle time cost per hour is 10s. for cars and, conservatively, 20s. for trucks (including drivers' wages).

To arrive at vehicle ownership cost per mile the vehicle time cost per hour is divided by the respective vehicle speed in m.p.h.

Time Cost of Freight and Passengers

Goods in truck operation and passengers in car or bus operation, both become " freight " in relation to motor vehicles as means of transportation. The longer the " freight " is in transit the greater are the losses and the higher is the road-user cost.

The cost of goods in transit may include the cost of capital tied up while the goods are in transit, the cost of storage, spoilage, damage, theft, etc. However, this cost is negligible in comparison with other costs (approx. a half-penny per mile for a heavy truck) and can be ignored.

The value of passengers' time depends on so many factors that, as yet, no one has succeeded in finding an entirely satisfactory method for its assessment. The adopted value has a considerable effect on the savings which may be expected from many road improvements which result in the shortening of travel time. In order to avoid an over-statement of savings, some road authorities prefer not to allot any monetary value to passengers' time on leisure trips. Until more objective data is available from research, it has been concluded that time saved by car occupants travelling on business should be valued at the average rate of their earnings. For the present, and for rural traffic, £20 per 40-hour week has been assumed as the average earning of persons travelling on business. Hence, car occupants' time (on business) has been valued at 10s. per person per hour.

Cost of Road Accidents

The cost of road accidents can be considered as composed of three main elements:

(i) material damage to vehicles and property,

(ii) loss through the disability of the injured accident victims, including medical and legal costs,

(iii) loss of production due to the loss of human life.

Apart from these losses, suffering caused to the victims themselves and to their relatives might also be taken as a cost; usually it is listed among "intangible" items, *i.e.*, those to which monetary values cannot be allotted.

The cost of accidents can be assessed but there is no simple means of doing so, and the effect of their omission from the calculation of road-user cost is not always significant. However, the cost of accidents is accounted for, at least partially, in the ownership cost of vehicles, where insurance premiums (third party and comprehensive) have been included.

Other Road-user Costs

There are other elements of road-user cost which are not readily assessable in monetary terms. Two of these elements which warrant consideration are:—

(*a*) The value of non-working time of car passengers. Some authorities allot an arbitrary value to this time. Alternatively, the saving of time by road-users can be quoted as an additional reason for adopting a particular proposal without attempting to assess its value in monetary terms.

(*b*) The cost of physical discomfort and mental irritation evidenced while travelling in congested traffic or on a poor road. Some authorities again adopt an arbitrary value for this comfort and convenience factor. However, in the majority of cases road improvements shorten travelling time and hence contribute to the mental and physical comfort of passengers. The comfort factor can therefore be accounted for in any assessment of the value of passenger time saved.

Total Road-user Cost

The main groups and elements of road-user cost discussed above can be summarised to give the total user cost in respect of the total traffic along a particular length of road.

Opinions vary as to whether the "intangible" factors should or should not be included when the road-user cost is used as an economic factor in conjunction with such "tangible" costs as construction cost or maintenance cost. Two alternatives are:

(i) to allot an arbitrary value to all intangible factors (on the basis that ignoring them means to admit that the best estimate available is zero)

(ii) to limit the concept of road-user cost to strictly economic factors which are expressed in commensurable units, *i.e.*, in money terms.

The latter alternative has been adopted in the method of determining road-user costs briefly outlined in this article. It is considered, however, that at least some "intangible" factors can be important when assessing the merits of road improvement proposals.

Accordingly, it is advisable to consider the effect of such "intangibles", whenever possible, as additional information, apart from the sum of costs expressed in money terms. Thus, for example, saving in non-working time can be indicated in thousands of hours. Also accidents can be listed in numbers per annum where reliable information is available.

EXAMPLE OF ROAD-USER COST CALCULATION

Assumed road conditions which may be characteristic of a section of road before and after an improvement involving deviation and shortening of the distance:

Item	Existing Condition	Improved Condition
Length of section—miles	4·60	3·16
Width of bit. pavement—feet—p	18	22
Condition of pavement	fair	good
Average gradient—%—g	3·12	3·04
Horizontal deflection—degrees—D	107	78
Practical capacity—veh./hour	550	750
AADT—		
Cars	3,550	3,550
Trucks	900	900
GW of trucks—tons	10	10
Persons on business (per average car)	0·8	0·8
Persons in non-working time (per av. car)	1·2	1·2
Average speed (m.p.h.)—		
Cars	34	46
Trucks	28	34

Comparison of road-user costs before and after improvement:

Item	Existing Condition		Improved Condition	
	Cars	Trucks	Cars	Trucks
Basic unit cost—pence/mile	5·0	24·0	5·0	24·0
Adjusting factors—				
Pavement—*Fp*	1·035	1·075	1·020	1·050
Gradient—*Fg*	1·024	1·049	1·023	1·046
Curvature—*Fc*	1·014	1·014	1·010	1·010
Traffic—*Ft*	1·011	1·011	1·000	1·000
Combined—*F*	1·086	1·156	1·054	1·109
Adjusted unit running cost—pence	5·43	27·74	5·27	26·62
Annual vehicle-miles ('000)	5,960	1,511	4,095	1,038
Annual vehicle-hours ('000)	175·3	54·0	89·0	30·5
Vehicle running cost—£'000	134·8	174·6	89·9	115·1
Vehicle time cost—£'000	87·7	54·0	44·5	30·5
Time value — passengers on business £'000	70·1	..	35·6	..
Total road-user cost—£'000	521·2		317·6	
Passengers' non-working time —hours '000	210·4		106·8	
Annual savings resulting from improvement—				
Road-user cost	..		£203,600	
Passengers' non-working time	..		103,600 hrs.	

NEW GLADESVILLE BRIDGE

An aerial photograph of the new six-lane bridge under construction over the Parramatta River at Gladesville. The photograph shows that the third rib of the concrete arch span has been completed and a commencement has been made with the assembly of the fourth and final rib. The erection of the fourth rib has since been completed. On the left of the photograph is the existing two-lane opening-span bridge built in 1881

The Hon. P. D. Hills, M.L.A., Minister for Local Government and Minister for Highways, speaking at the ceremony to mark the official opening of the Institute

UNIVERSITY OF
NEW SOUTH WALES

INSTITUTE OF HIGHWAY AND TRAFFIC RESEARCH

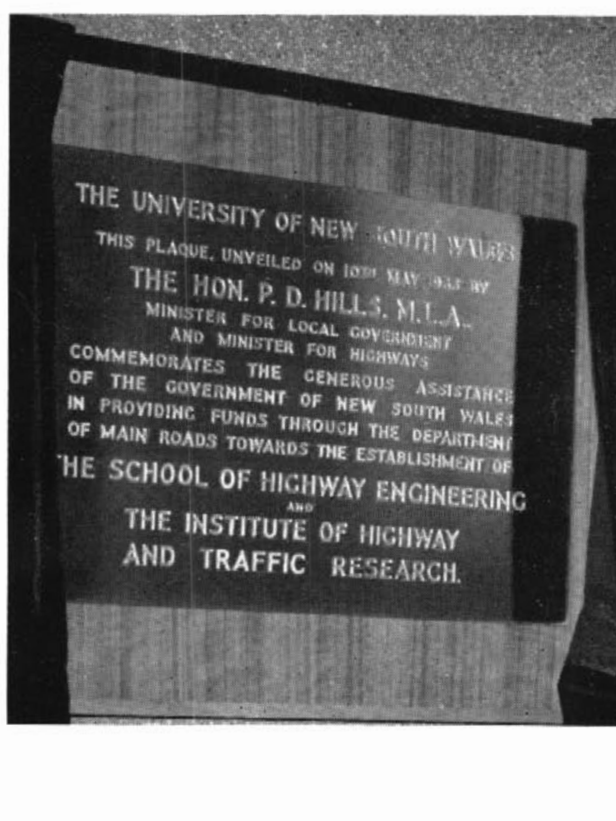
OFFICIAL OPENING

THE Institute of Highway and Traffic Research at the University of New South Wales was opened officially by the Minister for Local Government and Minister for Highways, the Hon. P. D. Hills, M.L.A., on Friday, 10th May, 1963.

The establishment of the Institute at the University of New South Wales resulted from negotiations between the Department of Main Roads and the authorities of the University for the provision of facilities for road research associated with the Chairs of Highway Engineering and Traffic Engineering already set up at the University.

Research, both in the laboratory and in the field, has always been a feature of the work of the Department of Main Roads, but this research has been confined mainly

The plaque unveiled by the Hon. P. D. Hills, M.L.A., at the opening ceremony



An interior view of the Workshop at the Institute of Highway and Traffic Research

to day-to-day problems. There are, however, many important technical problems in the highway and traffic engineering fields which await solution and the Department of Main Roads considered that these problems could best be handled at a suitably-equipped university where there is a wide range of specialised scientific knowledge and skills.

This is a course which has been followed successfully in the United States of America where road authorities were faced with a situation in regard to research similar to that in Australia.

When the Department approached the University of New South Wales, it was found that the University lacked equipment and buildings necessary for intensive research of the type proposed.

Investigation of the facilities needed to establish the Institute of Highway and Traffic Research indicated that the cost involved would be about £200,000. To allow payment of this amount to the University by the Department of Main Roads, the Main Roads Act was amended by the State Government in August, 1960.

These funds are being made available to the University over a period of four years and are being used for the provision of buildings and equipment, furniture and fittings.

MAIN ROADS EXHIBIT

Royal Easter Show

SYDNEY 1963

THE Department of Main Roads was an exhibitor at The Royal Agricultural Society's Easter Show held from the 5th to the 16th April, 1963.

The object of the exhibit was to foster good relations with members of the public, to inform them of the work the Department carried out and to encourage their interest in the activities of the Department.

The theme of the Department's exhibit was " Main Roads of Yesterday, Today and Tomorrow ". The central features of the exhibit were an illuminated map of the State Highway System and a model of the Gladesville-Tarban Creek-Fig Tree area.

The map of the State Highways showed by lighting in successive phases at intervals of five seconds the dustless surfaces which had been provided at the end of 1940 and 1962 and which would be provided by 1970. This feature was flanked on one side by a coloured map showing the routes of the existing Pacific Highway and of the Expressway, now in course of construction, between Sydney and Newcastle; on the other side a coloured map showed the existing and planned Main Road System, including Expressways, in the County of Cumberland.

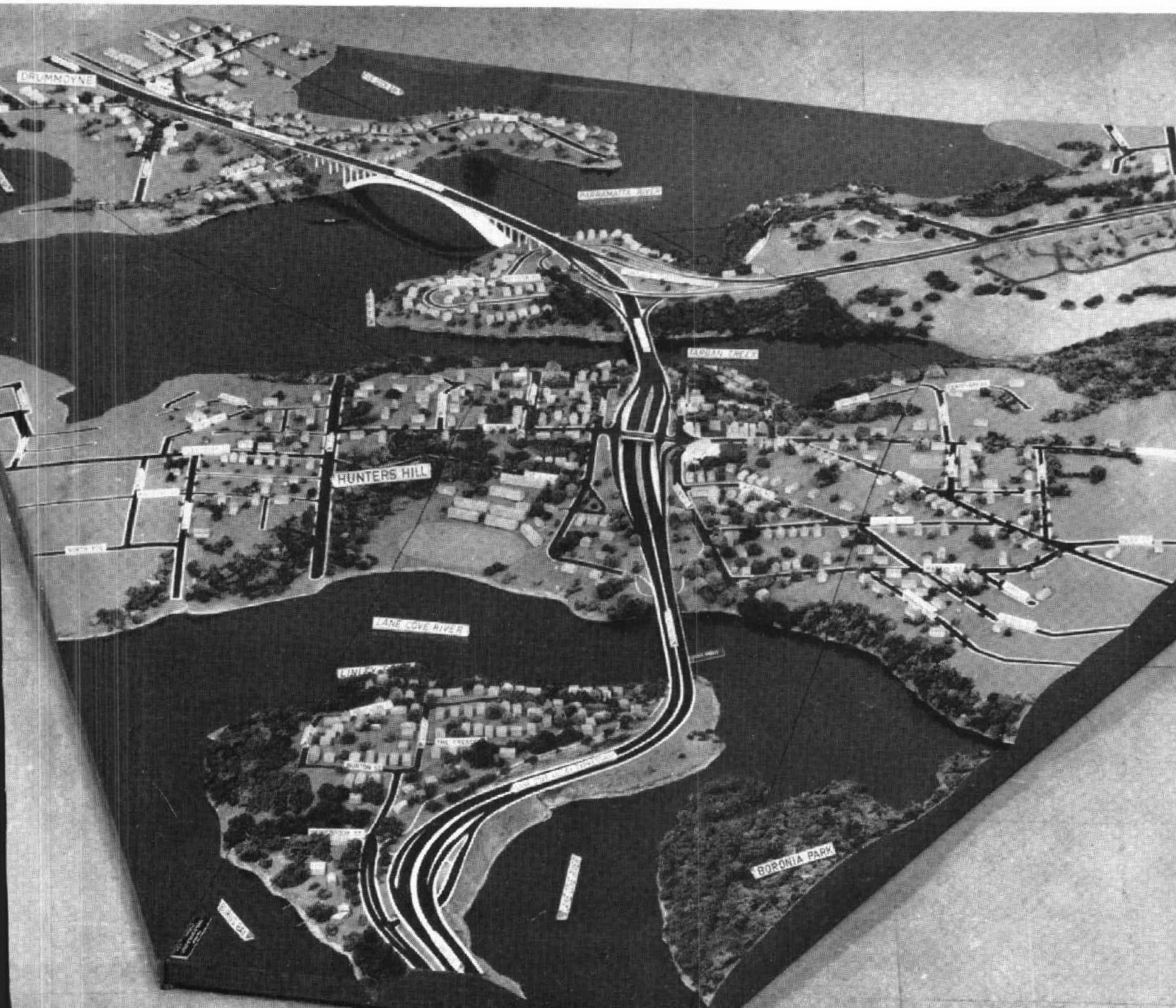
In front of the illuminated map, a large model occupied the centre of the stand. This model, illustrated, showed how the new bridges over the Parramatta River at Gladesville, over Tarban Creek and over the Lane Cove River at Fig Tree will look when completed and how the associated road works forming part of the North-Western Expressway and Lane Cove Valley Expressway will serve the area.

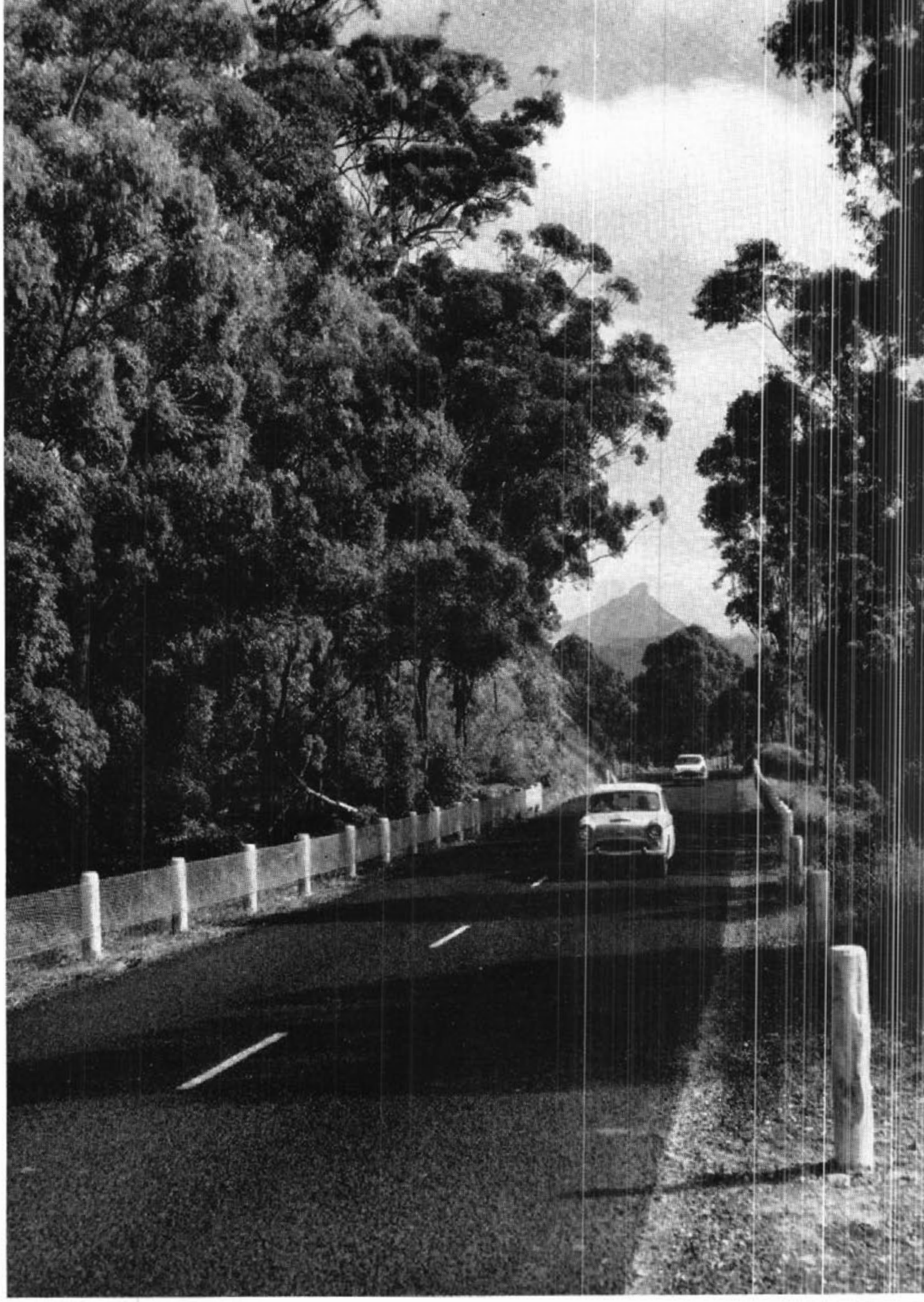
Two island blocks of 24 coloured transparencies illustrated the work of the Department both in the Sydney Metropolitan Area and in the Country.

During the period of the Show more than 230,000 brochures and maps were distributed to members of the public.

▲ General view of the Exhibit

Photograph of model displayed at the Exhibit to show the new Gladesville, Tarban Creek and Fig Tree Bridges and associated roadworks





Typical bitumen surfaced shale road pavement

SHALE ROAD PAVEMENTS

Reprint of a paper presented by N. F. Hatcher, Highways Engineer, Department of Main Roads, New South Wales, to the International Road Federation Fourth World Meeting held in Madrid, Spain, in October, 1962.

In most countries shale is regarded as an unsatisfactory material for constructing road pavements. In Australia in the State of New South Wales, the Department of Main Roads has had to make use of shale in many areas because of the absence of more suitable pavement materials. It is proposed in this paper to outline the circumstances under which the Department has found it necessary to construct shale pavements and also to describe construction procedures and laboratory test techniques which have been developed as a result of many years experience with this material.

Many shales which appear to be sound when extracted from the parent deposit, are unsuitable for use in a road pavement because they soon revert to clay. For this reason shales are not generally favoured as a road-making material. However, in some areas of New South Wales no other suitable materials are available locally. Faced with the alternative of importing proven materials at considerably greater cost, the Department has been forced to adopt the less costly form of construction by using the better class of shale materials available.

Laboratory tests have been developed to assist in the selection of suitable materials and careful study has been given to construction techniques to ensure that the selected materials are used to the best advantage in producing sound pavements.

THE ROAD PROBLEM IN NEW SOUTH WALES

In order to provide some understanding of the road construction problem in New South Wales, it is considered appropriate to give here some information concerning conditions of geography, climate, population, traffic and so on.

The State of New South Wales covers one-third of a million square miles in south-east Australia. Its population is 3,800,000, of which slightly more than 2,000,000 live in the City of Sydney—the State capital, principal sea port and commercial centre. The Country is largely of low relief with two-thirds of its area less than 1,000 feet above sea level and only two per cent. above 4,000 feet elevation. Nevertheless, there are areas of very rugged topography in the eastern part of the State.

Temperatures are generally mild to hot; ground freezing and frost heaving in roads are almost unknown. Rainfall on the coast averages about 50 inches per year, with local maxima exceeding 70 inches, but it decreases towards the west to less than 15 inches per year.

The total length of all roads in the State is 129,701 miles, of which only 20,177 miles have been paved with a dustless surface of bitumen or concrete. The primary road system which is the concern of the central Road Authority (the Department of Main Roads) comprises a total length of some 22,500 miles of road and carries about 75 per cent. of all road traffic. Of this network of classified roads, only 9,000 miles, i.e. about two-fifths of the length, are substantially paved with a dustless surface.

An important need is to extend the construction of bitumen surfaced pavements to provide an adequate basic system of all-weather roads throughout the State. In order that this objective may be attained in reasonable time it is necessary to build pavements as cheaply as practicable, using local natural materials where available for the construction of base courses.

PAVEMENT MATERIALS

The types of materials commonly used for flexible pavement construction outside the major cities are as follows:—

(*a*) Natural soil aggregate mixtures (generally referred to as gravels in Australia) and sand clays.

(*b*) Shales broken up by various construction techniques to produce material equivalent to a natural "gravel".

(*c*) Soils and sub-standard gravels stabilised with bitumen, lime, cement, or fly-ash and lime together.

(*d*) Sandstones and other rocks of similar texture which do not produce a well-graded material and are too soft for macadam pavements, are sometimes used as sub-bases.

(*e*) Crushed stone suitable for construction of waterbound macadam and fine crushed rock pavements. In some cases crushed rock may be blended with natural material to produce a dense graded soil-aggregate.

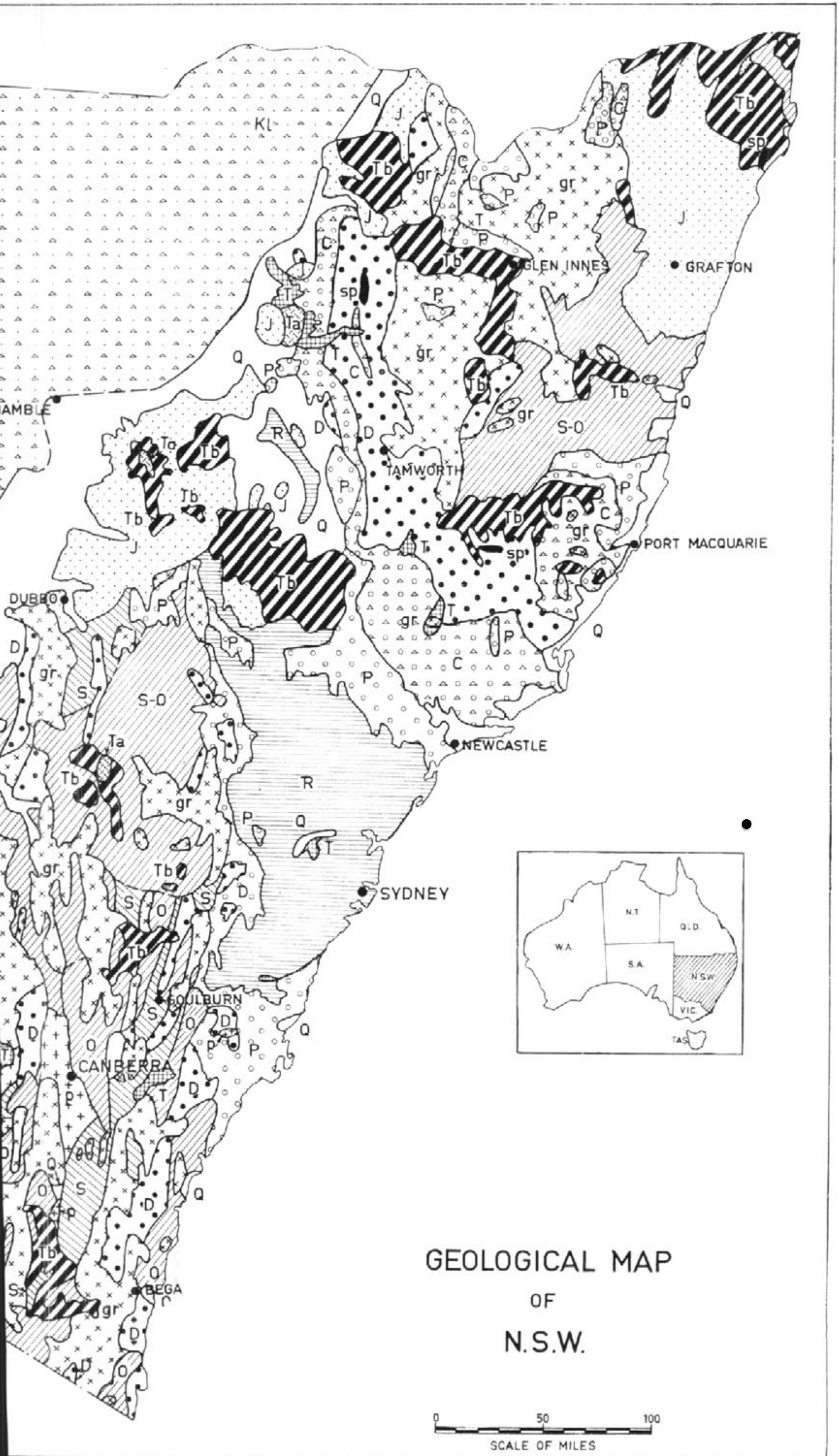
In many areas of the State, igneous rocks and deposits of good quality graded materials are rare. (A geographical map of New South Wales appears on pages 112 and 113.) The only available materials are shales, the properties of which vary widely. Many are obviously unsuitable for use in road pavements. Others, which on first inspection appear suitable, break down during the construction of the pavement or subsequently, to produce a material of excessive plasticity. It has accordingly been necessary to develop testing procedures capable of identifying those shales which are suitable as pavement courses and also to adjust construction techniques to suit particular classes of shale.

Typical shale deposit

Acknowledgement
This map is based on the Bureau of Mineral Resources Geological Map, 1952 and the Department of Mines, N.S.W. Tectonic Map, 1960.

	GEOLOGICAL PERIOD	SYMBOL	TYPE OF ROCK
	Quaternary	Q	Mainly alluvium
	Tertiary	T	River and lake deposits, deep leads, diatomaceous earth, etc.
	Cretaceous	Ku Kl	Surface outcrops are mainly sandstone
	Jurassic	J	Porous sandstone in many areas
	Triassic	℞	Shales and interbedded sandstone
	Permian	P	Mainly sandstone and conglomerate with interbedded shales and coal.
	Carboniferous	C	Tuffs with interbedded lava and conglomerate
	Devonian	D	Much quartzite and sandstone with interbedded conglomerate and shale, etc.
	Silurian	S	Mildly metamorphosed fine grained sedimentary rocks interbedded with limestone, tuff and lava.
	Ordovician	O S-O	Mainly slate and quartzite with some limestone, tuff and agglomerate.
	Proterozoic	P	Metamorphosed sediments of the Torrowangee series.

	GEOLOGICAL PERIOD	SYMBOL	TYPE OF ROCK
	Archaeozoic	Al	Willyama complex gneisses, granite gneiss
	—	gr	Granite
	—	p	Porphyry
	—	Ta	Andesite (Tertiary)
	—	Tb	Basalt (Tertiary)
	—	sp	Serpentine.



GEOLOGICAL MAP
OF
N.S.W.

Self-propelled loader and crusher unit for processing over-size shale on road

CONSTRUCTION TECHNIQUES FOR SHALE PAVEMENTS

Deposits of shale are usually found on spurs, saddles or sidlings in hilly or undulating country, sometimes heavily timbered. After the area has been cleared, any overburden of plastic soil is removed so that it will not be mixed with the shale during winning operations. The overburden is usually pushed off the shale by bulldozers and it may be used for levelling the quarry floor, providing fill material for adjacent road embankments, or in the case of shallow deposits, it may be stockpiled and used later for restoring a covering of soil over the area from which the shale has been taken.

The method of winning the shale depends on its hardness, its bedding and the depth of the deposit. Since the recent development of integral rippers attached to large tractor dozers, most shales can be ripped. This is an effective way of loosening the shale; because the fracture produced by ripping makes the stone easier to handle and reduces the effort required at the roadside to break the stone down to a size suitable for pavement construction. Material loosened by ripping is usually dozed over side-loading ramps into lorries or heaped for loading by mechanical loaders.

When the shale is too hard to rip, it must be loosened by drilling and blasting, using techniques designed to produce maximum fragmentation. If the shale is broken down sufficiently it is loaded into trucks by excavating shovels or mechanical loaders for hauling to the road. If the quantity of shale to be won is large enough, a primary crusher may be installed adjacent to the quarry to break the shale down to a maximum size of 3 inches.

Haulage of pavement materials is carried out by tipping trucks working under contract to the Department. The length of haul seldom exceeds 10 miles.

Shale is used on roads carrying traffic varying from as low as 200 vehicles per day; in some cases up to 2,000 vehicles per day on the more important routes. Pavement widths for two-lane roads vary from 20 feet to 24 feet and formation widths from 28 feet to 44 feet, depending on traffic volumes.

The shale is usually spread by graders over the full width of the road formation, care being taken to avoid segregation of the larger particles. Unless the volume of traffic using the road is sufficient to justify the construction of temporary side tracks, it is usual for traffic to travel on one half of the formation while the pavement material is being spread on the other side.

Although considerable degradation of the shale usually results from the operations of quarrying, loading and spreading, it is generally necessary for the stone to be broken down further on the road to produce a satisfactory pavement material. The manner in which this is done depends on the plant available, the size of the job and the fragmentation already achieved in the quarry.

If a primary crusher has been used in the quarry, any further breakdown required can usually be achieved by tyning, watering and rolling with equipment preferably

Shale basecourse being spread by grader

having a grinding action, e.g. sheepsfoot, cleated, grid or rib type rollers.

If the material is not crushed at the quarry, the larger stones are sometimes broken by hand spalling and further breakdown is achieved by tyning, watering and rolling.

On some of the larger works a forced-feed loader drawing a portable crusher has been used to process uncrushed shale after it has been spread loosely on the formation. Depending upon the depth of pavement being produced, between three and seven passes of the machine are required before the full quantity of pavement material is processed. Traffic is permitted to pass over the processed material and further spreading, shaping and compaction with the addition of water are undertaken to produce a firm pavement.

In some cases tests will show that the material resulting from the breaking-down processes requires further treatment to make it satisfactory to receive a bitumen surface. This can often be achieved by adding a local granular material to correct a deficiency in grading or in some cases cement or lime may be added to overcome the effects of excessive plasticity. Mixing of material is done in place with conventional equipment, single-pass or multi-pass units being used as available.

When the shale is broken down on the road using conventional rolling equipment supplemented by knapping, tyning and watering, the processing of some hard shales may take several days. When the material has been crushed at the quarry, or processed by portable breaker equipment on the road, a finished pavement can be produced quickly.

Excessive working of shales during compaction can result in the formation of a thin layer of silt-sized particles on the surface or in an increase in plasticity. Careful inspection and control testing are necessary during the compaction process to ensure that a uniformly sound pavement will result.

SELECTION AND TESTING OF SHALES

The problem of selecting shale deposits suitable for use in road pavements is complicated by the variations which can occur in the material. Not only do the properties of shale vary with the type, size and relative proportions of the mineral constituents, they are also dependent upon the combination of natural processes through which the original sediment has been transformed into rock. For example, in the deposition of shale beds, even in the same lake, variations may occur in intertonguing, cross bedding, thickness of laminae, grain size, mineralogy and attitude of the beds. Subsequently the sediments may be transformed into shale by consolidation or cementation or by a combination of both processes and may be metamorphosed to varying degrees by heat or pressure.

As a result, the shale in any one deposit is usually not uniform in character. Because of these variations and because of the fragmentary nature of the materials, more extensive sampling is necessary than with naturally occurring graded materials.

Special care is required in control sampling of the constructed pavement. If the construction involves breaking down the shale by compaction equipment on the road, sampling must be done in a way that will reveal any segregation or non-uniform distribution of the particle sizes, both of which prevent the attainment of maximum density and impermeability, with the consequent risk of further degeneration of the shale.

The development of the testing methods used by the Department for flexible pavement materials generally, is described in a paper by Mr. A. T. Britton, entitled "Flexible Pavements—Design and Selection of Materials", published in the Proceedings of the Twenty-Seventh Annual Meeting of the Highway Research Board, December, 1947, and also in Report No. 74 by Mr. A. H. Gawith and Mr. T. M. Coulter at the Tenth Congress of the Permanent International Association of Road Congresses at Istanbul in 1955.

Cement modification of shale pavement

For the selection of pavement materials, the tests aim principally at ensuring that after compaction the grading and plasticity are within specific limits and that the proportion of stones exceeding ¾ in. gauge is kept to a reasonable limit.

The desirable limit for oversize stones is five per cent. of the whole, but this is frequently exceeded. If there is too much over-sized material present difficulty is experienced during final preparation by larger stones getting caught under the grader blade and tearing ruts in the surface of the pavement.

The Department requires that shales comply with the same specification as the naturally occurring soil-aggregate mixtures (or " gravels "). Before a shale can be tested in this way, it must first be reduced to a graded mixture similar to the material which will result when it is eventually compacted in the pavement. This presented the problem of devising a method for treating a sample of shale in the laboratory to reduce it to a gravelly material which would conform in grading and other properties to the material which would eventually form the compacted pavement.

It had been observed in many cases that some shales which appeared sound when quarried had failed as pavements because they subsequently weathered to produce a material of high plasticity. Other shales showed signs of excessive degradation in particle size during the construction process and this varied according to the construction techniques employed. It therefore became apparent that the laboratory procedure for preparing shale samples for testing should include some form of accelerated weathering as well as some method of crushing or abrading the shale to cause degradation of particle size.

In order to study the effects of weathering, shales were taken from various quarries and subjected to accelerated weathering treatments involving a series of alternate wetting and drying. Some shales were reduced to inferior plastic materials after two or three cycles of the weathering procedure; others were able to resist 10 to 20 cycles without being adversely affected. In most cases the degradation of the material which could be produced by the laboratory process of wetting and drying was substantially complete after 10 cycles of 24 hours each. This number of cycles has therefore been adopted by the Department in its standard pretreatment procedure in the testing of shales. Investigation has shown that samples from any one deposit of shale, whether taken direct from the quarry or from a road pavement, exhibit a characteristic degradation under the accelerated weathering procedure.

Samples of shale undergoing accelerated weathering and compaction tests

In view of the mechanical break-down of shale which results from the construction processes of shaping and compacting the pavement, it was decided to supplement the accelerated weathering treatment by a laboratory compacting process before testing the shale in the same way as a natural gravel. (The standard procedure used by the Department for testing of shales is set out in Appendix " A ".)

This method of testing has been in use by the Department for more than 15 years. During this time, the performance of shale pavements has been studied continually in order to determine whether any modification of the laboratory test procedures or revision of specified requirements is called for. In addition, an investigation is being made to determine whether microscopic examination of the mineral composition of shales may reveal why some are more resistant to degradation than others.

A study has also been made of the effect of excessive abrasion of shales during the construction processes of shaping and compacting. Laboratory tests, in which shales were treated in a ball mill, have indicated that some shales increase in plasticity when subjected to excessive abrasion. For this reason some shales need special attention to ensure that the equipment used for pavement compaction does not abrade the stone unduly.

Other experiments aimed at studying the progressive degradation of shales have involved the testing of samples taken at various stages during the after-pavement construction—at the quarry while the shale is being loaded for transport to the road, at intervals during the compaction process and subsequently from the completed pavement at regular periods extending over some years.

The results of these experiments indicate that most fissile rocks which meet the requirements of the Department's standard laboratory tests, show very little break-down after they have been compacted in the pavement, provided they have been correctly handled during the construction process.

As previously explained, the Department's standard laboratory test provides for the shale to be subjected to 10 cycles of alternate wetting and drying which causes certain degradation of particle size; this is followed by a compaction procedure which causes further breakdown of the material. The experiments described above indicate that this standard pre-treatment of laboratory samples is insufficient to reduce some of the harder shales to well graded pavement aggregate whereas heavy field compaction equipment may be capable of doing so.

Experiments are now being made to see if it is possible to determine from laboratory tests whether these harder materials can be reduced, at reasonable cost, to form well graded aggregate and if so what construction techniques are appropriate. In these experiments the single compaction treatment of the standard laboratory test is repeated until the material is broken down to a suitable grading for pavement use, if this is practicable. Research in this field is continuing. (The modified laboratory test procedure which has been adopted tentatively is described briefly in Appendix " B ".)

CONCLUSION

The first recorded case of bitumen surfacing over a shale pavement dates back to 1934 and this particular length of road has required normal maintenance attention only since that time. Some 850 miles of shale pavements have been sealed since 1934 and most of them are still in good condition. Where pavement deterioration has occurred prematurely, investigation has usually shown this to be caused by inadequate thickness of pavement, poor drainage or unsatisfactory construction technique, rather than inferior pavement material.

In addition to shales, the Department has used a range of fine grained, laminated and jointed sedimentary and metamorphic rocks including slate, schist, phyllite, greywacke, chert and some porphyries. Similar testing and construction techniques have been applied to these materials as to the shales.

As it is rarely necessary to haul the shale further than ten miles, its use as a pavement material has enabled a greater length of road to be improved to an acceptable standard than would have been possible if more orthodox materials involving high transport costs had been used. It has been estimated that the cost of providing comparable pavements using fine crushed rock would have been twice to three times the cost of using shale—say 15 shillings to 24 shillings (Australian) per square yard of crushed rock pavement 12 inches thick compared with 5 shillings to 13 shillings for shale.

The Department's experience has shown that shales and similar rocks can be used successfully and economically as pavement materials provided they are carefully selected and correctly handled during the construction process.

Research into testing procedures and construction techniques for shale pavements is being continued.

APPENDIX " A "

LABORATORY TESTING OF SHALES ACCELERATE WEATHERING TREATMENT

(i) Crush the entire sample in crusher until all passes the $\frac{3}{4}$ inch sieve or knap down by hammer. If using the crusher be careful not to set the jaws too close or an excessive quantity of fine material will be produced. The maximum size which falls through should be $\frac{3}{4}$ inch to 1 inch. Pass all through the crusher once; then sieve on the $\frac{3}{4}$ inch sieve, put the $+ \frac{3}{4}$ inch, if any, back through the crusher and repeat until all has been reduced sufficiently to pass the $\frac{3}{4}$ inch sieve.

(ii) Quarter out about 5,000 grams. Place in an enamel dish, paint on the reference number and just cover the material with water. This will provide sufficient for a full soil test, if necessary.

(iii) Allow to stand 18-20 hours. Decant off excess water *if clear* and evaporate to dryness on a hot plate. The water decanted can be used again to moisten the sample. Stir occasionally during drying to allow water vapour to escape. Make certain the material is thoroughly dry but do not " bake " it after drying out. To avoid this happening, it is necessary to stir the material when it is nearly dry.

(iv) Allow to cool and again cover with water. Repeat the wetting and drying cycles until ten cycles have been completed.

(v) Moisten to approximate optimum moisture, compact in 6 inch mould in $1\frac{1}{2}$ inch layers (compacted thickness) using 55 blows of the Proctor Rammer.

(vi) Remove from mould.

(vii) Dry on a hot plate and then test the resulting material in accordance with the Department's standard method for pavement gravels.

APPENDIX " B "

LABORATORY TESTING OF SHALES REPEATED COMPACTION TREATMENT (PROPOSED)

(i) Quarter the sample to provide 6,000 gm. for the repeated compaction pretreatment.

(ii) From the remaining material select one or more pieces of large dimensions and carry out three wet-dry cycles on it to assess the tendency to " fret ". Spalling or flaking of more than 30 per cent. of this lump of rock indicates a marked tendency to " fret " when exposed during quarrying operations. This indicates that the shale must be compacted into the pavement and sealed without much delay after it has been exposed in the quarry.

(iii) Cure the 6,000 gm. sample over-night with a moisture content of 5-10 per cent. in a covered container at 60° C.

(iv) Break the sample to pass a $1\frac{1}{2}$ inch sieve.

(v) Compact in a 6 inch split mould in three $1\frac{1}{2}$ inch layers, with 55 blows of a standard Proctor Rammer. Repeat the process until the sample has the appearance of a " road gravel ", i.e., contains a minimum of 30 per cent. passing the No. 0 British Standard sieve. There is no need to continue the compactions beyond this point, but at least two compactions must be done.

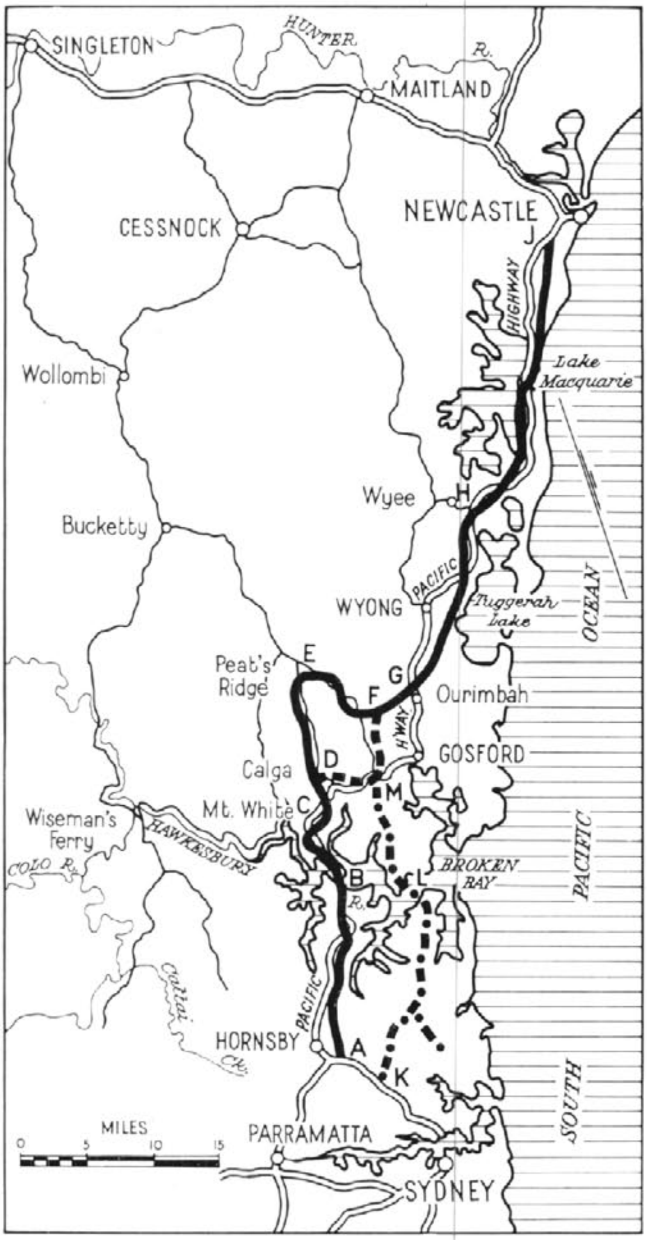
(vi) Interpret the results as follows:—

a. If more than three series of compaction are required, to produce a " road gravel " mixture, the sample is very tough and the material it represents would require very heavy compactive effort, or crushing, prior to use in the pavement.

b. If the number of compactions and the amount of oversize is high, or the soil mortar is deficient, the material should not be considered for use as a " road gravel ", but it may be suitable as a macadam.

(vii) If the material resulting from process (v) above is equivalent to a road gravel, test it in accordance with the Department's standard method for the testing of road gravels.

SYDNEY-NEWCASTLE EXPRESSWAY



Locality sketch

FOLLOWING acceptance by the Department of Main Roads of the tender of £2,011,996 18s. 2d. submitted by K. D. Morris and Sons Pty. Ltd. of Queensland, work on the construction of the Hawkesbury River-Mount White section of the Sydney-Newcastle Expressway commenced on the 23rd April, 1963. The contract time for completion of this section is two years.

Existing Road

The Pacific Highway between Hornsby and Gosford was constructed by the Hornsby Shire Council and the then Main Roads Board between 1925 and 1930. Whilst the grades of the existing road are easy, the maximum being 5 per cent., there are over 200 curves between Cowan and Gosford, the radii being as low as 100 feet.

Whilst this curvature was suitable for motor vehicles in use when the road was built, the steady increase in the ratio of horsepower to weight in cars and in the lighter classes of trucks, particularly since the 1939-45 war, has made the present road quite unsuitable for the traffic needs of recent years. Further, with the continuing rapid increase in the volume of road traffic in the post-war years, it became evident that, in addition to improvement in alignment, a four-lane road was required. It is of interest to note in this regard that a four-lane road with a divided carriageway has a traffic capacity of between three and four times that of a two-lane road.

Investigations for new route

The country between Cowan and Gosford is rugged and any substantial improvement of the existing road would involve very heavy earthwork, much of which would be in sandstone rock, and still would not provide an alignment allowing higher speeds. It was also evident that, for the most part, widening of the existing road to provide a width to accommodate four lanes would not be a satisfactory solution.

Accordingly, an investigation was undertaken by the Department of Main Roads to establish a route for a new road.

In the meantime, some relief to traffic has been given by the provision of climbing lanes on the existing Highway, where practicable, and by the extensive removal of trees and scrub to improve visibility.

The objective of the investigation was to locate a line at acceptable cost to give comfortable travel at a minimum of 50 m.p.h.

In addition, it was considered essential that the road should be a true expressway or in other words, there should be no frontage access from abutting properties, all intersecting roads should be carried under or over the expressway, and all interchanges where the expressway connects to the local road system should be designed to provide for traffic to join and leave the expressway with safety at reasonable speed.

The investigation covered the route of a road of expressway standard southward to link with the expressway system included in the County of Cumberland Planning Scheme and northward to Swansea to join the planned expressway between Swansea and Newcastle included in the Northumberland Planning Scheme.

Other factors which it was necessary to take into consideration in the investigation were:—

1. The retention of any existing assets suitable for incorporation in the expressway, such as the existing bridge over the Hawkesbury River.
2. The reduction to a minimum of interference with developed property, particularly houses and orchards and other intensely cultivated land. For this reason it was desirable that the route should skirt rather than pass through settled areas.
3. In view of the high total cost, the desirability of selecting a location which would permit stage construction and allow the road to be brought into use progressively, section by section.
4. The need to give priority in construction to the length between the Hornsby area and Gosford for the reason that this length carries more traffic than that north of Gosford and also because it embraces the sections of the existing road which present the more difficult driving conditions.
5. The need for a high standard connection to serve the north and north western parts of the State, passing to the west of Newcastle and linking with the existing New England Highway in the vicinity of Singleton. This link would also serve the coalfields area centred on Cessnock.

As a result of these investigations and bearing in mind the factors mentioned above, it appeared that the most favourable route would be that shown A–B–C–D–E–F–G–H–J, shown on the locality sketch with the existing road between Calga and Peat's Ridge used as part of this route in the first place. The location of the route through Peat's Ridge in the first place was due primarily to the high cost which would be involved in bridging the gorge of Mooney Creek farther to the south. On the other hand, Peat's Ridge will be the starting point for the ultimate high standard road to connect to the New England Highway near Singleton.

Looking towards Mooney Mooney Point and Peat's Ferry Bridge over the Hawkesbury River where the first section of the expressway will commence

Invitation of offers to build expressway

Prior to a firm conclusion on the general route being reached, offers were invited in Australia and overseas for the financing, construction and operation of a toll road to expressway standards between the Sydney and Newcastle areas. No route was specified, but the route shown A–B–C–D–E–F–G–H and J, was included in the information made available by the Department. The route shown K–L–M–F, was also included as a possible alternative.

Three offers were received, but none was accepted. Instead, the Government, in January, 1962, decided to adopt a proposal by the Department of Main Roads for the construction of an expressway along the route A–B–C–D–E–F–G–H–J.

Although the route shown K–L–M–F, is shorter than the route adopted, it has the major disadvantage of involving the construction of a new high level bridge nearly 6,000 feet long over the Hawkesbury River. It was apparent too, in arriving at the decision to adopt the route A–B–C–D–E–F–G–H–J, that no benefit to

The divided carriageway at Mount White, the terminal point of the first section of the expressway

through traffic could be obtained from the alternative route until the road, including the new bridge, had been completed from Sydney to the vicinity of Gosford.

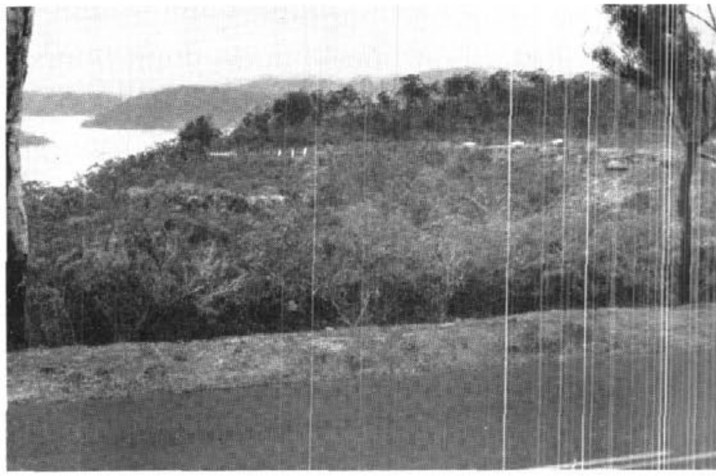
The adoption in the first place of the route A–B–C–D–E–F–G–H–J, also had the advantage that the existing road between Calga and Peat's Ridge, already reconstructed and bitumen surfaced, could be used by through traffic as soon as the length of road from Peat's Ridge to Ourimbah had been completed. The work between Peat's Ridge and Ourimbah is described in the December, 1960, number of " Main Roads ".

Construction of Hawkesbury River-Mount White section

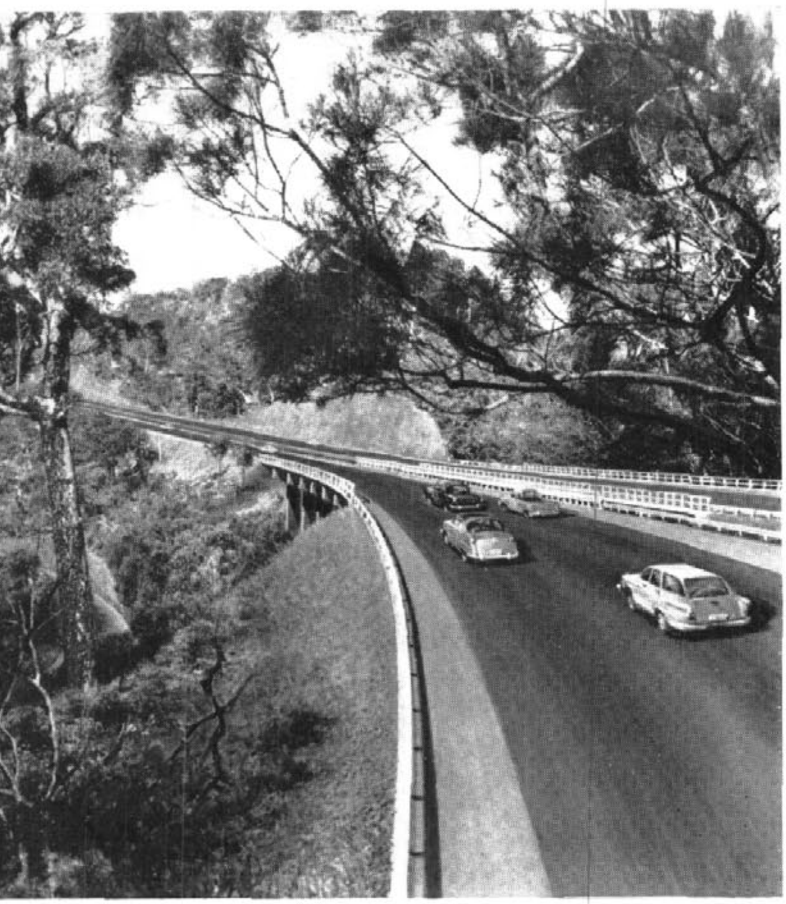
The five-miles section of the expressway now being constructed between the Hawkesbury River and Mount White will have two separate carriageways, separated generally by a minimum width of 30 feet, to carry two lanes of traffic in each direction.

The survey for this section was carried out and the plans and specifications were prepared by the staff of the Department of Main Roads. Special care was taken to ensure that the new road will be properly landscaped and that travel over it will be pleasant as well as safe and convenient.

This section of the expressway will be safe for car speeds of 60 m.p.h. if desired; the minimum radius of curvature will be 1,200 feet and the maximum rising grade 1 in 17.



The Pacific Highway four miles north of the Hawkesbury River



An artist's impression of the viaduct to be constructed near Joll's Lookout

The four travel lanes will be each 12 feet wide and the shoulders generally 10 feet wide. The shoulders will be surface treated so as to be hard and dustless. In addition, extra lanes will be provided on steeper grades, both up and down, where heavy vehicles will travel at lower speeds. This means there will be six lanes available to traffic on some lengths.

At Mooney Mooney Point, a bridge 130 feet long will be built to carry the expressway over the existing highway. The expressway will also cut across the line of the Pacific Highway at a number of other places, and the construction of deviations of the highway will be necessary to maintain its continuity.

The only other bridge to be constructed on this length of the expressway is at Joll's Lookout, where the expressway will be carried across a dry gully on a concrete viaduct 490 feet long.

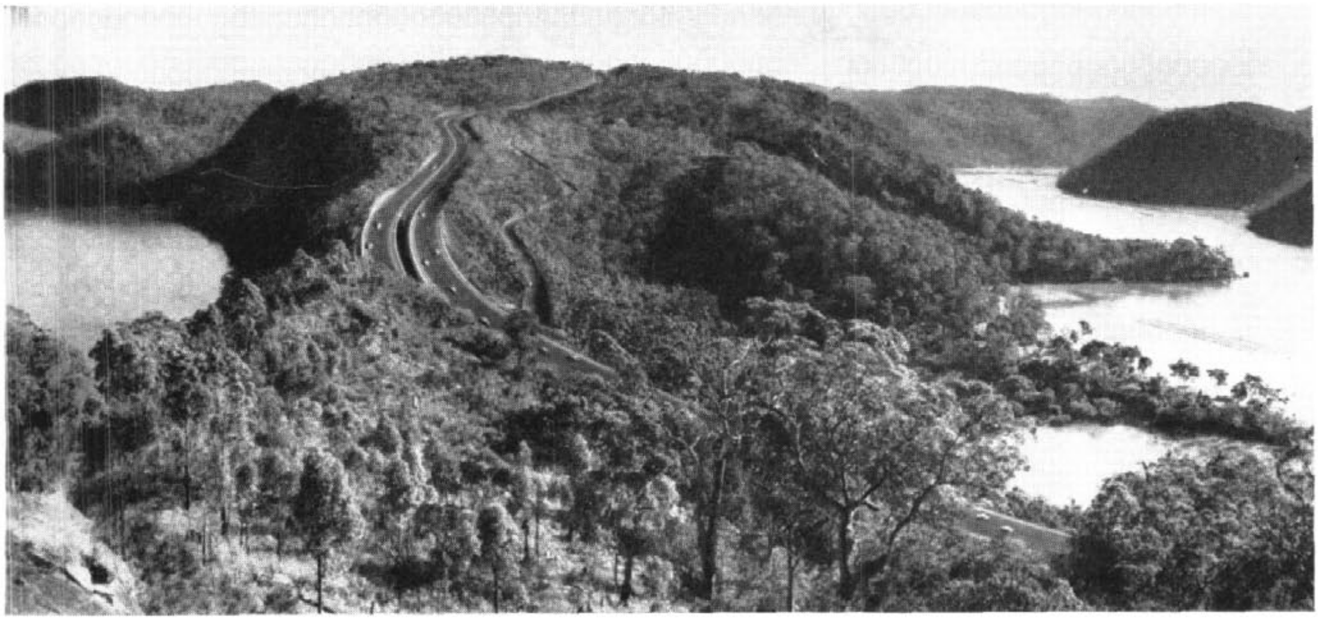
Construction of further sections

While the Hawkesbury River-Mount White section is being constructed, designs for a further section between Mount White and Calga, a distance of 4¼ miles, are being prepared.

It is expected that the whole length between the Hawkesbury River and Calga, a distance of 9·8 miles, will be completed within a period of four years from March, 1963.

After construction of the Hawkesbury River-Calga length, the next major section of the Sydney-Newcastle Expressway will be in the length from the Hawkesbury River to Wahroonga.

Ultimately, it is likely that the route of the expressway between Calga and Ourimbah will be as shown D–M–F, on the locality sketch. Construction along the route will involve the building of a bridge over Mooney Creek at a cost of about £3,000,000. However, the route through Peat's Ridge will need to be used for some years before construction of the alternative route will be economically practicable.



Artist's impression of the ascent from the Hawkesbury River

In the meantime, the two-lane road being built to expressway standards between Peat's Ridge and Ourimbah will be completed in December, 1963, and this, with the existing road between Calga and Peat's Ridge, will enable traffic proceeding to Ourimbah and beyond to divert from the Pacific Highway and avoid the winding section of the highway into Mooney Creek and also the closely settled area from Gosford to Ourimbah.

This through traffic is expected to average about 4,000 vehicles per day and will be well within the capacity of the new Calga-Peat's Ridge-Ourimbah road.

The existing Pacific Highway between Calga and Ourimbah, via Mooney Creek Bridge, will thus be greatly relieved of traffic with consequent advantage to drivers travelling to Woy Woy, Gosford, Terrigal and other places in the area.

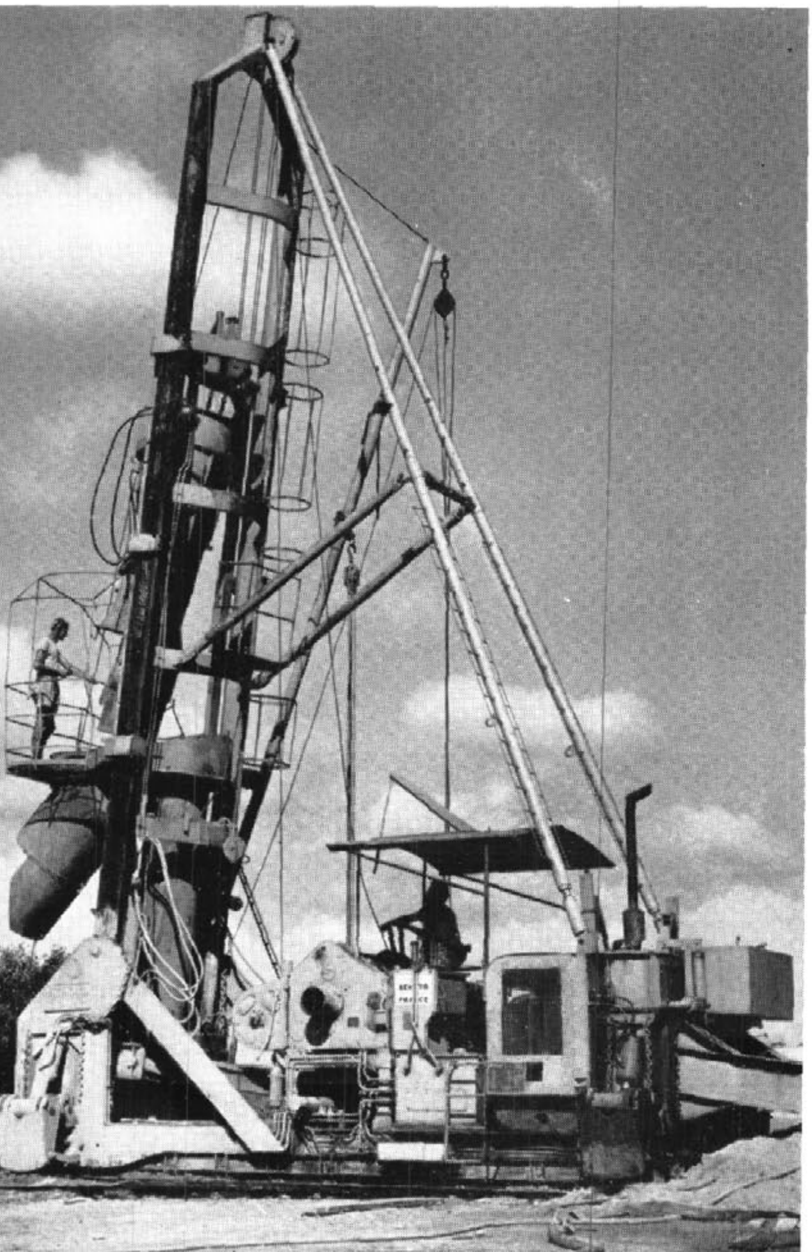
SYDNEY HARBOUR BRIDGE ACCOUNT

Receipts and Payments for the period from 1st July, 1962 to 31st March, 1963

Receipts	£	*Payments*	£
Road Tolls	1,261,694	Cost of collecting road tolls	133,010
Contributions—		Maintenance and minor improvement	209,489
Railway Passengers	104,929	Alterations to archways for occupation by tenants	1,474
Omnibus Passengers	12,204	Administrative Expenses and miscellaneous charges	29,671
Rent from Properties	87,810	Transfers to Expressways Fund	1,456,000
Other	649	Provision of traffic facilities	26,293
		Alteration to toll gates	1,499
	£1,467,286	Other	6
			£1,857,442

"BENOTO" BORING EQUIPMENT FOR BRIDGE FOUNDATIONS

Benoto pile boring machine



THE construction of concrete piles in situ by using mechanical boring equipment to make a hole in the ground, which is then filled with concrete, is a particularly useful procedure where site conditions are unsuitable for driving piles and where very large and/or very long piles are required. In the past, it has been usual under these conditions to sink large diameter concrete cylinders to rock, often necessitating the use of costly compressed air equipment to allow men to work in the cylinders below water level. These measures are obviated by the use of bored piles.

"Benoto" pile boring equipment was adapted in France from mechanical well-sinking plant, and provides a means of constructing bored piles to great depths in any type of foundation material. Unlike the majority of pile boring machines, the Benoto equipment may be used either on dry ground or over water.

Following investigation by the Department of Main Roads of the various sizes and types of pile boring equipment available and of their costs and potential uses in bridge foundation work, and EDF 55 type Benoto pile boring machine and ancillary equipment were purchased in 1960, and a special day labour organisation was established to operate the machine.

Operation

The boring of a hole by the Benoto unit is achieved by two distinct operations. A drilling tube fitted with a cutting edge is forced into the ground aided by oscillating rotary motions and, at the same time, the winch operated Benoto Hammergrab removes the material from inside the drilling tube. In hard ground the hammergrab is used to undercut the tube, whilst in very soft ground and quicksand the tube is pushed ahead of the excavation to maintain the stability of the ground.

The EDF 55 Benoto pile boring machine combines the two drilling operations within one self-contained machine controlled by three men. Hydraulic power is supplied to four main rams which operate the drilling tube, two for vertical movement of 50-ton total capacity and two for the oscillating movement of 130-ft. ton capacity. A single power unit drives the 2½-ton capacity winch operating the hammergrab and a series of five pumps supplying hydraulic power to twelve rams (including the four previously mentioned) incorporated in the machine for various purposes. There is also an auxiliary winch of 1 ton capacity for operating the drilling tube guide and hoisting derrick.

The standard EDF 55 machine is powered by an engine of French manufacture. In the machine purchased by the Department, the engine normally fitted has been replaced by a 120 H.P. diesel engine for which service and spare parts are readily available in Australia.

The drilling tubes are double-walled cylindrical sections approximately 20 feet long with interlocking ends which are bolted together as drilling progresses.

A number of removable cutting edges is provided with the tubes for use in various types of ground. When the hole has reached the required depth, the tube is filled with concrete, reinforced with mild steel bars if necessary and both tube and cutting edge are withdrawn by vertical and reciprocating motions so as to force the plastic concrete into the hole and into the space formerly occupied by the tube. The resultant surface of the concrete thus provides much greater friction than that attained with earlier models which required the steel outer casing to be left in the ground.

Four sizes of drilling tubes and hammergrabs are available for use with the EDF 55 machine, allowing piles of from 27 inches to 43 inches diameter and up to more than 250 feet in length to be placed. In the first instance, drilling tubes and hammergrab equipment have been purchased by the Department to construct piles of 27 inches and 38½ inches diameter. Sufficient tubing has been obtained to allow 38½-inch diameter piles to be bored to depths of 220 feet, whilst the smaller piles can be bored to depths of 120 feet. The machine can be readily adjusted to bore battered piles inclined 6 or 12 degrees to the vertical.

Benoto equipment supported over water on Bailey bridging

Bailey bridging erected on falsework to enable Benoto equipment to be used over water

The machine is fitted with a derrick-arm which enables lengths of drilling tube, hammergrabs and other equipment to be lifted into place using the auxiliary winch.

The Benoto EDF 55 machine is 36 feet long, 12 feet wide, and stands 45 feet high. When a 20-ft. length of drilling tube and the hammergrab are fitted, the total weight of the machine is over 36 tons.

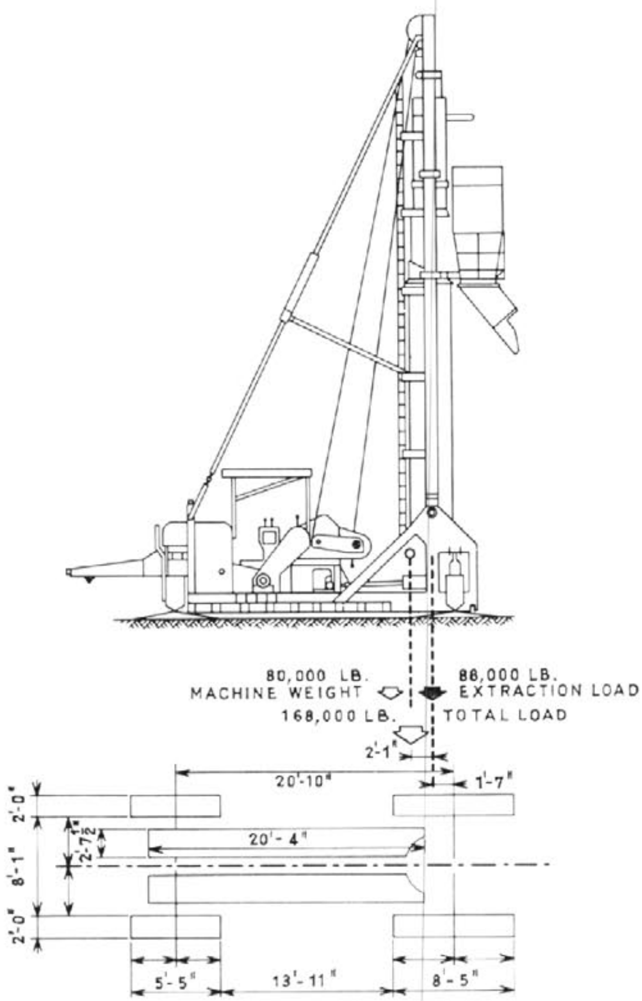
Movement of the machine from one pile position to the next is effected by means of a series of flanged rollers running on rails attached to the base. The machine can be moved forwards or backwards by two hydraulic rams a total distance of 4 feet. After the machine has moved this distance it lifts bodily off the ground on four large hydraulically operated jacking pads located at the corners. The rails are then moved forward and the machine lowered back on to them, thus allowing another "step" to be taken. As the rails on each side can be operated independently it is possible to turn the machine during movement. It can also be turned around completely on the same spot.

Ancillary Equipment

The Benoto Hammergrab was developed in 1932 for use in pile boring and well sinking operations. It provided a single tool which could be used in place of the clam-shell grabs, augers, sand-pumps and rock splitting tools previously needed to drill a hole in the ground through a variety of materials. The type CP 5 Hammergrab used with the EDF 55 machine weighs just under 1½ tons when fitted with cutting shells for the 38½-inch diameter piles, and is operated by a single hoist rope. The cutting shells close automatically when the grab has dug into the material at the bottom of the hole.

Various cutting shells are fitted to the hammergrab depending on the type of ground to be drilled. Four different shells are available for the 38½-inch diameter piles and three for the 27-inch diameter piles. One type of grab shell is watertight when closed and enables sand and soft mud to be removed from under water. Other shells are available for digging clay, gravel and rock. To penetrate hard rocks, the shells can be locked in the open position, and the hammergrab is then used as a percussive drilling tool. It is possible, therefore, to bore through practically any material whether dry, wet or even under water with the same hammergrab, although it may be necessary to change

Diagram of side elevation of Benoto equipment



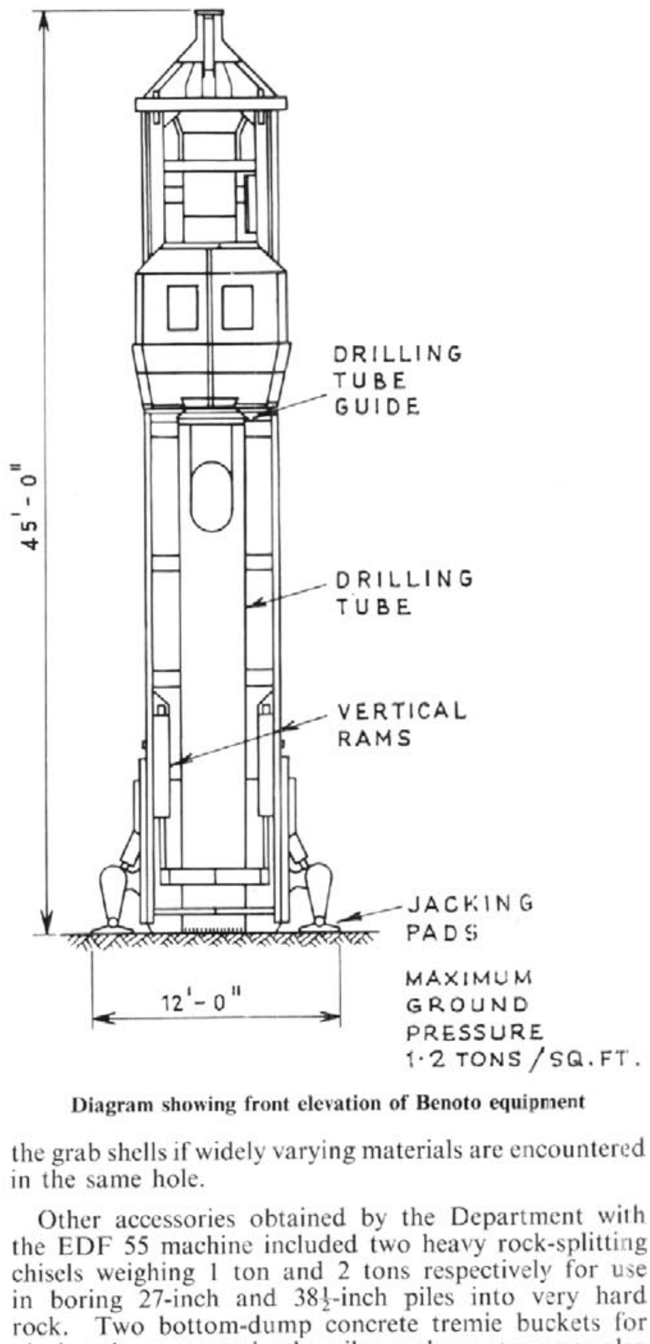


Diagram showing front elevation of Benoto equipment

the grab shells if widely varying materials are encountered in the same hole.

Other accessories obtained by the Department with the EDF 55 machine included two heavy rock-splitting chisels weighing 1 ton and 2 tons respectively for use in boring 27-inch and 38½-inch piles into very hard rock. Two bottom-dump concrete tremie buckets for placing the concrete in the piles under water were also purchased.

Cost

The total cost of the machine including drilling tubes, hammergrabs and other accessories for the two sizes of piles selected, special road bogies and spare parts was approximately £95,000.

Transport

For transport between bridge sites the Benoto is partly dismantled and the vertical frame is folded down to a horizontal position. By means of the four corner jacking pads, the machine is raised sufficiently to allow special sixteen-wheel road bogies to be fitted under each end. These bogies were designed and fabricated at the Department's Central Workshop, because the four-wheel bogies offered by the manufacturer would have produced wheel loads in excess of those allowed by the Local Government Ordinances dealing with weights of loads on roads. When mounted on the bogies, the machine is towed by a prime mover. On long steep grades two prime movers are sometimes necessary. Separate vehicles are required to transport the drilling tubes, hammergrabs and other accessories.

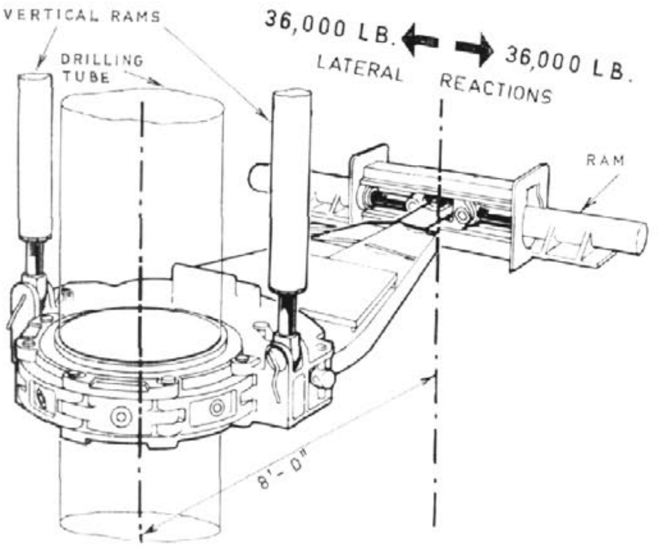


Illustration of oscillating and vertical movement mechanism of Benoto equipment

Applications

The Department's Benoto machine was first used for constructing bored piles for the foundations of a new bridge on the Mitchell Highway at Dunkeld near Bathurst. Ten bored piles with a total length of 131 feet of 38½ inches diameter were constructed.

Benoto piles have been incorporated also in the design of bridges being constructed over Little Salt Pan Creek, Salt Pan Creek and a tributary of Salt Pan Creek, on the route of Henry Lawson Drive between Picnic Point and Peakhurst.

In all, bored piles having a total length of almost 4,000 feet are required for the foundations of these bridges. The materials so far encountered during the boring of these piles include silt, sand, various clays and sandstone bedrock. The rock-fill for the bridge approaches has been placed preparatory to the construction of the abutment piles which will be bored through heavy rock fill up to 25 feet thick. The majority of these piles has already been constructed.

The working design load on 27-inch diameter Benoto piles, which were taken at least 1 ft. 6 in. into sound hard rock, has been calculated at 120 tons per pile, the corresponding load on 38½-inch diameter piles being 200 tons. The depths at which the piles were founded varied from 15 to 95 feet below the surface, the average depth being 54 feet. Twenty-four of the piles are battered and the remainder are vertical.

Where the piles in the two larger bridges were constructed in water, the Benoto machine was operated from falsework at these sites. This falsework needed to be strong enough to withstand the downward force of up to 75 tons produced by the machine while extracting drilling tubes, as well as a horizontal force of up to 16 tons from the oscillating motion. For this purpose use was made of Bailey Bridging 120 feet long at Little Salt Pan Creek and 310 feet long at Salt Pan Creek. The bridging was supported on driven timber piles. When the row of piles under the Bailey Bridging was completed, it was moved sideways to allow the construction of the next row of piles.

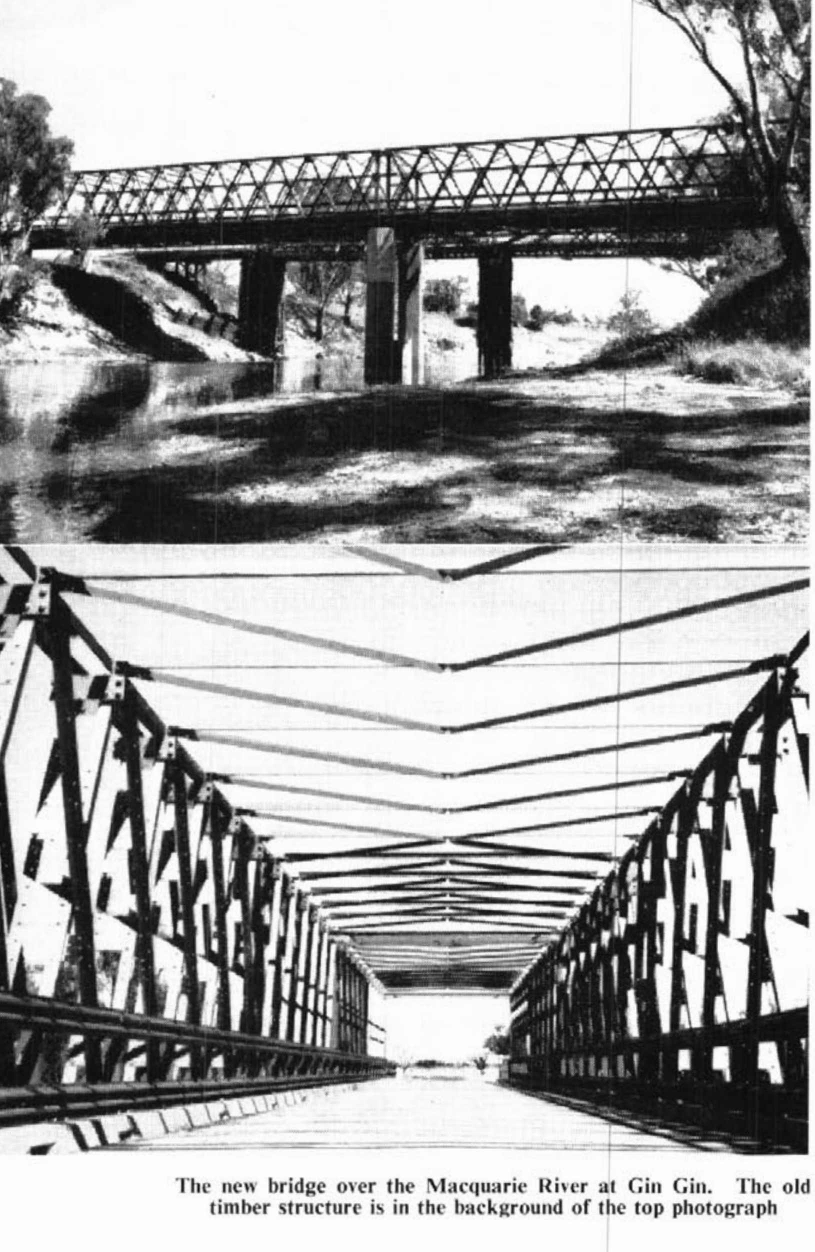
Mild steel casing $\frac{3}{16}$-inch thick was used as formwork for the concrete in the uppermost portion of each pile, where it was placed in soft mud or water, and was left in position. Steel casing of 22 inches outside diameter was used for the 27-inch diameter piles and 34½-inch outside diameter casing for 38½-inch piles, these being the maximum sizes which would fit inside the drilling tube. This resulted in the piles being slightly smaller at the top than at the bottom. The average length of casing used for each pile was 20 feet but the length for each pile varied according to ground conditions. Steel casing was also used in the abutment piles to reduce the friction between the rock fill and the outside of the piles, thus allowing the fill to consolidate without overloading the piles.

A steel reinforcing cage consisting of ten 1⅛-inch diameter vertical bars welded to ⅜-inch diameter stirrups at 12-inch centres was used in the upper portion of each pile, the reinforcement being extended down into the stiff clay zone to resist bending forces on the pile. In shallow piles the reinforcement was continued to rock. The vertical bars were allowed to protrude from the top of the pile for joining with the headstocks.

All except three of the piles were concreted under water using the Prepakt grout-intrusion process. After drilling was completed and the permanent steel casing and reinforcement were in place, the piles were filled with 1½-inch aggregate and the drilling tube was extracted. A mixture of sand, cement, pozzolan, water and special additive was later pumped into the pile to form a penetration concrete. The grout was introduced at the bottom of the pile by means of a central pipe and as the grout rose inside the pile, it displaced the water at the top.

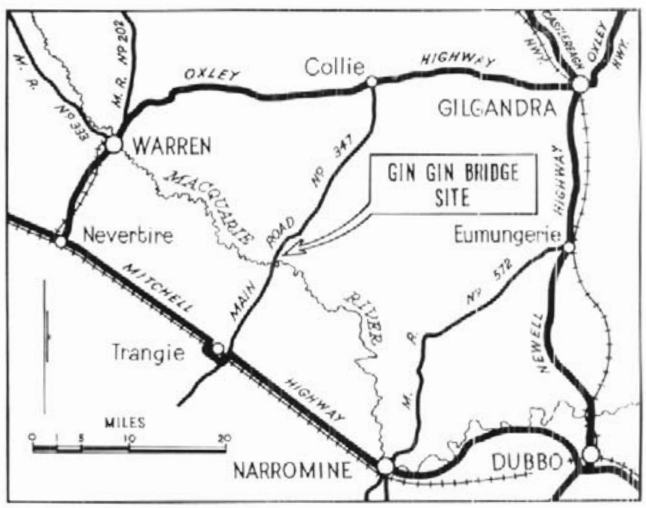
Three relatively shallow piles in the abutment of the Little Salt Pan Creek Bridge, which could be dewatered without difficulty, were filled with ready-mixed concrete in the normal way.

The overall unit cost of the Benoto piles in the three bridges, including all falsework, depreciation of the Benoto equipment, materials, labour and supervision charges, was slightly more than £20 per foot of pile constructed. It is expected, however, that this cost will be reduced on future work.



The new bridge over the Macquarie River at Gin Gin. The old timber structure is in the background of the top photograph

OPENING OF NEW MAIN ROAD BRIDGE AT GIN GIN



Locality sketch

A NEW bridgeon Main Road No. 347 in the Shire of Timbrebongie was officially opened to traffic by the Commissioner for Main Roads, Mr. J. A. L. Shaw, on the 15th February, 1963. The bridge replaced an old timber structure across the Macquarie River at Gin Gin, near Trangie, which was built in 1893.

The new bridge is a high-level, steel and reinforced concrete structure, comprising four spans. It is 330 feet long and has a width of 22 feet between kerbs, providing for two lanes of traffic. The bridge is founded on concrete piles at all piers and abutments, and includes two steel Callendar-Hamilton truss spans each 120 feet long with a 40-feet steel girder span at each end.

A number of Callendar-Hamilton trusses have been imported by the Department for use on various bridges throughout the State. They consist of standardised steel components and are designed for quick erection. The two truss spans at Gin Gin, valued at approximately £29,000, were erected in two weeks.

Fabrication of other steel work for the bridge was carried out under contract with the Department by Morison and Bearby Pty. Ltd. for the sum of £3,820.

The bridge was designed by the Department and was erected under contract by Central Constructions Pty. Ltd. for an amount of about £72,000. The approaches were completed by the Department's day labour forces at an estimated cost of £12,600.

Full cost of the work, approximately £117,000, was met by the Department.

The work was carried out under the supervision of the Department's Divisional Engineer at Parkes in the early stages Mr. R. E. Playford, and latterly Mr. H. J. Vant.

TENDERS ACCEPTED BY COUNCILS

The following tenders (in excess of £3,000) were accepted by the respective Councils for Road and Bridge Works during the three months ended 31st March, 1963.

Council	Road No.	Work	Name of Accepted Tenderer	Amount £ s. d.
Ashford Shire ..	M.R. 187 T.R. 63	Bitumen surfacing T.R. 63 from 10.42 m. to 11.34 m. south of Yetman. Main Road 187 from 39.3 m. to 41.34 m. north of Inverell.	Emoleum (Aust.) Ltd. ..	3,893 10 11
Bibbenluke ..	S.H. 19 M.R. 274 M.R. 288	Reconstruction and bitumen surfacing various lengths	Allen Bros. (Asphalting Contractors) Pty. Ltd.	4,123 12 11
Bland and Weddin.	S.H. 6 and 17	Supply and delivery of 2,347 cu. yds. of surfacing aggregate.	I. N. & J. Miller ..	6,746 1 0
Bogan ..	T.R. 57	Reconstruction and bitumen surfacing from 3.42 m. to 4.63 m. south of Nyngan.	J. L. Johnston	9,686 3 0
Carrathool ..	S.H. 6	Reconstruction and bitumen surfacing from 17.57 m. to 22.45 m. west of Rankin's Springs.	Allen Bros. (Asphalting Contractor) Pty. Ltd.	7,114 9 8
Gloucester ..	T.R. 90	Reconstruction and bitumen surfacing 0.4 m. to 1.4 m. and 7.5 m. and 5.32 m. and 8.20 m. north of Gloucester.	Shorncliffe Pty. Ltd. ..	4,386 2 6
Goodradigbee ..	T.R. 84	Bitumen resurfacing between 18.4 m. and 23.1 m. from Yass.	B.H.P. By-Products Pty. Ltd.	3,509 7 0
Gundagai ..	M.R. 243 M.R. 280 T.R. 87	Bitumen resurfacing various lengths	B.H.P. By-Products Pty. Ltd.	9,824 7 0
Gundurimba ..	S.H. 16	Reconstruction and bitumen surfacing between 25.34 m. and 27.27 m. west of Ballina.	Leitzel Construction Pty. Ltd.	64,136 19 7
Gunning ..	M.R. 249	Construction of approaches to Inglewood Bridge over Lachlan River.	A. C. Stephen & Son ..	6,729 13 3
Jerilderie ..	M.R. 321	Supply and delivery of ½ in. aggregate to various locations.	Stevenson's Blue Metal Quarries.	3,326 0 0
Jindalee.. ..	T.R. 78	Bitumen surfacing between 1.8 m. and 11.7 m. north of Cootamundra.	B.H.P. By-Products Pty. Ltd.	5,754 16 7
Jindalee.. ..	T.R. 78	Supply of aggregate for bitumen resurfacing north of Cootamundra.	Crushed Aggregates Pty. Ltd.	4,974 0 0
Ku-ring-gai ..	M.R. 328	Improvement of intersection of Babbage Road, Clive Street, East Roseville.	Tomkin & Hagen Pty. Ltd.	7,788 16 6
Lyndhurst ..	M.R. 390	Construction of four cell 9 ft. x 5 ft. R.C. box culvert at 11.90 m. from Blayney.	R. Hubbard	4,132 1 0
Manilla ..	T.R. 63	Construction of three span concrete bridge over Greenhatches Creek.	Kennedy Bros. of Lismore	12,167 10 0
Maitland ..	M.R. 104	Construction of 4 cell 10 ft. x 6 ft. R.C. box culvert and approaches at 7.58 m. from New England Highway.	F. H. Compton & Sons ..	4,730 16 6
Manning ..	M.R. 112	Reconstruction and bitumen surfacing from Wingham to Mooral Creek Turnoff.	Shorncliffe Pty. Ltd. ..	3,799 5 2
Murray ..	M.R. 388	Reconstruction and bitumen surfacing 8.9 m. to 14.1 m. from Deniliquin.	Emoleum (Aust.) Ltd. ..	3,264 3 1
Nundle	M.R. 105	Construction of reinforced concrete bridge over Dungowan Creek.	Dayal Singh Constructions Pty. Ltd.	13,146 10 9
Rylstone ..	M.R. 215	Construction of 4 span 120 ft. R.C. Bridge over Bylong Creek.	M. R. Hornibrook (N.S.W.) Pty. Ltd.	16,818 0 0
Rylstone ..	T.R. 54	Construction of 3 cell 10 ft. x 6 ft. reinforced concrete box culvert over Ryan's Creek 1 m. from Ilford.	Jacksons Concrete Products.	3,146 10 0
Talbragar ..	M.R. 206	Construction of R.C. box culvert over Deep Creek ..	Australian Concrete Products Pty. Ltd.	6,305 12 0
Tallaganda ..	Various	Supply and delivery of aggregate to various stockpiles	Australian Blue Metal Pty. Ltd.	3,177 6 0
Tumbarumba ..	M.R. 282	Construction of 3 bridges over Tumbarumba and Mannus Creeks at Tooma.	Albury Constructions ..	32,727 2 6
Wakool ..	S.H. 14	Construction of reinforced concrete bridge 279 ft. 10 in. long, and four R.C. box culverts over Yanga Creek.	Albury Constructions ..	63,063 9 0
Walcha ..	D.R. 1227	Construction of timber beam bridge and approaches over Mukki Creek at 7.72 m. east of Topdale.	L. A. Duncombe ..	4,471 0 0

TENDERS ACCEPTED BY DEPARTMENT OF MAIN ROADS

The following tenders (in excess of £3,000) for Road and Bridge Works were accepted by the Department during the three months ended 31st March, 1963.

Work or Service	Name of Accepted Tenderer	Amount £ s. d.
State Highway No. 2—Hume Highway—Shire of Demondrille. Construction of 5-span prestressed concrete girder bridge over Jugiong Creek between Yass and Jugiong.	Bowers Constructions Pty. Ltd. ..	59,995 8 0
State Highway No. 7—Mitchell Highway—Shire of Bogan. Construction of 3 R.C. box culverts at 32.54 m., 35.27 m. and 39.52 m. north of Nyngan.	M. & A. Warnock	8,959 6 8
State Highway No. 8—Barrier Highway—Broken Hill District. Supply and delivery of 1,050 cu. yds. of ½ in. aggregate to various stockpiles 74 m. to 80 m. east of Broken Hill.	Australian Blue Metal	4,846 8 1
State Highway No. 10—Pacific Highway—Shire of Stroud. Supply and delivery of 51,500 cu. yds. of gravel between Viney Creek and Bulahdelah.	Frost Developments Pty. Ltd.	72,100 0 0
State Highway No. 10—Pacific Highway—Shire of Port Stephens. Supply of 48 precast pretensioned concrete bridge units 35 feet long for bridge over Twelve Mile Creek.	Stresscrete Pty. Ltd.	3,590 0 0
State Highway No. 16—Bruxner Highway. Construction of reinforced concrete retaining walls and stairs in approaches to new bridge over Richmond River at Ballina and Elliott Streets, Lismore.	R. & B. Constructions Pty. Ltd. ..	36,638 0 0
State Highway No. 17—Newell Highway—Shire of Boolooroo. Construction of 3 R.C. box culverts at 6.55 m., 13.57 m. and 13.88 m. south of Moree.	A. Badesso & Son	9,920 0 0
Sydney—Newcastle Expressway—Shire of Gosford. Construction of section Hawkesbury River Bridge to Mount White.	K. D. Morris & Sons Pty. Ltd.	2,011,996 18 2
Sydney-Newcastle Expressway—Shire of Gosford—Construction of Section 16.87 m. to 19.96 m. immediately east of Ourimbah.	Thiess Bros. Pty. Ltd.	230,235 15 1
North Western Expressway—Municipality of Hunter's Hill. Construction of 7-span prestressed concrete bridge of 626 feet 6 inches in overall length and 38 feet wide at Huntley's Point.	Hutcherson Bros. Pty. Ltd.	119,949 16 6
Trunk Road No. 51—Shire of Tallaganda—Construction of four-span prestressed concrete girder bridge 233 feet long over Mongarlowe River.	Central Constructions Pty. Ltd.	43,796 18 0
Main Road No. 165—Victoria Road—City of Parramatta. Manufacture and delivery of prestressed concrete bridge units and footway slabs, for reconstruction of bridge over Subiaco Creek.	Stresscrete Pty. Ltd.	5,893 4 0
Main Road No. 194—Municipality of Rockdale. Widening of bridge over Cook's River at Mascot.	Leewil Constructions Pty. Ltd.	35,864 0 0
Secondary Road No. 2021—Municipalities of Marrickville and Canterbury. Conversion of Tramway Bridge over Cook's River at Undercliffe to Road Bridge.	Pearson Bridge Pty. Ltd.	22,565 0 0

MAIN ROADS STANDARD SPECIFICATIONS

Note: Drawings are prefixed by letter "A", instructions are so described; all other items are specifications or forms (Revised schedule March, 1963)

ROAD SURVEY AND DESIGN

	Form No.
Design of two-lane rural highways (Instruction) (1960)	355, 355A, 355B
Design of urban roads (Instruction)	369
Design of intersections (Instruction)	288
Design of acceleration and deceleration lanes (Instruction)	402
Design of kerb-lines and splays at corners (Instruction)	499
Design of subsoil and subgrade drainage (Instruction)	513
Horizontal curve transitions for 30, 40, 50 and 60 M.P.H. design speeds. (1963.)	A 1488, A, B and C.
Method of setting out horizontal curve transitions	A 1487

STREET DRAINAGE

Concrete converter	A 1418
Concrete kerb and gutter, light type	A 221
Gully grating	A 190
Gully pit, Specification (245) and Drawings; gully pit with grating (A 1042); kerb inlet only (A 1043); grating and extended kerb inlet (A 1352); extended kerb inlet only (A 1353).	
Integral concrete kerb and gutter	243
Mountable type kerb with reflectors	A 3536
Perambulator ramp	A 3491
Vehicle dish crossing	A 134A

CULVERTS

(a) Cast in place reinforced concrete box culverts—	
Reinforced concrete culvert	206
Single cell, height of opening 4 ft. to 12 ft.	A. 1014-20B
Two cell, height of opening 4 ft. to 12 ft.	A 1023-30A
Three cell, height of opening 4 ft. to 7 ft. (A 1033-36); 8 ft. (A 1038); 9 ft. (A 1040); 10 ft. to 12 ft. (A 4843-45).	
Four cell; height of opening 4 ft. to 12 ft.	A 4846-54
Reinforced concrete box culverts with concrete wearing surface and concrete handrailing, heights of opening 3 ft. to 12 ft. 1, 2, 3, and 4 cells.	A 4994-97
Posts and handrails for culverts	A 3732
(b) Precast reinforced concrete box culverts—	
Culverts with height of opening 12 in. 18 in., 24 in., and 30 in.	A 3847
Precast concrete box culvert	138
(c) Pipe culverts—	
Pipe culverts and headwalls	25
Drawings are available for the following pipe culverts— (*a*) Single row of pipes—15 in. to 6 ft. dia. (*b*) Double row of pipes—15 in. to 6 ft. dia. (*c*) Treble row of pipes—15 in. to 3 ft. dia.	
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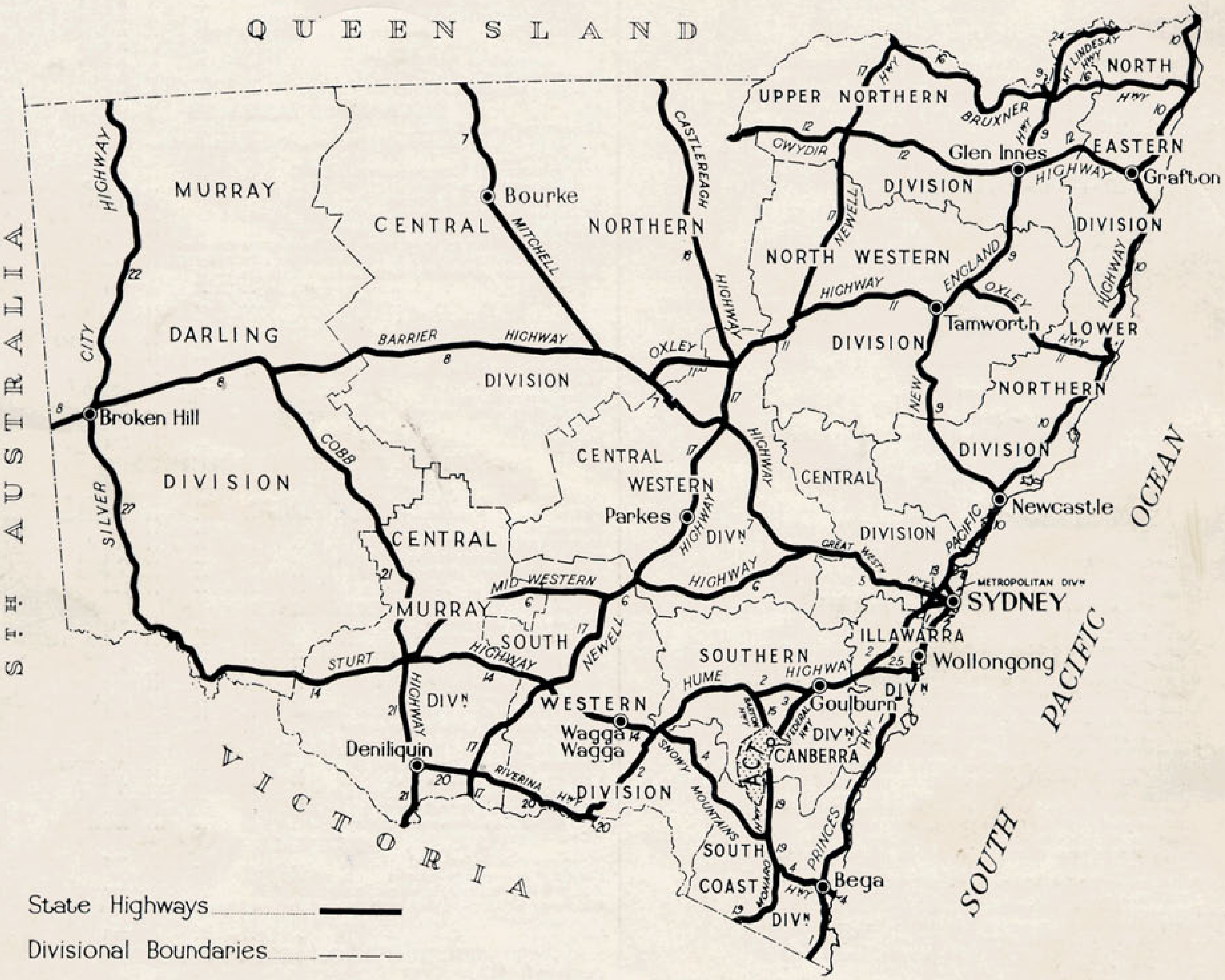
MANUALS AND BULLETINS

Bulletin relating to Miscellaneous activities on Main Roads.
Control and guidance of traffic at Works in Progress.
General Conditions of Assistance to Councils.
Guide to Main Roads Administration for use of Aldermen and Councillors.
Highway Bridge design, Specification of State Road Authorities.*
Manuals, No. 1—Plant*; No. 2—Survey and Design for Main Roads Works*; No. 3—Materials*; No. 4—Roadside Trees*; No. 5—Explosives*; No. 6—Bridge Maintenance*; No. 7—Road Maintenance*.
Proclaimed Main Roads (Schedule of gazetted descriptions).
Policy for geometric design of rural roads—State Road Authorities*.

All standards may be purchased from the Head Office of the Department of Main Roads, 309 Castlereagh Street, Sydney. Single copies are free to Councils except those marked *.

Sydney: V. C. N. Blight, Government Printer—1963

State Highway System of the State of New South Wales



State Highways .... ▬▬▬

Divisional Boundaries .... – – – –

Divisional Offices .... ⦿

SCALE OF MILES

40 20 0 40 80 120 160 200

Area of New South Wales, 309,433 square miles.

Length of public roads within New South Wales, 129,763 miles.

MILEAGE OF MAIN AND DEVELOPMENTAL ROADS, AS AT 30th JUNE, 1962.

State Highways	6,493
Trunk Roads	4,163
Main Roads	11,647
Secondary Roads (County of Cumberland only)	100
Tourist Roads	54
Developmental Roads	3,082
	25,539
UNCLASSIFIED ROADS, in Western part of State, coming within the provisions of the Main Roads Act	1,031
TOTAL	**26,570**