MAIN ROADS

SEPTEMBER 1969

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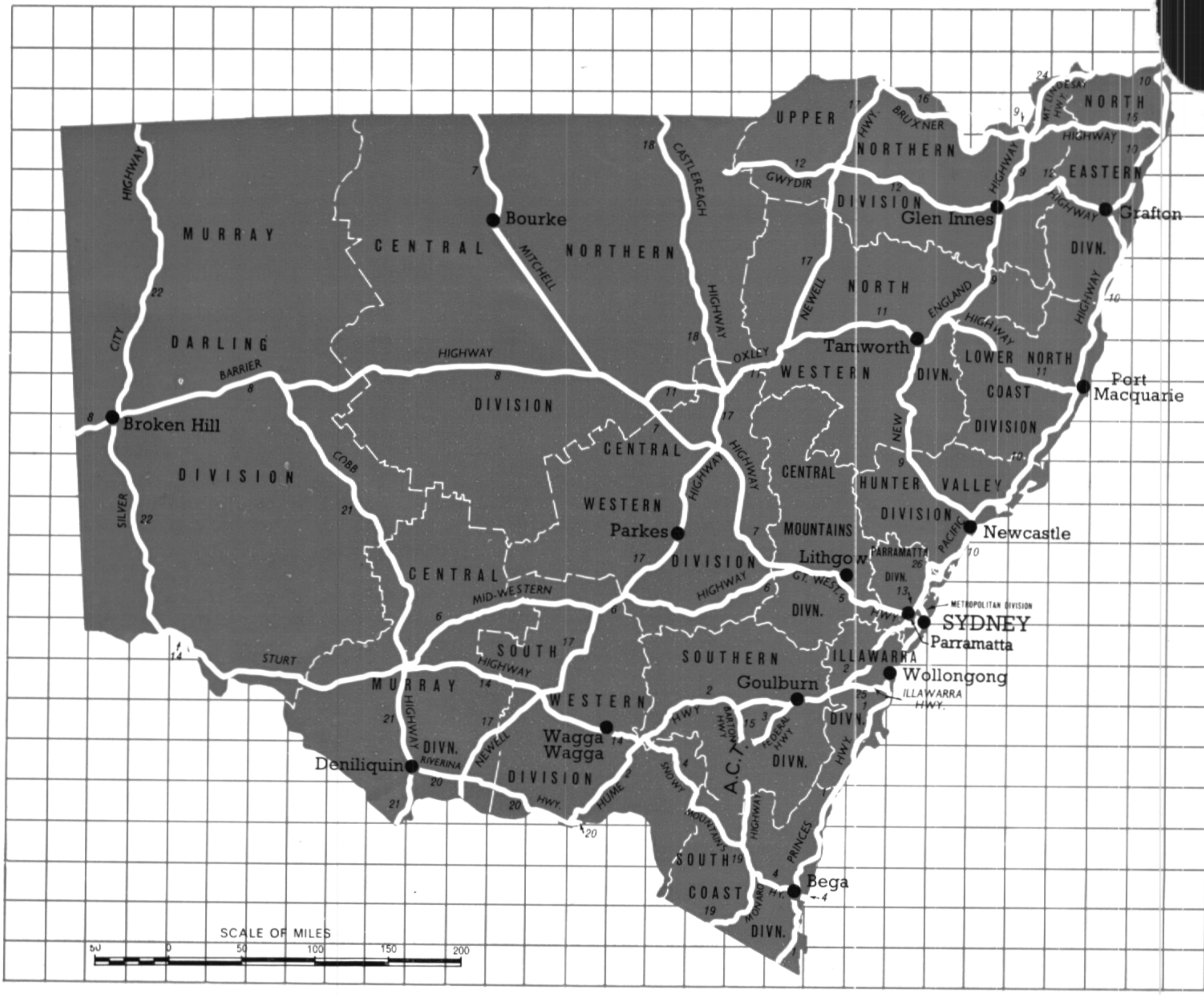

HIGHWAY SYSTEM OF NEW SOUTH WALES

Mileage of Main, Tourist and Developmental Roads, as at 30th June, 1969

Expressways	24
State Highways	6,535
Trunk Roads	4,210
Ordinary Main Roads	11,550
Secondary Roads (County of Cumberland only) ..	164
Tourist Roads	219
Developmental Roads	2,719
	25,421
Unclassified roads, in western part of State, coming within the provisions of the Main Roads Act	1,572
TOTAL	26,993

Area of New South Wales—309,433 square miles

Length of public roads within New South Wales—131,300 miles

Population of New South Wales at 30th June, 1969—4,474,600

Number of vehicles registered in New South Wales at 30th June, 1969—1,847,597

STATE HIGHWAYS
DIVISIONAL BOUNDARIES
DIVISIONAL OFFICES

MAIN ROADS

Journal of the Department of Main Roads, New South Wales

SEPTEMBER, 1969

VOLUME 35 NUMBER 1

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Front Cover: New bridge over the Macquarie River at Dubbo.

Back Cover: Some roads and bridges in the Newcastle-Hunter Valley Region—
(1) *Pacific Highway north of Raymond Terrace.*
(2) *Deviation of the New England Highway near the Liddell Power Station between Muswellbrook and Singleton.*
(3) *The attractive Fitzgerald Bridge over the Williams River at Raymond Terrace.*
(4) *Dual carriageways on the New England Highway and Hexham Bridge on the route of the Pacific Highway in the background.*
(5) *Bridge over the south arm of the Hunter River from Tourle Street, Mayfield to Kooragang Island.*
(6) *Bridge over the Hunter River at Shallow Crossing* 40 *miles west of Scone on Main Road No.* 105.

Building Big Bridges

Included in this issue is a detailed description of the design and construction of the new bridge over the Macquarie River at Dubbo. This bridge is 2,013 feet long and is the fourth longest road bridge in New South Wales. The first three places are filled by—

- the Sydney Harbour Bridge—3,770 feet
- the bridge over the Murrumbidgee River at Gundagai—3,025 feet and
- the bridge over the Clarence River at Harwood—2,915 feet.

However, this order will change on completion of—

- the bridge over the north arm of the Hunter River at Stockton—3,358 feet and
- the bridge over the Nepean River at Camden—3,380 feet.

With wide coastal rivers to cross it is inevitable that long bridges will feature frequently in the work of the Department. In addition, many narrow rivers require long bridges because in times of flooding the watercourses are extended hundreds of yards over adjacent flood plains. This situation applies at Gundagai where the Department proposes to build a new bridge on a deviation of the Hume Highway. A design is being prepared for a structure approximately 3,750 feet long.

The Department is not only concerned with building "big" bridges. Good roads also depend on short and unobtrusive crossings of the many smaller rivers and creeks which intersect the Main Roads System at a multitude of locations. During the year ended 30th June, 1969 the Department completed the construction of sixty new bridges and eighty bridge-size culverts while a further seventy-five bridges and seventy bridge-size culverts were under construction.

Although it is generally "big" bridges which capture the attention of the motorist, the Department is aware that his safety and ease of travel depends on well designed and capably built structures of all sizes.

FIVE YEAR PROGRAMME OF WORKS

The June, 1969 issue of* Main Roads *referred in its editorial to the programme of works in urban areas likely to be constructed or commenced at an earlier date than had been planned, due to the allocation of special funds for arterial roads in these areas under the new Commonwealth Aid Roads Act.

This increased activity in road and bridge construction will be projected throughout the State because of the emphasis now placed on the requirements of arterial roads, i.e. those roads carrying large volumes of traffic between major centres of population. This article outlines some of the more important projects likely to be commenced within the next five years.

The road planning proposals of the Department provide for the construction of expressways in the urban corridor of Newcastle-Sydney-Wollongong to cater for traffic needs.

In the County of Cumberland provision is made for 180 miles of expressways. Beyond the boundaries of the County of Cumberland it is planned that expressways will extend southerly to Wollongong and Kiama, southwesterly to Mittagong, westerly to the Blue Mountains and northerly to Newcastle. Because of financial limitations these expressways can only be built in stages and of necessity only those sections where urgent traffic relief was needed have been provided so far.

SYDNEY-NEWCASTLE EXPRESSWAY

Completed Tollwork The 10-mile section of expressway between the Hawkesbury River and Calga was completed in two stages. In December, 1965 the first stage between the Hawkesbury River and Mount White was opened to traffic as a Tollwork. Ten months later, in October, 1966 the section from Mount White to Calga was completed and opened to traffic as an extension of the Tollwork. In December, 1968 the section of expressway, between Berowra and the Hawkesbury River, was completed and it is also operating as a Tollwork. This section is linked with the widened Pacific Highway by an interchange just north of Berowra. At present the Tollwork north of the Hawkesbury River carries approximately 84 per cent of all traffic and the section south of the Hawkesbury River carries approximately 70 per cent of all traffic. The Pacific Highway adjacent to these sections carries 16 per cent and 30 per cent respectively.

Hawkesbury River Bridge The Department is currently planning the construction of a new six-lane bridge over the Hawkesbury River to serve expressway traffic only and to link the completed Tollworks operating north and south of the river. Plans are being prepared and the Department has already invited tenders for the construction of the foundations for the new bridge. While this part of the work is proceeding, the Department will complete the design and call tenders for the main construction. By arranging for the construction of the bridge in this manner, the Department plans to have it completed and opened to traffic before Christmas, 1971.

Ourimbah to Doyalson One of the more difficult sections for traffic to negotiate on the Pacific Highway at the present time is through the shopping area at Wyong. In order to alleviate the position by allowing through traffic to go around Wyong, the Department proposes that the section of the expressway between Ourimbah and Doyalson will be the next to be constructed.

The original planning for this expressway, undertaken in the 1940's, provided for the route to pass between Wyong and Tuggerah Lake, that is, to the east of Wyong. Because of more recent planning proposals with regard to land use and in view of current road design requirements, this proposal has been re-examined and the Department has now determined on a route from Ourimbah to Doyalson passing to the west of Wyong. This route also has the advantage that, should a major airport be established north of Wyong and to the west of the railway, convenient road access will be available to the expressway. It is also proposed that this 13-mile section be a tollwork and it is expected to be in operation by December, 1972.

Swansea The Sydney-Newcastle Expressway is planned to cross the entrance to

Lake Macquarie east of Swansea. At the present time the Department is proceeding with the bridge and road design of a section of the expressway, including the bridge over the entrance to Lake Macquarie, from north of Swansea to a point where the expressway route crosses the existing highway $1\frac{1}{2}$ miles south of Swansea. This will provide a route around the business centre where through traffic at times is greatly inconvenienced by the movement of local and pedestrian traffic. It is proposed to call tenders in the latter half of 1970 for the construction of the bridge. It will be a high level structure, free from interruption by shipping, which is a difficulty at present experienced on the opening bridge on the Pacific Highway at Swansea.

EASTERN EXPRESSWAY

William Street Underpass The construction of an underpass under William Street will be the first step in the construction of the Eastern Expressway. This work will be complementary to the construction of the King's Cross road tunnel. It will grade separate traffic in William Street from that proceeding to and from the Cahill Expressway along the streets now used, namely Crown and Palmer Streets. The area of land involved in this work is bounded by Palmer, Bourke, Cathedral and Stanley Streets and the Department will commence negotiations for the acquisition of these properties in the near future.

This work is being planned with a view to its completion at about the same time as the King's Cross project.

SOUTHERN EXPRESSWAY

The proposed Southern Expressway provides for a fast through route leading from Sydney to Wollongong and beyond towards Kiama. During past years, work has been carried out on this expressway by the provision of the Captain Cook Bridge over the Georges River and its immediate approaches and work at Wollongong which provides a road around the central area of the city south to Fig Tree. In addition much property has already been purchased to provide for the construction of the remaining sections.

Due to the rapid and unanticipated growth of industry at Wollongong, the Department proposes to raise the standard of the facility at Wollongong so that six lanes can be provided for traffic in lieu of the four lanes originally planned and built. Planning of this work is in hand.

Wollongong—Extension of work Plans for the section between Fig Tree and Five Islands Road are well advanced. This section, however, is extremely complex as it involves considerable bridging across existing roads, waterways and railways and for this reason final plans will take some time to complete. In the meantime, the Department will actively carry on with the construction of a further section south from Five Islands Road to Kembla Grange, where the structural needs are not likely to restrict progress. This section of expressway will provide a new route for through traffic avoiding the business centre and the railway level crossings at Unanderra.

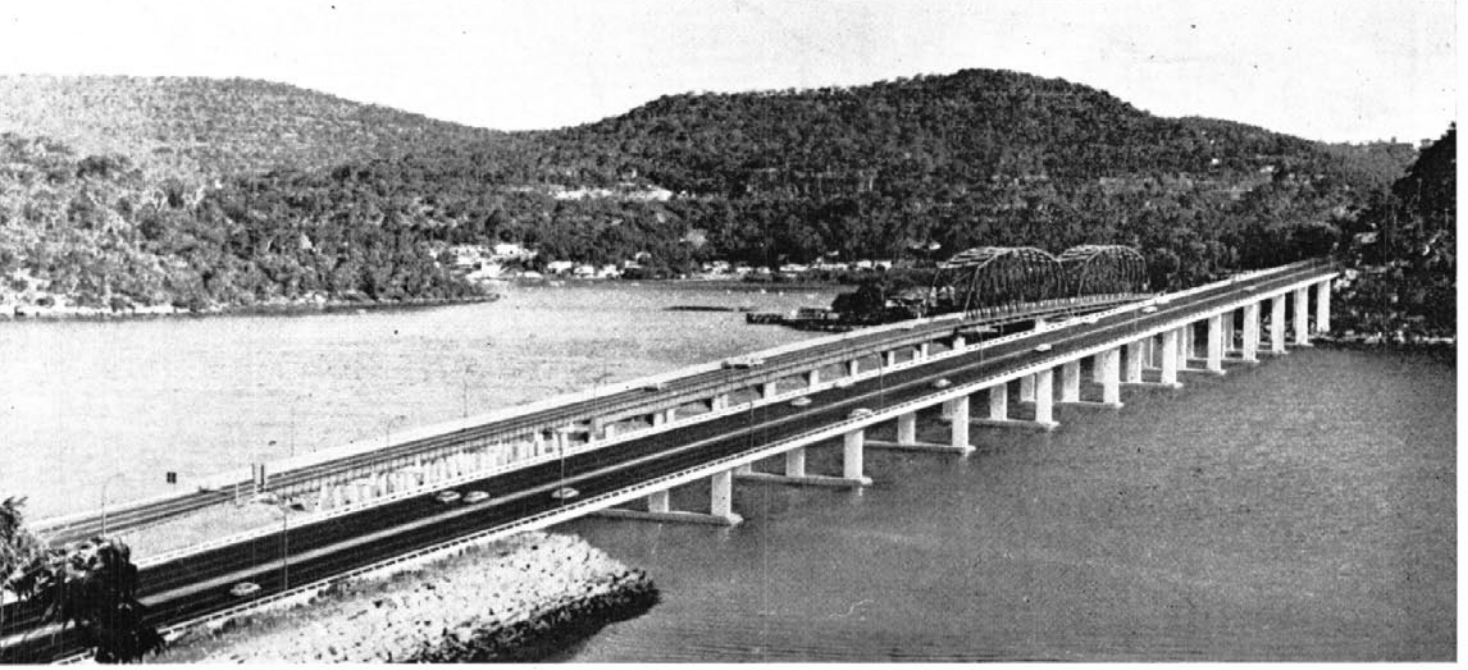
Concurrently, action is in hand for the extension of a branch of the expressway northward from North Wollongong towards Bulli. It has also been found desirable to raise the standard of this section in view of the population expansion. The Department has acquired much of the property on this route and will shortly commence the acquisition of the remaining properties needed to allow work to proceed.

Waterfall-Bulli Pass The Prince's Highway is to be widened to four lanes to Waterfall. Between Waterfall and the top of Bulli Pass, from where there are two roads to Wollongong, the Department is in the final stages of investigation for the construction of a 14-mile section of the expressway.

When these works on the Southern Expressway are completed, and this should be within three years, greatly improved facilities will be available for traffic between the centres of Sydney and Wollongong, thus alleviating many of the difficulties which now occur due to the present inadequate two-lane roadway from Loftus to Bulli Pass.

St Peters-Tempe The Department appreciates the difficulties encountered by motorists on the Prince's Highway between Tempe and St Peters and in

Artist's impression of the proposed bridge over the Hawkesbury River to serve Sydney-Newcastle Expressway traffic. The view is looking south and shows the present bridge on the left



consequence will accelerate the preparation of plans for the partial construction of a section of the Southern Expressway from the vicinity of St Peters to Tempe. This proposal is now being investigated and when the design has been finalised, the necessary properties will be acquired prior to construction being commenced.

SOUTH WESTERN EXPRESSWAY

Cross Roads to Campbelltown This work was referred to in some detail in the March, 1969 issue of this journal. In recognition of the rapid rate at which the population in the Campbelltown area is increasing and will continue to increase, the Department will undertake construction of the section of the South Western Expressway from the Cross Roads, Liverpool to the Campbelltown-Camden Road, a distance of 9 miles. Plans are being prepared and property acquired for the right of way. Construction is planned to commence this year and is programmed for completion before 30th June, 1972.

NORTH WESTERN EXPRESSWAY

The North Western Expressway is planned to provide a convenient route for through traffic from the city to the north-western sector of the Sydney Metropolitan Area. In traversing the Lane Cove Valley, it will become the Lane Cove Valley Expressway which in turn will link with the Sydney-Newcastle Expressway at Wahroonga. A major section, consisting of the Gladesville, Tarban Creek and Figtree Bridges together with the complex of roadworks associated with them, has already been built and has provided considerable relief for traffic.

Druitt Street, Sydney to Bridge Road, Glebe The working drawings and specifications for this section of the expressway are being prepared for the Department by consultants. These plans are expected to be completed by mid-1970. This section will be a very complex undertaking as a considerable amount of the work will be in structure. Already the Department has acquired some properties and negotiations will proceed for the necessary remaining properties to be acquired so that construction may commence soon after the plans have been completed.

Artist's impression of the first stage of the Western Distributor (upper left) and section of the North Western Expressway (right) crossing Darling Harbour Goods Yard

WESTERN DISTRIBUTOR

Sydney Harbour Bridge to Day Street near Erskine Street The full length of the Western Distributor will extend from the southern end of Sydney Harbour Bridge to Ultimo where it will link by an interchange with the Southern and Western Expressways. It is proposed to construct it in stages and the first section will extend from the bridge to Day Street near Erskine Street. This will lead traffic under Pyrmont Bridge and also provide for grade separation of traffic on the southern approach to the Sydney Harbour Bridge.

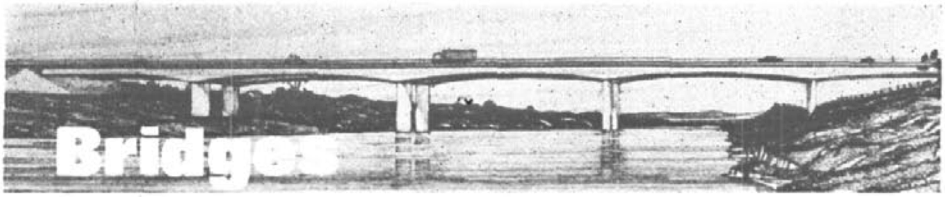
The Department is currently examining tenders submitted for the construction of this section and it expects that work will commence shortly after a tender is accepted. Meanwhile the Department is acquiring the balance of properties required for the work and arranging for the necessary alterations to public utility services. The work is planned to take 3 years to complete.

WESTERN EXPRESSWAY

The planned Western Expressway will provide a fast through route from the City to the lower Blue Mountains. Of necessity, as with other expressways, it will be constructed in sections.

Prospect to Emu Plains At the present time the Department has arranged for the construction of a bridge over the Nepean River at Regentville as the first step in the construction of this expressway. The western approaches to this bridge, built to expressway standards, will link with the Great Western Highway at Emu Plains. The Department proposes to progressively construct the expressway from the bridge easterly to link with the widened Great Western Highway west of Prospect. However, in order to provide relief as quickly as possible, one carriageway only will be built in the first instance and this will be later supplemented with the second carriageway.

Homebush-Auburn In order to relieve traffic on the Great Western Highway in this area, when the Sydney Markets are moved to their new location, it is proposed to construct a section of the expressway between Homebush and Auburn. The Department is currently investigating proposals for this section and is about to acquire the balance of the properties required.



For a number of years the Department has been engaged in an extensive programme of bridge construction throughout the State.

Numerous major bridges have been constructed to replace old structures and ferries and at locations where none previously existed.

Within the next 5-year period the Department will continue this programme of bridge building and many important works will be undertaken.

Murrumbidgee River at Gundagai The design for this bridge, which will be situated on a deviation of the Hume Highway around the town of Gundagai, is being prepared by the Department. There have been considerable problems to be overcome because of the extreme flood conditions but it is expected that this bridge and the deviation should be completed within 5 years. The Department has had discussions with council concerning the route to be adopted.

Georges River at Alford's Point The Department proposes to construct a new bridge over the Georges River at Alford's Point on the route of a county road which will link Henry Lawson Drive with the road leading to Menai. The design for this bridge is now being prepared and tenders are expected to be invited during the current financial year. This new bridge will provide another major road crossing of the Georges River to serve the fast developing southern section of the Sydney Metropolitan Area.

Lake Illawarra at Windang The design for this bridge, duplicating the existing structure at this location, is being prepared and the Department expects to invite tenders later this year with a view to commencing construction early in 1970. When completed this work will provide considerable relief for traffic in this busy area.

Bellinger River, South Arm at Urunga The existing bridge on the Pacific Highway at this location is due for replacement shortly. A design is being prepared and it is likely that construction will commence in 1970.

Bega River at Bega The existing bridge on the Prince's Highway is located north of the town of Bega. It is an old narrow structure due for early replacement. A design is being prepared for a new bridge, situated on a deviation of the highway. It is likely that this bridge will be commenced in 1971. The deviation when completed will ultimately pass around the town of Bega.

Brisbane Water at The Rip The Department has prepared a design for this bridge which will provide a convenient access to tourist areas on the central coast. The council has to acquire the necessary land for the approaches. When this has been done tenders can be invited and it is expected that construction will commence late in 1969 or early in 1970.

Macleay River at Smithtown At the present time a ferry service operates at this site on Main Road No. 556, the road which leads to South West Rocks. The Department has arranged for consultants to prepare a design for a new bridge at this location and it is likely that construction will commence in 1970.

Cooks River at Arncliffe Construction of a new bridge over Cooks River will be carried out as part of the improved access roads to Sydney (Kingsford Smith) Airport. Its approaches will be linked with Marsh Street, Arncliffe. Design is well in hand and construction is expected to commence about October, 1969.

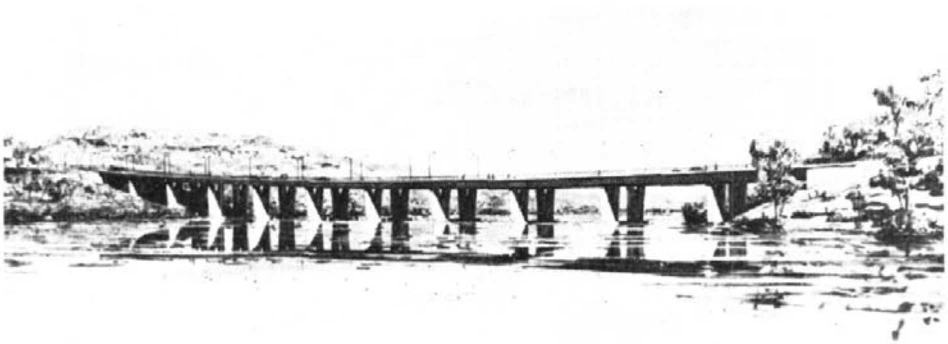
Wilson River at Telegraph Point A new bridge is required at this location on the Pacific Highway and a design will be prepared with a view to inviting tenders in 1970–71.

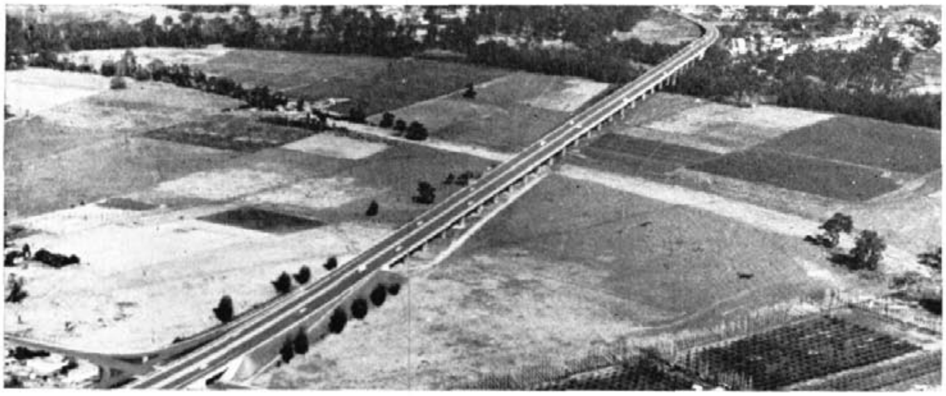
Murrumbidgee River at Hay The existing bridge at this location is due for replacement and a design is now being prepared. It is likely that tenders will be invited in 1970.

Murray River Crossings Major bridges across the Murray River are required at Echuca, Swan Hill and Mildura. The existing bridges at these important connections between Victoria and New South Wales require replacement in the

Below: Artist's impression of the proposed bridge over the Georges River at Alford's Point

Bottom: Artist's impression of the proposed bridge over Brisbane Water at the Rip

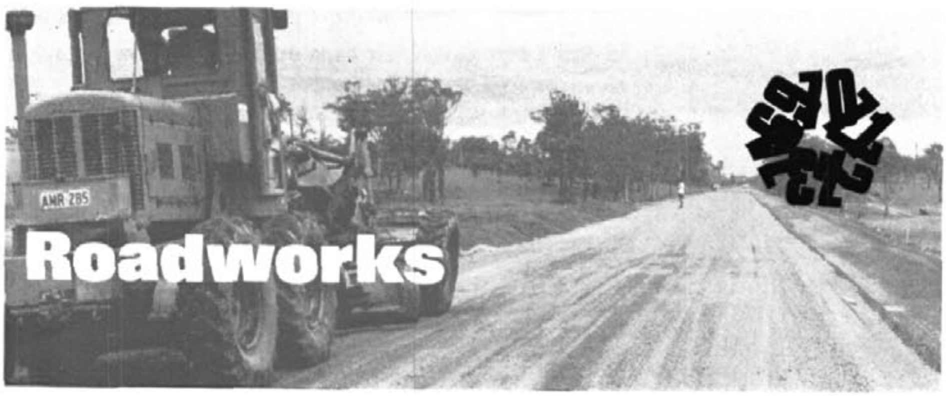




Artist's impression of the proposed bridge over the Nepean River at Camden which will be constructed on a deviation of the Hume Highway—looking southwest

near future. The Department is conferring with the Victorian Country Roads Board, concerning their location. The bridge at Echuca is likely to be the first to be constructed. Following agreement with the Board a design will be prepared and it is likely that a start could be made in 1970–71.

Nepean River at Camden A new bridge is being constructed over the Nepean River at Camden on a deviation of the Hume Highway. It will replace the existing bridge which is subject to flooding. The Department has already commenced construction of the foundation piles and will shortly call tenders for the main construction. This bridge will have an overall length of 3,380 feet and, when completed, it will be the second longest road bridge in New South Wales.



The Department will continue to press on with the reconstruction and bitumen surfacing of Main Roads throughout the State.

It has programmed for the provision of not less than 4,000 lane miles of new bitumen surfaced roads (i.e. equivalent to 2,000 miles of two-lane rural road) in the three years from 1st July, 1968 to 30th June, 1971.

At the same time the Department is undertaking the provision of increased widths of pavements, additional lanes on existing roads and climbing lanes for slow-moving vehicles as well as strengthening, realignment, regrading and maintenance resurfacing, all of which are necessary in the interests of road safety.

Some of the important roadworks in this programme include:

Barrier Highway The completion of the reconstruction and bitumen surfacing of the Barrier Highway between Broken Hill and Wilcannia by June, 1970. This will be followed by an acceleration of similar work between Wilcannia and Cobar with a view to sealing the highway throughout, thus providing a sealed connection from the South Australian border via Wilcannia and Cobar, to Sydney by mid-1972.

Mitchell Highway The reconstruction and bitumen surfacing of the Mitchell Highway between Bourke and the Queensland border at Barringun is being undertaken as a continuing programme and will be carried through to completion.

This improved road will considerably aid the movement of stock from south-western Queensland to the meatworks and the rail terminus at Bourke. A sealed road already exists between Bourke and Sydney.

Oxley Highway Several years ago the Department embarked upon a programme of improvement on the Oxley Highway. The completion of the reconstruction and bitumen surfacing between Wauchope and Walcha is planned by the end of 1972, thus providing another bitumen surfaced link from central New South Wales to the coast.

Newcastle By-pass Work is proposed on the provision of a new high-speed express-way type road in the Newcastle area from Windale to Sandgate. This road will link the residential areas along the Charlestown-Swansea peninsula and the industrial areas north and west of Waratah and provide a through route around New-castle for highway traffic travelling bet-ween Sydney and areas north of Newcastle.

Hume Highway Numerous improvements have already been carried out on the Hume Highway between Sydney and Albury and more are planned. These will include the construction of a modern overpass to provide for safe interchange of traffic between the Hume and Federal Highways at their junction eight miles south of Goulburn where traffic is heavy.

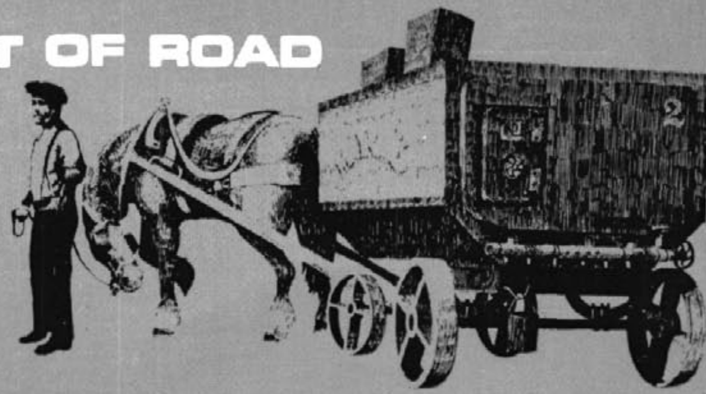
Associated with this work, a dual carriageway will also be provided on the Hume Highway, between this junction and Goulburn, including a new bridge over the main southern railway line.

Great Western Highway Work is already in hand to extend the dual carriageways on the Great Western Highway from the western end of the Prospect Deviation towards Penrith. This will be in association with work on the Western Expressway easterly from Penrith. Other improvement works have already been provided on this highway, such as the climbing lanes on the Victoria Pass and work is now under way on a deviation near Yetholme.

Prince's Highway In order to provide greatly improved traffic facilities on the Prince's Highway and to provide a first class road to link with the proposed Waterfall-Bulli Pass section of the Southern Expressway, the Department will provide four lanes on the Prince's Highway between Loftus and Waterfall by extending it southwards from Loftus to link with the work already completed at Engadine and then on through Heathcote to Waterfall.

Bruxner Highway Considerable work has already been undertaken on the Bruxner Highway and this is being continued. The reconstruction and bituminous surfacing between Tenterfield and Boggabilla will be carried on until completed.

THE DEVELOPMENT OF ROAD AND BRIDGE ENGINEERING OVER THE PAST FIFTY YEARS



WITH SPECIAL REFERENCE TO THE NEWCASTLE-HUNTER VALLEY REGION

At the end of the First World War, the road system in the Hunter Valley region was in a very undeveloped state, although it was probably adequate for the relatively small volumes and variety of traffic then using it. The total number of registered motor vehicles in New South Wales at that time was in the vicinity of 35,000 compared with 1,750,000 today. In the Hunter Valley region there were only about 4,000 registered motor vehicles as horse drawn vehicles were still the main means of transportation. Communication between Sydney and Newcastle was by means of the railway which was completed in 1889 and the other principal centres in the district were served by branch lines and feeder roads. A great deal of movement of goods was undertaken by coastal and river shipping.

In 1919 there were barely 30 miles of road provided with a dustless surface in the whole of the Hunter Valley region. Sealed pavements consisted mostly of conglomerate gravel although wood blocking had been laid down on a number of streets in the inner Newcastle area.

Timber beam and truss bridges, and, on occasion, bridges of steel or wrought iron had been constructed over many important crossings but many streams were still not bridged. Considerable use was made of punts and ferries at tidal streams.

By 1919 Newcastle had already launched into an era of rapid growth that has made it one of Australia's most important industrial centres, and, next to Sydney, the most important city in New South Wales.

Despite this fact it is interesting to note that no direct road linked the two cities. The road connection between Sydney and the Hunter Valley served the farms of Morpeth and Wallis Plains but it became increasingly obvious that the weight of importance had swung to the highly developed industrial complex at Newcastle.

As motor vehicles became a reliable means of undertaking long journeys, there was an increasing demand for improved roads and this resulted in the creation of the Main Roads Board in 1925. The foundation of the Board, later succeeded by the Department of Main Roads in 1932, commenced a new era in Main Roads financing and administration. One of the first activities of the Board was the proclamation of numerous principal roads as Main Roads and subsequent proclamations and a classification system have resulted in a statewide road network, the Main Roads System of today. The classification system, introduced in 1928, enabled Main Roads subsidies to be paid to local governing bodies as follows: State Highways—100 per cent of cost; Trunk Roads—75 per cent; Ordinary Main Roads—$66\frac{2}{3}$ per cent; and Developmental Roads—generally 100 per cent. In December, 1960 the Main Roads Act was amended to provide for the proclamation of Tourist Roads and to allow the Department to grant financial assistance on a 50 per cent basis.

Perhaps the most important individual work put in hand by the Main Roads Board was the construction of a direct road link between Sydney and Newcastle via Peat's Ferry. Work was commenced on this road at Berowra as early as July, 1925, under the supervision of the Hornsby Shire Council, and within the following 12 months active operations were in hand at various points between Hornsby and Gosford and in the vicinity of Catherine Hill Bay. The total length from Sydney to Newcastle by the new route was 107 miles, as against 155 miles via the old Wiseman's Ferry route, and apart from sections in the suburbs of Sydney and Newcastle, the bulk of the length required construction or reconstruction. The road was opened to traffic in August, 1930, following the

OLD DAYS -- OLD WAYS

Top: Muscle, shovel and horse power on the Newcastle-Maitland Road. This photograph was probably taken in 1926
Centre: Bullock team at work on the Catherine Hill Bay deviation of the Sydney-Newcastle Road in 1927
Bottom: Another scene showing the construction of the Sydney-Newcastle Road in November, 1928. *Trucks appeared more frequently in photographs as this work progressed*

establishment of a modern ferry service across the Hawkesbury River from Kangaroo Point to Mooney Mooney Point. This ferry service was replaced by the present Hawkesbury River (Peat's Ferry) Bridge which was opened to traffic on 5th May, 1945.

The Sydney-Newcastle Road was proclaimed a State Highway on 17th May 1929 under the name of the Great Northern Highway. However, on 29th May, 1931 it was included in the coastal route, between Sydney and the Queensland border, which was proclaimed the Pacific Highway.

In 1932, in order to provide closer co-operation and understanding with Councils, the Department decided to decentralize its administration by the establishment of six divisional areas including the Lower Northern Division with headquarters at Newcastle. The boundaries of this division were altered in June, 1966, following the establishment of a new divisional office at Port Macquarie, and the name was changed to Hunter Valley Division. Today the Department has 16 divisional offices throughout the State.

Over the past fifty years, steady progress has been made in the improvement of existing Main Roads. What were previously narrow, winding, and unsealed roads have been reconstructed to a high standard to provide for increased traffic volumes and the smoother riding qualities that modern high performance vehicles require. There are now 215 miles of State Highways, 41 miles of Trunk Roads, 760 miles of Ordinary Main Roads, 11 miles of Tourist Roads and 46 miles of Developmental Roads within the Department's Hunter Valley Division, and only a small proportion is without some form of dustless pavement.

ADVANCE PLANNING

Planning the Main Roads System has always been a continuous process, and although investigations were temporarily interrupted during the Second World War, they were resumed soon after. The plan for the Hunter Valley region was co-ordinated with those for Sydney and Wollongong and this resulted in the formulation of the Northumberland County Plan. This Plan, which includes the existing network of roads, provides for additional routes known as County Routes which have been reserved for future development. Under the Plan, the Department is responsible for the fixing in this area of the boundaries of approximately 113 miles of the Main Roads

Location	Annual Average Daily Traffic Volume 1967	Annual Average Daily Traffic Volume 1968	Percentage Change
Sydney-Newcastle Expressway Hawkesbury River-Calga Tollway south of Mt White in Shire of Gosford	10,270	11,290	+10%
New England Highway—State Highway No. 9 2·9 miles east of the Singleton-Gostwyck Road (Main Road No. 128) in Shire of Patrick Plains	3,090	3,430	+11%
Pacific Highway—State Highway No. 10 Swansea—2 miles south of bridge over the entrance to Lake Macquarie in Shire of Lake Macquarie	7,590	7,960	+5%
Charlestown—south of Smart Street in Shire of Lake Macquarie	30,110	31,390	+4%
Hexham—Bridge over Hunter River in City of Newcastle	9,200	10,190	+11%
Karuah—Bridge over Karuah River in Shire of Port Stephens	3,090	3,370	+9%
Main Road No. 101—West Maitland-Weismantels Paterson—Bridge over Paterson River in Shire of Port Stephens	320	300	—6%
Main Road No. 104—East Maitland-Raymond Terrace Raymond Terrace—Ferry over Hunter River in Shire of Port Stephens	280	269	—4%
Main Road No. 108—Adamstown-Newcastle-Stockton-Nelson Bay Broadmeadow—Southwest of Samdon Street in City of Newcastle	26,720	28,030	+5%
Stockton—Ferry over Hunter River in City of Newcastle	3,818	3,910	+2%
Main Road No. 217—Birmingham Gardens-Wyong Boolaroo—North of First Street in Shire of Lake Macquarie	11,530	11,940	+4%
Main Road No. 220—Glendon Brook-Cessnock-Brunkerville-Toronto Brunkerville—Post Office in City of Greater Cessnock	2,180	2,460	+12%
Main Road No. 223—West Wallsend-Kurri Kurri New Lambton Heights—North of Ridgeway Road in City of Newcastle	16,900	16,110	—5%
Main Road No. 503—Wilberforce-Singleton Howes Valley—3.5 miles north of Post Office in Shire of Patrick Plains	990	1,070	+8%

System and of this approximately 46 miles are proposed new routes. These new routes include the northern end of the Sydney-Newcastle Expressway between Swansea and Adamstown Heights, State Highway No. 23 between Bennett's Green and Sandgate, a new location for the New England Highway to avoid the built-up area of Maitland and a route across Kooragang Island. To date the location and boundaries have been fixed over approximately 58 miles and investigation is proceeding on the remaining 55 miles while some stage construction has already been undertaken on County Routes.

The network itself is constantly under review in order to take into account changes in traffic patterns and new development projects such as the Kooragang Reclamation Scheme and the large aluminium smelter nearing completion at Kurri Kurri.

As organization and reorganization in the fields of planning and administration have proceeded hand in hand with the development of the Main Roads System, there have also been significant developments in specialized engineering fields such as surveying, traffic service, materials and research, plant and equipment, road construction, etc. Some of the more important features are outlined hereunder.

SURVEY AND PHOTOGRAMMETRY

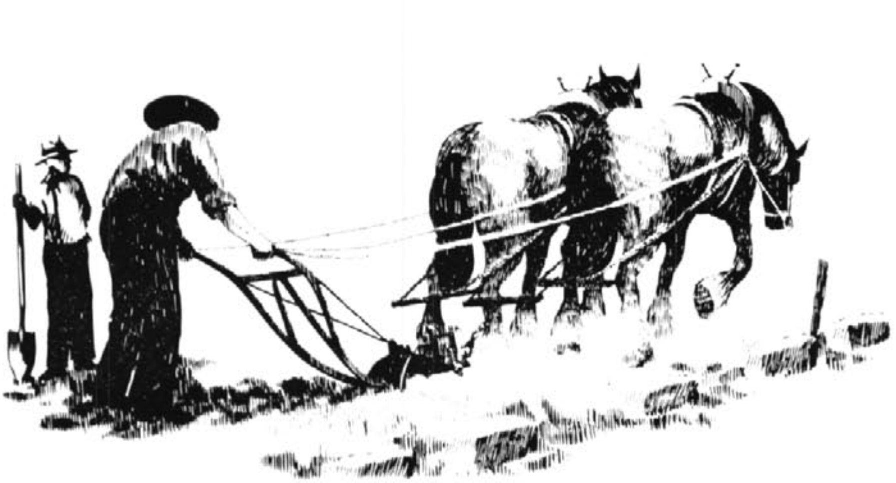
Prior to 1935, only conventional survey methods were available to the Department for road location purposes.

Aerial photography became available about 1935 and was first used by the Department in 1937. The whole of the Main Roads System in the State has now been covered by aerial photography carried out by this Department and the Lands Department. The advent of photogrammetrical equipment has permitted the completion of contour plans from aerial photographs with a minimum of ground activity and considerable savings in time and cost over conventional methods. A helicopter is now used extensively for road location purposes and has made possible better grading and alignment for many routes and in many cases with spectacular cost savings.

TRAFFIC SERVICE

From its inception in 1925, the Board adopted a policy of taking traffic counts on each Main Road and providing an efficient and consistent arrangement of road signs. Linemarking was commenced by the Department in 1938. Traffic matters gradually constituted such a great importance that in 1956 the Department established a Traffic Service Section which now deals with matters relating to signposting, linemarking, channelized intersection design, control of advertising signs, roadside selling, and the effects on Main Roads traffic of all types of traffic-generating development. The first comprehensive traffic volume study on all Main Roads in the County of Cumberland was published for the year ending 31st December, 1960 and a year later for Main Roads in rural areas. More detailed studies on specific areas, including the Hunter Valley region have since been produced and are used extensively in the determination of priorities for roadworks.

Traffic is at present counted mechanically at over 150 locations in New South Wales. A selection of Annual Average Daily Traffic Volumes, obtained from permanent and semi-permanent counting stations for the calendar years 1968 and 1967, is presented on page 9.



Present and projected traffic volumes are used to determine the pavement widths to be provided, and the number of lanes required in each carriageway to meet present and future traffic needs. With the provision of an initial road reserve width adequate for future expansion, stage construction is possible, and this is practised to a great extent throughout the State. Many of the roads which at present have only a single carriageway will be duplicated or increased in width according to the traffic volumes they will be required to carry.

MATERIALS AND RESEARCH

The Department's first testing laboratory was established in 1929. This laboratory now called the Materials and Research Laboratory, is staffed and equipped to carry out testing and research on a wide range of road making materials. Field services provided include seismic and geological surveys, skid resistance measurements and load deflection tests. In addition the Laboratory Equipment Officers supply the instrumentation for special tests and provide a maintenance and calibration service throughout the State.

Apart from the main laboratory, there are now sixteen Divisional Laboratories, seven Works Office Laboratories, three mobile units and a number of vehicles fitted out to facilitate field control testing. These laboratories are equipped mainly for the routine testing of soils and aggregates and some are equipped also for control testing of bituminous plant mixes and cement concrete. The principal laboratory for the Hunter Valley Division is at present located at Waratah and is staffed by an Engineering Analyst and seven Testing Operators. However, extensions to the Divisional Office at Newcastle are being constructed to include a new laboratory.

Last year the divisional and field laboratories processed about 54,000 samples of road and bridge making materials involving more than 200,000 tests, including approximately 10,500 density-in-situ tests carried out during the construction of formations and pavements. In addition, over 1,300 precast concrete culvert and bridge units and girders were load tested.

As well as routine testing, research work is carried out on a number of materials and processes, such as skid resistant surfacings, additives to improve adhesion between bitumen and aggregates, design of flexible pavements and subsoil drainage pipes.

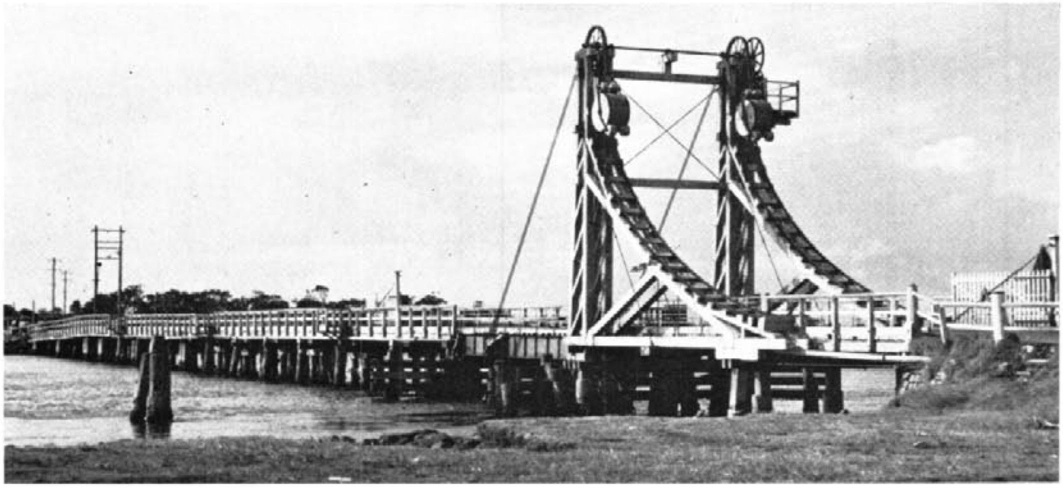
A LOOK AT THE PAST

Top: The second bridge over the entrance to Lake Macquarie at Swansea. This bridge was a timber beam structure with a timber bascule opening span at the southern end. It was constructed by Messrs Peter Callen and Sons of Newcastle, opened to traffic on 27th November, 1909, and replaced by the present bridge on 14th December, 1955.

Centre right: An important day in the construction of the bridge over the Hawkesbury River showing the first span being floated across the river from the erection falsework (left) to its position on the piers (bottom right). As the tide fell it was secured in position on 9th February, 1944. This bridge was designed by the Department, constructed by Balgue Constructions Pty Ltd, and opened to traffic on 5th May, 1945.

Centre left: Map published in the First Annual Report of the Main Roads Board for the year ended 30th June, 1926, showing the then current and proposed routes between Sydney and Newcastle.

Bottom: An unfortunate day for Long Bridge, Maitland. Bridges in the Hunter Valley region have been vulnerable in the past to the devastating effects of floods like this one in February, 1955.



The Department also supports research work carried out by the Australian Road Research Board and universities.

DESIGN

In 1925 the design standards adopted by the Board specified a ruling gradient of 1 in 20 and a curvature of not less than 300 feet. As speed design was unknown, grading was considered of most importance and was controlled by the maximum economical grade permissible for haulage by animal teams. Ruling grades closely following the natural surface were popular and were considered economical and aesthetic. Pavement widths were generally 16 feet with an occasional 20 feet carriageway on more important roads.

By 1930 the relative order accorded grading and alignment had been reversed —a sign of the passing of the era of animal transport. Alignment took foremost place and although the ruling gradient remained at 5 per cent, short lengths of up to 7 per cent were accepted. Curve widenings and super-elevations with transitions were introduced in 1927. In 1936 the design standards were revised to cater for the higher speeds of traffic and the increased rate of traffic growth. Speed was the main factor in the new standards, which provided for the selection of a designed speed from considerations of traffic volume, topography, road classification and economy of construction. Plan transitions approximating lemniscates were introduced and maximum acceptable grades of 12 per cent and 8 per cent were determined for 30 mph and 50 mph design speeds respectively.

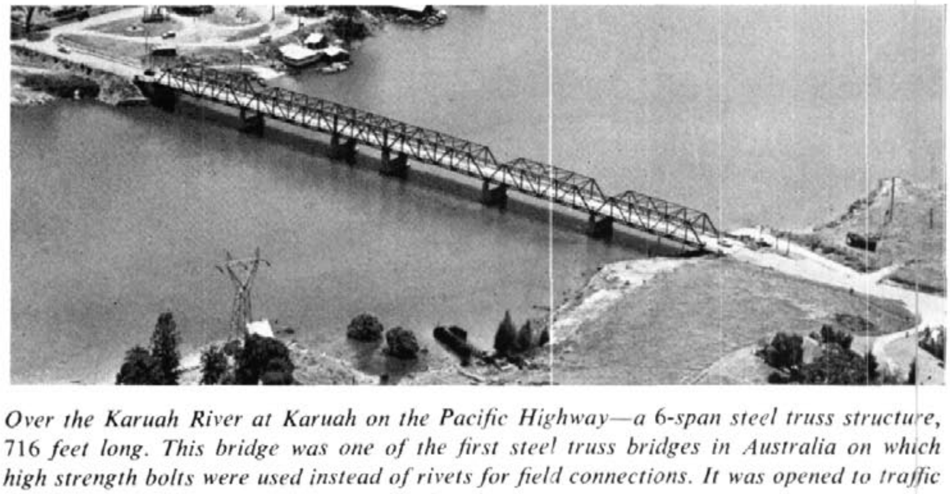
Design standards were again revised in 1964 to accord generally with the Australian standards published by the National Association of Australian State Road Authorities. These standards had been determined following a consideration of design practice in use in all States, trends in overseas design, and local changes in conditions considered relevant. The standards provided for plan transitions based on spiral curves, the length being related to curve radius and design speeds. Maximum acceptable grades for 30 mph and 60 mph design speeds are 8 per cent and 6 per cent respectively.

In recent years, the Department has paid increasing attention to the aesthetics of blending high standard urban roads into their environment as exemplified by the alignment and landscaping on the

THREE STYLES OF BRIDGES

At Fennell Bay, Toronto on the Newcastle-Cockle Creek-Toronto main road—a 9-span reinforced concrete structure, 664 feet long. It was opened to traffic on 20th December, 1967 and replaced a narrow timber bridge

Belmore Bridge over the Hunter River at Maitland—an 8-span steel and concrete structure, 643 feet long. The round single column piers were designed to provide least resistance to floodwaters and to deflect debris. This bridge was opened to traffic on 4th April, 1964 and replaced an old lattice girder bridge (shown on the right) opened on 4th October, 1869



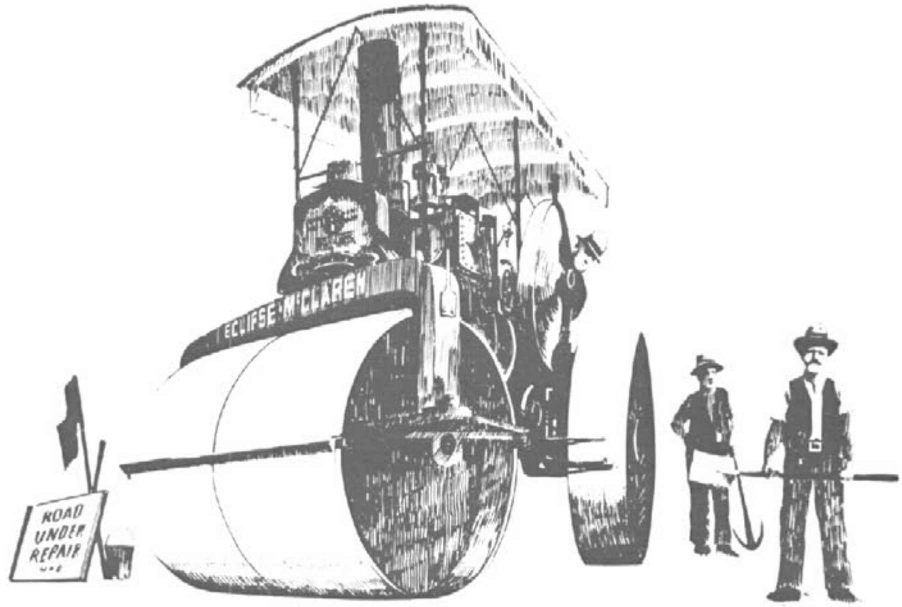
Over the Karuah River at Karuah on the Pacific Highway—a 6-span steel truss structure, 716 feet long. This bridge was one of the first steel truss bridges in Australia on which high strength bolts were used instead of rivets for field connections. It was opened to traffic on 14th December, 1957 and replaced a ferry service

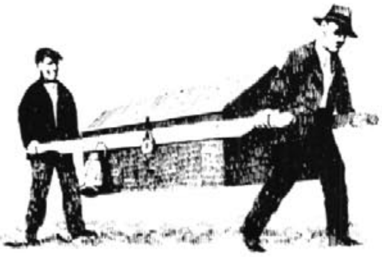
Sydney-Newcastle Expressway between Berowra and Calga.

PAVEMENT SELECTION AND DEVELOPMENT

By the mid 1920's the transition from horse-drawn to motor traffic had been so widespread that the former could no longer be considered a controlling factor in pavement design. Motor traffic had to be provided for, and pavements built to withstand the constant impact of heavy loads on solid tyres. The development of the pneumatic tyre also created problems. The suction of the tyres reduced the attrition of the stone and the binding fines were loosened and blown away reducing unsealed macadam pavements to a pile of loose stones. Thus, new types and methods of road pavement construction had to be evolved to cater for the increasing volumes and types of fast and heavy traffic. This pavement deterioration led to the adoption of cement concrete pavements on some of the more heavily trafficked roads in urban areas, such as Sydney and Newcastle. The concrete pavement on the Pacific Highway south of the Hawkesbury River was completed in 1930, and it is of interest to note that this is the first documented case where factory production methods and time and motion studies were applied to road construction works in New South Wales. On other roads requiring a high class pavement, premixed or penetrated tar or bituminous macadam was applied over a broken stone or gravel base course. This form of construction was used in 1928 on the Pacific Highway between Wyong and Catherine Hill Bay. These types of pavement were costly to construct and were not the solution to the problem of providing the great mileages of all-weather road that were required throughout the State. In the early 1930's, long lengths of thin gravel pavements were constructed and sealed with tar or bitumen, but at that stage there were no proper tests to determine the suitability of gravels or the strength of sub-grades. Pavement thicknesses were judged and gravels tested by feel and appearance and by striking with a hammer. With the growth of motorised transport, widespread failures occurred on such pavements and it was necessary to develop a more scientific approach to the problem. In 1938 the Department commenced a comprehensive programme of analysis of pavement samples and comparing the results with service histories of the pavements. From this work evolved the "Department of Main Roads' Method" for the calculation of pavement thickness, which was first applied in 1942 and published in 1947. Another development was the creation of "A1 Gravels" by the blending of naturally occurring materials and the chemical modification or stabilisation of near "A1" materials using cement or lime.

Low cost gravel roads with light bituminous surfaces are usually adequate where light or medium traffic conditions are encountered and have been widely adopted in rural areas. Where the traffic is heavy and the traffic density exceeds about 3,000 vehicles per day more substantial bituminous surfaces are usually necessary and more economical in the long run. Such surfaces are now generally of plant mixed materials of either the open grade or dense grade (asphaltic concrete) type, which have superseded the penetration macadam, so useful in the 1930's.



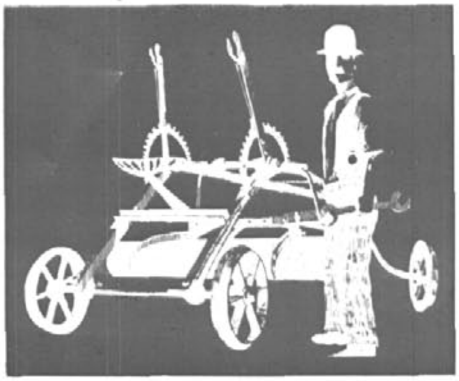


PLANT AND EQUIPMENT

It is understandable that with the development of road systems there has been a corresponding development in roadmaking plant, equipment, and procedures. The hand tools and animal-drawn equipment of the 1920's have been replaced by modern machinery, without which our present road needs could not be met. Picks and shovels have been replaced by tractor-dozers and bucket-type loaders; hammers and gads by modern jackhammers and track-mounted air drills; tumbler scoops by motorised scrapers; ploughs by rear-mounted hydraulic rippers; steam shovels by bucket-end loaders mounted on track-type or pneumatic-tyred tractors and horse-drawn drays by high-speed trucks. The introduction of this modern plant has necessitated the training of operators and personnel and the establishment of plant maintenance and repair facilities.

ROAD CONSTRUCTION METHODS

In the 1920's and 1930's, rock excavation was a laborious undertaking involving the use of jumper bars and fuse-fired blasting powder. The loosened material was broken down by hand spallers, loaded by hand into drays or waggons pulled by horses and end tipped on embankments. Today, instead of drilling and blasting, softer material can be loosened by powerful rippers and transferred to embankments by dozers, motorised scrapers, or rock buggies fed by powerful loaders. Rock or earth can



be spread in layers on embankments and raised to final level with a maximum degree of compaction using rolling equipment such as a sheepsfoot roller, grid, vibrating or heavy pneumatic-tyred roller.

Even in the 1920's a number of important pavements were still laboriously constructed using hand-knapped stone, each piece placed individually by hand to form a Telford base. Today, modern crushing machines produce a uniformly graded material which can be spread by mechanical means to a uniform thickness and density. When local materials of a suitable quality can be found, they are hauled to the work and spread on the road before the application of the final surface. Prior to 1925 the only means of providing a dustless surface was by the use of tar, which had limited life, and then later, by the use of sprayed bitumen with a layer of covered stone. In recent years there has been much greater use of premixed bitumen-stone, now known as asphaltic concrete. This pavement can be mechanically spread to the desired thickness and results in a very durable, smooth, and pleasant surface on which to drive. To a large extent these developments in pavement and surface layers have been due to materials research. The Department has been singularly fortunate in obtaining slag skulls from the iron and steel works at Newcastle which have been extensively used in making a macadam type pavement of enduring strength for the higher class pavements now being constructed in the district.

BRIDGE CONSTRUCTION METHODS

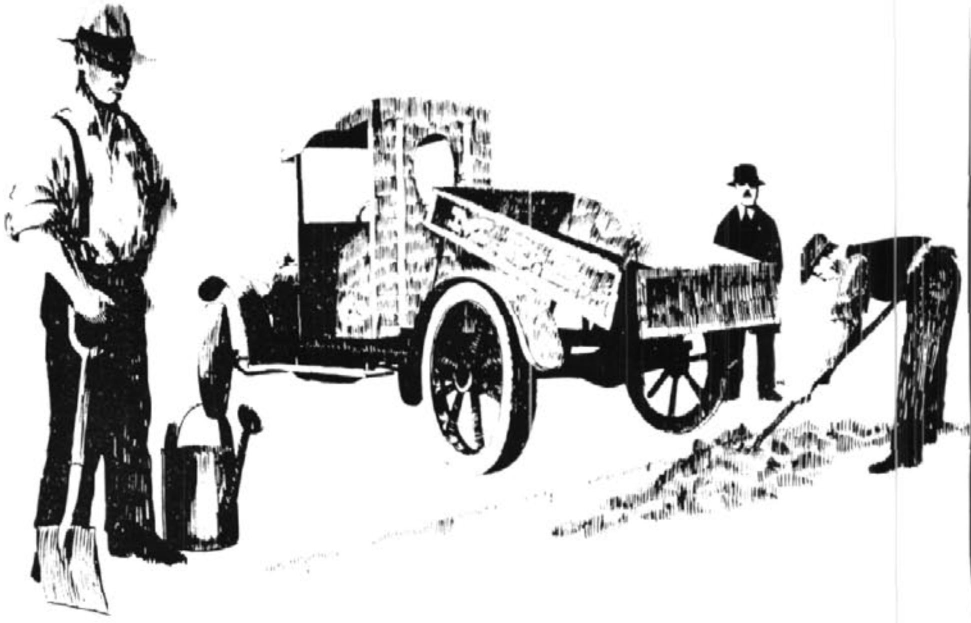
With the advance in concrete technology and the development of new construction techniques such as prestressing and post-tensioning the Department has been able to build concrete bridges with longer spans and much more pleasing to the eye. Whereas cast-in-situ concrete spans were limited to about 50 feet, spans of up to 100 feet are now possible with pre-cast, prestressed girders. Spans up to 300 feet in length are possible with pre-cast segment construction using launching trusses and the post-tensioning of girders. Foundations for bridges vary from spread footings and driven piles to groups of concrete cylinders depending on the nature of strata under the bridge. In recent years the old and slow caisson system of sinking piers has given way to the bored pile technique. This method has been used successfully in the Hunter Valley region with piles up to 3 feet 3 inches in diameter and 160 feet below natural surface. The Department has made use of these improved techniques on the recently constructed bridges over the Williams River at Raymond Terrace, over Fennell Bay at Toronto, at the Entrance to Tuggerah Lake and on the bridges being constructed over the Hunter River at Raymond Terrace and over the north arm of the Hunter River between Kooragang Island and the Stockton peninsula. The last-named bridge will have an overall length of 3,358 feet, a maximum span of 270 feet and a vertical clearance for shipping of 100 feet. (An article on this bridge appeared in the December, 1968 issue of this Journal.)

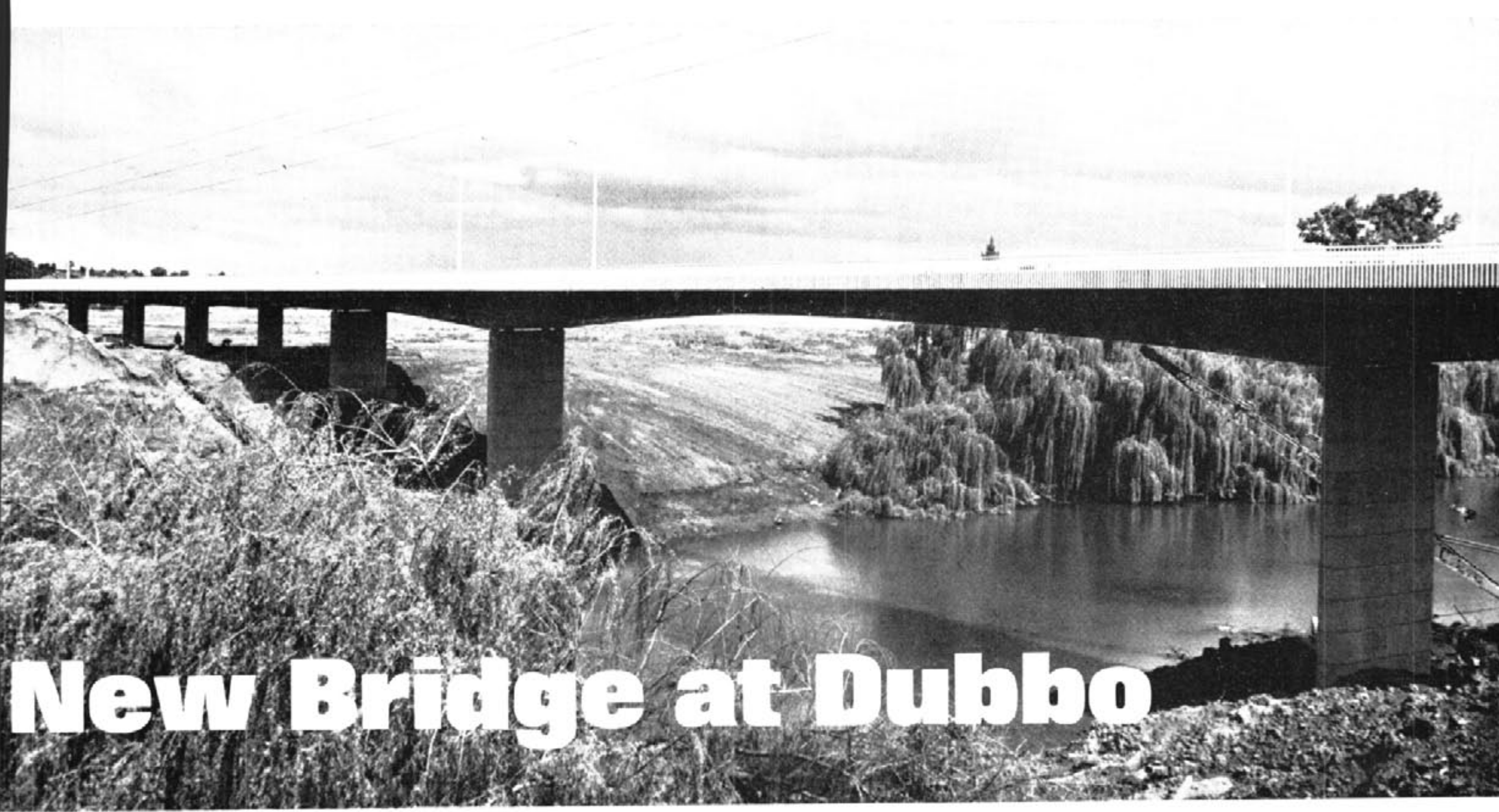
CONCLUSION

From the foregoing account of the Department's activities it will be seen that much has been done in developing the Main Roads System to meet changing traffic requirements. However, much more needs to be done, not only to provide for present day traffic but also to cater for future needs, and this particularly applies in the fast growing Newcastle-Hunter Valley area.

Not the least significant factor in the progress over the past 50 years has been the increase in the employment of professional engineers by councils and the Department. In 1933 the Department employed 81 men in engineering positions. Today the Department employs 330 professional engineers and is sponsoring a total of 79 trainees to full-time civil engineering courses at universities.

The rate at which future programmes of work are carried out must necessarily depend on the funds and other resources available for that purpose. The Department of Main Roads is geared for a considerable amount of expansion, and this, coupled with the continued co-operation of councils, the increasing interest of contractors in the road engineering field, the increasing mechanisation and improved road building techniques, and the recently announced grants for roadworks by the Commonwealth Government, promises an exciting and busy future for road and bridge building in New South Wales. Planned works on the Sydney-Newcastle Expressway and the Newcastle By-pass are outlined in the article "Five Year Programme of Works". In these and other projects the Department will continue to assist in the development of both industry and agriculture in the progressive Newcastle-Hunter Valley region.





New Bridge at Dubbo

On the 26th September, 1969, a new bridge to carry the Mitchell Highway over the Macquarie River at Dubbo was officially opened to traffic by the Hon. P. H. Morton, M.L.A., Minister for Highways.

The bridge was named after the late Mr L. H. Ford, O.B.E., M.L.A., who at the time of his death in 1964 was the Member for Dubbo in the Legislative Assembly of New South Wales and Mayor of Dubbo. He had been elected Mayor for fifteen successive terms and had been most active in pressing for the provision of a new bridge.

The new bridge will be of immense assistance in the development of Dubbo. The geographical position of this city, which is the converging point of railways and airways as well as of roads, has aptly qualified it for the title "Hub of the West" and the new bridge is a valuable contribution by the Department to the continued progress of Dubbo and the surrounding districts.

The cost of approximately $1,250,000 for the bridge and approaches was met by the Department. The bridge was built under contract by M. R. Hornibrook (N.S.W.) Pty Ltd while the approaches were constructed by the Department's own forces. The design of the new bridge was prepared by the Department and

The Hon. P. H. Morton, M.L.A., Minister for Highways (right) and the Commissioner for Main Roads, Mr R. J. S. Thomas (left) watching Mrs L. H. Ford cutting the ribbon at the official opening of the new bridge

Construction of the new bridge nearing completion in August, 1969

architectural advice was obtained from Mr D. C. B. Maclurcan, Consulting Architect, of Sydney.

Having an overall length of 2,013 feet, the bridge is at present the fourth longest road bridge in New South Wales although longer bridges are now being constructed by the Department at Stockton (3,358 ft) and Camden (3,380 ft). The new bridge is the third to be erected at the site and is situated about 200 feet upstream of the previous structure.

HISTORY OF EARLIER BRIDGES

The first bridge at this site was opened on Queen Victoria's birthday, 24th May, 1866, at which time it was officially named "Albert Bridge" after Queen Victoria's consort. A rival faction in the town also held an unofficial but more widely attended ceremony earlier in the day and named the structure "Oxley Bridge" after John Oxley, the first explorer in the district.

This structure was also known by two other names, "Dubbo" and "White" bridge. The name, "White Bridge", appears to have been derived from the fact that the structure was painted white, and this title distinguished it from the railway bridge which was painted red.

It was a high level truss bridge constructed mostly of iron-bark and consisted of three timber truss spans, each 80 feet in length, and a total of five 30 feet timber beam approach spans. The bridge was designed by Mr W. C. Bennett, Commissioner of Roads, and constructed by Mr A. McCauley of Mudgee at an estimated cost of £7,000.

Situated on the Great Western Road, the original bridge served nearly all the traffic to stations along the Macquarie River and settlements on the way to Bourke and beyond. The bridge helped to stimulate the growth of Dubbo and the increase in traffic on the Great Western Road for over four decades. By the early 1900's, however, it was apparent that the bridge had reached the end of its economic life and agitation arose for the construction of a new bridge.

Following a Government decision in 1902, work was commenced on a new structure in February, 1904. The bridge, which has now been replaced by the present structure, was designed by Mr E. M. de Burgh of the Department of Public Works. It had three composite steel and timber truss spans of the Pratt type (a centre span of 106 feet flanked by spans of 105 feet) and a total of six 30 feet timber beam approach spans. The overall length was 500 feet and the width 18 feet.

The bridge was completed and opened to traffic by the Minister for Works, the Hon. C. Lee, on 8th March, 1905. The final cost of the bridge was approximately £11,300. The structure was named the "Macquarie Bridge" because it spanned the Macquarie River and was in the electorate of Macquarie, but it was still generally referred to as the "White Bridge". Built for a slower-moving age this bridge eventually became inadequate for the present day traffic needs of faster cars and heavier trucks. Having withstood for over sixty years both swirling floodwaters and the punishing loads of modern day road transport the old "White Bridge" will be demolished during October.

DESIGN OF NEW BRIDGE

In times of heavy flooding the approaches to the "White Bridge" were blocked to traffic, thus isolating West Dubbo.

The new bridge at its eastern or Dubbo end has its deck at street level which is a little below the highest flood height. It rises on a grade of 0·78 per cent to a level well above the highest floods at the western bank of the river. A flood-free crossing of the river has thus been provided for all but rare floods which would also inundate parts of the City of Dubbo.

Any restriction of the river floodway would have resulted in the raising of flood levels. Obviously this was unacceptable in view of the location of the bridge adjacent to the city centre and therefore a bridge spanning virtually the full flood plain was required. The bridge consists of twenty-five 65 feet long spans over the flood plain and two 92 feet long anchor spans and a 206 feet long main span across the permanent river channel. All the spans are of prestressed concrete.

The carriageway of the bridge is 30 feet wide, with two traffic lanes and a break-down lane. The break-down lane was provided because of the length of the bridge and allows traffic to pass any stopped vehicles without interruption to the traffic flow. The carriageway is flanked by a cycleway on the northern side and a footway on the southern side, each 7 feet wide.

A straight bridge could not have been joined smoothly onto the existing highway and so the new bridge was designed to cross the river in an elegant spiral curve beginning with a 2,700 feet radius curve at the eastern abutment and finishing with a 9,000 feet radius curve at the western end. It is the first bridge the Department has built with such a variable curvature.

Foundations

Test bores over the bridge site showed extremely variable materials including considerable depths of very soft saturated silts. The bridge was therefore designed as a statically determinate structure consisting of simply supported spans and free cantilevers only.

The flood channel spans are supported on precast concrete piles up to 40 feet long, driven to strata of adequate supporting capacity. The main spans are supported on steel piles driven to a bed of firm mixture of cobbles and clay at a depth of about 70 feet, all the steel piles being in solid undisturbed ground and well below permanent water level.

Piers

All the piers were designed with single columns to offer the least resistance to the flood flows which have directions varying greatly across the width of the river and also with the level of the flood waters. The single pier columns also offer a more pleasing appearance than would multiple column piers, particularly when such a long bridge is viewed at an angle.

The pile caps, 25 feet long, and the headstocks, 46 feet long, of the approach piers are both cantilevered from the central single column which is 7 feet 6 inches by 4 feet in cross-section with rounded ends. The pile caps are reinforced concrete beams while the headstocks are prestressed concrete beams with the prestressing applied in two stages as the deck girders were placed. The pier columns are of cast-in-place concrete tied to the pile caps and headstocks with post-tensioning bars.

The main pier columns are 15 feet 6 inches by 4 feet wide in section and were made wider than the approach pier columns since no great skew of the stream flow is met in the main river channel. The columns for the main piers were built of precast segments tied together vertically by tensioned high strength steel bars.

Superstructure of the approach spans

As the flood plain spans make up 80 per cent of the total length of the bridge, particular attention was taken in their design in order to achieve economy and speed of construction.

The spans are made up of constant depth precast pretensioned concrete I-beams which are joined transversely with in-situ concrete to form a monolithic hollow box girder. The design of this box girder is such that it distributes all traffic loads across the full width of the deck including the cycleway and footway widths and a satisfactory stiffness of the slender spans is thereby achieved. The 65 feet long spans are post-tensioned transversely at each fifth point of the span length with high strength steel prestressing bars.

The varying radius of curvature of the bridge deck causes the approach spans to vary in length and curvature. The design overcame this problem and achieved a straightforward precasting technique in the following ways. Firstly, the precast girders themselves are straight and only exposed features such as the fascia slabs, cast-in-place kerbs and the handrailing follow the curved bridge lines. Secondly, by placing wedge shape cast-in-place concrete joints of varying widths at the girder ends on the piers, the girders could be made square ended and only four variations of girder length were necessary to cover all the spans.

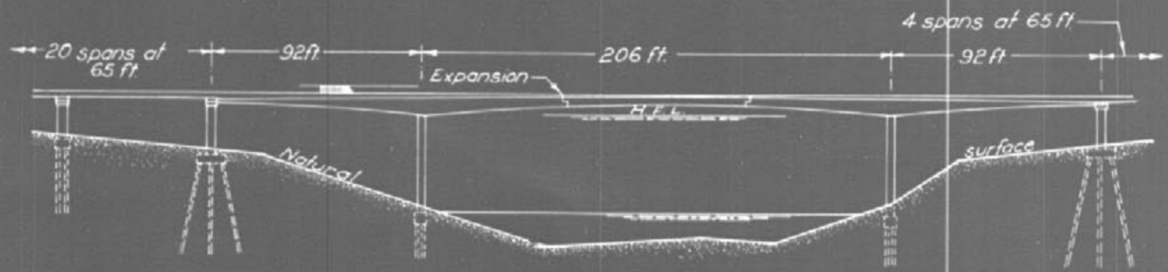
The changes in girder lengths due to temperature changes and to concrete shrinkage and creep are provided for in a simple way. Each pier headstock is of an inverted tee shape which both supports and separates the adjacent spans so that each deck joint is required to allow for the movement associated with only one half of the girder length. The girders are all seated on 11 inch by 7 inch rubber pads and movement is absorbed by a $2\frac{1}{2}$ inch by $\frac{3}{4}$ inch strip of self-expanding compressed cork placed at the deck surface at the end of each span and at each side of the pier headstock. A bituminous concrete pavement has been placed continuously over the deck with no breaks in the surface over the piers.

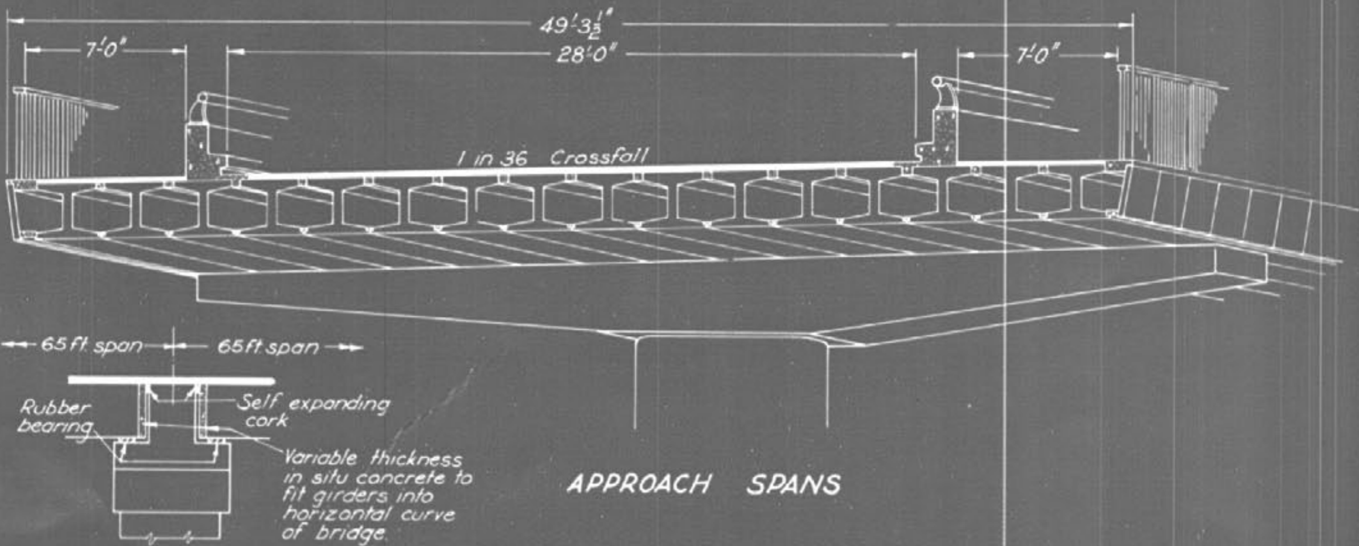
Superstructure of the main spans

The main spans are of spine-beam construction in which a narrow hollow box beam supports a widely cantilevered deck slab. The hollow box beams vary in depth from the piers and are made up of parallel twin boxes precast in segments about 6 feet 6 inches long, all joined together with cast-in-place concrete and longitudinal and transverse prestressing tendons. The longitudinal prestressing was applied through thirty-eight tendons with a total jacking force of 6,200 tons.

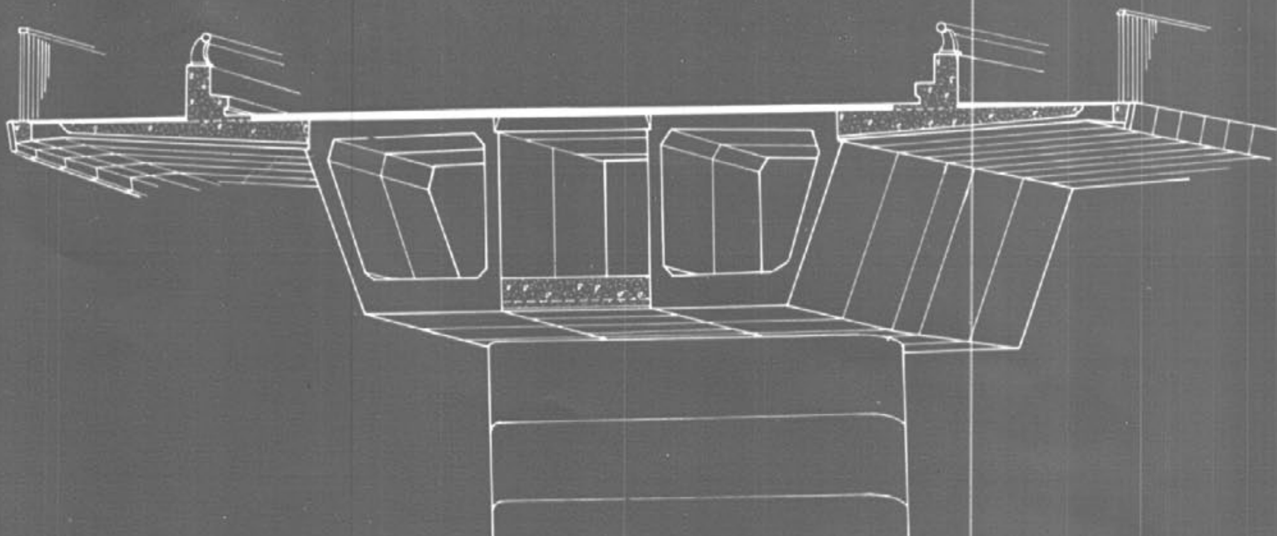
The two lines of box girder segments were assembled on falsework and post-tensioned longitudinally after the joint concrete had hardened. Partial prestress

The "White Bridge"—opened 8th March, 1905—to be demolished during October, 1969





APPROACH SPANS



MAIN SPAN

DUBBO BRIDGE

40 per cent of the total, was applied at this stage sufficient to make the girders self-supporting. Precast slabs were placed between the boxes and the precast cantilever deck slabs attached to the sides with tensioned high strength steel rods. The final longitudinal prestressing was then applied to the fully assembled girders after which the central suspended span, of similar construction, was placed into position on the ends of the girders cantilevered from the piers.

Temperature and concrete shrinkage and creep movements are taken up in an open expansion joint on one cantilever adjacent to the suspended span, where hard grade stainless steel roller bearings and overlapping galvanised steel finger deck plates are provided.

The cycleway and footway are separated from the vehicle carriageway by concrete crash barriers topped by a large pipe rail. White painted grill railings are provided on the outer edges of the bridge.

A major aesthetic problem in the development of the bridge design was the need to combine the completely different constructions of the approach and main spans into a harmonious whole. To this end, the main spans were haunched to a depth compatible with the approach spans and fascia panels were continued over the whole bridge, uniting the bridge spans.

CONSTRUCTION

Construction of the bridge was programmed to co-ordinate the completion of the approach spans with the completion of the erection of the east and west sections of the main river spans. By planning this way, mobile equipment was able to have access at the crucial time on to the main spans and thereby assisted in the construction of the suspended girder in Span 23. Although flooding has been a hazard in previous years, the construction of the Burrendong Dam near Wellington eliminated many of the risks of flash flooding and its consequences on work in, and adjacent to, the river. During the period of construction, ample water storage was available in the dam. River rise during the wettest period in July, 1969, did not exceed five feet. No more than four weeks were lost due to wet weather which mainly affected the operation of mechanical plant in soft ground.

Piles

Piles used on the bridge were of two types—viz. 16 inch by 16 inch reinforced concrete piles and $9\frac{1}{4}$ inch by $9\frac{3}{8}$ inch steel H piles. On the eastern bank, 250 concrete piles, with lengths varying from 30 feet to 46 feet, were driven. Harder ground than anticipated was encountered and in order to reach the planned levels, considerable pre-drilling was necessary. It was observed during pile driving on the eastern flat, that as driving proceeded in each group of piles, penetration rates became slower due to increased compaction of the lower gravel layers. Steel piles were used only under Piers 21, 22, 23 and 24.

Hard shales and sandstone were experienced near the surface on the western bank. Spread concrete footings were substituted for piles under Piers 25, 26, 27 and Abutment B. In the latter case a series of 3 feet diameter holes were drilled to a depth of 7 feet 9 inches to dowel the footings into the rock. Special measures were taken for the foundation of Pier 23. Steel piles were taken well below the expected scour level of the river by drilling and sleeving the holes to a depth of 31 feet. Steel H piles were then driven to refusal inside the tube. Finally, the cavity was dewatered and infilled with concrete by tremie pipe. Steel piles in Pier 24 were also driven inside sleeved holes.

Pile caps

The reinforced concrete pile caps had embedded anchor-plates cast in them for the post stressing of the pier columns to the caps. Short lengths of Macalloy bars in ducts complete with grout tubes were used as starters, threaded couplers being used to connect the remaining length of vertical bars.

Piers

Pouring of concrete was carried out in one continuous operation using steel inside and outside formers. Concrete was placed in skips from the top by crane using a 6 inch diameter tremie pipe for the lower layers. Pier heights varied from 9 feet to 18 feet. The main span piers 21, 22, 23 and 24 were constructed from precast segments each 3 feet $5\frac{3}{4}$ inches in height. Joints were packed with mortar. Foam rubber rings prevented the entry of mortar into the stressing ducts. Light tubular scaffolding was erected as the work progressed. After vertical stressing and grouting of the segments, a solid reinforced concrete pier block finished the pier column.

Headstocks

Two shop-made sets of steel support frames were used as falsework for the boxing of the twenty-three identical headstocks. The frames were built with telescopic legs and had pin joints for easy dismantling in two halves and re-erecting by crane. Construction teams became proficient in their use being able to erect the frames, box and cast a complete headstock in four days. Reinforcing cages were prepared in advance complete with eighteen $1\frac{3}{8}$ inch diameter Macalloy bars in metal ducts for post-tensioning of the headstock. Initial stage stressing was carried out usually thirteen days after pouring the headstock. Falsework was then dismantled and re-erected. By use of two sets of support frames, good progress was maintained. Final stressing of the headstock took place after the full number of girders had been placed each side of the headstock.

Pretensioned Girders

Precasting of the 400 approach span girders began in July, 1968 and was completed in April, 1969. The casting was done at Narromine, 25 miles west of Dubbo where a stressing bed of 400 tons capacity was available together with equipment suitable for accurate batching of low slump concrete mixes. Steam for the accelerated curing of the girders was provided by a 50 h.p. oil-fired boiler specially installed for the work. Two girders were cast in line each day.

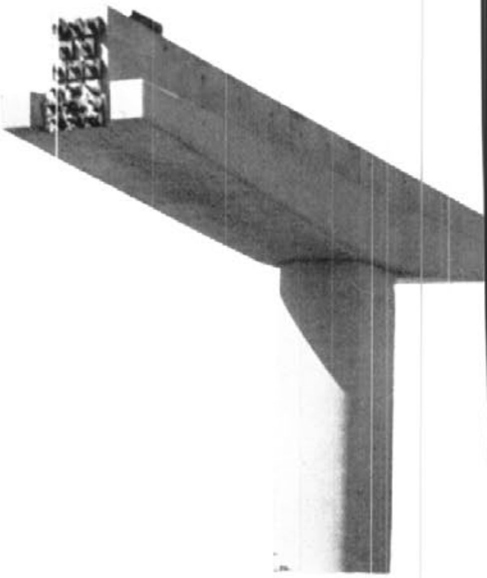
From the storage yard, the 13-ton girders were transported individually by road to Dubbo by means of a truck prime-mover with a single bolster jinker attached to the rear of the girder. The wide flanges gave good lateral stiffness for transport by this method. Up to eighteen girders per day were transported and placed in position. Hog in the girders was approximately $1\frac{3}{4}$ inches and quite constant. This property considerably reduced the work of aligning the cross ducts in each span for the transverse Macalloy bars.

Following placement of the girders on the headstock, cross diaphragms and bottom flange gaps were concreted. Inflatable duct tubing maintained continuity in the cross diaphragms until the concrete hardened. The cross ducts were then tested for grout tightness before infilling of the top flange gaps between the girders. After the infill concrete had reached a strength of 4,500 pounds per square inch, usually after four days, the sixteen girders in each span were stressed transversely and all ducts grouted.

Main Span Segments

Casting

A small on-site precasting yard produced all the segmental concrete units required for the bridge, using concrete supplied in agitator trucks from a local



Above: Approach pier, showing prestressing anchorage

Top left: Approach girders being placed

Centre left: Construction of approach piers

Bottom left: Construction of main span over the Macquarie River

central batching plant. Steel forms were used throughout except for the intricate boxing required in the end anchor segments which were boxed with ¾ inch plastic-faced plywood. With day temperatures frequently in the region of 100° F, loss of slump became a problem when pouring the relatively thin walled sections. Steel forms were hosed down to cool them and half batches only were delivered at one time. Where placing conditions were particularly difficult, a retarding agent was used in the mixes. Both internal and external vibrators were employed. In all, 120 hollow girder segments, 236 cantilever footway slabs and 340 top and bottom infill slabs were cast between November, 1968 and May, 1969.

Erection

Erection commenced in September, 1968 on the eastern bank following completion of Piers 21 and 22. Tubular steel scaffolding was used for the falsework in span 22 which was erected on level benches bulldozed out of the bank. Under the cantilever arm of Span 23, prefabricated steel falsework founded on timber piles was used. A 40-ton mobile crane on tracks was able to hoist segments into their final position in Span 22. In

Span 23, a small gantry operating on 80 lb rail tracks on top of the falsework handled the segments after they were lifted to a point within the rail tracks by crane. The segments were then levelled and lined, after which the nineteen cables were threaded through the ducts assisted by the pull from a power winch. Final adjustments and survey checks were then carried out and ducts made continuous across the 3 inch gaps between segments. The joints were then filled using a concrete mix of $\frac{3}{8}$ inch maximum size aggregate. By early January, 1969 both upstream and downstream girders on the eastern bank were completed up to first stage stressing. The headstock at Pier 21 was then completed and post-stressed by the V.S.L. system after which the cross girder at Pier 22 was concreted.

Between the girders at the bottom, precast ribbed slabs, 6 feet 6 inches long, were bolted into position and covered with in-situ concrete. Cantilever footway and cycleway slabs were lifted into position by crane onto prepared falsework. Each slab was fitted with a $1\frac{1}{4}$ inch Macalloy bar before leaving the ground and, after positioning the slab, the bar was pushed by hand through the transverse ducts in the main girders. Precast slabs, 8 inches thick, were then placed between the two main girders on each side of the transverse $1\frac{1}{4}$ inch bars. End joints were poured, Macalloy bars from each side coupled and the bars stressed after joint concrete had attained the required strength. Lightweight concrete of maximum density 120 pounds per cubic foot was used as infilling between the ribs of the cantilever slabs.

The lightweight expanded shale aggregate was railed from Sydney to the batch plant and the concrete delivered in agitator trucks to the site. No difficulties in placing or density control arose. Second stage stressing and grouting concluded this stage of construction.

Operations on segment erectionwere then directed to the western side and followed largely the sequence used on the eastern side. By the end of May, 1969 all work up to the cantilevered ends of the main girders had been completed and all approach span girders placed, thus giving full access to the river span for the construction of the suspended girders.

Suspended span

In the centre of the river, under the main span, twin steel trestles were erected on timber piles. These were used to support one end of heavy R. S. J. beams, the other ends of which were held by adjustable hangers, in turn supported by yokes resting on the ends of the concrete cantilevers. Timber and tubular steel falsework was formed up on the R.S.J. beams. The segments were then transported singly by mobile crane out along the finished cantilevers from the eastern end and then transferred to a gantry. The gantry running on rails was used to position the segments in the 80 feet suspended span.

After jointing and stressing, the mid-river ends of the R.S.J. support beams were strapped to the prestressed girders and the central support trestles removed. The 80 feet girders and support work were then lowered individually; the all-up weight of each at this stage being 120 tons. Lowering was effected by two 50 ton hydraulic jacks in pairs used at each end. Final settings for the steel expansion bearings were made, the girders seated, and the bearings dry packed with mortar. Three days were required to lower the two girders.

Infilling and completion work followed the previous sequences on the east and west main spans. The falsework was then lowered by hand winches.

Kerbs

The heavy crash-type kerb was constructed using mobile forms of steel.

Fascia panels

Precasting of the 1,282 fascia panels was done at Tamworth. A warm terra cotta coloured concrete was selected having a rough textured surface. There was considerable experimentation to achieve this colour. Local gravel of a natural colour, iron stone gravel and broken brick, were all mixed in turn with concrete in an endeavour to achieve the desired effect. Finally red iron oxide was used to give a texture matching in colour the red soil of the western plains. The panels were cast in the open on vibrating tables set at a comfortable working height. The textured surface was obtained by using a steel trowel on the vibrated concrete with an upward suction effect to lift the surface to a regular pattern. This operation took less than one minute per slab to perform and gave a distinctive appearance to the panel. Some difficulty was experienced from shrinkage cracks, resulting from the hot weather during the period of manufacture. Evaporation rate from the thin panels cast in the open was high. Early application of water sprays would have destroyed the rough textured surface. The problem was solved by using a saturated sponge plastic membrane $\frac{1}{2}$ inch thick, placed over the slab approximately 20 minutes after casting. The plastic sheet had a sealed upper surface and an open sponge type under surface. After lifting from the moulds next day, curing was continued by this method. As a secondary precaution, a light birdwire mesh was added to the reinforcement and an air entraining agent used in the mix to reduce "bleeding" of the concrete. After erection of all panels, they were acid-etched to remove any efflorescence and sealed with a clear acrylic laquer containing silicones.

Concrete

Almost all of the 4,400 cubic yards of concrete placed at the bridge site was supplied in agitator trucks from a central batching plant. No difficulties were met in achieving required strengths. In hot weather, a retarding agent was allowed in those mixes which required considerable hand trowelling. The precast concrete sections manufactured at Narromine required 2,700 cubic yards of concrete.

Stressing

Transverse and vertical Macalloy bars were stressed by hand-operated pumps and jacks, except for a short period when power equipment was available. The V.S.L. system was used for the tendons on the main river spans. Cables consisted of eleven $\frac{1}{2}$-inch diameter 7 wire strands and all jacking was done with electric powered equipment.

Paving

Bituminous concrete was selected for the paving of the bridge. A modern semi-automated batch plant was set up at a local quarry especially for the work. The roadway treatment comprised a levelling layer on the approach spans to equalise the effect of hog in the girders followed by a uniform correction course containing aggregate of $\frac{3}{4}$ inch maximum size. The finishing course of approximately $\frac{3}{4}$ inch thickness had $\frac{3}{8}$ inch maximum size aggregate giving an average overall thickness of approximately $2\frac{3}{4}$ inches. The material was spread and tamped by a rubber-tyred surfacing machine, in strips 10 feet wide, and rolled immediately after laying, resulting in a very smooth, even surface. On the footpath and cycleway, $\frac{3}{16}$ inch maximum sized aggregate was hand-spread and screeded, then compacted by a light footpath roller to a final thickness averaging $1\frac{1}{2}$ inches.

Handrails

The steel handrails were fabricated in Sydney and were painted after erection with a white polyurethane undercoat and finished with a white enamel.

MAIN ROADS FUND

Receipts and Payments for the period 1st July, 1968 to 30th June, 1969

	County of Cumberland Main Roads Fund	Country Main Roads Fund
Receipts	$	$
Motor Vehicle Taxation (State)	6,967,353	27,869,412
Charges on heavy commercial goods vehicles under Road Maintenance (Contribution) Act, 1958 (State)	2,959,884	11,839,537
Commonwealth Aid Roads Act, 1964	5,618,544	21,918,175
Road Transport and Traffic Fund	—	—
From Councils under Section 11 of Main Roads Act and/or for cost of work	7,617,752	182,310
Other	653,936	326,363
Total Receipts	**23,817,469**	**62,135,797**
Payments		
Maintenance and minor improvements of roads and bridges	4,146,532	15,479,836
Construction and reconstruction of roads and bridges	10,794,051	37,821,718
Land Acquisitions	4,680,840	602,508
Administrative Expenses	1,700,758	3,678,322
Loan Charges, Payment of Interest, Exchange, Management and Flotation Expenses—State Loans	164,750	962,380
Interest and provision for Repayment of Loan Borrowings under Section 42A of the Main Roads Act	693,547	155,176
Miscellaneous*	1,751,354	3,629,708
Total Payments	**$23,931,832**	**$62,329,648**

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

SYDNEY HARBOUR BRIDGE ACCOUNT

Receipts and Payments for the period 1st July, 1968 to 30th June, 1969

Receipts	$
Road Tolls	4,302,533
Contributions—Railway Passengers	284,416
Omnibus Passengers	27,730
Net Rent from Properties	125,640
Miscellaneous	*9
Loan Borrowings for the Warringah Expressway Approach	—
Total Recepts	**$4,740,310**
Payments	
Cost of Collecting Road Tolls	584,275
Maintenance and minor improvement	577,746
Alteration to Archways etc.	72,694
Provision of traffic facilities	132,184
Administrative Expenses	101,205
Loan charges, payment of interest exchange, management and flotation expenses—State Loans	1,175,450
Interest and provision for repayment Loan Borrowings under Section 7 of Sydney Harbour Bridge Administration Act	897,952
Miscellaneous	—
Transfers to Expressway Fund	900,000
Total Payments	**4,441,506**

* Debit.

TENDERS ACCEPTED BY THE DEPARTMENT OF MAIN ROADS

The following tenders (in excess of $10,000) for Road and Bridge Works were accepted by the Department during the three months ended 30th June, 1969.

Road No.	Work or Service	Name of Successful Tenderer	Amount
			$
State Highway No. 5	Shire of Turon. Construction of a 3-span prestressed concrete bridge 30 feet long over Frying Pan Creek on a deviation of the Great Western Highway near Yetholme.	E. Saunders & Son	30,744.09
State Highway No. 9	Shire of Murrurundi. Supply and delivery of 66 precast pre-tensioned concrete bridge planks 49 feet 8 inches long for the bridge over the Pages River at Murrurundi.	A. Goor	27,540.00
State Highway No. 9	City of Newcastle. Supply and delivery of asphaltic concrete for the construction of a deviation of the New England Highway at Beresfield.	Bituminous Pavements Pty Ltd	13,398.00
State Highway No. 9	City of Newcastle. Haulage of slag products from B.H.P. Ltd, for the construction of a deviation of the New England Highway at Beresfield.	W. D. Smith (Constructions) Pty Ltd	18,630.00
State Highway No. 10	Shire of Lake Macquarie. Supply and delivery of precast concrete crib units for reconstruction on the Pacific Highway between Ida Street, Charlestown and the Newcastle City Boundary.	Humes Ltd	20,549.00
State Highway No. 10	Shire of Lake Macquarie. Supply and delivery of asphaltic concrete for reconstruction on the Pacific Highway between Ida Street, Charlestown and the Newcastle City Boundary.	Boral Pty Ltd	53,820.00
State Highway No. 10	Shire of Lake Macquarie. Haulage of slag products from B.H.P. Ltd, for reconstruction of the Pacific Highway between Ida Street, Charlestown and the Newcastle City Boundary.	R. Phillips and R. A. Green	15,370.00
State Highway No. 16	Shire of Ashford. Construction of a 4-cell reinforced concrete box culvert over Towell Creek 5·1 miles east of Bonshaw.	K. A. Constructions Pty Ltd	25,970.20
Trunk Road No. 81	City of Broken Hill. Supply and delivery of prestressed concrete bridge units for the construction of a bridge over the railway lines at Gypsum Street, Broken Hill.	Dyson-Holland Concrete Pty Ltd	13,604.00
Trunk Road No. 81	City of Broken Hill. Construction of a 4-span reinforced concrete bridge 140 feet long over the railway lines at Gypsum Street, Broken Hill.	A. Cipolla & Co.	53,624.00
Main Road No. 167	Municipality of Bankstown. Supply, haul and spread up to 2,300 tons of $\frac{3}{8}$ in gauge asphaltic concrete on Milperra Road between Henry Lawson Drive and The River Road.	Bituminous Pavements Pty Ltd	27,945.00
Main Road No. 328	Shire of Warringah. Construction of a pedestrian overbridge at the intersection of Warringah Road and Forest Way at French's Forest.	Pearson Bridge Pty Ltd	39,930.00
Main Road No. 593	Municipality of Botany. Manufacture and delivery of footway slabs and facia panels for the overbridge at Gardeners Road.	South Coast Paving & Terrazzo Pty Ltd	18,956.00
Main Road Nos 593 and 344.	Municipality of Botany. Manufacture and delivery of 138 prestressed concrete bridge planks for the construction of a new bridge over Millpond Creek on Main Road No. 593 and the widening of the existing bridge over Millpond Creek on Main Road No. 344.	Humes Ltd	22,761.00
Secondary Road No. No. 2043	Municipality of Ku-ring-gai. Reconstruction and widening between Springdale Road and Koola Avenue.	Roadworks & Building Pty Ltd	28,817.20
Secondary Road No. 2070.	Municipality of Lane Cove. Reconstruction and widening between Warraroon Road and William Edward Street.	Tonkin Constructions Pty Ltd	31,261.40
Secondary Road No. 2070.	Municipality of Lane Cove. Reconstruction and widening east of Best Street to Burns Bay Road.	Tonkin Constructions Pty Ltd	47,388.50
Secondary Road No. 2070.	Municipality of Lane Cove. Reconstruction and widening between Canberra Avenue and Anglo Lane.	Tonkin Constructions Pty Ltd	19,409.40
Secondary Road No. 2070.	Municipality of Lane Cove. Reconstruction and widening between Gore Creek Reserve and Northwood Road.	Kenco Constructions Pty Ltd	36,286.60
Southern Expressway	City of Greater Wollongong. Construction of a prestressed concrete pedestrian overbridge 237 feet long over the Southern Expressway near Byarong Avenue, Mangerton.	The Hornibrook Group	40,234.00

ERRATUM: The schedule on Page 128 of the June, 1969 issue showed, under Main Road No. 593, the acceptance of tenders from V.S.L. Prestressing (Aust.) Pty Ltd and Marr Contracting Pty Ltd. The entry should have been . . .

Main Road No. 593	Municipality of Botany, Bridge at Gardeners Road, Mascot. Supply, delivery, erection, jointing and stressing of beams, ties and struts.	Pearson Bridge Pty Ltd	140,800

TENDERS ACCEPTED BY COUNCILS

The following tenders (in excess of $10,000) for Road and Bridge works were accepted by the respective Councils during the three months ended 30th June, 1969.

Council	Road No.	Work or Service	Name of Successful Tenderer	Amount
				$
Boorowa	M.R. 241	Construction of a 3 span reinforced concrete bridge 90 feet long over Harry's Creek 6 m. east of Boorowa.	R. Orford	27,823.00
Canobolas	Various	Supply, heating and spraying of bitumen at various locations.	Emoleum Pty Ltd	10,242.20
Carrathool	T.R. 80	Win, haul and spread 136,075 cubic yards of earthworks between 43·44 m. and 51·41 m. south of Langtree.	Anunaka Constructions	14,968.25
Cockburn	D.R. 1032	Reconstruction between 6·42 m. and 8·40 m. east of Limbri.	Dayal Singh Constructions Pty Ltd	33,989.25
Coffs Harbour	M.R. 540	Construction of a 5 span reinforced and prestressed concrete bridge 175 feet long over Boambee Creek 6·35 m. from the Pacific Highway.	S. Turner & Son (Constructions) Pty Ltd	58,258.00
Conargo	M.R. 552	Construction of a 4 span reinforced concrete bridge 120 feet long over Forest Creek 27·64 m. from Deniliquin.	Danckert Constructions Pty Ltd	29,241.80
Coolah	D.R. 1304	Construction of a 3 span reinforced and prestressed concrete bridge 35 feet long over Cainbil Creek 12·2 m. from Trunk Road No. 55.	K. A. Constructions Pty Ltd	31,666.25
Culcairn	T.R. 78	Bitumen resurfacing between 0·55 m. and 7·55 m. south of Culcairn.	Allen Bros Pty Ltd	10,006.90
Gilgandra	T.R. 77	Bitumen surfacing between 5·26 m. and 10·41 m. from Gilgandra.	Shorncliffe Pty Ltd	11,495.43
Jindalee	T.R. 84 & M.R. 235.	Supply of aggregate for bitumen surfacing and resurfacing on Trunk Road No. 84 between 13·29 m. and 22·2 m. west of Cootamundra and on Main Road No. 235 between 5·57 m. and 19·17 m. west of Bowning.	Boral Road Services	12,202.49
Lachlan	M.R. 231	Supply and delivery of 1,461 cubic yards of aggregate to stockpiles between 9 m. and 16 m. from Lake Cargelligo.	Ganmain Quarrying Co.	12,060.78
Leeton	M.R. 539	Bitumen surfacing between 1·2 m. and 4·88 m. south of Whitton.	Emoleum Pty Ltd	12,684.49
Maitland	M.R. 101 & 102	Supply and delivery of 1,190 tons of asphaltic concrete between 2·0 m. and 2·6 m. north of Maitland on Main Road No. 101 and between 0.6 m. and 1·6 m. on Main Road No. 102 north of East Maitland.	Bituminous Pavements Pty Ltd	12,883.10
Stroud	M.R. 111	Supply and delivery of precast box culvert crown sections for reconstruction from Smith's Lake and Charlotte Bay between 21·4 m. and 24·8 m. from the Pacific Highway.	Monier (N.S.W.) Pty Ltd	11,609.80
Tallaganda	T.R.'s 51 & 92 M.R. 271.	Supply and delivery of 1,466 tons of aggregate to various locations.	Ready Mixed Concrete (Canberra) Pty Ltd	10,356.35

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