MAIN ROADS

June 1955

MAIN ROADS.

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CONTENTS.

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Cover Page

Bitumen surfacing in progress on the Bell-Lithgow Road. (M.R. 516) 7 miles from Lithgow.

Next Issue: September, 1955.

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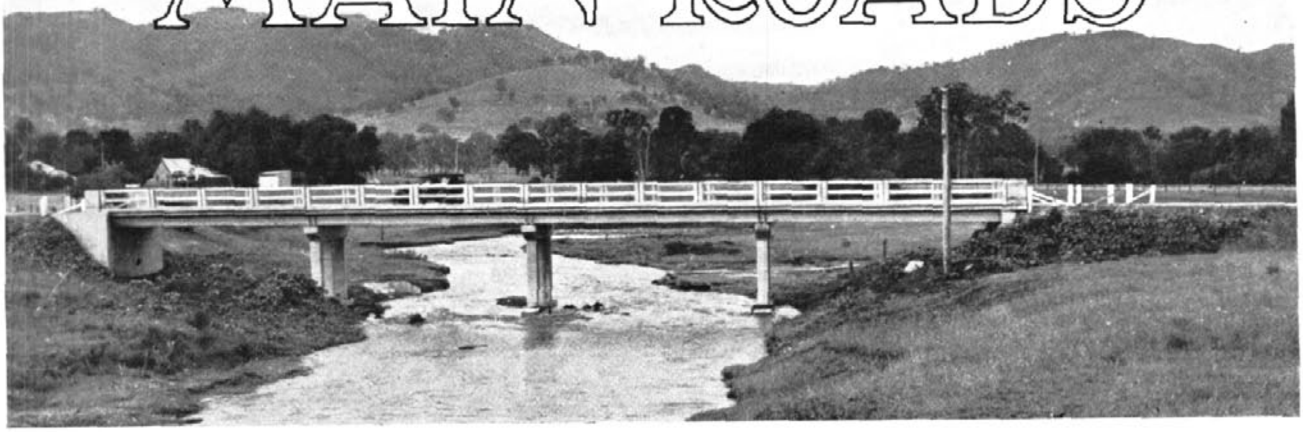
MAIN ROADS



Vol. XX, No. 4. *June, 1955.* 97

Extension of Bitumen Surfacing Progress on Main Roads

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It is anticipated that during the year ending the 30th June, 1955, bitumen surfacing will have been extended by Councils and the Department of Main Roads over an additional 550 miles of the Main Roads system, giving 6,000 miles of dustless surface out of a total mileage of 23,291 miles of Main Roads.

This is the best progress which has been made in any post-war year, and has been made possible by close co-operation between Councils and the Department of Main Roads.

During recent years increases in the revenue of the Main Roads funds have been offset by rises in costs, and it is primarily the greater stability in costs during the past year which has made possible the greater progress in bitumen surfacing. An increased sum available from Federal sources has also assisted. Another factor has been the Department's decision, in a number of cases in hilly country, to apply a bitumen surface to roads without first reconstructing to the standards of width, alignment and grading considered ultimately necessary.

It is not possible to point to any especially long individual length of bitumen surfacing carried out during the year; the work is generally in small lengths, and is spread throughout the State.

As the bitumen extends outwards from towns year by year, gradually lengths are joined up, and continuity is secured. The following are important Main Roads where this process was brought to completion on certain lengths during the past summer, giving continuous bitumen surfaces between the following towns:—

- State Highway No. 20—Finley-Deniliquin.
- State Highway No. 21—Deniliquin-Moama.
- State Highway No. 16—Ballina-Tabulam.
- State Highway No. 9—Glen Innes-Tenterfield.
- State Highway No. 12—Moree-Glen Innes.
- Trunk Roads Nos. 57 and 78—Albury-Illabo (via Wagga Wagga and Junee).
- State Highway No. 7—Trangie-Nyngan.
- State Highway No. 10—Taree-Kempsey.
- State Highway No. 10—Raleigh-Grafton.
- State Highway No. 1—Moruya-Bodalla.
- State Highway No. 1—Bega-Pambula.

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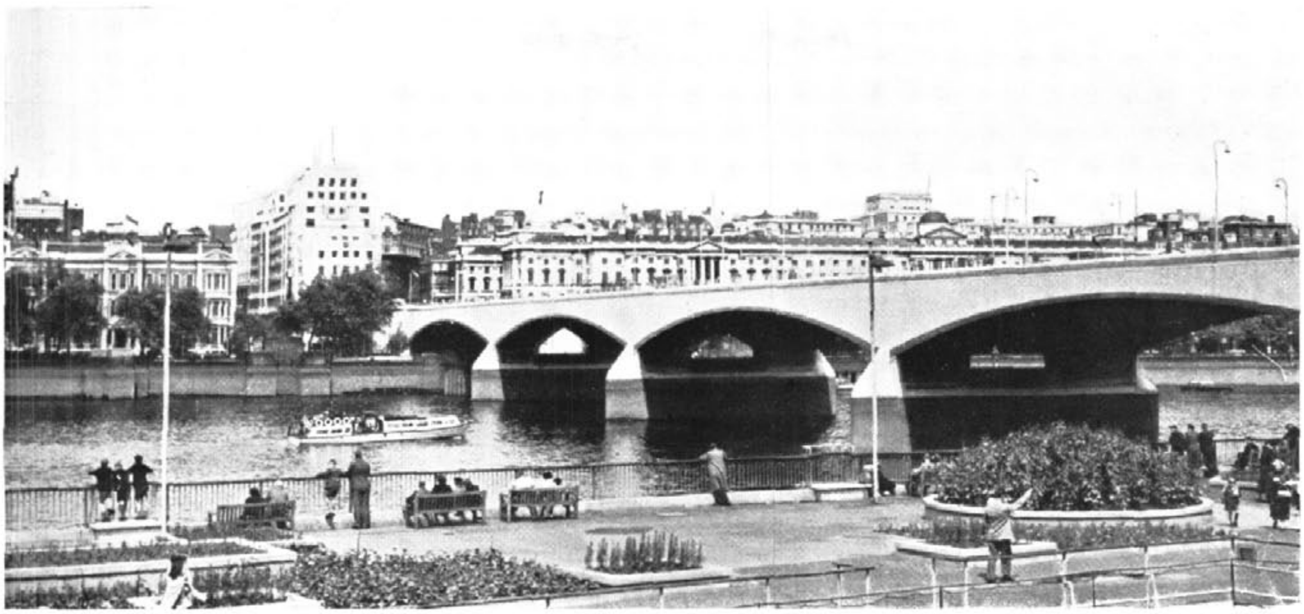
View of recently completed work on State Highway No. 21 in the Shire of Murray.

State Highway No. 4—Tumut-Adelong.
Main Road No. 211—Wagga Wagga-Mangoplah.
Main Road No. 181—Windsor-Wiseman's Ferry.
Main Road No. 537—Wallgrove-Richmond.
Main Road Nos. 184 and 516—Kurrajong-Lithgow.

The completion of the bitumen surface between Glen Innes and Tenterfield follows the carrying out during recent years of extensive heavy improvement works on this length; as a result, now, for the first time, a continuous bitumen surface has been provided between Sydney and Brisbane.

In spite of the progress being made, the Department has been unable to assist all Councils to the extent of their desires to carry out bitumen surfacing work. The first charges on the Department's funds are maintenance of existing roads and bridges and the replacement of old bridges. New bridges are also required to replace those which are too narrow or badly sited from the aspect of traffic safety. Bridges are required also to replace ferries where these are resulting in congestion of traffic. Heavily trafficked roads must be widened and strengthened to adapt them to modern traffic conditions, especially the routes carrying the bulk of Interstate haulage, i.e. Sydney to Albury, and Sydney to Wallangarra. It is necessary that the available funds be spent in such a way as to ensure a balanced programme, and so that not only are all parts of the Main Roads system given due attention, but also that all the different types of work described are provided for to the extent that available funds will permit. Subject to reasonable provision being made for work of all types, it is the Department's objective to assist Councils to the utmost to expand the mileage of bitumen surfacing on the Main Roads system. The need for this work to proceed at a much accelerated rate arises from the great post-war expansion of traffic using the Main Roads, and to the Department's inability hitherto during post-war years to provide for the extension of bitumen surfacing at a sufficient rate to keep up with traffic growth, while at the same time overcoming arrears of work resulting from the war and other pressing needs. The Department's inability to do this has arisen almost entirely as a result in the loss in value of money since the war. If the present stability of money values and economic conditions continues, it may be possible further to increase the rate of progress of bitumen surfacing on Main Roads.



Waterloo Bridge over the River Thames, London, England.

Bridge Design, Construction and Maintenance Overseas Practice and Developments

Extracts from a report by A. J. Clinch, M.A., B.C.E., B.Sc., A.M.I.E.Aust., Bridge Engineer, following a visit to Europe and the United States in 1954.

(Continued from "Main Roads", March 1955.)

(E) Reinforced Concrete Bridges.

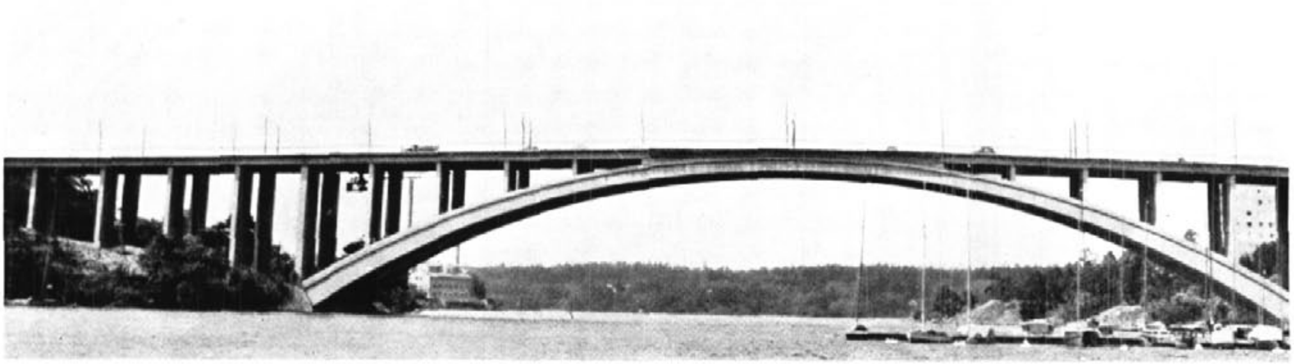
(a) *Orthodox reinforced type.*—While in general reinforced concrete bridge design and practice has not altered much for many years, such alterations being mainly due to better concrete, better steel, and particularly the adoption overseas of deformed bars, certain countries have exploited and improved particular types of bridges.

Sweden.—Sweden has developed the reinforced concrete arch type to a high degree of perfection. Three notable R.C. arch bridges in Sweden are the Traneberg Bridge (1934) in Stockholm, the main span consisting of two rectangular box section arch ribs of 181 metres span; the Svinesund Bridge in northern Sweden connecting with Norway, span 155 metres; and the Sando Bridge, which has a main span of 266 metres. Both the latter bridges have a single rectangular box-section fixed arch rib, and were completed in about 1943.

England.—No works were seen under construction in England but an inspection was made of one of the more notable reinforced concrete bridges in that country, namely the new Waterloo Bridge over the River Thames in London. To still further improve the very fine appearance of this bridge an ornamental band of granite aggregate concrete about 18 inches wide has been cast in the outside faces of the bridge along the soffitts of the arches. This has been wire brushed to roughen the texture and gives a pleasing finish and relief to an otherwise plain white face.

Germany.—An interesting restoration work seen was a 3-hinge reinforced concrete arch over the River Inn near the Austrian Border between Munich and Salzburg. The central portion of this bridge was blown up by the German Army towards the end of the war and the two sides fell inwards into the river. The two sides were jacked up on their original abutment hinges, cut back to sound steel and concrete, and the central portion rebuilt. The new work is so well matched that the junctions between the old and the new work are scarcely discernible.

America.—In America normal continuous girder construction is in common use as an alternative to rolled steel girders in the East and Mid-West, while continuous box girders are favoured on the Pacific Coast. Where normal continuous girder spans are used in underpass structures over expressways they normally incorporated framed abutments. Curved soffitts are common, giving a continuous arch appearance. Box girder structures are of constant depth, being also framed at the abutments. In Oregon State constant depth T-beam continuous girder bridges have been used in many instances, the girders being widened over piers to enable the principal steel to be spaced more widely.



Traneberg Bridge, Stockholm, Sweden. Side view of main span. 181 m.

Two very interesting bridges in reinforced concrete were the Floating Bridge over Lake Washington at Seattle, Washington, and a new pre-cast bridge at Sand Point over Lake Pend Oreille in Idaho State. Particulars of the former have been published in technical papers, and it is sufficient to state that no side movement of the bridge can be detected even in the heaviest gales.

The Sand Point Bridge consists of 168 simple spans, of which 142 are 35 feet long, 25 are 17 feet long tower spans, and the other is a 77 feet long plate girder span, to be converted to a vertical lift span if navigation requirements later justify such action. The Contractor pre-casts all the reinforced concrete spans and transports them to the piers by pontoon lifting gear. He is using steel forms, pre-assembling his reinforcement, and steam curing the concrete. As a result he can move a complete span from his casting jetty every seven days.

(F) Pre-Stressed.

(i) *Pretensioned.*—This group depends on the bond between steel and concrete. The first system of construction to use this principle was the Hoyer system in which the steel reinforcement consists of separate small diameter wires. It is particularly suitable for factory production of precast sections such as railway sleepers, lintels, floor beams and bridge girders.

Holland.—Two bridges of spans 10 metres and 13.5 metres were seen in the vicinity of Rotterdam being constructed on the Hoyer principle. In situ concrete will be poured over and between the girders to form the deck. In casting the girders for both bridges checker plate steel forms have been used, giving an indented surface for the in situ concrete to bond with.

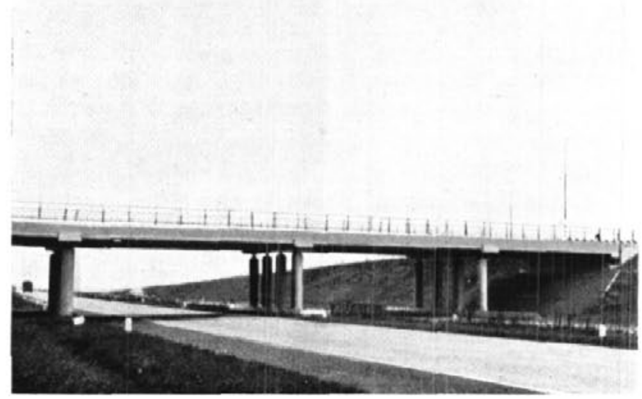
England.—The only pretensioned work seen in England was Northam Bridge over the River Itchen at Southampton, being built by the firm of Christiania-Nielson for the Southampton Borough Council. This is a five-span bridge of spans 85 feet + 105 feet + 105 feet + 105 feet + 85 feet with the girders tied together over the piers to form a continuous girder structure. The design provides that the main girders carry all dead load as simply supported girders and that the continuity gives the added strength for live load.

America.—Two fabricating yards making pre-tensioned prestressed concrete members were visited, one in Pennsylvania at Pottstown near Philadelphia, the other at Tacoma in Washington State.

The former factory is operated by Concrete Products of America, which has a second factory on the Ohio River near Pittsburgh. The Company makes a full range of precast reinforced concrete sections, including reinforced concrete pipes using the vacuo-

Bridge on Sagan via Östanbro near Enköping, Sweden. 5 span continuous girder R.C. Bridge using high tensile reinforcing bars.

Typical underpass structure over Amsterdam-Utrecht Expressway, Holland. Note column piers continuous construction.



concrete process for securing quick setting and therefore a quick turnover of forms, and has applied the same quick curing principle to its pre-stressed girders. The girders manufactured by this Company are of square or rectangular section with a cylindrical hollow running from end to end to reduce weight. In larger girders two holes or a single elliptical shaped hole are used. Indentations cast in the sides of the girders are packed with mortar to form a bond between adjacent girders in a span and steel rods threaded at the ends and passing through holes in the girders clamp the girders together, this being similar to one Hoyer system bridge seen in Holland. The steel used for pretensioning, unlike the Hoyer method, consists of 7-wire twisted cables, and not of plain wires. The Company considers that the twisted cable gives better bond, more than compensating for the slight reduction in allowable stress in the steel due to the twist.

The factory at Tacoma is operated by the Concrete Engineering Company (Anderson Brothers). This Company also makes a full range of pre-cast reinforced concrete sections. They make both pretensioned and post-tensioned girders. Like the Pottstown Company, this Company uses a twisted cable. The girders are of conventional T or I types, not square or rectangular —in this respect following the original Hoyer practice. Vacuo-concrete is not used, but using a dry mix and both internal and external vibration on steel forms, 5,000 lbs. per square inch concrete has been obtained in 24 hours.

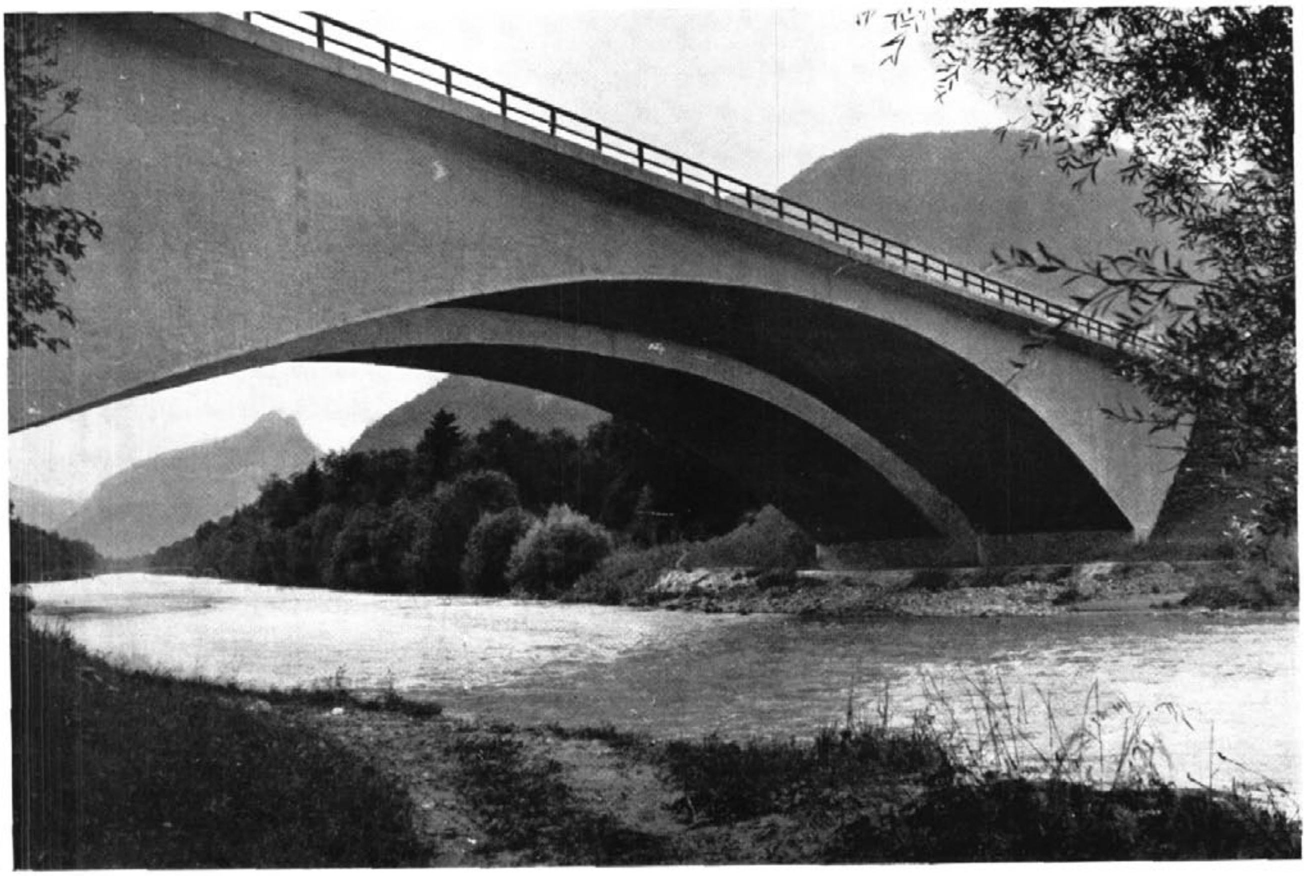
(ii) *Post-tensioned, using cable consisting each of a number of small wires.*—This group can be further subdivided into those systems which use a number of separate cables each extending from one end of the prestressing length to the other and tensioned individually before anchoring and those in which a continuous cable (or group of cables) is wrapped round the length to be prestressed and then tensioned in one operation.

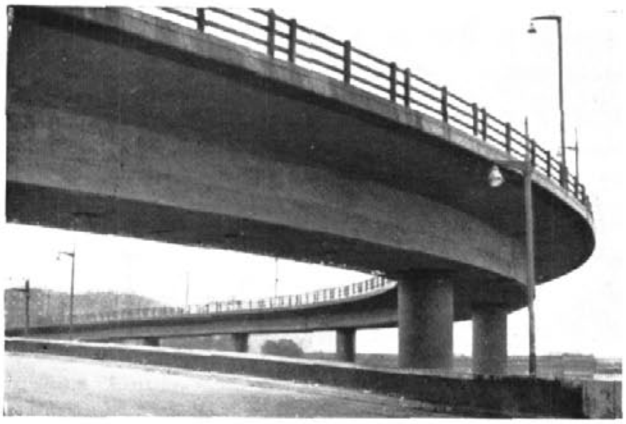
The former type include the systems of Freyssinet (France), Magnel (Belgium), Gifford-Udal (England and Sweden), Rinaldi (Italy), Roebling (U.S.A.), Prestressed (U.S.A.), Franki-Smet (Belgium), Anderson (U.S.A.). They differ mainly in number and arrangement of wires, methods of jacking and type of anchorage.

The latter type includes the Stern and Leonhardt systems of Germany.

The post-tensioned system does not depend upon bond between steel and concrete but on the thrust against anchorages occasioned by the tensioning. The ducts through which the steel passes, are normally filled with grout after tensioning. This serves to preserve the cables against corrosion and incidentally gives added strength from the bond thus provided.

Two-hinged R.C. arch bridge over River Inn near Austrian border between Munich and Salzburg, Germany. Restored by jacking up the ends and re-concreting the centre.





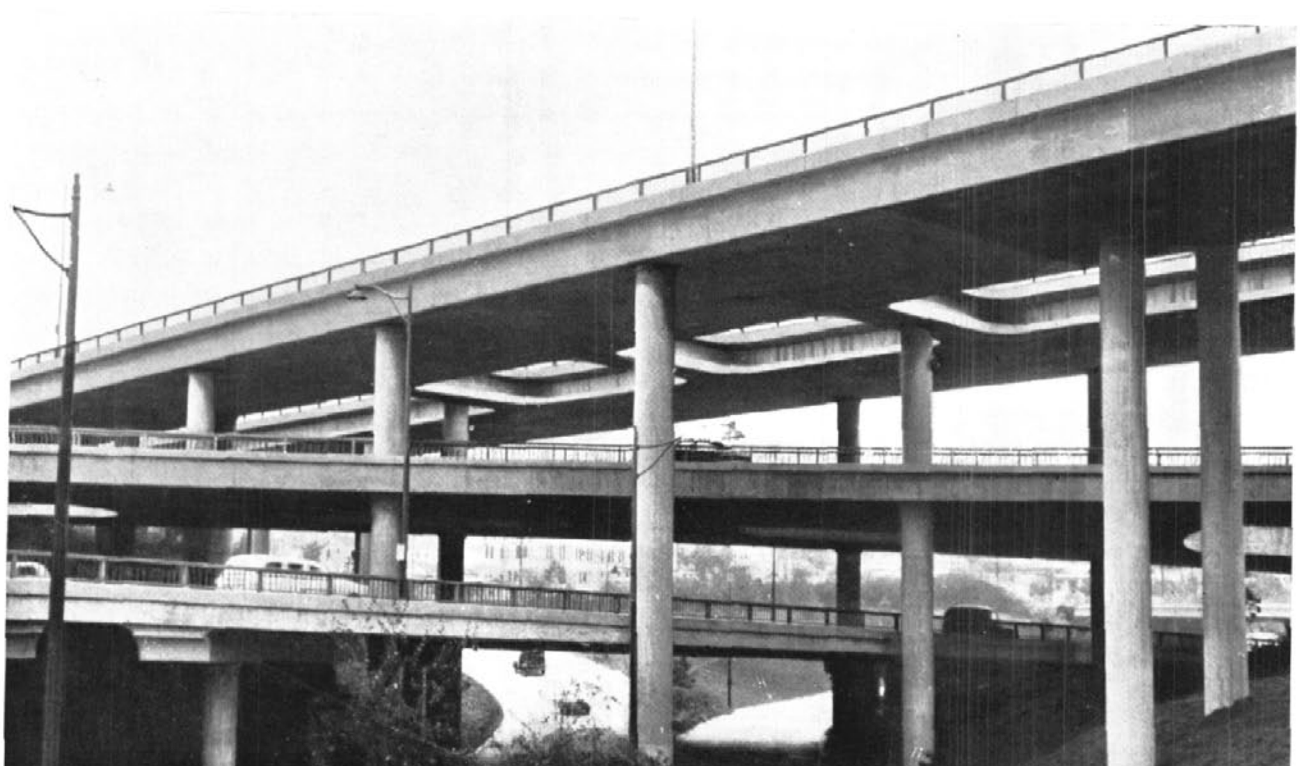
High Bridge Interchange Ramp, leading to cross city expressway, New York, U.S.A. Note single column piers.

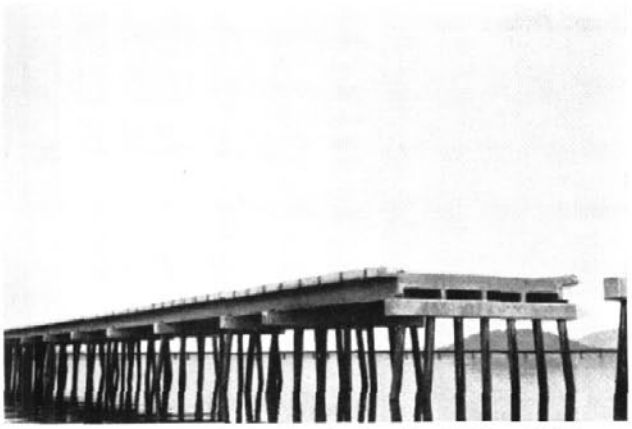
Sweden.—The Freyssinet system has been used for a number of bridges in Sweden. One such bridge seen was a three-span continuous slab bridge over a railway line near Storvik.

This structure is very light-looking in appearance being only about 50 cm. thick. The angle of skew is 20 degrees and the piers are each three circular column struts, with spherical ends bearing against the underside of the slab at the top and hinged at the bottom, thus giving vertical support only. The slab is fixed at one abutment and expands at the other. The slab is tensioned both longitudinally and transversely.

Holland.—The new bridge over the Amstel River at Amsterdam consists of five spans, the end spans of 29 m. and 28 m. being simply supported, and the three centre spans of 34 m., 56 m., and 34 m. continuous. The depth of girder is increased over the two centre piers. This bridge is built in the Freyssinet system and is one of the most beautiful modern bridges seen on the tour. Spans 2, 3 and 4 were cast on the river bank in sections and prestressed sufficiently for handling. Temporary trestle piers had in the meantime been built in the river, one in each of spans 2 and 4, and two in span 3. The pre-fabricated sections covering piers 2 and 3 were then floated out and lowered into position on these piers and the temporary piers on either side, then the pre-fabricated end sections of spans 2 and 4, and finally the pre-fabricated centre section of span 3. The remaining cables were then passed through the ducts and the five sections tensioned together, and the transverse stressing was applied. The end spans were erected on falsework. The undersides of all girders and outsides of the outer girders are painted white, the piers are faced with masonry and the abutments are tiled. The bridge carries four lanes of vehicular traffic in the middle, a cycleway on each side (separated from the roadway by wide raised kerbs) and two footways. Steel lamp-posts are located on the wide kerbs between the cycleways and the roadway, and these posts and the steel handrailing are painted with green paint giving a very pleasing finish

Four level interchange, Hollywood Freeway, Los Angeles, California, U.S.A.





Sand Point Bridge, Lake Pend, Oreille, Idaho, U.S.A. Section of work showing precast spans in place.

to the whole structure. Underwater foundations are driven piles, on which the piers and abutments are built up.

Italy.—Most of the prestressed concrete bridges in that part of Italy visited—the Bologna-Parma area—are on the Rinaldi system. Bridges seen were the Fiume Santarno Bridge near Fontantalice, a four-span bridge of 26 m. each span, on four-column braced piers 25 metres high, all in prestressed concrete; a four-span (21 m. each) bridge at Corti, 62 Km. south of Bologna; and the Fiume Idice Bridge on the Bologna-Ravenna Road.

Belgium.—Most of the prestressed concrete bridges constructed in Belgium are of the Magnel type, but Freyssinet and other types have also been used.

The first large prestressed concrete bridge built in Belgium by the Magnel system (the bridge over the River Meuse at Sclayn, built in 1949) had incorporated in it a proportion of accessible wires, on which measurements could be taken as to creep, slip, temperature extension, etc. This bridge consists of two spans of 62.7 metres each cantilevered from a central pier, and a simply supported span of 60 metres. The main spans are a three-cell hollow box girder with the test cables running through the cells. The test measurements indicate no slip, but creep caused a drop in cable tension from 85 to 78 kilograms per sq. cm. practically all of which occurred in the first six months.

Two other Magnel type bridges seen were respectively 26 + 52 + 26 metre continuous spans and $28\frac{1}{4} + 56\frac{1}{2} + 28\frac{1}{4}$ metre continuous spans. Cable ducts in these bridges are external and were later concreted in. The ducts outside the girder stems do not enhance the beauty of a bridge, although they are only seen from below. In other respects these two Ring Canal bridges are very attractive structures. The abutments are faced with texture brickwork, pre-cast panelling supported by bronze bolts cast into the deck slab hides the outer girders, and the piers and bottom girders are painted with white paint. The piers are slender diaphragms hinged at the bottoms, with a fixed end at one abutment and expansion at the other. All foundations are on piles. The deck is poured in situ over the girders as an ordinary reinforced concrete slab and the bridge is only pre-stressed transversely in the abutments themselves to close up any cracking, the ordinary deck reinforcement being regarded as sufficient otherwise.

France.—Most of the prestressed concrete bridges in France are in the Freyssinet system, although other systems have also been used. In most of the latest Freyssinet designs 7 mm. wires are being used in the cables instead of the 5 mm. wires formerly employed, and the appropriate larger jacks are now available. These incorporate a device for removing the wedges after the cable is anchored. The use of thin sheet metal tubes instead of rubber ductubes or coiled metal sheaths is now almost universal, and it is the general practice to precast the ends of girders, including the female cones, before casting the remainder of the girders. External vibration of the bottoms of the girder forms, where it is difficult to insert an internal vibrator, is common practice.

America.—In America several examples of Freyssinet bridges have been, or are being built. One of these was the Willow Creek Bridge on the Columbia River Highway in Oregon State, consisting of three spans each 98 feet long with the spans simply supported. Each girder is 5 feet 4 inches deep and 4 feet wide at top, there being 9 girders at 7 feet 3 inch centres per span. This bridge is stressed longitudinally, and transversely through cross diaphragms. The diaphragms, and the gaps in the deck between the top flanges of the girders, were cast in situ.

One American system seen was that developed by the Anderson Brothers in Tacoma, Washington. This is similar in principle to the Freyssinet system but uses the twisted cable instead of the straight wire cable of the latter. Female cones are made of steel and male cones of soft metal. The stressing jacks are double acting jacks of the same general type as the Freyssinet jacks, but adapted to take twisted cables. At the time of the visit to the factory some 90 feet girders were being manufactured. These were not designed by the company, although the Anderson system was being used. The stems of the girders were too thin to allow internal vibrators past the cables, so that external vibration only could be used.

Lake Pend, Oreille, Idaho, U.S.A. Removing test load on pile of pier of Sand Point Bridge.

The only systems known to be using groups of cables for prestressing are the Leonhardt and Stern systems of Germany, although it is possible that the Fabers system of France, about which it was not possible to get details, may belong to the same group.

In the Leonhardt system a continuous cable of flexible twisted wire is wound round and round the length of bridge to be prestressed, until sufficient steel is present, the two ends only of the cable being fixed. At each end of the length to be prestressed are attached semi-circular drums to which are fixed vertical positioning strips with lugs on them to hold each loop of the cable in its correct position. These drums may be a steel framework or concrete with rubbing strips of steel cast into them, and are separated from the main stressing length of bridge, either at one or both ends, by a gap large enough for the insertion of the stressing jacks. The cable is placed in rectangular ducts, which may in some cases be external to the girders but are usually within the girders. The cable is kept in position in the ducts by similar steel strips with positioning lugs. Usually in this system the bridges are 2-girder spans, but if a 3-girder span is used the cable passes down the middle girder twice for every once down the outer girder. When the cable is in position the concrete is poured. After it has acquired the necessary strength the jacks are placed in the prepared cavities and the moveable drum and sections jacked away from the main section by an initial stress of about 20 per cent. This takes the slack out of the cables and induces any equalising slipping between them that may be necessary. Ten days later the initial stress is increased to full stress. Steel wedging pieces are inserted between the drum ends and the main stressed in length, the jacks are removed, and the gaps concreted in. Finally the ductubes are grouted.

In the Stern system, of which only cantilever and arch bridge examples constructed by cantilevering from the abutments were seen, groups of cables of measured length were anchored in the concrete at their abutment ends and laid in ducts in the form of loops embracing the portion of the bridge length to be stressed. Jacking was then applied outwards and sideways at the insides of the outer portions of the loops, followed by wedging and concreting up. For the next sections the loops would be longer progressively, while in the centre the loops from either end would overlap, double stressing the crown of the arch or the central portion of the girder.

(iii) *Post-tensioned using solid rods for tensioning.*—As with post-tensioned systems using cables, this system gains its strength by tensioning against anchorages and not from bond.

Dywidag System.—This system was mentioned as having been used in Sweden, Holland and Germany and is known to have been used in other countries also. Examples seen on tour include:—

Bridge under construction over the Oster Dalalven, near Tunsta, about 100 miles north-west of Stockholm, Sweden.—This is a 3-span, double cantilever girder bridge with the abutment spans counterweighted and tied down as anchor spans for the centre and the span lengths are 44, 106.5 and 44 metres. The bridge is fixed on the piers and expands at the abutments, the tie-down links being hinged to allow of free expansion taking place. The abutment spans were constructed first, on falsework, and the centre span was being built out by cantilevering from the piers, using moving forms supported on the finished work, in 5 metre lengths towards the centre. Dywidag bars are supplied in 10 metre lengths and a proportion are stressed and anchored off each 5 metres while screw connectors are used to extend the others. Finally only sufficient bars are left to stress up the last pours at the centre. The threads on Dywidag bars are cold-rolled, the cold working increasing the strength of the steel sufficiently to make

Bridge over River Armstel at Amsterdam, Holland. Freyssinet prestress. 3 centre spans continuous.

Ring Canal Bridge at Ghent, Belgium. Side view of structure. Note thin diaphragm piers which are hinged at bottom, all expansion being at one abutment, the other being fixed.

it equally as strong at the base of the threads as in the main bars. This facilitates the gradual "building-on" type of construction.

Bridge over River Rhine at Coblenz.—This is a 3-span cantilever bridge with spans 102, 113 and 101 metres. The piers carry double cantilevers, and the abutments anchored single cantilevers. Joins between adjacent cantilevers are at centres of spans and consist of rockers held in compression by vertical tie rods which tie together the overlapping portions of the two joining cantilevers. Ties are flexible enough to permit longitudinal movement between the two sides.

Double cantilever bridge over Danube River at Ulm.—This is a similar job to the Tunsta Bridge in Sweden, with a centre span of 78 metres, and is being built by the same system. An interesting feature of this bridge was that to permit traffic to pass at one end, the anchor span was built only partly on false-work, being then extended by cantilevering over the pier which was built up to it from below, before full cantilever construction of the centre span was resumed. The support at the piers is by a diamond-shaped system of struts, not unlike the Wichert steel bridge arrangement of America, except that the joins of the diamond are not hinged.

Lee McCall System.—The only actual Lee McCall bridge seen was in America, where one of the four trial bridges built in Massachusetts was in this system. In this bridge the tubes were not grouted up immediately and after some creep had taken place the bars were re-stressed, some bars being broken during this process. This bridge had a further test by fire. The contractor had stacked against the centre pier a considerable quantity of straw for mulching the road embankments, and had finished pouring the in situ concrete strip along the medial strip between the two halves of the bridge leaving a 1 inch gap for the full length, the pine forms being still in place. During a week-end the straw and the formwork caught fire and burned fiercely, aided by the draught through the 1-inch gap. The ordinary concrete of the pier and the in situ pour in the deck flaked badly, but the pre-stressed concrete in the girders was scarcely affected, this being probably due to the effect of compression closing up minute pores in the concrete and preventing access by the flames. Subsequent load tests showed no reduction in girder strength.

(G) Opening Bridges.

Examples were seen of modern opening bridges such as swing spans, vertical lift spans, the three types of bascule spans—Strauss, Scherzer, and ordinary trunnion and drawbridges. In all cases machinery was electrically driven, with interlocked controls. A stand-by independent prime mover for use in case of an electrical power failure was sometimes provided. Gates were of the banner type (as used in many railway level crossings), the swing type, or vertically lowered types In one case stout steel posts were caused to rise up through the deck. In many instances two sets of gates were used, a light banner type advance gate and a heavy second gate to stop vehicles which may crash through the advance gate. The normal three colour traffic lights to halt traffic were used in most cases, sometimes with the addition of a red flashing light and in a few instances a bell or siren to give a sound warning. In a few cases red lights only were displayed to halt traffic.

Examples seen of the different types of opening span were:—

(a) Swing Spans.

(i) New bridge over Lake Malaren at Hjulsta, Sweden, opened in December, 1953. The overall length of the swing span is 87.62 metres giving two clear openings of 35 metres each between the dolphins. The swing span structure is a steel through truss with welded members and riveted joints. The width between kerbs is 9 metres, allowing three lines of traffic.

The deck is of timber. The bearing is of the pivot type, with balancing wheels running on a circular track. In the closed position one end of the swing span is jacked up on to bearing beds, this automatically forcing the other end down on to its bed. During movement the span is tilted slightly downwards towards the jacking end, which is heavier. The span is operated from a control cabin at one end of the bridge. This control room is a considerable distance away from the actual opening and extra care has to be taken to ensure that road traffic is actually at a standstill before the gates are closed and the span moved.

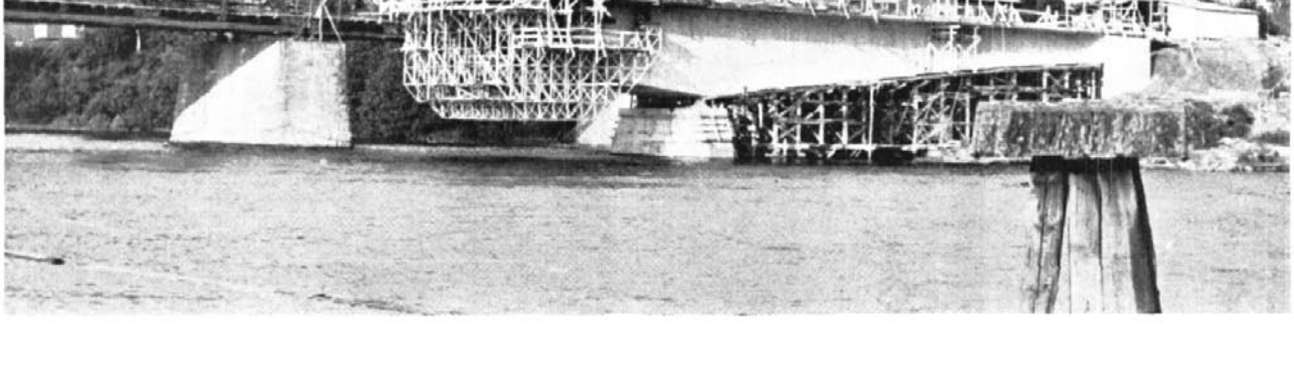
(ii) Bridge over the James River at Yorktown, Virginia, U.S.A. opened to traffic in May, 1952. This is a double swing span bridge, each span being 500 feet long. When both spans are swung the shipping lane is 450 feet wide between dolphins. This wide lane was required because of naval establishments up-stream. Each span can be swung independently, but it is more usual to swing both together. River traffic is not consistent, but the bridge is swung every day to move the machinery, even if no ships require passage. Spans, as in the Hjulsta Bridge, are of through truss construction, all riveted, and turn on pivot bearings. The deck is steel open mesh. Machinery is electrically operated from a control cabin situated in the centre of one span. Two gates are installed on each side—an advance banner gate and a vertical steel drop gate. Normal traffic lights, a flashing light, and sound warning are all installed. At ends of the swing spans a section of deck is unlocked and lifted up by a transverse shaft to give freedom for the span to swing. The adjacent end of the fixed approach span (or the other swing span for the centre join) has a sliding section which provides expansion at the junction. The doubling of lights and gates on this bridge was required because of the failure of motorists to observe signals—in fact an incident has been recorded in Virginia where a motorist passed through two gate positions after a red signal light was showing and crashed against the heavy gate at the other end of the opening; and where another motorist after driving through a red signal light stopped his car at the operator's cabin to inform him that his light was showing red.

(iii) Bridge over "Steamboat Slough" at Everett, north of Seattle in Washington State. This bridge, which was under construction and almost completed at the time of inspection, is of the standard through truss type with a pivot bearing. The overall length of the swing span is 288 feet. It is a new bridge to carry one-direction traffic on a divided highway, the other direction traffic being carried on an older parallel swing bridge built in 1926, which at present carries the two opposing lanes of traffic, about 300 feet away. The new dolphin jetty between the sea lanes is being built as an extension of the old dolphin so that the operators can walk freely from one bridge to the other, and both bridges will be operated simultaneously from one control cabin on the old bridge. Advance banner gates and vertical drop gates are being provided. The drop gate is not a heavy steel gate but consists of steel wire cables stretched between frames, which slide up and down in the posts. The posts themselves are strong enough to take a blow greater than would break the wire ropes. The latter will stop a light truck going at 15 m.p.h. Warning to traffic is by a flashing red light and the word "STOP" in red neon light.

(*b*) *Vertical lift spans.*

(i) Harlem River Bridge on New York Central Railroad system at 155th Street, New York City. This bridge is actually two separate side by side vertical lift structures, set slightly forward of one another to fit the skew of the crossing, and rendered necessary by the fact that railway tracks on the old bridge will need to be demolished to permit of the completion of the whole project. The first bridge was nearing completion at the time of the visit, following which portion of the railway traffic will be diverted, portion of the old bridge dismantled, the second bridge built and the final demoli-

New Bridge at Tunsta, Sweden. Dywidag cantilever prestress. View of work in progress. Mixing building at right.



tion work carried out. The towers are pairs of rectangular braced steel vertical type, and the lift span itself is a steel truss approximately 250 feet long with a lift of 100 feet.

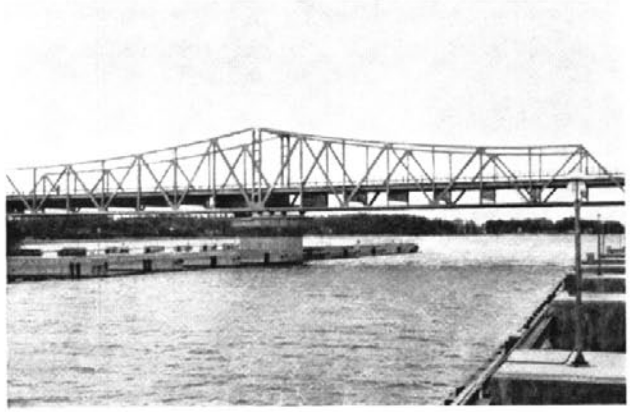
(ii) Bridge over the Hackensack River in Newark, New Jersey. This bridge carries the heavy truck transport traffic from the South into New York City via the Holland Tunnel, and is a six-lane bridge 1,420 feet long, of which the lift span is 220 feet long, giving a clear shipping opening of 200 feet. Height of lift is 100 feet. The towers are normal braced steel riveted construction of rectangular shape and the lift span itself a riveted truss. The deck is open mesh steel. Machinery is located on the top floor of each tower, the two sets being synchronised. Motors are designed to take an out of balance load of 12 tons. There is no stand-by unit in case of power failure. One point noted was that an overhead crane (hand operated) was installed in the machinery room so that it would be easy to lift out and move any machinery item for repairs. A lift runs to the top of each tower. Two operators are always on duty, one in each tower in diagonally opposite lookout rooms. They are in telephone communication with each other, but the controls are worked from one control room only. A model of the span, showing its position of movement at any time is connected with the control board. Gates are in pairs, advance banner gates and heavy steel swing gates, at each end. Normal three colour traffic lights and a hooter warn traffic that the gates are about to close, but there is no flickering light. An interesting feature of this bridge was that the concrete deck of the plate girder approach spans was poured by the vacuo-concrete method, forms being stripped in three days.

(iii) Terminal Island Bridge, Long Beach, California. This is a bridge of similar type to the Hackensack River bridge, with a lift span length of 220 feet. The fixed clearance is 50 feet and the lift 50 feet to give 100 feet clearance. This bridge is built on piles, but the whole area in the vicinity is very soft and the bridge has sunk 4 feet since construction. One of the towers tilted and had to be jacked back and reinforced. Terminal Island is an artificial island.

(iv) The Steel Bridge over the Willamette River at Portland, Oregon. This is an old bridge which was designed by Professor Waddell, and is included here only because it has two lifts. It is a double-decked road and railway bridge, with the roadway on the upper and the railway tracks on the lower deck. With small vessels requiring an opening the operator can raise the lower deck only, to the underside of the roadway, and allow the vessels to pass. If a large vessel requires passage the raised lower deck and the upper deck go up as one unit to the top of the towers. The lower deck is raised about twelve times a day, and the combined opening made about two-three times a week.

(c) *Bascule Spans.*

(i) *Strauss type.*—An example of this type of bridge is the new bridge being built over the entrance to the new ship lock leading into the Antwerp Docks, Belgium. The span is 47 metres, the bridge being the largest of this type in Belgium and one of the largest in the world. The bridge opening, lock gates, road and shipping traffic will be all controlled from one central control room opposite the lock gates, and a complete interlocking system of signals and machinery movements will be installed. The bridge itself will be operated by electric motors, the time of opening being 3 minutes, and a reserve diesel engine is to be provided in case of power failure. This will take 60 minutes. The work was not sufficiently advanced to see the types of gates and signals to be used for the road traffic, construction having only reached the stage that the main truss assembly was about 90 per cent. complete. The steelwork is all riveted.



Hjulsta Bridge, Sweden. View of swing span.

(ii) *Scherzer Rolling Lift type.*—Although quite a number of rolling lift bascule bridges were seen, the only modern one was the Meridian Street Bridge over portion of the harbour of Boston, Massachusetts, which was opened to traffic in August, 1954. This is a double bascule bridge of steel riveted through truss construction, and with an open mesh steel deck. The clear opening for navigation is 112 feet. Machinery is electrically operated with normal interlocks except that the navigation green light is operated automatically by the limit switch when the span is fully open. Gates are of swing type, with no advance gate.

Dywidag prestress cantilever bridge over Danube River at Ulm, Germany. Note pier design.

(iii) *Trunnion Bascule type.*—One example of this type of bridge is the double bascule bridge at Sunderland, England, in which the principal interest lies in the fact that it was constructed of aluminium alloy plates and angles, riveted together with steel rivets. No corrosion defects can be attributed to the steel and aluminium being in contact, the only corrosion in evidence being at one of the kerbs, not at a rivet. In this bridge the counterweight is underslung.

Another interesting type of simple bascule is to be found in the smaller canal bridges of Holland in which the counterweight is carried overhead on an extended lever arm, giving a resemblance to the ancient bucket lifts with which water is lifted from the River Nile in Egypt.

A modern trunnion type bascule bridge is to be found in the pair of double bascule bridges being constructed over the Chicago River on the new Congress Street Expressway in Chicago, United States of America. As in the pair of vertical lift bridges being built over the Harlem River in New York, one of the Chicago River bridges is placed forward of the other to fit the skew of the stream. The distance between trunnion bearings on the two sides of the river is 244 feet 8 inches, giving a clear opening of approximately 200 feet, of which 144 feet is required for navigation purposes. Counterweights weigh 1,200 tons each, contain Barium sulphate and steel punchings as aggregate to give weight, and are underslung. Each bridge will carry four lanes of traffic and one footway. The deck is of welded open mesh steel and the floor system is carried on two riveted steel deck truss girders. The machinery is electrically operated, the two sets of machinery being interlocked to open both bridges together, and is controlled from one control panel. There is no stand-by prime mover for emergency use. The gates are of the vertical drop type with advance banner gates.

In another double bascule bridge in Chicago—on Lakeside Drive—also an underslung counterweight trunnion double bascule bridge, the heavy traffic barrier consists of steel posts which rise up through openings in the deck at about 4 feet spacing. Here again advance banner gates are used.

(*d*) *Drawbridges.*

Under the heading of "opening bridges" should also be included floating drawbridges.

In the ancient type of pontoon bridge, consisting of a series of concrete pontoon boats held against the stream current by anchors and supporting a flexible deck, as represented by the pontoon bridges over the River Po in Italy, the flexible deck is disconnected and a section supported by a few pontoons floated out

New dual vertical lift railway bridge over Harlem River on N.Y.C. Railroad, New York City, U.S.A. Span about 200 feet, vertical lift about 100 feet. First bridge nearing completion. One tower of second bridge can be seen.

by the current to give passage for navigation. This is a very slow process and is only justified by the very infrequent openings required.

In the modern floating bridge over Lake Washington the pontoons are of massive construction, their upper surfaces forming the roadway. In this bridge the opening section is drawn back into a "dock" formed by the side wings or loops which normally carry traffic round the "dock".

In the new Lake Washington Bridge now being designed a portion of the deck will be lifted vertically sufficiently for the draw section to be drawn into the "dock", which will be underneath the lifted section. This will eliminate the loops of the older bridge. These loops with their short radius curves have proved dangerous to traffic.

(H) Timber Bridges.

While timber is now mainly used abroad as an accessory material in bridge construction, it is still used as a permanent material in some instances.

In Bavaria one all-timber covered bridge was seen still in use, and it is understood that there are stiil a few others in Europe and in America.

Timber is still extensively used for underwater piles, where no attacks by teredo and other similar pests are feared. In America the creosoted softwood timbers have a long life, even in tidal waters, and in New Jersey it was stated that timber was preferred to concrete or steel piles in such circumstances. I was informed of one case of a timber viaduct thirty-five years old which was in such good order on test that a concrete deck was placed on it in lieu of an old timber deck.

In the Pacific north-west of America quite a number of new bridges are being built of timber trestle piers with a concrete deck, the concrete usually consisting of precast concrete headstocks and girders with an in situ poured deck. Sometimes even the deck consisted of pre-cast concrete slabs. In this area also the improvement of technique in the production of glued laminated beams has led to a revival in timber truss construction, using laminated sections as main members. The creosoting is done after the timber is glued together. The members are held in place by bolts passing through steel gusset plates or through special washers fitting into machined grooves in the timber, the whole of the bridge being factory made and field assembled. Truss spans of up to 100 feet in length have been built. Ring connectors, also fitted into machined grooves, are only used where the member carries a light load, as in some roof trusses.

Timber laminated decks, with each plank nailed to the next, as built experimentally recently in New South Wales, are sometimes used where lightness in the deck is important, but concrete decks are more usual. Laminated decks are laid transversely on stringers or longitudinally on cross girders, the use of the laminated planks as girders in themselves not being practiced.

One advantage of the softwood timbers of the "Oregon" type over Australian hardwood is that the creosote protection extends at least a quarter of an inch into the timber and that from this depth it is not readily dissolved out, thus preserving the timber for a very long time. Another advantage, especially if timber stringers are used, is that permanent set does not take place.

(I) Aluminium Bridges.

The only aluminium bridge seen on the tour was the bascule bridge in Sunderland, England.

An aluminium truss is, however, being used, in the construction of the new bridge over the Sacramento River between Richmond and San Raphael, as a falsework on which to build the permanent steel truss spans of that bridge. Its lightness enabled it to be transported readily from span to span.

Aluminium is also coming into use for handrails, particularly on concrete bridges. In one bridge in the United States of America it was learnt that handrails of this material subject to wind action vibrated badly and after a time broke off, the aluminium not being resistant to fatigue.

Highway Bridge Design Specification

UNTIL recently each Australian State Road Authority had its own design specification for highway bridges which defined among other things, widths, clearances, loads to be designed for, and working stresses. These design specifications differed from one another in some respects; with the growth of long distance road traffic it became evident that a standard design specification on a Commonwealth-wide basis was most desirable.

The Conference of State Road Authorities of Australia, which meets annually, decided in 1949 that uniform standards of design should be prepared, and all State Road Authorities, as well as the Commonwealth Department of Works, have been represented on a technical committee entrusted with the task, which has now been brought to finality. The new specification is based by permission on a specification prepared by the American Association of State Highway Officials (A.A.S.H.O.) with such variations as are desirable for Australian conditions.

The specification has been printed and will shortly be issued by the various State Road Authorities. It should provide a valuable guide to all engineers engaged in the design of Australian highway bridges.

Copies of the specification may be obtained at the offices of the State Road Authorities in the various capital cities at a cost of 6s. 6d. per copy.

Recent Improvements on Country Main Roads

Reconstruction and Bitumen Surfacing Completed on Long Lengths

★

As stated elsewhere in this issue, it is the objective of the Department of Main Roads to provide continuous lengths of bitumen surfaced roadways and to link up as quickly as possible sections between which the pavement has, for one reason or another, remained untreated.

Some important links recently completed are described hereunder.

State Highway No. 9: New England Highway.

The New England Highway leaves the Pacific Highway at Hexham, a little north of Newcastle, and runs over the Hunter Valley and the New England tableland to the Queensland border at Wallangarra; from that point the road proceeds via Warwick and Ipswich to Brisbane. The Highway constitutes the principal inland route between New South Wales and Queensland.

Prior to the war, the highway had been bitumen surfaced throughout with the exception of three lengths towards its northern end. These comprised 4½ miles over the Ben Lomond Range; a length of 32 miles extending from a point six miles south of Deepwater to Bungulla, including the crossing of the Bolivia Range, and 8½ miles between the northern boundary of the Municipality of Tenterfield and Wallangarra.

Reconstruction of the most northerly of these gaps was commenced in 1947 by the Tenterfield Shire Council. At that time the section was classified as Main Road No. 374, but in 1950 it was reclassified as a State Highway. When reconstruction of the road was decided upon its length included four railway level crossings and an overbridge, the approaches to which were badly aligned. The plans approved for the reconstruction provided for three deviations designed to eliminate all the level crossings and to improve the approaches to the overbridge.

The first of the deviations to be undertaken avoided two of the level crossings, included a two-span timber beam bridge, and provided a 16 feet wide gravel pavement which was later increased to a width of 20 feet. This work was completed in 1946.

Further work, commenced in 1948, eliminated the remaining level crossings and included the provision of a 20 feet wide gravel pavement. When this work was completed, reconstruction of the remaining length was commenced and went forward continuously until completion in 1953. On this length a new timber beam bridge with two 30 feet spans was constructed over Tarban Creek, an existing low level bridge over Tenterfield Creek was redecked and widened, and the approaches to the overbridge were reconstructed on improved alignment. In places where the original alignment of the road was retained the pavement was strengthened to the extent required for present-day heavy loading.

Bitumen surfacing of the full length of 8½ miles was undertaken immediately upon completion of the reconstruction work. The work throughout this length was under the control of the Tenterfield Shire Council.

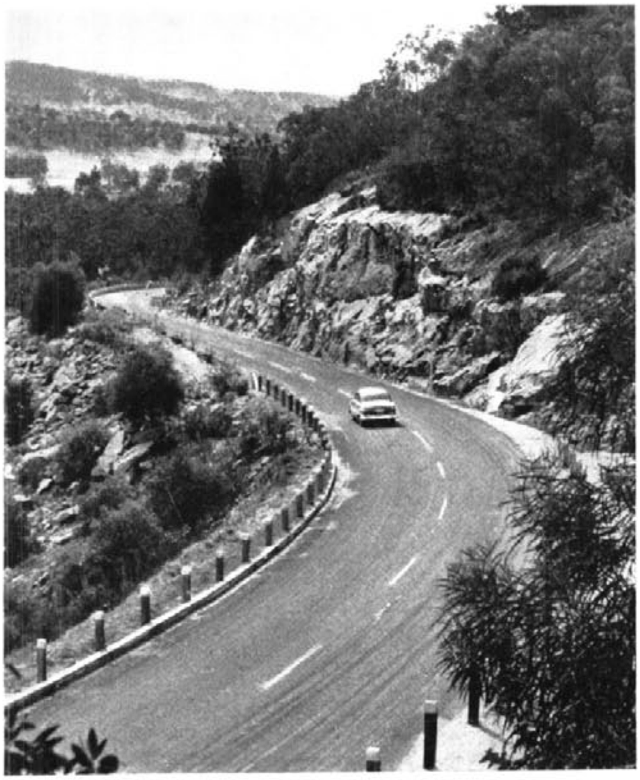
Work on the 32 miles section from Bungulla to south of Deepwater was commenced by the Department of Main Roads in 1945 and continued in subsequent years. The length involved sections of heavy earthworks and rock excavation, and was described in detail in the September, 1951, number of this journal. Bitumen surfacing of the entire length has recently been completed.

Between Guyra and Glen Innes, the New England Highway crosses the Ben Lomond Range, where it reaches an elevation of 4,600 feet. The sub-grade is mainly of decomposed basalt, and heavy strengthening of the pavement was necessitated by the poor foundation conditions. Over approximately one-third of the length, fine crushed rock stabilised with loam, was used and over the remainder granite gravel was used.

Bitumen surfacing of this length has recently been completed by the Department of Main Roads, thus completing the provision of a bituminous surface from Sydney to the Queensland border and on to Brisbane.

State Highway No. 12: Gwydir Highway.

The Gwydir Highway runs in a westerly direction from near the coast at South Grafton to Collarenebri on the western plains, a distance of 326 miles. The western portion of the Highway links the important towns of Glen Innes, Inverell and Moree, and passes through Delungra, Warialda, Gravesend and Biniguy. It intersects the New England Highway (State Highway No. 9) at Glen Innes and the Newell Highway (State Highway No. 17) at Moree, and thus forms part of a network of arterial roads serving a wide area of primary industry.



New England Highway, S.H. 9, Bolivia Range. Shire of Tenterfield.

Between Glen Innes and Moree, 130 miles, there were, until recently, approximately $52\frac{1}{2}$ miles of intermittent lengths of bituminous pavement. As opportunity offered during the war years, some intervening sections of sub-standard alignment were reconstructed, and with the end of the war a progressive programme of pavement improvement was undertaken by the Councils concerned and has now resulted in the provision of a bitumen surface over the full length between the two centres.

The work was facilitated by the availability of deposits of gravel suitable for surface treatment at locations involving comparatively short hauls throughout the entire length of the work. Because of this, gravel was spread over the full width of the formation, thus giving improved shoulder construction and at the same time reducing tendency to fretting of the edges of the bitumen surfaces.

To ensure thorough compaction of the pavement gravel much watering was required, and careful attention was given to the final preparation of surfaces prior to priming. In the later stages of the work rubber tyred rollers were used with good effect.

Altogether, since the war, some 80 miles of missing links on the Gwydir Highway between the tablelands and the western plains have been provided with a bitumen surface at a total cost of approximately £180,000, provided by the Department of Main Roads.

State Highway No. 20: Riverina Highway.

The Riverina Highway leaves the Cobb Highway at Deniliquin and runs in an easterly direction for approximately 137 miles to the Hume Reservoir about ten miles beyond Albury. Running roughly parallel with the Victorian border it intersects the Newell Highway at Finley and the Hume Highway at Albury.

Between Deniliquin and Finley the road practically bisects the Berriquin Irrigation Area and serves country devoted to the raising of fat lambs, wool growing, cereal crop production and dairying. It also serves to link Deniliquin and the intervening country with the nearest New South Wales rail-head at Finley.

The length between Deniliquin and Finley is approximately 38 miles, and until 1950 was classified as an ordinary Main Road. In that year the road was reclassified to form part of State Highway No. 20, and the Department assumed control of the portion through the Shires of Berrigan and Conargo.

Prior to reclassification as a State Highway the reconstruction and bitumen surfacing of various sections of the Deniliquin-Finley length had been undertaken by the respective Councils. By 1950, a section extending for $12\frac{1}{4}$ miles from the Deniliquin Municipal boundary towards Finley had been treated by the Conargo and Berrigan Shire Councils. Following this work a length of $4\frac{1}{4}$ miles was reconstructed and bitumen surfaced within the Municipality of Deniliquin. This work was completed during 1952.

Gwydir Highway, S.H. 12, 17 miles west of Glen Innes in Macintyre Shire.

Riverina Highway, S.H. 20, 13 miles from Deniliquin in the Shire of Conargo.

The bitumen surfacing of these lengths left incomplete only a section of about 12 miles situated approximately in the centre of the length between Deniliquin and Finley. This has recently been completed, and a bitumen surface is now available over the whole length between the two centres.

Although the old road had been formed throughout and some sections loamed, the value of the earlier work had largely been lost through the actions of traffic and weather. Some sections were liable to inundation after even moderate falls of rain. The road was therefore reformed, low sections being built up for heights varying from 6 inches to 3 feet, and a new pavement provided, before sealing with bitumen was undertaken.

There are no gravel deposits in the district, but extensive investigation resulted in the location of deposits of sand-clay suitable for use in a pavement proposed to be surfaced with bitumen. These deposits comprised horizontal layers, from 3 to 12 feet in depth, of varying quality materials, and before use the material in the various layers was blended so as to obtain a uniform quality.

The finished work comprises a 26 feet wide formation with a 20 feet wide pavement and a bitumen surface 18 feet in width.

The total cost of reconstructing and surfacing the 38 miles of roadway has amounted to £101,000.

State Highway No. 21: Cobb Highway.

The Cobb Highway commences at the Victorian border at Moama and runs in a northerly direction to Wilcannia, 374 miles distant, in western New South Wales. It intersects the Sturt Highway and connects with the Mid-Western Highway at Hay, and joins the Barrier Highway a few miles south of Wilcannia. The Cobb Highway follows generally an old mail route travelled by the coaches of Cobb and Co., and provides a direct link with Victorian markets and rail-heads for the country served by the towns of Deniliquin and Hay.

The distance between Moama and Deniliquin is 46 miles. Of this, 42.6 miles are within the Shire of Murray and 3.4 miles in the Municipality of Deniliquin.

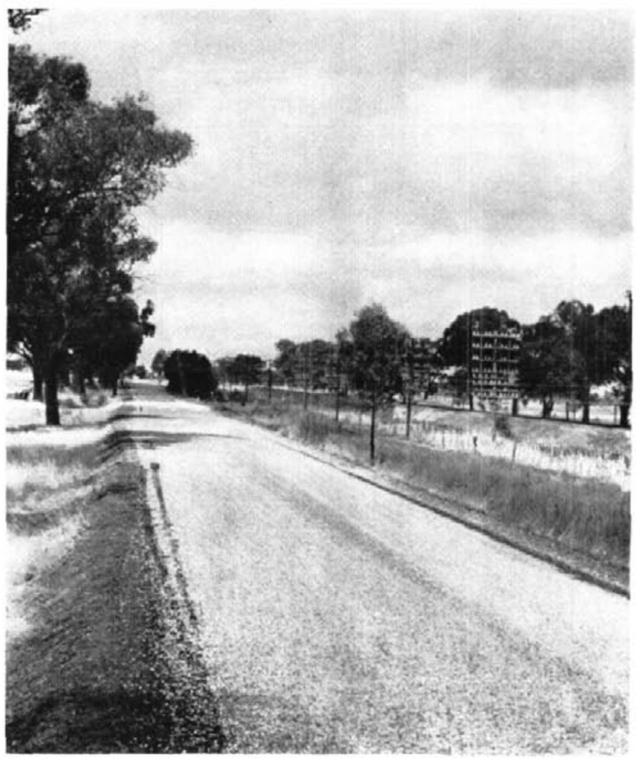
Early in 1940 the Moama Municipality, which has since been absorbed into the Murray Shire, commenced the reconstruction and bitumen surfacing of the pavement. Similar work was also undertaken by the Municipality of Deniliquin, and by April, 1941, a total length of 18.4 miles had been reconstructed and surfaced with bitumen.

Shortly after the end of the war the reconstruction of several unsurfaced lengths was commenced, and by June, 1951, a bituminous pavement extended for 17 miles north from Moama and for 14 miles south from Deniliquin. This left a break of nearly 15 miles of unsurfaced pavement between the two centres.

Work on the bridging of this gap was commenced during 1954, and bitumen surfacing of the entire length was recently completed. The finished work comprises a 26 feet formation, and a 20 feet sand-clay pavement with a bitumen surface 18 feet wide.

All of the work was carried out under the control of the Councils concerned at a total cost, for the 46 miles, of approximately £114,300, which was provided by the Department of Main Roads.

Trunk Road No. 57, Albury to Wagga Wagga. A typical length in the Shire of Culcairn.



Trunk Road No. 57: Albury to Wagga Wagga.

The direct route between Albury and Wagga Wagga, Trunk Road No. 57, branches from the Hume Highway about 5 miles north of Albury, runs parallel with the main Sydney-Melbourne railway line, and joins the Sturt Highway 3 miles from Wagga Wagga and 85 miles from Albury. En route it passes through the Shires of Hume, Culcairn, Kyeamba and Mitchell, and the towns of Culcairn, Henty, Yerong Creek and The Rock, and serves the surrounding good pastoral and agricultural country. The road carries heavy local traffic as well as through traffic.

In 1943, 3 miles of road at the northern end were bitumen surfaced to serve a military camp at Kapooka. From then until 1947 no bituminous work was undertaken, but from then on the various Councils, from time to time, carried out annual programmes of reconstruction and surfacing, the extent of the work undertaken depending primarily on the availability of funds.

Throughout the road the country traversed is undulating to flat, presenting no constructional difficulties. The alignment and grades of the original road were generally satisfactory, and improvement before bitumen surfacing consisted, for the most part, of such improvement to line and grade as could be carried out by a heavy motor grader.

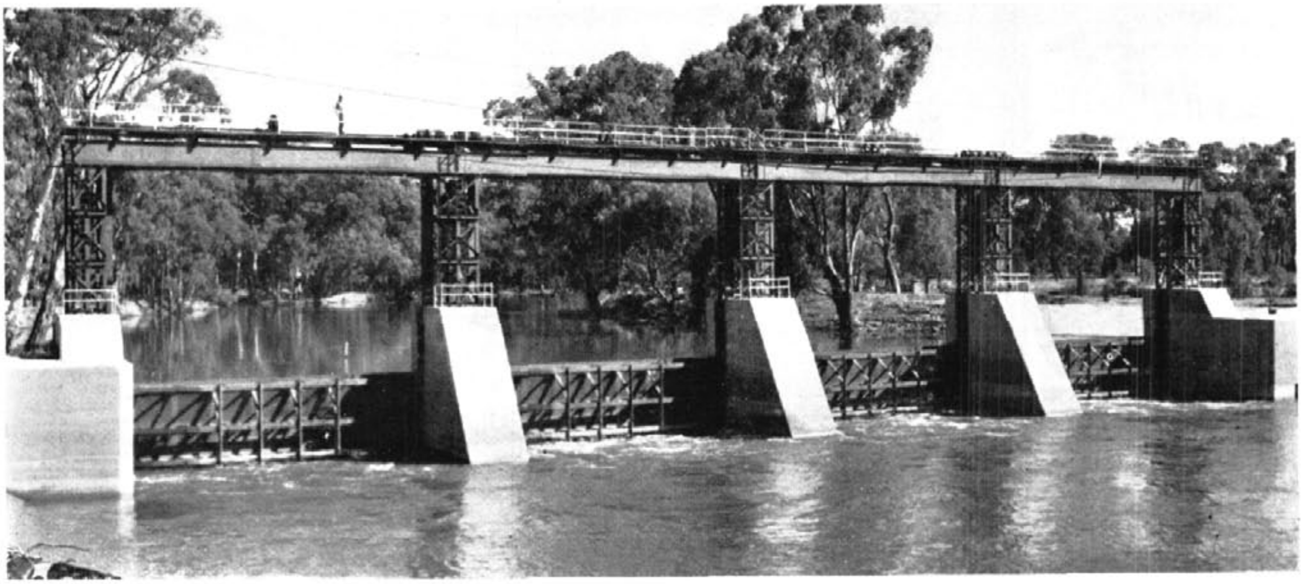
It was necessary to strengthen and widen the pavement to a width of 18 feet, curves were properly set out and super-elevated to a 50 m.p.h. standard, and shoulders provided.

All of the work, except the 3 miles between Wagga Wagga and the Kapooka Camp, was carried out by the Councils within their respective areas at a total cost of approximately £90,000. Of this amount, £67,500 was provided by the Department of Main Roads.

PAYMENTS FROM THE ROAD FUNDS

For period 1st July, 1954 to 31st March, 1955

	Amount Paid. £
County of Cumberland Main Roads Fund:	
Construction and reconstruction of Roads and Bridges	892,443
Acquisition of Land and Buildings for Road Widening	53,722
Maintenance and minor improvements of Roads and Bridges	709,404
Other Expenditure	404,119
Total	£2,059,688
Country Main Roads Fund:	
Construction and reconstruction of Roads and Bridges	2,874,811
Acquisition of Land and Buildings for Road Widening	24,165
Maintenance and minor improvements of Roads and Bridges	3,343,711
Interest, Exchange and Repayment of Loans	125,733
Purchase and repair of Plant, Motor Vehicles and Other Assets	384,947
Other Expenditure	307,863
Total	£7,061,230
Developmental Roads Fund:	
Construction and reconstruction of Roads and Bridges	£113,847
Summary All Funds:	
Construction and reconstruction of Roads and Bridges	3,881,101
Acquisition of Land and Buildings for Road Widening	77,887
Maintenance and minor improvements of Roads and Bridges	4,053,115
Interest, Exchange and Repayment of Loans	125,733
Purchase and Repair of Plant, Motor Vehicles and Other Assets	384,947
Other Expenditure	711,982
Total	£9,234,765



Stevens Weir, Edward River near Deniliquin.
[Photo by courtesy Water Conservation and Irrigation Commission.

Resources Survey and Investigation of Developmental Road Requirements in the Deniliquin District

By

J. Brunt, B.Sc., Planning Assistant, Department of Main Roads

IN 1951 and 1952 the Department of Main Roads carried out a comprehensive invesitgation to determine the Developmental Road requirements of an area of about 4,224,000 acres within the influence of a number of existing and proposed irrigation works in a south-western area of the State. The area, shown in Figs. 1, 2 and 3, lies between the Billabong Creek-Edward River-Wakool River system and the Murray River and extends from the junction of the Murray and Wakool rivers in the west to Mulwala in the east.

It includes the Municipality of Deniliquin, the Shires of Berrigan and Murray and portions of the Shires of Wakool, Windouran, Jerilderie and Conargo. Within the area are the Berriquin, Deniboota, Wakool and Denimein Domestic and Stock Water Supply and Irrigation Districts, the Barramein Domestic and Stock Water Supply District, the Tullakool Irrigation Area and Goodnight, Bungunyah-Koraleigh, Bringan, Glenview and Bama Irrigation Trust Districts.

The investigation took the form of a survey of physical, economic and human resources of the district, including the determination of the existing land use pattern from field inspection and examination of aerial photographs. From the information obtained, it was possible to make a broad estimate of the areas where development is likely to take place and of anticipated increases in production and settlement over a period of 10 years. The existing road system was examined and a programme of proposed Developmental Road works, including bridges, was formulated.

PHYSICAL RESOURCES.

(A) Climate.

The climate of the Deniliquin district is characterized by annual precipitations of between 12 and 20 inches, by mild to cool winters and hot summers. Rainfall is markedly seasonal in character with a definite maximum in the winter months.

The average annual rainfall decreases from 19.78 inches at Mulwala in the south-east to less than 12 inches at the Wakool junction in the north-west.

The effective rainfall west of a line between Jerilderie, Deniliquin and Gonn Crossing is generally insufficient for successful commercial wheat farming without irrigation, and except for the eastern section of the district in the vicinity of Berrigan and Mulwala, any further developments in agriculture are dependent upon irrigation.

DENILIQUIN DISTRICT

fig 1
MAIN ROADS SYSTEM

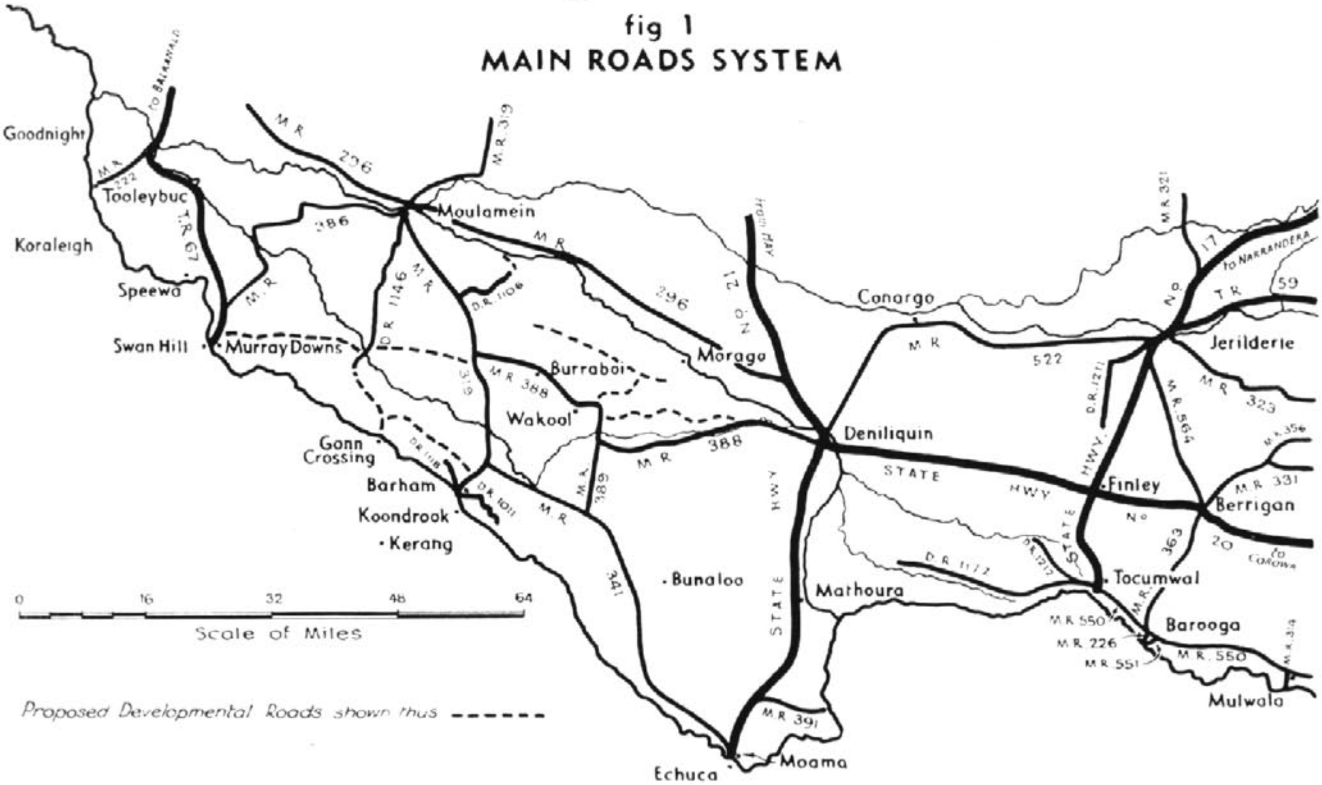


fig. 2
EXISTING and PROPOSED IRRIGATION SCHEMES

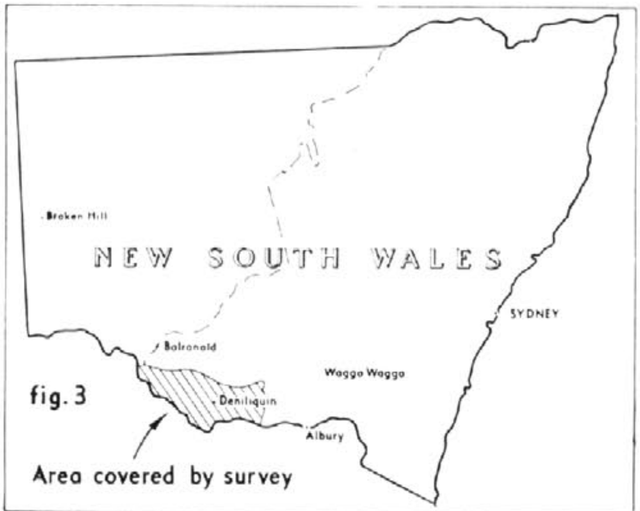


fig. 3

(B) Topography and Drainage.

The Deniliquin district is part of an old flood plain built up by deposits from the Murray River system and from past effluent streams in recent and late Pleistocene times, and is typified by large expanses of flat and gently sloping land with a general elevation of between 200 and 400 feet above mean sea level. The plain has a slight fall to the west and, except for isolated residual hills in the east and mallee rises in the west, slopes rarely exceed one degree.

The drainage pattern is dominated by the Murray River and its two major anabranches, the Edward and Wakool rivers, except in the north-east where Billabong and Yanko creeks provide the main lines of drainage. The area between the Edward River and the Wakool River is dissected by a complex system of distributaries, the largest of which is the Niemur River.

In the Deniliquin-Finley-Berrigan and Mathoura-Bunaloo-Moama areas, there are extensive tracts of well drained coarse sediments not subject to flooding, whilst along the Murray River between Tocumwal and Moama and adjoining the Edward, Niemur and Wakool rivers west of Deniliquin there are extensive areas of poorly drained low-lying sediments including large tracts subject to periodic inundation.

In the Deniliquin districts, it is the drainage rather than the slope factor which determines the topographical limits to agricultural development. The superior drainage conditions of the areas east and south of Deniliquin present few problems of access and little obstacle to settlement, whereas poor drainage conditions, numerous channels and liability to flooding in the extensive area between Deniliquin and Swan Hill make the provision of access relatively difficult and expensive and impose obstacles to settlement.

(C) Soils.

The soils belong to the broad group of pedocals, which are lime-forming soils characterized by high content of bases and correspondingly low percentages of iron and aluminium.

Three broad zonal groups of soils can be recognised. These are:—

Red-brown earths,
Grey and brown soils of heavy texture; and
Solonized brown soils (Mallee soils).

(i) *The red-brown earths.*—Soils of this group occupy extensive areas east and south of Deniliquin and also occur as scattered outliers in the Wakool-Burraboi district. The soils are mainly red-brown, sandy loams and loams of moderate to high fertility. They are generally well drained soils suitable for wheat growing and for the development of annual winter-growing pastures under irrigation. The better drained soils are found at the tops of rises and these are generally suitable for lucerne and fruit growing (citrus and stone fruits) under irrigation, but unfortunately are not always commandable for irrigation except by pumping lifts.

In the absence of any extensive sources of road building gravels in the district, the red-brown loams have been used widely as road surfacing materials.

(ii) *The grey and brown soils of heavy texture.*—These occur in two main sub-groups, the soils of the treeless plains and the grey soils of the box woodland, subject to periodic inundation.

The former are grey and brown clay loams overlying heavy clays containing gypsum. They are generally infertile, somewhat saline soils largely unsuited to irrigation development except for rice growing. These soils occur extensively on the plains to the north of the Edward River and are found also north-west of Wakool between the Wakool and Niemur Rivers.

The latter occur extensively between the Edward and Murray rivers west of Main Road No. 389. They are heavy grey clays sometimes containing lime, and are generally free of sodium salts and gypsum. These soils are moderately fertile and support a dense stand of natural grasses and herbaceous plants where the timber stand is open. The chief disadvantages of these soils are their broken, often crab-holey surface, their dissection by numerous watercourses and their liability to flooding. The cost of clearing and preparing the land for irrigation is high, but once the initial disadvantages are overcome, the soils are eminently suited to the growth of winter pastures and rice.

(iii) *The solonized brown soils.*—These soils occur on high ground to the north-west of Swan Hill between Trunk Road No. 67 and the Wakool-Murray junction. They are light to medium textured red-brown and brown soils, with a well developed calcareous layer in the "B" horizon. Under natural conditions the vegetation cover of the solonized brown soils has little pastoral value. Some areas have been developed for wheat farming, but low and unreliable rainfall and susceptibility to wind erosion have militated against the success of such ventures.

The better class soils of this group are capable of development for vine and citrus production under

A concrete crossing over the main canal which supplies water to the Berriquin and Wakool Districts.
[Photo by courtesy of Water Conservation and Irrigation Commission.

irrigation, but pumping lifts are necessary to irrigate any significant area of the "Mallee" soils.

(D) Water Resources and Development.

The water resources of the Murray River endow the area under review with a potential for development far beyond that possible were such a source of water supply not available. Under the Agreement of 1914, incorporated in the River Murray Waters Act, 1915, the share of the Murray waters allotted to New South Wales was assessed at 1,957,000-acre feet per annum. This figure will be increased substantially when additional water becomes available from the Snowy Mountains Scheme, and the proportion available for diversions will be increased when the storage capacity of the Hume Reservoir is raised to 2,500,000-acre feet as proposed.

The New South Wales Water Conservation and Irrigation Commission has carried out an extensive programme of irrigation development in the Deniliquin district. Four major schemes have been established for stock and domestic water supply and irrigation on an extensive basis. These are Berriquin (779,564 acres) and Denimein (147,025 acres) which are served by gravitation from Yarrawonga Weir, Wakool (494,652 acres) served by gravitation from Stevens Weir on the Edward River, and Deniboota (303,064 acres), which is not yet in operation. The distribution of a controlled water supply to the Deniboota District is contingent upon the completion of the Lawson Syphons under the Edward River and Aljoe's Creek near Deniliquin, connecting with the Berriquin District channel system. This work is now approaching completion.

Other existing irrigation schemes include Tullakool Irrigation Area (16,305 acres), annexed from the Wakool District and developed for rice growing, fat lamb raising and dairying, and Bringan (4,933 acres), Glenview (661 acres), Bungunyah-Koraleigh (1,804 acres) and Goodnight (1,167 acres) Irrigation Trust Districts which have been developed for orcharding, viticulture and dairying under intensive irrigation from the Murray River.

A number of possible future irrigation schemes are under consideration. In the area reviewed these include irrigation extension by gravitation from the Torrumbarry Weir to "East Murrakool" (about 175,000 acres) and the construction of the proposed Marraboor Weir above the effluence of the Little Murray River to serve the proposed "Lower Murrakool" district (about 300,000 acres). Other possible schemes are for the development of "Moaquin" (about 200,000 acres) and "Caloola" (about 103,000 acres). The two last-mentioned schemes, however, would involve considerable capital expenditure in the provision of pumping lifts.

ECONOMIC RESOURCES AND DEVELOPMENT.

The economy of the Deniliquin district is based largely upon primary production. Secondary industries are relatively unimportant and are confined almost exclusively to the processing and handling of the district's raw materials and to the supply of local needs. The larger centres of population function mainly as service towns to their surrounding agricultural and pastoral districts.

Prior to the widespread development of irrigation facilities in the district, the western and north-western sections were devoted to wool-growing on unimproved pastures and to the east and south of Deniliquin extensive areas were developed for wheat growing in combination with wool growing.

The development of the Berriguin, Wakool and Denimein Domestic and Stock Water Supply and Irrigation Districts has enabled the establishment of a thriving fat lamb industry throughout these districts and the introduction of dairy farming and rice growing in certain localities. Wool growing continues to be the major activity in the dry areas to the north-west of Deniliquin and wheat growing is of some importance in the Berrigan and Bunaloo districts but the present economy of the Irrigation Districts is based primarily on the development of irrigated pastures and the production of fat lambs.

At 30th June, 1953, about 187,000 acres of pastures were under irrigation in addition to which some 16,000 acres were sown to lucerne and other fodder crops.

(A) Pastoral Production.

(i) *Sheep and wool.*—At 31st March, 1952, some 2 million crossbred and merino sheep were carried in the Deniliquin district, with stocking rates ranging from 6 lambing ewes per acre on some high grade, irrigated pastures of the Finley district to 1 dry sheep to 13 acres in the partly-cleared Mallee country, east of Tooleybuc. Average carrying capacities are between 2 and 3.5 ewes per acre on irrigated pastures and between 1 sheep to 2 acres and 1 sheep to 5 acres over much of the non-irrigated pasture land.

About 1 million lambing ewes are carried, yielding an average drop of about 750,000 lambs in autumn. Annual wool production from sheep and lambs is about 17 to 19 million pounds weight.

Irrigated Pasture (clover and rye grass) on Developmental Road No. 1146.

(ii) *Cattle.*—Some 38,000 cattle are depastured in the Deniliquin district, including about 9,000 dairy cows. Beef cattle raising is a widespread minor activity throughout the district, whilst dairying is locally important at Finley, Barham, Speewa, Wakool, Moama and Murray Downs.

The emphasis in dairying is on cream production for butter, and producing areas are served by butter factories at Finley (N.S.W.), Echuca (Vic.), Koondrook (Vic.) and Swan Hill (Vic.). Annual production from about 6,000 milking cows in the district is about 900,000 lbs. of butter.

With further development in existing irrigated areas and with the anticipated extension of irrigation to Deniboota, East Murrakool and Lower Murrakool, increases of the order 25 to 50 per cent. in the production of wool, fat lambs and cream are considered possible within the next 10 years.

(B) Agricultural Production.

In 1951-52, 96,000 acres were sown to wheat, the main areas of production being the Berrigan-Mulwala and the Mathoura-Bunaloo districts. Production for this year was 1,910,592 bushels of grain and 3,226 tons of wheaten hay.

In the Irrigation Districts, the trend has been towards increasing the acreage of irrigated pastures at the expense of the wheat acreage, resulting in a decline in wheat production which, however, has been partially offset by higher and more stable yields in the irrigated areas.

The cultivation of rice under irrigation is an important feature of the agricultural economy of the Tullakool Irrigation Area and the Wakool Irrigation District. Since 1948, between 5,000 and 12,000 acres have been sown annually to rice in the Wakool-Burraboi-Moulamein district. Average production has varied between 1 and 2 tons of paddy rice per acre. The entire crop is sent by rail to the Echuca rice mill from sidings on the Balranald line (mainly Burraboi and Wakool).

C. HORTICULTURAL PRODUCTION.

Irrigated horticulture and viticulture are practised in scattered localities adjoining the Murray River, the major producing areas being at Barham and Barooga for citrus and stone fruits and at Koraleigh and Goodnight for vines. The total area under orchards and vineyards for the year 1951-52 was 3,218 acres, of which 1,488 acres were in orchard fruits and 1,730 acres in vines.

D. FORESTRY PRODUCTION.

The State Forests and Forest Reserves of the Deniliquin district are timbered areas totalling 241,313 acres mainly of red gum, box and cypress pine. Red gum and box forests predominate, there being about 236,500 acres of State Forests and Forest Reserves in which red gum is the main commercial species. The mean increment of these hardwood forests is about 12 million super feet per annum.

At the time of the survey, 15 sawmills were operating in the district, the chief centres being Barham, Deniliquin, Moama, Moulamein and Mathoura.

Population Distribution and Trends.

At the census of 30th June, 1947, the population of shires and municipalities in the Deniliquin district totalled 17,478. The main centres of population are Deniliquin (1947 population, 3,668) Tocumwal (1,341), Finley (828), Jerilderie (803), Barham (718), Berrigan (698) and Mulwala (617). Parts of the area reviewed are within the influence of adjoining Victorian towns, the more important of which are Echuca (1947 population, 4,490), Swan Hill (4,305), Kerang (2,717) and Yarrawonga (2,393).

In the initial field count for the census of 30th June, 1954, the population of the district totalled 22,694 an increase of 5,216 over the 1947 figure.

Increases in individual local government areas are indicated in the following table, from which it will be noted that substantial increases have occurred in areas within the influence of irrigation schemes.

Typical unconstructed section on black soil. Developmental Road No. 1146.

Local Government Area.	Population.		Increase.	
	1947 Census.	Field Count 30-6-54.	Amount.	Per Cent.
Municipalities—				
Deniliquin ...	3,668	4,715	1,047	28·5
Moama* ...	662 }			
Shires—		2,983	383	14·7
Murray* ...	1,938 }			
Berrigan ...	4,907	5,825	918	18·7
Conargo ...	950	1,772	822	86·5
Jerilderie ...	1,498	1,938	440	29·4
Wakool ...	3,387	4,758	1,371	40·5
Windouran ...	468	703	235	50·2
Total ...	17,478	22,694	5,216	29·9

* Moama Municipality incorporated in Murray Shire 5-12-52.

The overall increase represents an average gain of 4.27 per cent. per annum, which is considerably higher than the average for New South Wales for the intercensal period (1.98 per cent. per annum).

Further considerable increases of population appear likely throughout much of the district in view of opportunities for additional closer settlement in the Wakool, Berriquin and Denimein Irrigation Districts and of the likely development of the Deniboota Irrigation District and ultimately of the East and Lower Murrakool schemes. Comparable increases in the populations of the larger towns, particularly Deniliquin, Swan Hill, Echuca, Finley and Barham can be expected in response to increased demand for goods and services occasioned by an expanding rural economy.

It has been estimated that, subject to continued irrigation development and further promotion of closer settlement both by private and Government sponsored subdivisions, the population of the Deniliquin district could reach 27,500 by about 1962, as a result of a natural increase of about 2,000 over the 1954 figure and an increase of about 2,800 by net immigration.

New construction Developmental Road No. 1146.

Developmental Road Requirements.

At 30th June, 1952, the road system of the Deniliquin district (Deniliquin Municipality, Berrigan, Conargo, Jerilderie, Murray, Wakool and Windouran Shires) included:—

State Highways—248.0 miles = 4.3 per cent. of total.
Trunk Roads—57.5 miles = 1.0 per cent. of total.
Main Roads—534.0 miles = 9.3 per cent. of total.
Total main roads—839.5 miles = 14.6 per cent. of total.

Developmental.

Roads & Works—102.5 miles = 1.8 per cent. of total.

Unclassified.

Roads—4,836.0 miles = 83.6 per cent. of total.
Total public roads—5,778 miles.

Of the total mileage of public roads in the district, 72 miles (1.25 per cent.) had been bitumen surfaced, 580 miles (10.05 per cent.) had been surfaced with gravel, loam or crushed rock, 1,274 miles (22.10 per cent.) had been formed only, and 3,852 miles (66.60 per cent.) were unformed.

The Deniliquin-Finley-Berrigan-Mulwala district and the Mathoura-Moama district are at present reasonably well served by an existing close network of formed roads in terrain that is naturally well drained and generally flood free. Many miles of minor access roads will ultimately be required in these areas and in particular to the south of Main Road No. 552 between Jerilderie and Conargo and to the north-west of Mathoura, but their construction will be relatively simple and inexpensive.

West of Deniliquin in the areas lying between the Edward and Murray Rivers, the existing system of road communications lacks a direct route connecting Deniliquin and Swan Hill. It also lacks a north-south route connecting with the Victorian road system at Gonn Crossing bridge over the Murray River.

The provision of minor access roads is complicated by poorly drained soils, limited supplies of suitable surfacing materials, numerous creeks and billabongs and liability to flooding over wide areas. While shire councils have done much to alleviate the position, there remains an immediate need for an extensive road and bridge construction and improvement programme in order to provide for the needs of present and future settlers.

It was considered that the most effective way in which the Department could assist in the development of the district generally was to implement an area programme of road and bridge construction works designed to overcome the more important deficiencies in both access and intercommunication. As a result, action is being taken for the early completion of Developmental Road No. 1146 and for the proclamation of 7 roads totalling 98 miles as Developmental Roads, in addition to which the work of constructing a timber beam bridge over the Edward River at Morago has been proclaimed Developmental Work No. 3086.

The works in the programme are estimated to cost approximately £110,000 including the construction of 8 timber bridges, and will be carried out by the councils concerned with moneys granted from time to time by the Department of Main Roads.

HARWOOD FERRY-CLARENCE RIVER. SUPPLEMENTARY FERRY SERVICE

OWING to growth of traffic on the Pacific Highway during recent years, the vehicular ferry service at Harwood on the Clarence River has often been overtaxed at holiday periods or when the regular ferry vessel has been laid off for repairs or annual overhaul.

In order to minimise delays to traffic at such times, the Department of Main Roads recently completed the construction of additional ramps and approaches so as to enable the operation of a supplementary service. The work was carried out in time to permit the supplementary service being available during the Christmas-New Year 1954-55 period.

The new arrangement enables the largest relief vessel available to operate alongside, but clear of the regular vessel; the two vessels have a combined average capacity of 40 vehicles per crossing.

BRIDGE WORKS AT BALLINA

AT Ballina, two new reinforced concrete bridges are being constructed by the Department of Main Roads on the Pacific Highway over the North Creek Canal, one of them at a point $1\frac{1}{4}$ miles west of Ballina and the other at $1\frac{1}{2}$ miles north of the town. Both are five-span structures on driven concrete piles, one being 220 feet in length and the other 200 feet. They will replace old worn-out timber bridges on unsatisfactory alignments.

The manufacture and driving of the piles have been carried out by contract; the remainder of the work is being carried out by day labour. It is anticipated that construction of both bridges will be completed during 1955.

Arrangements are also being made in conjunction with the Ballina Municipal Council for the reconstruction of the Missingham Bridge between Ballina and East Ballina on Main Road No. 545. The existing structure is narrow with a timber superstructure on a concrete substructure, and is inadequate for the heavy traffic which uses it, particularly at holidays and week-ends. The bridge is to be widened and a footway provided for pedestrian traffic.

ROAD WORKS IN BELLINGEN SHIRE

THE Bellingen Shire Council has recently undertaken additional bitumen surfacing on Main Roads in its area. The work has included a length on Trunk Road No. 76 between Thora and Bellingen, and a length on Main Road No. 540.

Trunk Road No. 76 links the New England Highway at Armidale and the Pacific Highway near Raleigh. The work on this road comprises strengthening the existing pavement with gravel stabilised with loam, and surface treatment with bitumen emulsion and screened river gravel.

Main Road No. 540 serves local and tourist traffic to the seaside resort of Sawtell, and connects Sawtell with the Pacific Highway. The work comprised strengthening the old pavement with local shale to serve as a base course, the provision of a gravel surface course, and surface treatment with bitumen emulsion and screened river gravel.

On the steep and winding Dorrigo Mountain section of Trunk Road No. 76, the restoration of slips by means of timber cribs and stone walls is being undertaken by Council as part of an extensive programme of remedial work rendered necessary by flood and storm damage.

FLOOD DAMAGE ON ROADS, FEBRUARY, 1955

1. Yarrawa Bridge over Goulburn River near Denman, Muswellbrook Shire.
2. Bridge over Goulburn River at Sandy Hollow, M.R. No. 208, Muswellbrook Shire.
3. Damage in High Street, Maitland. New England Highway, S.H. 9.
4. Collapsed section of Long Bridge, Maitland. New England Highway, S.H. 9.
5. Damaged approach to Long Bridge, Maitland, New England Highway, S.H. 9.
6. Broken peir and washaway, Minore Bridge, Talbragar Shire.

Typical route number sign indicating that road continues straight ahead.

Erection of Route Number Signs

In co-operation with the State Road Authorities of adjoining States, the Department is proceeding with the erection of route number signs on the principal State Highways.

The numbering of the Hume Highway between Sydney and Melbourne was carried out last year, this road being chosen because it carries the heaviest volume of long distance traffic in the State. It was decided to regard the marking of the Hume Highway as a test, both from the point of view of the display of the signs and from the point of view of public reaction.

A number of points about the display of the signs was learnt as a result of experience on the Hume Highway. Public reaction to the signs has been very favourable.

Steps are now being taken in conjunction with Road Authorities of adjoining States, to proceed with the erection of route number signs on the following additional State Highways:—

Pacific Highway, Sydney to Brisbane.

New England Highway, from Pacific Highway at Hexham to Brisbane.

Prince's Highway, Sydney to Melbourne and Adelaide.

Sturt Highway, from Hume Highway near Tarcutta to Adelaide.

Route number signs are erected at such locations as will guide and reassure traffic regarding the route to be followed. Signs for guidance are placed in advance of important intersections, at intersections where the route makes a turn, and where the pavement surface type changes. Signs for reassurance are placed beyond junctions or intersections, and at intervals of from 5 to 10 miles where no other markers exist.

The general form of the signs is in conformity with the Road Signs Code of the Standards Association of Australia, the shape of the signboard being based on the shape of the shield in the Australian Coat of Arms.

The system of route markers which has been adopted for the principal Australian roads is based on the system of route marking established throughout the United States by the American Association of State Highway Officials. The American numbered system embodies the principal cross-country roads of the United States, and comprises 4.33 per cent. of the total United States road mileage.

Route number sign indicating a turn.

Stripping of Bitumen from Aggregate

Use of Plate Test

Under the title "Stripping of Bitumen from Aggregate" an article in the March, 1952, issue of "Main Roads" gave particulars of the experience of the Department of Main Roads with the problem of bituminous binders being stripped from aggregate in the presence of water. Investigations up to that time had been based on the Immersion-Compression Test developed by the United States Bureau of Public Roads. Details of this test were given and several tentative conclusions were listed.

Shortly after this time some erratic results with certain aggregates indicated that, while the Immersion-Compression Test seemed suitable for checking the hydrophilic properties of aggregates used in densely graded bituminous mixes it was not wholly reliable for testing some aggregates used as surface dressings. This article describes difficulties encountered in using the Immersion-Compression Test, the development of an alternative method of testing and some particulars of recent experiences with the testing of various aggregate bitumen combinations with and without the addition of anti-stripping agents.

THE IMMERSION-COMPRESSION TEST.

In accordance with the procedure adopted by the United States Bureau of Public Roads, test specimens for the Immersion-Compression Test are prepared with the same aggregate gradings and bitumen contents as proposed in the actual construction work. The test appears to give fairly reliable results in comparing stripping resistance of crushed aggregates in dense bituminous mixes but difficulty has been experienced in preparing satisfactory specimens to represent the more open textured mixtures. Furthermore, a large proportion of the bituminous surface treatment work done in New South Wales is of the sprayed surface dressing type using cover aggregate of nearly uniform gauge and it has been found impracticable to prepare stable test specimens without the addition of the smaller gauges specially crushed from the stone under test. This is not an important objection when using a crushed aggregate of uniform quality, but a more serious difficulty arises in testing non-uniform material such as river gravel containing pieces of quartz, quartzite, shale etc., in the one sample, particularly if the aggregate is to be used in the uncrushed condition, as is often the case. Crushing to produce suitable gauges for preparing a stable test specimen then introduces some material of different shape and surface texture, to the actual sample under test and so renders the test unreliable.

It was therefore decided to conduct trials with a Plate Test based largely on procedures adopted by other authorities in Australia and overseas.

THE PLATE TEST.

The procedure being used by the Department of Main Roads for this test is as follows:—

(*a*) Spread 30 grams of 90 penetration residual bitumen to cover the top surface of an etched zinc plate 6 in. x 6 in. x $\frac{1}{8}$ in.;

(*b*) Heat gently to ensure uniform thickness of film;

(*c*) Allow plate to cool to room temperature;

(*d*) Select 50 pieces of the dominant fraction from the aggregate under test and by hand press each piece gently into the film of bitumen;

(*e*) Place in an air oven at 60 degrees C. for 24 hours and then in a water bath at 50 degrees C. for four days;

(*f*) Lower the bath temperature to 25 degrees C. and pull the stones from the plate by hand or with the aid of pliers;

(*g*) Sort into groups according to whether the stones are completely stripped (no bitumen adhering), partly stripped (a substantial part of the contact area still covered by binder), or not stripped (binder still adhering to almost the whole of the contact surface);

(*h*) Calculate the percentage of stone stripped after visual assessment of each stone as follows:—

for full stripping, count one unit;
for part stripping, count half unit;
for no stripping, count nil.

It is difficult to obtain a precise correlation between the results of this test and field service and until further information in this respect is available the results can be regarded as indicative only.

A few cases of failure, apparently due to hydrophilic action have been closely investigated and in each instance the plate test showed good correlation with the field observations. However, the collection of data on the field performance of various anti-stripping agents under natural weather conditions must necessarily be slow; the critical stage for fully testing the efficacy of the agent occurs during the first day or two after the pavement has been constructed and rain may not fall during this period on the few sections chosen for controlled testing. On the other hand data obtained from observing ordinary routine surfacing on a large number of works are generally difficult to interpret because failures which may be due to the hydrophilic nature of the aggregate are often associated with other adverse factors which make it difficult to gauge the extent of stripping involved e.g., over-fluxing of binder, improper rolling etc. The effect of stripping may also be masked to some degree by the mechanical interlock of angular particles of aggregate.

CURRENT INVESTIGATIONS.

In the first instance work with the Plate Test was aimed at determining the most suitable conditions of test, i.e., viscosity of binder, time and temperature of curing, time of immersion, etc. The test was then directed at testing bitumen/aggregate combinations with and without the addition of additives to determine:—

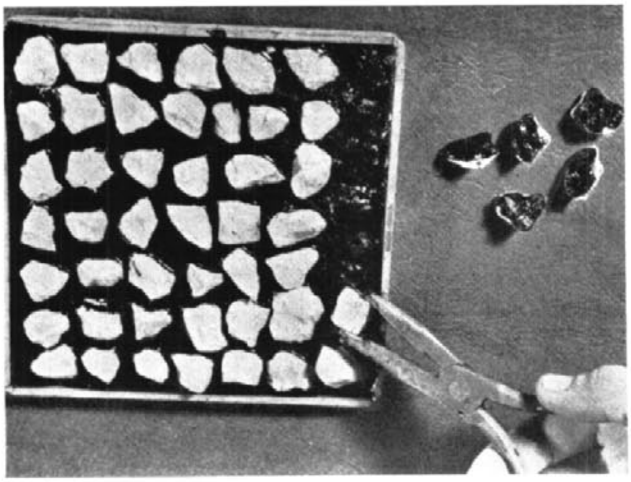
(*a*) If additives were necessary;

(*b*) the most suitable additive for any particular case;

(*c*) whether the best results could be obtained from adding the anti-stripping agent to the binder or applying it as a light coating on the stone.

The Plate Test follows in a general way the construction processes for light surface dressings and consequently each routine test affords an opportunity to study the general behaviour of the stone and binder under conditions resembling those encountered in the field, e.g., observations may be made of the effect of damp or dusty aggregate, increased stripping resistance resulting from a high collar of bitumen around each stone, the physical effect of surface texture, initial adhesion in the absence of water, effect of curing time, softening of some aggregates when soaked in water, and so on. For this reason the test can be a useful guide to the expected behaviour of a sprayed surface dressing except that the effects of rolling and traffic are absent. Where traffic is heavy or where water is retained in the pavement for long periods (e.g., in open plant mix surface courses) the effect of traffic is important and it may eventually be found necessary to similate the effect of traffic as part of the test procedure as already done by some testing authorities. It may also be found necessary to obtain correlation with field behaviour by artificially wetting test sections of pavement during the first few days of its life.

Removing stones from coated plate with the aid of pliers.



CONCLUSIONS.

Although the stage has not been reached where definite conclusions can be stated, work with the Plate Test confirms in a general way the tentative conclusions enumerated in the previous article, viz.:—

(*a*) The "stripping" behaviour of the various combinations of aggregate, bitumen and additive is so varied that the results of any particular combination cannot be predicted from test of others.

(*b*) More than half the aggregate/bitumen combinations without additives showed a marked tendency to strip.

(*c*) Additives which reduce the tendency to strip with one type of stone may be ineffective or actually harmful with another type.

(*d*) There are marked differences between the various bitumens alone and in their response to additives.

(*e*) For all but a few of the rock samples tested there is a reasonably safe bitumen or bitumen-additive combination.

In addition the following conclusions now seem to be justified.

(1) The time and conditions of curing of the bitumen/aggregate interface has a marked effect on the subsequent tendency to strip, i.e. loss of stone from stripping is considerably reduced if the binder has had time to "set" before rain falls on it.

(2) Physical factors such as height of the bitumen film, the mechanical interlock of stones and the action of traffic are important factors affecting the tendency of aggregate to be stripped from surface courses.

(3) Good initial wetting of the aggregate with the bitumen is usually an important factor in reducing any subsequent tendency to strip in the presence of water.

(4) Stripping agents may in some cases deteriorate if held at high temperature for several hours.

FUTURE WORK.

The chief aims for future work with the Plate Test are as follows:—

(*a*) To obtain a satisfactory correlation between the laboratory testing and service records. (Recent results indicate that some change may be desirable in certain conditions of the test, e.g. reduction in the air-curing time of 24 hours.)

(*b*) To determine the most effective method of using the additive, i.e. applied to the stone or incorporated in the binder.

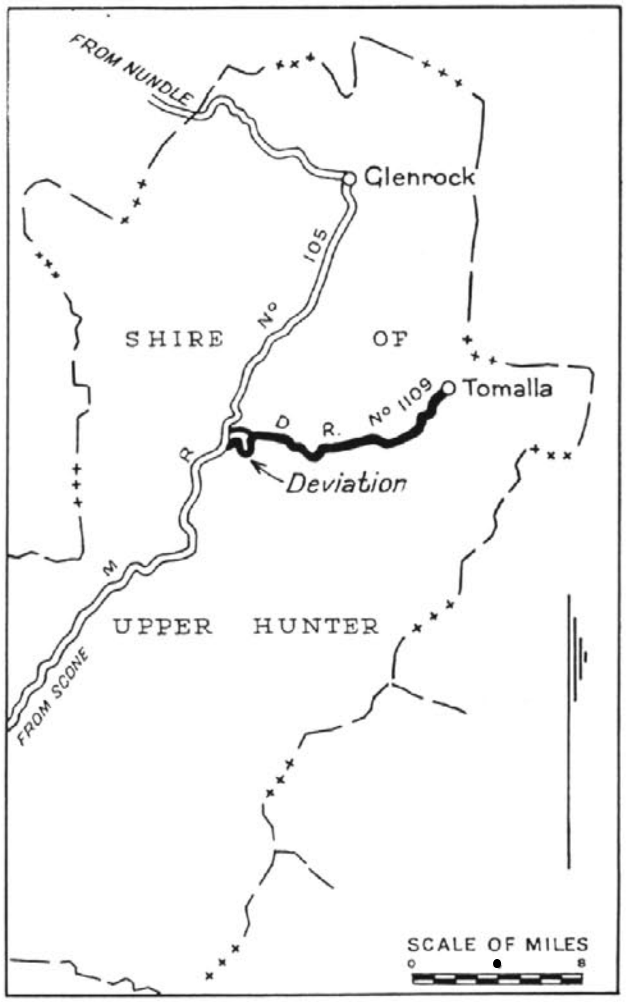
(*c*) To select the most suitable additives for the various bitumen/aggregate combinations.

A microscopic study is also being made of several rocks to determine whether there is any connection between mineral composition and adhesion properties.

A Developmental Road Work in the Shire of Upper Hunter

Developmental Road No. 1109: From Main Road No. 105 near Scone to Tomalla.

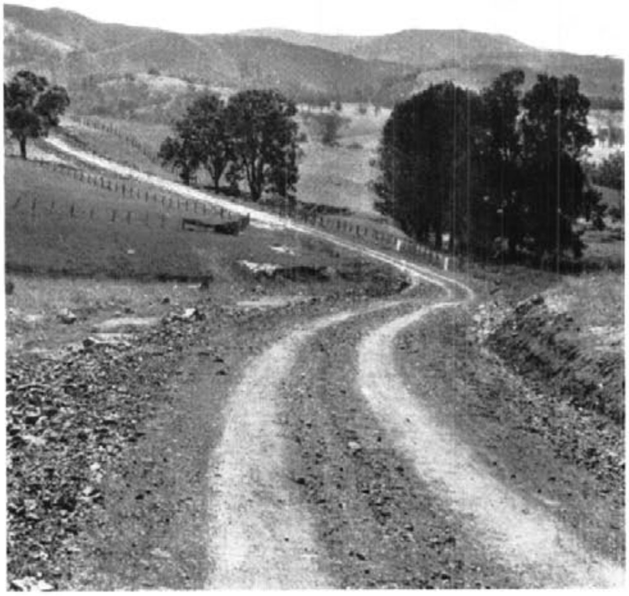
Developmental Road No. 1109 leaves the Scone-Nundle Road (Main Road No. 105) at a point 43 miles from Scone and extends over the Mount Royal Range to Tomalla Post Office, a distance of 16 miles. The road links the Tomalla area with Main Road No. 105 and thence with the New England Highway and the Main Northern Railway at Scone. The road serves an area lying astride the Mount Royal Range, a spur of the Great Dividing Range, and is principally used by local settlers, mail carriers and timber hauliers.



The area served is mostly heavily timbered, elevated virgin country but parts have been cleared for settlement. The largest holding in the area comprises about 14,000 acres most of the remainder being holdings of from 2,000 to 4,000 acres. Rainfall over the area averages 40 inches per annum and the land is used for sheep and cattle grazing. Many of the holdings include areas of up to 40 acres for the growing of potatoes; apples are also grown with success but not to any great extent. Timber is hauled from the area, within which the Hunter River rises, to mills on the Main Northern Railway.

Between Scone and Tomalla the Hunter River twice crosses the road and until recently the only crossings were fords, situated close together and frequently impassable for periods of up to twelve weeks. To avoid these crossings local residents constructed a track over rough country between Dry Creek on Development Road No. 1109 and a point on Main Road No. 105 on the Scone side of the fords, but the steep grades enabled its use only by vehicles with four-wheel drive.

A deviation is at present being constructed by the Upper Hunter Shire Council, by day labour, this following generally the route of the track made by the settlers. The deviation has been designed for a speed of 30 m.p.h. with a formation width of 20 feet and a 12 feet

Typical views on the completed work.

wide gravel pavement 6 inches thick. Earthworks are the major items in the design, a total estimated quantity of 16,720 cubic yards of which one quarter is in granite rock, being involved. Buts and fills range up to 6 feet.

Drainage will be provided by standard reinforced concrete pipe culverts except in a narrow deep gully where it is proposed to install a 120-inch diameter multi-plate steel pipe culvert made from one quarter-inch plate.

Plant in use includes a D.7 tractor with a dozer and scoop; a heavy motor grader; a two-hammer air compressor for drilling and blasting; a two-bag concrete mixer for culvert headwalls, etc., and motor lorries.

The full cost of the work, estimated at £15,056, will be met by the Department of Main Roads from Developmental Road Funds.

Access to the Tomalla area will be greatly improved when the deviation is completed.

SYDNEY HARBOUR BRIDGE ACCOUNT

Income and Expenditure for period 1st July, 1954 to 31st March, 1955

Expenditure.			*Income.*	
	£	£		£
Cost of Collecting Road Tolls ...		45,006	Road Tolls ...	529,488
Provision for Traffic Facilities		4,770	Contributions—	
Alterations to Archways ...		3,285	Railway Passengers ...	90,006
Maintenance and Minor Improvements		78,723	Tramway and Omnibus Passengers ...	19,490
Administrative Expenses ...		1,934	Rents from Properties ...	11,169
Loan Charges—	£		Miscellaneous ...	115
Interest ...	163,500			
Exchange ...	11,250			
Sinking Fund ...	45,000			
		219,750		
Miscellaneous ...		1,159		
		£354,627		£650,268

Tenders accepted by Department

The following Tenders (exceeding £3,000) were accepted by the Department during the months of January, February and March, 1955:—

Work.	Name of Accepted Tenderer.	Amount.
		£ s. d.
Prince's Highway. State Highway No. 1, Shire of Eurobodalla. Construction of Bridge over Clyde River at Bateman's Bay. Riveting of field connections of erected steelwork.	Eastern Construction Co. Pty. Ltd.	7,800 0 0
Additions and alterations to the Department's Divisional Office, Glen Innes.	S. Kevan	5,940 0 0
Hume Highway. State Highway No. 2. Construction of bridge over Bogolong Creek in the Shire of Goodradigbee.	Central Construction Company...	16,397 10 0

Tenders Accepted by Councils

The following Tenders (exceeding £3,000) were accepted by the respective Councils during the months of January, February and March, 1955 :—

Council.	Road No.	Work.	Name of Accepted Tenderer.	Amount.
				£ s. d.
Abercrombie S. ...	252	Construction of reinforced concrete bridge over Pepper's Creek.	Messrs. E. H. Stockton & Co.	11,386 0 0
Coolamon S. ...	243	Sealing of gravel pavement from 9 m. 5,016 ft. to 13 m. 2,400 ft. from Shire boundary.	B.H.P. By-Products Pty. Ltd.	3,053 8 2
Do ...	243	Resealing from 13 m. 2,400 ft to 20 m. 1,056 ft. between Coolamon and Narrandera.	do do ...	3,040 14 4
Dorrigo S. ...	119	Bituminous sealing works—Main and Trunk Roads Improvement Programme, 1955.	do do ...	5,026 13 10
Eurobodalla S. ...	51	Operation of ferry over Clyde River at Nelligen for three years.	Messrs. Patrech and Butcher	7,500 0 0
Gloucester S. ...	1,150	Construction of deviation together with gravel pavement 12 ft. wide, culverts and subsidiary works at Tibbuc.	Carsons Northern Timber Co.	8,840 0 0
Goobang S. ...	57, 238, 350, 348	Supply, delivery and spreading 23,096 cu. yds. gravel at various locations.	E. Short	7,987 7 4
Greater Wollongong C.	522	Reconstruction of sub-structure of Windang Bridge	R. G. Cram and Son Pty. Ltd.	36,319 9 0
Grenfell M. ...	239	Reconstruction and construction of culverts	A. C. Stephen & Son ...	4,188 3 4
Guyra S. ...	9	Construction of three 8 ft. x 3 ft. R. C. Culverts south of Llangothlin level crossing.	J. Gabauer	3,124 17 0
Holbrook S. ...	211	Supply and delivery of 1,100 cu. yds. aggregate between 0 m. and 9 m.	Albury Sand & Gravel Co....	3,327 10 0
Do ...	211	Sealing from 0 m. to 9·35 m. from State Highway No. 2.	B.H.P. By-Products Pty. Ltd.	4,096 11 8
Jerilderie S. ...	...	Supply, delivery and spreading of gravel under 1955 Programme.	D. D. McCallum Constructions Ltd.	6,104 6 0
Manning S. ...	10, 90, 192, 111	Bituminous surfacing and resurfacing, excluding supply of aggregate.	B.H.P. By-Products Pty. Ltd.	3,684 4 1
Nymboida S. ...	12	Construction of bridge over Wintervale Creek 45·8 m. from South Grafton.	Boulder Construction Company.	6,606 0 0
Do ...	12	Construction of bridge over Straight Creek 45·9 m. from South Grafton.	do do ...	6,225 0 0

Tenders accepted by Council—*continued.*

Council.	Road No.	Work.	Name of Accepted Tenderer.	Amount. £ s. d.
Port Stephens S.	101, 108, 301, 302	Bituminous surfacing and resurfacing, excluding supply of aggregate.	B.H.P. By-Products Pty. Ltd.	8,471 9 1
Urana S. ...	59	(*a*) Supply and delivery 5,280 cu. yds gravel between 22·5 m. and 25·8 m. and (*b*) 2,720 cu. yds. gravel between 19·5 m. and 21·2 m. from boundary with Lockhart Shire.	F. W. Hall	9,567 0 0
	131	Supply and delivery of 4,800 cu. yds. gravel between 18·4 m. and 21·4 m. from junction with Main Road No. 125.		
	385	(*a*) Supply and delivery of 1,360 cu. yds. gravel between 21·55 m. and 22·4 m. and (*b*) 8,800 cu. yds. between 23·8 m. and 29·3 m. from junction with Trunk Road No. 59.		
Wagga Wagga C.	14	Resealing from 299·62 m. to 302·60 m. at Wagga ...	B.H.P. By-Products Pty. Ltd.	3,877 18 1
	57	Resealing from 1 m. to 2 m. and 3 m. to 3·73 m. from Wagga.		
	211	Resealing from 0·2 m. to 1·01 m. south from State Highway No. 14.		
	57	Roadmix reseal and light flush seal coat 0 m. to 0·85 m. south and 0 m. to 0·45 m. north.		
	57	Sealing Parken Praegan Deviation—central 20 ft. width only.		
Wallarobba S. ...	128	Bitumen surfacing and resurfacing, excluding supply of aggregate.	do do ...	4,001 4 0
Waradgery S. ...	319	Repairs and additions to bridge over Budgee Creek ...	Town and Country Works...	3,472 0 0
Do ...	14	Shouldering and resheeting with loam 35·05 m. to 40.85 m.	L. G. Jones	7,241 17 6
Warringah S. ...	164	Widening on west side between Burnt Bridge Creek and Gordon Street. Supply of ready mixed Concrete.	Warringah Concrete Constructions.	3,527 10 0
Wollondilly S. ...	177	Supply and laying 2,829 tons hotmix	Bituminous Pavements Pty. Ltd.	18,047 16 1

MAIN ROADS STANDARD SPECIFICATIONS, DRAWINGS AND INSTRUCTIONS.

NOTE: Drawings are prefixed by letter "A", instructions are so described; all other items are specifications or forms. Year of revision, if within last 10 years, is shown in brackets.

Form No.

ROAD SURVEY AND DESIGN.

A 478, A 478A — Specimen drawings, country road design.
A 478C Specimen drawing, flat country road design.
A 478B Specimen drawings, urban road design.
A 1645 Stadia reduction diagram.
355 Design of two-lane rural highways. (Instruction.)
369 Design of urban roads. (Instruction.)
288 Design of intersections. (Instruction.) (1952.)
402 Design of acceleration and deceleration lanes. (Instruction.)
499 Design of kerb-lines and splays at corners. (Instruction.) (1952.)
A 1614 Widening at points of "A" sight distance.
A 83 Earthwork quantity diagram.
Manual No. 2—Survey and design for main road works
A 1640 Mould for permanent mark block.

STREET DRAINAGE.

243 Integral concrete kerb and gutter and vehicle and dish crossing, and drawing. (A 134A.)
245 Gully pit and drawings: with grating (A 1042); kerb inlet only (A 1043); with grating and extended kerb inlet (A 1352) extended kerb inlet (A 1353).
A 190 Gully grating.
A 1418 Concrete converter.
A 3491 Perambulator ramp.
A 3536 Mountable type kerb with reflectors.

CULVERTS.

138 Pre-cast concrete box culvert (1947) and drawing: 12 in., 18 in., 24 in., and 30 in. high (A 3847).
206 Reinforced concrete culvert (1948) and instruction sheets. (A 304, A 305, A 306, A 359.)
A 1012–20 Single cell reinforced concrete box culvert: 6 in. to 1 ft. 3 in. (A 1012); 1 ft. 4 in. to 3 ft. (A 1013); 4ft. (A 1014); 5 ft. (A 1015); 6 ft. (A 1016); 7 ft. (A 1017); 8 ft. (A 1018); 9 ft. (A 1019); 10 ft. (A 1020); 11ft. (A 1020A); 12ft. (A 1020B).
A 1021–30 Two cell, reinforced concrete box culvert: 6 in. to 1 ft. 3 in. (A 1021); 1 ft. 4 in. to 3 ft. (A 1022); 4 ft. (A 1023); 5 ft. (A 1024); 6ft. (A 1025); 7 ft. (A 1026); 8 ft. (A 1027); 9 ft. (A 1028); 10 ft. (A 1029); and with concrete wearing surface–10 ft. (A 1030).
A 1031–41 Three cell, reinforced concrete box culvert: 6 in. to 1 ft. 3 in. (A-1031); 1 ft. 4 in. to 3 ft. (A 1032); 4 ft. (A 1033); 5 ft. (A 1034); 6 ft. (A 1035); 7 ft. (A 1036); 8 ft. (A 1038); 9 ft. (A 1040); and with concrete wearing surface–7 ft. (A 1037); 8 ft. (A 1039); 9 ft. (A 1041).
25 Pipe culverts and headwalls, and drawings: single rows of pipes: 15 in. to 21 in. dia. (A 143); 2 ft. to 3 ft. dia. (A 139); 3 ft. 6 in. dia. (A 172); 4 ft. dia. (A 173); 4 ft. 6 in. dia. (A 174); 5ft. dia. (A-175); 6 ft. dia. (A 177); Double rows of pipes: 15 in. to 21 in. dia. (A 211); 2 ft. to 3 ft. dia. (A 203); 3 ft. 6 in. dia. (A 215); 4 ft. dia. (A 208); 4 ft. 6 in. dia. (A 207); 5 ft. dia. (A 206); 6 ft. dia. (A 213). Treble rows of pipes: 15 in. to 21 in. dia. (A-210); 2 ft. to 3 ft. dia. (A 216). Straight headwalls for pipe culverts: 15 in. to 24 in. dia. (A 1153).
A 1 Joint for concrete pipes.
A 142 Inlet sump for pipe culvert 3 ft. dia. or less. (1947).
139 Timber culvert (1950) and drawings, 1 ft. 6 in. high (A 427); 2 ft. (A 428); 3 ft. (A 429); 4 ft. (A 430); 5 ft. to 8 ft. high (A 431).
A 1223 Timber culvert 20 ft. roadway. (1949.)
A 3472 Timber culvert 22 ft. roadway. (1949.)
303 Supply and delivery of pre-cast reinforced concrete pipes.

BRIDGES AND FERRIES.

18 Data for bridge design. (1948.)
371 Waterway calculations. (Instruction.)
300 Pile driving frame, specification for 25 ft. and drawings for 50 ft. (A 209); 40 ft. (A 253); and 25 ft. portable (A 1148).
A 3693 Pontoon and pile driving equipment.
164 Timber beam bridge (1947) and instruction sheets, 12 ft. (A 3469); 20 ft. (A 70) (1949); and 22 ft. (A 1761) (1949).
326 Extermination of termites in timber bridges. (Instruction.)
350 Reinforced concrete bridge. (1949.)
495 Design of forms and falsework for concrete bridge construction. (Instruction.)
314 Regulations for running of ferries. (1948.)
A 4 Standard bridge loading. (Instruction.) (1948.)
A 26 Waterway diagram. (1943.)
A 1886 Arrangement of bolting planks. (1948.)
A 45 Timber bridge, standard details. (1949.)
A 1791 Timber beam skew bridge details. (1949.)
A 3470, A 3471 — Low level timber bridge, for 12 ft. and 20 ft. between kerb. (Instruction.) (1949.)
A 1216 Running planks.
A 1207 Reinforced concrete pile—25 tons. (1945.)
A 1208 Reinforced concrete pile—35 tons. (1945.)
A 1621 Reflector strip for bridges.

FORMATION.

70 Formation. (1949.)
513 Subsoil and subgrade drainage. (Instruction.)
A 1532 Standard typical cross-section.
A 1149 Flat country cross-section, Type A.
A 1150 Flat country cross-section, Type B.
A 1151 Flat country cross-section, Type D1.
A 1152 Flat country cross-section, Type D2.
A 1476 Flat country cross-section, Type E1.
A 1101 Cross-section one-way feeder road.

Form No.

A 1102 Cross-section two-way feeder road.
A 114 Rubble retaining wall.

PAVEMENTS.

71 Gravel pavement. (1949.)
228 Reconstruction with gravel of existing pavement.
254A Supply and delivery of gravel.
72 Broken stone base course. (1947.)
216 Telford base course.
68 Reconstruction with broken stone of existing pavement to form a base course.
257 Haulage of materials.
65 Waterbound macadam surface course.
230 Tar or bitumen penetration macadam surface course, 2 in. thick.
66 Tar or bitumen penetration macadam surface course, 3 in. thick.
125 Cement concrete pavement, and plan and cross-section. (A 1147.)
A 380 Galvanised iron strip for deformed joint.
A 381 Bituminous filler strip for transverse expansion joint.
493 Supply of ready mixed concrete.
266 Asphaltic concrete pavement.

SURFACE TREATMENT.

301 Supply and application of binder. (1950.)
122 Surfacing with tar. (1949.)
145 Surfacing with bitumen. (1949.)
93 Re-surfacing with tar. (1949.)
94 Re-surfacing with bitumen. (1952.)
466 Fluxing of binders for bituminous flush seals and reseals. (Instruction.)
351 Supply and delivery of aggregate.
354 Road-mix resealing. (1949.)
397 Fluxing for tar road-mix reseal. (Instruction and chart.)
A 1635 Fluxing chart for bitumen road-mix reseal.
167 Resheeting with plant-mixed bituminous macadam by drag spreader. (1951.)

FENCING AND GRIDS.

141 Post and wire fencing (1947) and drawings: plain (A 494); rabbit-proof (A 498); flood gate (A 316).
143 Ordnance fencing and drawing. (A 7.)
144 Chain wire protection fencing and drawing. (A 149.)
246 Location of protection fencing. (Instruction.)
224 Removal and re-erection of fencing.
A 1705 Plain wire fence for use in cattle country
A 3598 Wire cable guard fence.
A 1301 Motor traffic by-pass 9 ft. wide.
A 1875 Motor traffic by-pass 20 ft. wide.

ROADSIDE.

A 1337 Concrete mile post, Type A.
A 1338 Concrete mile post, Type D.
A 1366 Standard lettering for mile posts
A 1367 Timber mile post, Type B1.
A 1368 Timber mile post, Type B2.
A 3497 Timber mile post, Type B3.
A 2815 Concrete kerb mile block.
A 1420 Steel mould for concrete mile posts.
A 1381–3, A 1452–5 — Tree guards, Types A, B, C, D, E, F, and G.
Manual No. 4—Preservation of roadside trees.

MATERIALS.

296 Tar. (1949.)
337 Residual bitumen and fluxed native asphalt.
305 Bitumen emulsion. (1953.)
349 Light and medium oils for fluxing bitumen. (1948.)
A 27 Slump cone for concrete.
A 178 Mould for concrete test cylinder.
76 Design of non-rigid pavements. (Instruction.)
Manual No. 3—Materials.

TRAFFIC PROVISION AND PROTECTION.

121 Provision for traffic (1954) with general arrangement (A 1323), and details (A 1325) of temporary signs. (1947.)
252 Supply and delivery of guide posts.
253 Erection of guide posts. (Instruction.)
A 1342 Temporary warning sign, details of construction.
A 1346 Iron trestle for road barrier.
A 1341 Timber trestle and barrier.

PLANT.

A 1414 Gate attachment for lorries with fantail spreader.
A 1450 Half-ton roller with pneumatic tyres for transport.
A 2814 Two-berth pneumatic tyred caravan.
A 2828 Multi-wheeled pneumatic tyred roller.
A 2976 Fantail aggregate spreader.
A 3530 Benders for steel reinforcement.
A 3547 Steel bar cutter.

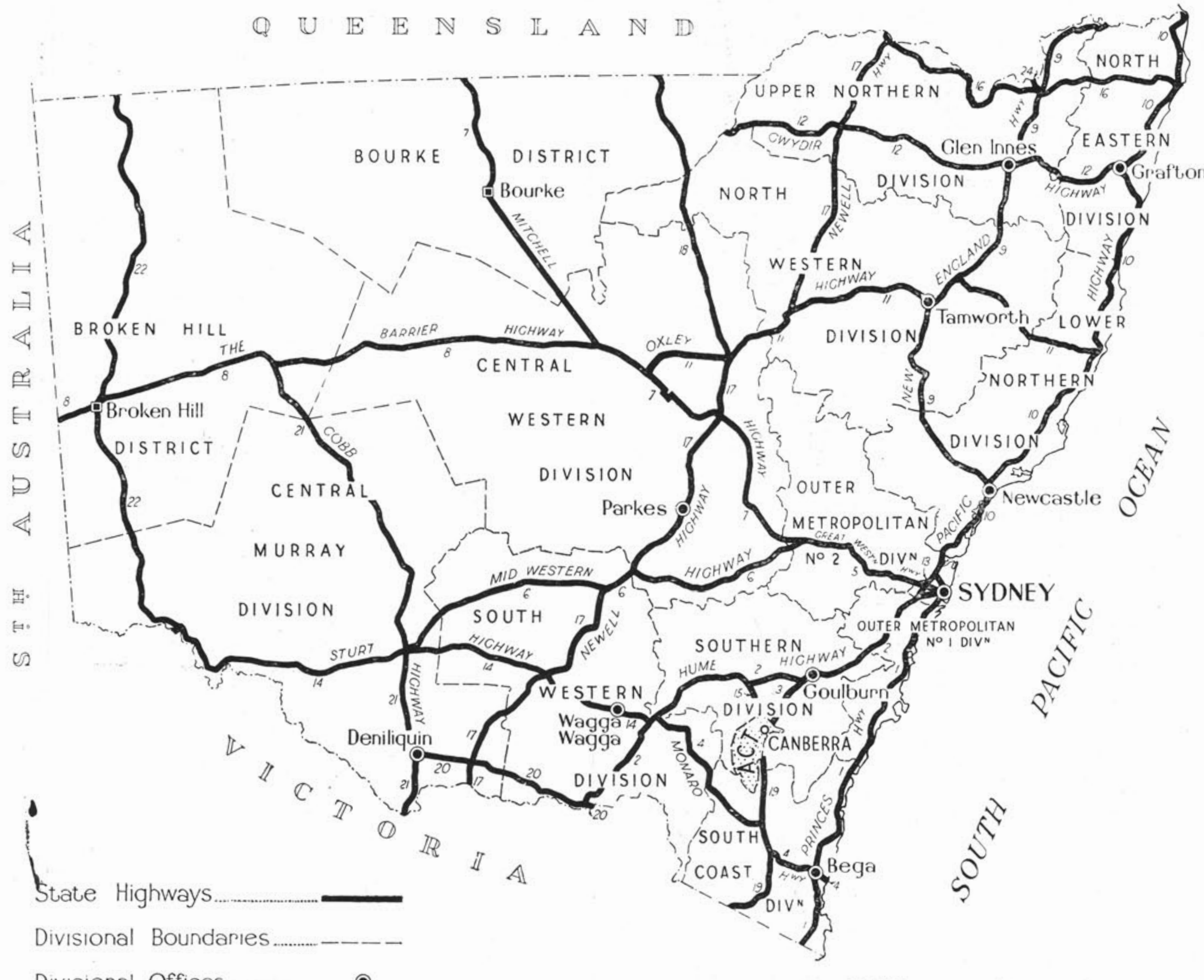
CONTRACTS.

24B General conditions of contract, Council contract. (1953.)
342 Cover sheet for specifications, Council contract. (1950.)
64 Schedule of quanities form.
39 Bulk sum tender form, Council contract. (1946.)
38 Bulk sum contract form, Council contract.
193 Duties of superintending officer. (Instruction.)
498 Caretaking and operating ferry.

All Standards may be purchased from the Head Office of the Department of Main Roads, 309 Castlereagh Street, Sydney, single copies being free to Councils.

Sydney. A. H. Pettifer, Government Printer—1955.

State Highway System
of the
State of New South Wales



SCALE OF MILES
40 20 0 40 80 120 160 200

Area of New South Wales, 309,433 square miles.
Length of public roads within New South Wales, 127,551 miles.

MILEAGE OF MAIN AND DEVELOPMENTAL ROADS, AS AT 30th JUNE, 1954.

State Highways	6,527
Trunk Roads	4,228
Main Roads	12,534
Secondary Roads (County of Cumberland only)	77
Developmental Roads	2,933
	26,299
UNCLASSIFIED ROADS, in Western part of State, coming within the provisions of the Main Roads Act	3,213
TOTAL	29,512