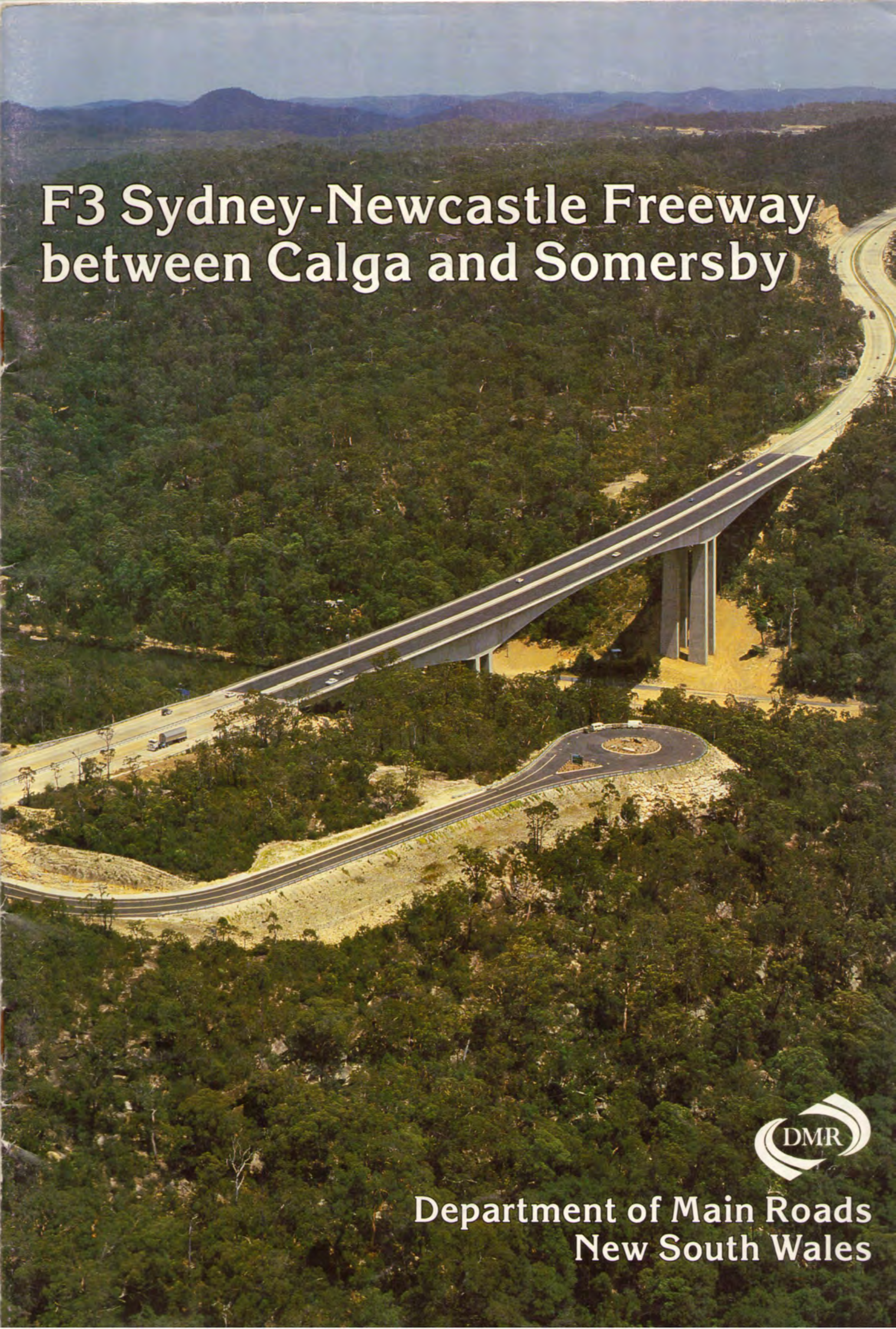
F3 Sydney-Newcastle Freeway between Calga and Somersby



DMR

Department of Main Roads
New South Wales

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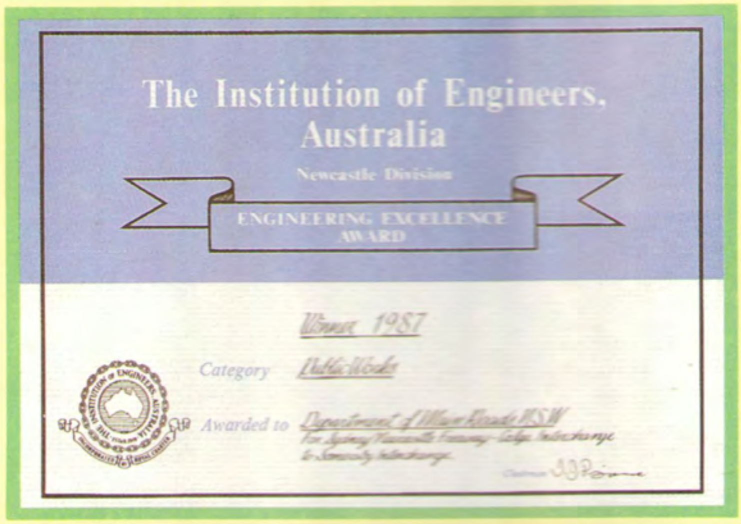


In the Public Works category, the Department won the 1987 Newcastle Engineering Excellence Award and was highly commended in the 1988 National Bicentennial Engineering Excellence Awards.

Department of Main Roads
New South Wales

THE INSTITUTION OF ENGINEERS, AUSTRALIA

ENGINEERING CONFERENCE 1988

NATIONAL ENGINEERING EXCELLENCE AWARDS

CATEGORY

Public Works

HIGHLY COMMENDED

This commendation is presented to

Department of Main Roads

for the F3 Sydney-Newcastle Freeway between Calga and Somersby

David E. Skirrington

PRESIDENT

21st February 1988

First published 1987

Front Cover:

Aerial view of spectacular twin bridges over Mooney Mooney Creek looking to the southwest showing viewing area.

Title Page:

Sweeping curves of the F3 north of Kariong just prior to completion, showing overbridge at Reeves Street.

Back Cover:

The largest embankment, the largest cutting and the largest bridge on the Calga-Somersby section of the F3 are all featured in this view, looking west from Girrakool towards Calga.

Produced by Department of Main Roads, New South Wales, April 1987.

F3 Sydney-Newcastle Freeway between Calga and Somersby

This impressive engineering achievement extends for 15 km through rugged and undulating country north of the Hawkesbury River and to the west of Gosford. Completed at a cost of $80 million, it was officially opened by the Prime Minister of Australia, the Hon R J L Hawke, AC, MP, on 14 December 1986.

The development of this route has seen the successful resolution by the Department of major challenges in undertaking dual carriageway freeway construction through this region. The challenges have included the severe constraints imposed by the terrain (particularly the steep ridges to the south); the difficulties of access; the proximity to a national park; and the consequent need for special environmental conservation measures to control erosion and sedimentation, to preserve the flora and to protect fauna and aboriginal sites.

This freeway length includes three interchanges and twenty bridges, and the massive scale of the work is indicated by the statistics which reveal that:

- 4.7 million m^3 of earthworks were undertaken;
- 120 km of subsoil drainage were installed;
- 137,000 m^3 of concrete pavement were placed; and
- 270 road signs were erected.

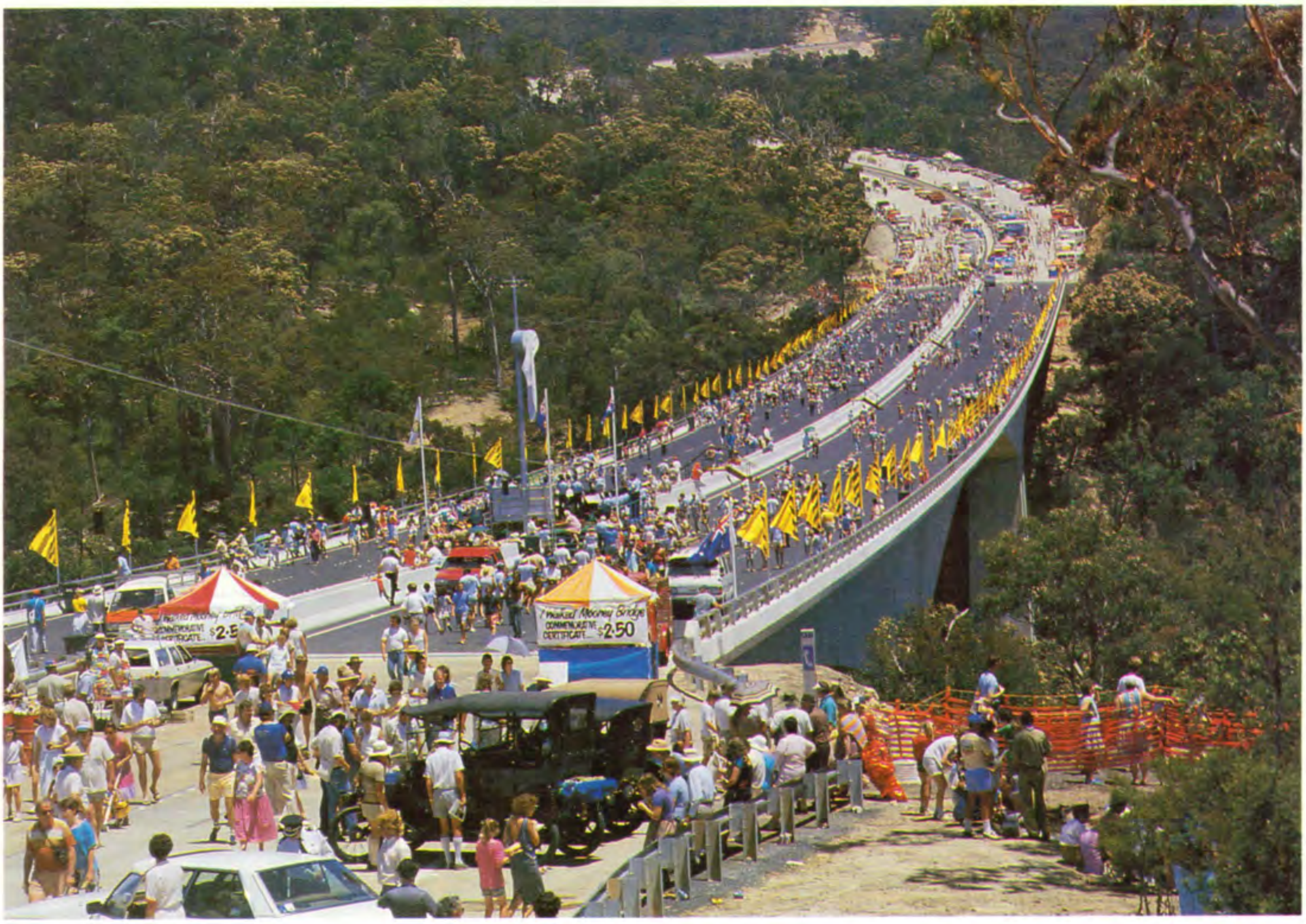
Undoubtedly, the most spectacular feature along the freeway section, from both an engineering and visual viewpoint, is the crossing of Mooney Mooney Creek. These elegant twin bridges stand 16 m higher than the deck of the Sydney Harbour Bridge.

The completion of the project has brought outstanding community benefits of a scale never reached before by any roadworks in this State. The project is now resulting in savings to the community of an estimated $43 million each year, because of dramatic reductions in travelling times and distances, compared with the previous circuitous route via Peats Ridge.

By cutting a massive 14 km off the previous length of 29 km, it is estimated that the new section will save motorists 84 million km and 1.7 million hours of motor vehicle travel in its first year of operation. This will result in community savings from reduced vehicle operating costs and far less accidents. Such a high level of savings is unequalled for travel on any other new section of road in New South Wales.

The project forms part of the National Highway between Sydney and Brisbane and has been funded by the Federal Government through the Australian Bicentennial Road Development Trust Fund.

Thousands of people walked over and through Mooney Mooney Creek Bridge, during celebrations to officially open the freeway section on Sunday 14 December 1986.



F3
SYDNEY-NEWCASTLE FREEWAY
CALGA TO SOMERSBY

Length of project	15 km
Cost of construction	$ 80M
Number of bridges	20
Quantity of earthworks	4 700 000 m³
Quantity of pavement concrete	140 000 m³
Savings to road user	$43M per year

LEGEND

- FREEWAY COMPLETED
- FREEWAY UNDER CONSTRUCTION
- STATE HIGHWAYS
- MAIN ROADS
- TOURIST ROADS
- LOCAL ROADS
- RAILWAYS

Brief Overview

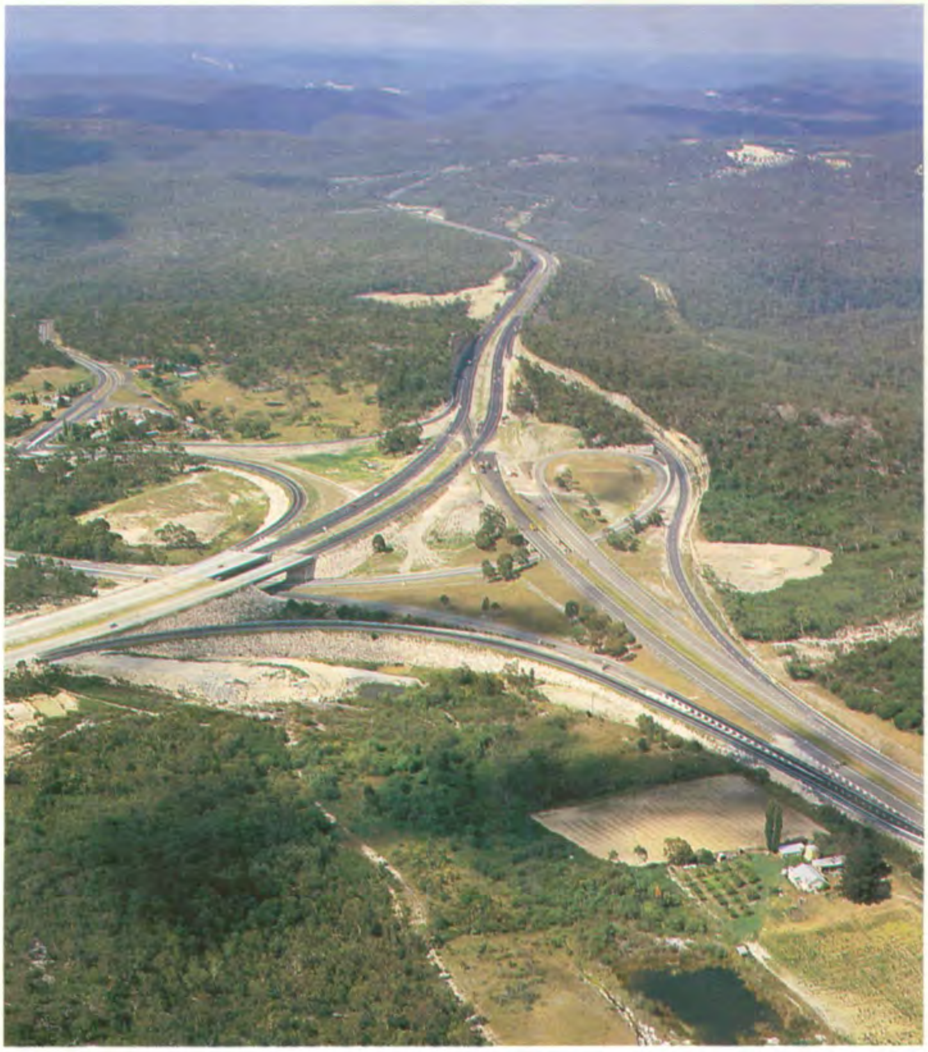
The planned route of the F3 Sydney-Newcastle Freeway extends 120 km from Wahroonga to near West Wallsend, via Berowra, Hawkesbury River, Calga, Kariong, Somersby, West Wyong, Warnervale, Morisset and Freemans Waterhole.

Construction of the route has been undertaken in stages. The first section from the Hawkesbury River to Mt White was completed in December 1965 and then extended to Calga by October 1966. The freeway then linked to a new two-lane route provided in 1964 for through traffic, between Calga, Peats Ridge and the Pacific Highway south of Ourimbah. The Berowra to Hawkesbury River freeway section was opened in December 1968 and sections north and south of the River were linked by a new freeway bridge completed in October 1973. In December 1983 the Wyong Bypass section, from north of Ourimbah to near Warnervale, was opened to traffic, together with a section from Somersby to south of Ourimbah.

Work is currently proceeding on the extension to Morisset and beyond, as well as on the Hornsby Bypass section from Wahroonga to Berowra, which is expected to be completed by the end of 1988.

Until completion of the Calga-Somersby section, Gosford-bound traffic previously had no option but to travel along 18 km of narrow, winding and steep highway. Road-users bound for Newcastle and further north took the long north-westerly route from Calga to Peats Ridge and then eastwards, reaching Somersby after a journey of 29 km.

From the new interchange at Calga (63 km north of Sydney), the freeway runs for 7 km due northeast to Kariong Interchange, traversing some of Australia's most rugged coastal terrain. From Kariong, the freeway continues a further 8 km north to Somersby Interchange, almost halving the distance from Calga to Somersby via the previous Peats Ridge route. Associated with development of the freeway, the Pacific Highway is being upgraded to a four-lane facility for the 7 km between Kariong and Gosford.



Above: Calga Interchange, looking south, showing links between the freeway, Pacific Highway (on left) and the Calga-Peats Ridge road (bottom right).

Below: Kariong Interchange, looking south, showing extensive bridgeworks needed to cross the off-loading ramp, Piles Creek and Pacific Highway.

Investigation and Location

The investigation and location of the freeway route were carried out by staff of the Department of Main Roads. Early investigations found a suitable route generally easterly from Mount White towards Woy Woy and Gosford.

However, subsequent extension of the Brisbane Water National Park to the west meant that this route would have bisected the Park and, as this was undesirable, a new route further to the west was located.

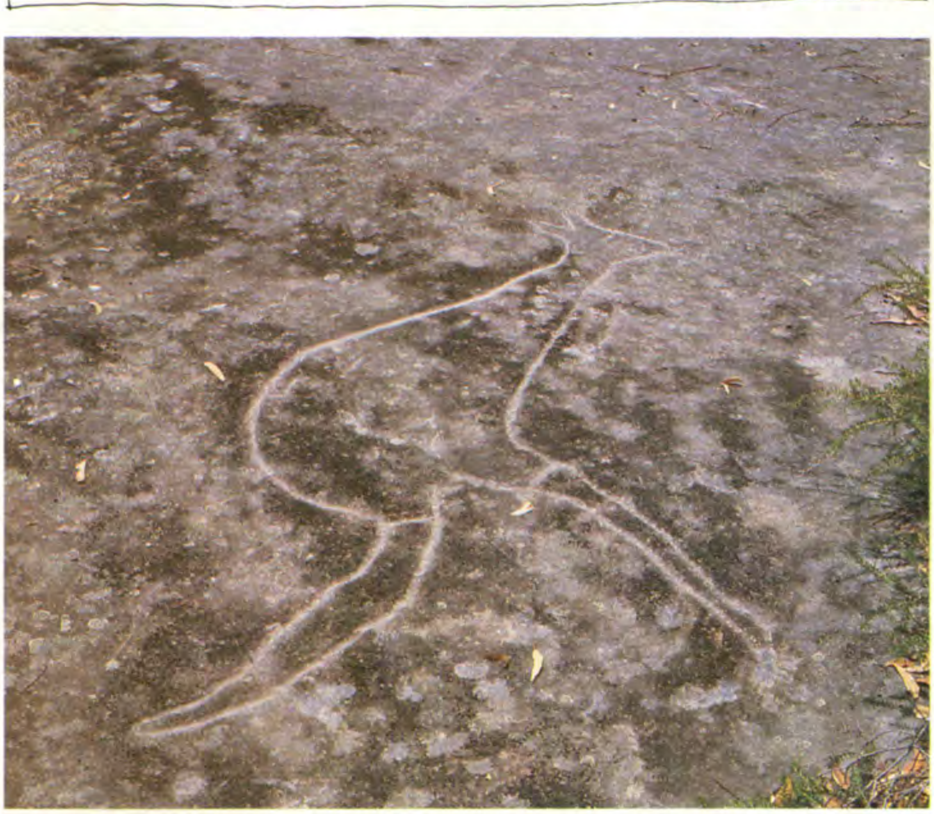
While this new route also crosses the Park, it has had a far less adverse effect on it. The new route was adopted and detailed design, including location of a suitable crossing of Mooney Mooney Creek, was also carried out by Departmental staff.

Environmental Concern

In the preparation of the Environmental Impact Statement for this section of freeway, several specialist consultant studies were undertaken. These were:

- a vegetation survey by the Royal Botanic Gardens to identify the vegetation communities and any rare species along the corridor of the two routes then being investigated;
- a faunal survey by The Centre for Environmental Studies at Macquarie University;
- an archaeological survey by J C Lough and Associates for Aboriginal relic sites; and
- a soils survey by The Soil Conservation Service of New South Wales.

Cartoon from environmental protection booklet issued to all personnel working on the project.



Studies undertaken by Departmental officers included geology, meteorology, land use, socio-economic aspects, traffic and landscape treatment.

As a result of these environmental considerations the Department had the location of the freeway constantly under review. This was reflected in the choice of the preferred route and also in the final location.

The following examples are only two of many instances where the freeway alignment was varied because of the environmental investigations. The first illustrates a change for economic mineral resource reasons and the second for archaeological reasons.

Because of constraints imposed by the Brisbane Water National Park to the south and Old Sydney Town to the north, a dormant quarry was directly affected by the alignment of the freeway interchange at Kariong. Environmental investigations revealed the significance and renewed importance of the dimensional sandstone deposits from this location for the restoration of old buildings. Because of this and other considerations, the freeway alignment was moved further away from the quarry and the interchange design was modified.

The second example involved Aboriginal relics. Consultant archaeologists worked in conjunction with Departmental surveyors to accurately locate the sites of rock engravings to ensure that they remained undisturbed wherever possible. Some problems arose, particularly because of the large number of sites involved, but nevertheless it was found possible to avoid all significant sites.

Aboriginal rock carvings were protected from construction damage by temporary fencing and by urging workmen to be concerned and careful.

Design

The design of the freeway has provided for dual carriageways of varying widths.

Each of the two carriageways is a minimum of 11.6 m wide, providing for two traffic lanes, with shoulders on each side, while on steeper sections three lanes have been provided on each carriageway.

The carriageways are separated by a variable width depressed median, averaging 15 m between carriageways.

Due to constraints imposed by the terrain, it has been necessary to exceed the most desirable gradient at two locations.

The approaches on both sides of the Mooney Mooney Creek Bridge have a grade of 7%, while the maximum grade north from Kariong is 6.5%.

Careful blasting and earthworks operations ensured minimum effect on the natural environment.

The design for the 20 bridges along this freeway section were undertaken both by Department of Main Roads staff and consultants.

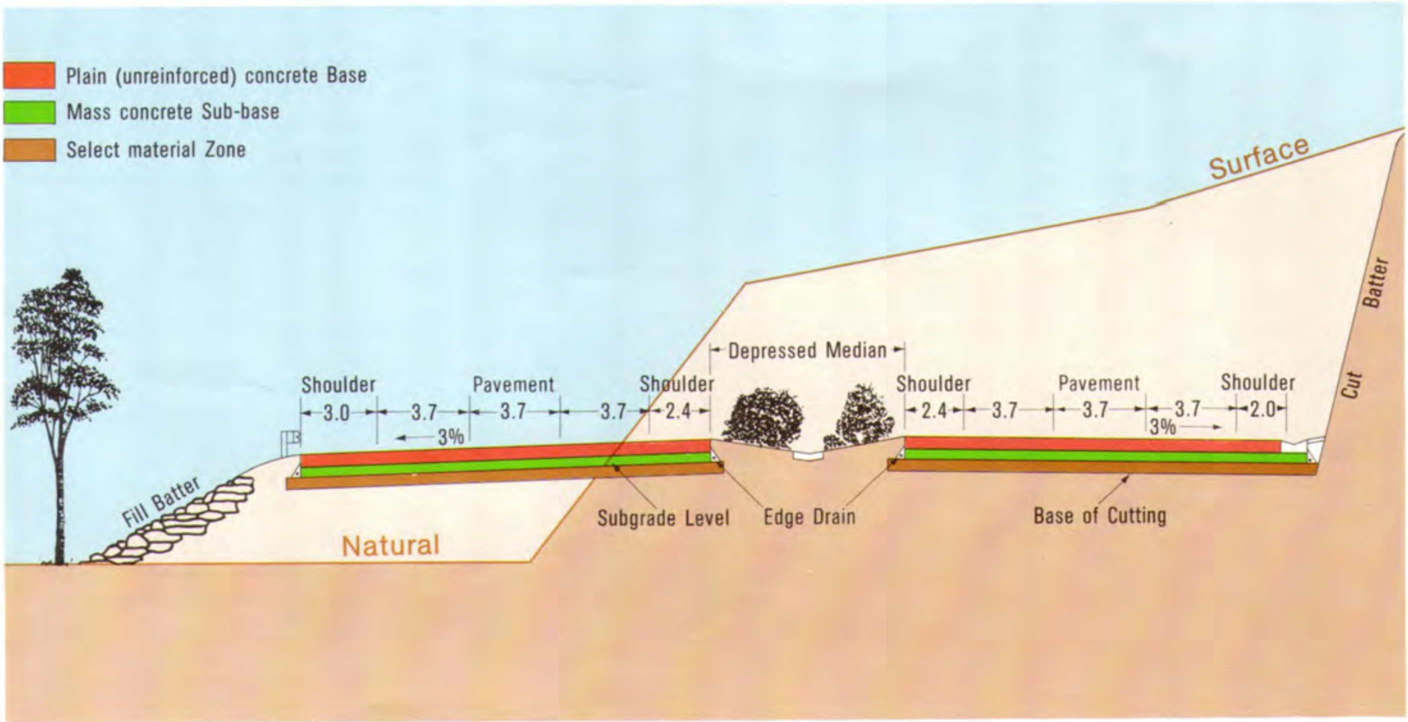
Those designed by the Department are:

- twin bridges at Calga Interchange;
- two steel arch underpasses;
- twin bridges at Mooney Mooney Creek;
- bridge to carry Pacific Highway over freeway;
- four bridges over Piles Creek;
- twin bridges over off-loading ramp at Kariong Interchange; and
- twin bridges over the Pacific Highway at Kariong Interchange.

Those designed by consultants are:

- twin bridges over Gindurra Road by Brown Verge Harris and Sutherland Pty Ltd;
- bridge to carry Reeves Road over freeway by Taylor Thomson Whitting Pty Ltd; and
- twin bridges at Somersby Interchange by Sinclair Knight and Partners Pty Ltd.

Freeway cross section on the approach to Mooney Mooney Creek Bridge



CONSTRUCTION CONTRACTORS

WORK	CONTRACTOR	TENDER AMOUNT
Pacific Highway Deviation, Kariong – earthworks and drainage	Robson Excavations Pty Ltd	$1,340,000
Pacific Highway Deviation, Kariong – pavement and finishing works	G Hawkins and Sons Pty Ltd	$1,900,000
Pacific Highway Overbridge	Gervay Constructions Pty Ltd	$ 480,000
Calga Interchange . . . and pavement and finishing works between Calga and Mooney Mooney Creek and 2 bridges	John Holland Constructions Pty Ltd	$9,900,000
Calga to Mooney Mooney Creek – earthworks, drainage and steel arch underpass	Leighton Contractors Pty Ltd	$2,800,000
Twin Bridges over Mooney Mooney Creek	Enpro Constructions Pty Ltd	$14,600,000
Mooney Mooney Creek to Kariong – earthworks, drainage, dual carriageway pavements, and 12 bridges	Leighton Contractors Pty Ltd	$15,500,000
Kariong to Somersby – earthworks, drainage, dual carriageway pavements, and 3 bridges	Abignano Ltd	$12,100,000

QUANTITY OF WORK DONE AND MATERIALS USED

ITEM		QUANTITY
Earthworks		4,700,000 m^3
Stormwater Drainage	– excavation	53,000 m^3
	– concrete pipes	19,000 m
	– corrugated steel pipes	2,400 m
	– concrete lining of drains	40,000 m^2
	– rock filled mattresses	6,500 m^2
	– gutters	38,000 m
	– earthworks for erosion control	21,000 m^3
Subsoil Drainage		120,000 m
Lime or Cement for Soil Stabilisation		1,800 t
Crushed Rock Base and Sub-base		80,000 m^3
Concrete Sub-base		58,000 m^3
Concrete Base		79,000 m^3
Contraction Joints in Concrete Pavement		170,000 m
Asphaltic Concrete Paving		30,000 t
Pavement Markings	– lines	160 km
	– raised markers	25,000
Guardrail		30,000 m
Signposting	– sign faces	1,200 m^2
	– number	270
Street Lighting	– light columns	100
	– electrical conduit	8,000 m
Protective Treatment of Rock Seams		2,300 m^2
Premixed Concrete in bridges, including Precast Girders		32,000 m^3
Steel Reinforcement		5,500 t
Steel Bridge Girders		1,300 t
Emergency Telephones		24

Construction

Construction of the Calga-Somersby section started in October 1981 and, including a preliminary deviation of part of the Pacific Highway, it was carried out entirely by contractors, as listed on the left.

Building this 15 km section of freeway (including twenty bridges, three interchanges, a highway deviation and minor roads) required an immense amount and variety of work. The project took five years to complete. For the record, the items of work in the schedule (below left) indicate the scale of the project.

Earthwork Operations

The project involved approximately 4.7 million m^3 of earthworks, mainly hard sandstone, and its placement to form embankments. By way of comparison, this volume is equivalent to almost twice that of the Great Pyramid of Cheops at Giza in Eygpt (which took 20 years to build)!

The deepest cutting is 40 m deep on the northeastern side of Mooney Mooney Creek and the largest embankment is 110 m wide at ground level and contains 500,000 m^3 of fill. Embankments along the freeway route were faced with a 1.2 m thick layer of specially selected large sandstone rocks which were individually placed using a hydraulic crane. The rock facing was built up in layers ahead of each layer of filling.

Large numbers of modern earthmoving plant, including the largest dozers and scrapers available in Australia, were used on the project to move a peak quantity of 15,000 m^3 a day. The largest dozer used by the contractors was a Caterpillar D10, weighing 80 t and developing 520 kW. The largest scraper on the project was a 60 t, 410 kW Caterpillar 651, with a capacity for carrying 34 m^3 in each load.

Pavement Design

For the main carriageways of the freeway, pavement designs were prepared to compare flexible and rigid systems. These "test" designs used an assumed value for subgrade strength and a traffic load expressed in terms of the equivalent standard axle loadings expected during the forty-year design life of the pavement.

The cost of these pavements was estimated using current tender prices and the rigid pavement was found to be the most economical. The pavement used is a 150 mm thick mass concrete sub-base (of 5 MPa strength), covered by a concrete base (of 30 MPa strength) of either 215 mm or 230 mm thickness.

The freeway onloading and offloading ramps at interchanges are narrower and of more variable width and crossfall than the main carriageways. They are therefore less suitable for concrete paving using modern large scale methods and more suitable for conventional flexible pavement construction methods. The flexible pavement consisted of a base of crushed rock overlaid by an intermediate course of asphaltic concrete and a wearing surface of open-graded asphaltic concrete.

Characteristics of the Concrete Pavement

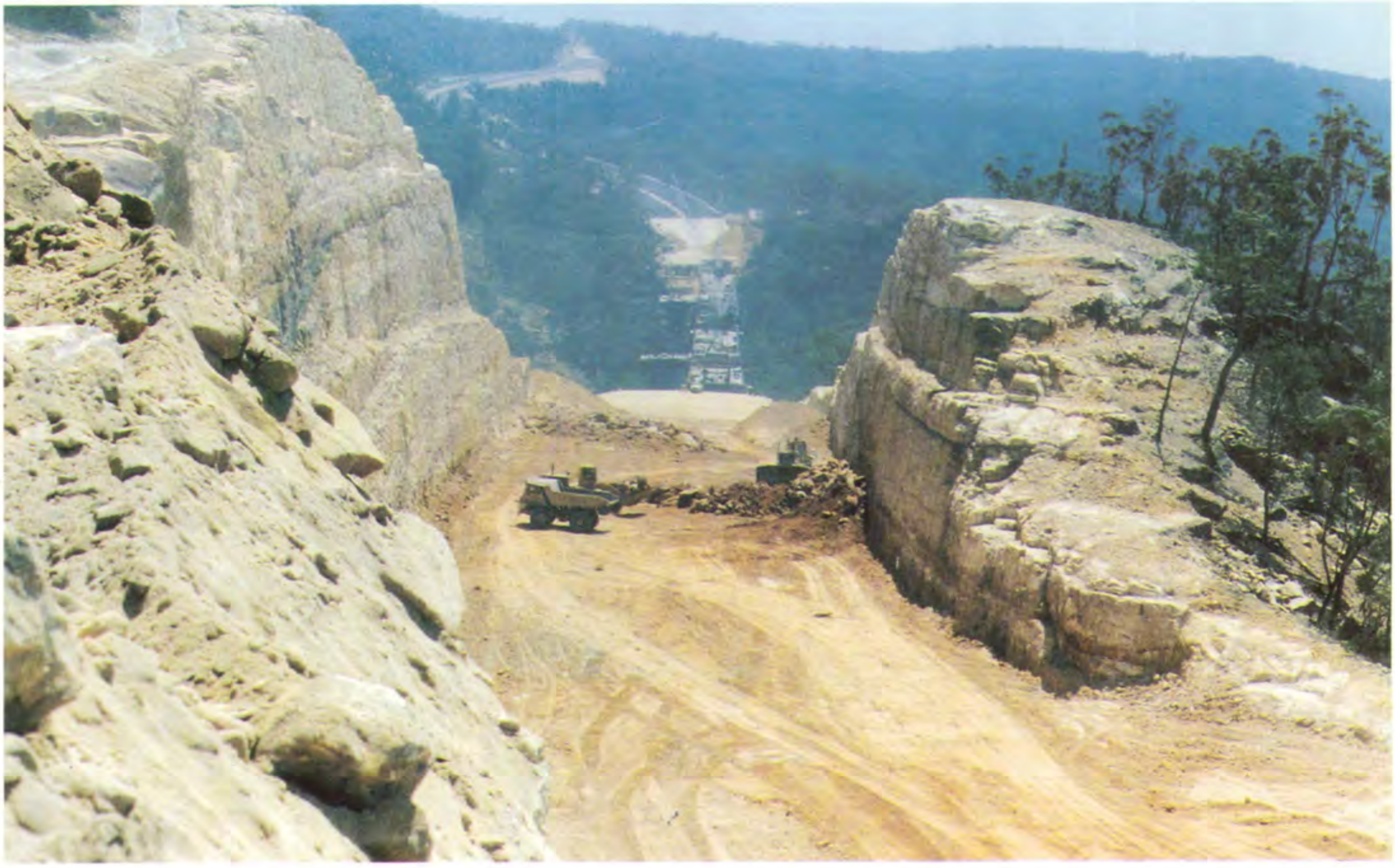
The concrete pavement consists of a two-layer unreinforced slab laid directly on the naturally occurring subgrade material. The lower layer (or sub-base) is a low-strength working platform made of concrete with low shrinkage of 330 micro-strain (maximum drying shrinkage after three weeks air drying) to minimise shrinkage cracking.

Construction contractors used some of the largest earthmoving equipment available in Australia.

The upper layer (or base), which was separated from the lower layer by a wax emulsion bond breaking membrane, is a high strength concrete in which shrinkage cracking was induced at made joints. The upper surface of this layer forms the "wearing" or travelling surface for freeway traffic.

The base layer has contraction joints in both the longitudinal direction along the edge of each lane and in the transverse direction at about 4 m spacing. The joints were made by sawing a 65 mm deep groove in the newly hardened concrete prior to the onset of shrinkage cracking. The groove was subsequently filled with a preformed neoprene seal. To avoid a repetitious and monotonous sound as vehicles pass over the closely-spaced transverse joints, they are located at intervals varying from 3.7 m to 4.6 m throughout the project. The longitudinal joint has 1 m long tie bars beneath the sawn groove spaced at 500 mm centres. A magnetometer or "metal detector" was used to monitor the accuracy of the placement of these tie bars.

The deepest cutting (40 m) on the project is just east of Mooney Mooney Creek.



The finished surface of a freeway must be suitable for safe, high speed travel. It must give a smooth riding sensation yet easily shed rainwater and be resistant to polishing.

On the F3 Calga-Somersby section, smooth riding has been achieved by enforcement of strict surface tolerances of no more than 10 mm above or 5 mm below specified levels and no deviation of more than 3 mm from the bottom of a 3 m straight edge. This has resulted in an average NAASRA Roughness Standard over the project of 47 at 80 km/h, which is rated as "Very Good".

The shedding of rainwater and reduction in the likelihood of aquaplaning is assisted by texturing the pavement surface in the transverse direction, with a "rake" made of flat spring steel tynes spaced randomly. The use of quartz sand for 38% of the total concrete aggregate has ensured a surface resistant to polishing.

Concrete Paving

Most of the paving concrete was produced on site using local aggregates in computer-controlled split-drum mixers which produced up to 200 m^3/h. The fresh concrete was then hauled to the slipform paving machines by tipping trucks. The paving machines slipformed low slump concrete up to 11.6 m wide in a single pass. The maximum output achieved was 1,872 m^3 in one 11 hour working day. If placed in formwork 50 m^2, the total volume of concrete placed would reach up to a height of 55 m, roughly equivalent to a 15 floor office building of solid concrete.

Contract concrete slipform paving machines provided full pavement width in one operation.

Concrete Slab Anchors

As already mentioned, the approaches to twin bridges over Mooney Mooney Creek are on grades of 7% for at least 1 km on both sides. Without some restraining influence, the concrete road pavement would creep downhill due to expansion, contraction and gravitation effects and exert overturning forces on the bridge abutments.

This creeping has been restrained by the installation of 13 reinforced concrete slab anchors, cast into trenches cut into the floor of the rock cutting and embankment subgrade at varying spacing from 50 m to 300 m. These slab anchors include a new method of forming expansion joints. This has involved placing reinforced subgrade beams under the pavement to transfer loads across the joints, thereby eliminating the usual large steel dowel bars which interfere with paving operations.

Keeping Traffic Moving

The F3 Calga-Somersby section was built to join two sections of freeway already in use, as well as to connect with the Pacific Highway both at Calga and at Kariong.

To allow subsequent construction of the freeway to proceed unhindered by traffic, a 3.5 km long deviation of the existing Pacific Highway near Kariong was built on a new alignment. This deviation was opened in October 1983 and included a 60 m long single-span bridge over a future freeway cutting.

Subsequently, construction of the freeway involved building new interchanges at Kariong and Somersby and completely reconstructing the interchange at Calga. While work proceeded, heavy through traffic had to be kept flowing both on the Calga-Peats Ridge-Ourimbah route, and on the Pacific Highway to and from Gosford and other Central Coast locations.

Consequently, at Calga this entailed building two separate temporary "side-tracks" totalling 1.3 km in length. These "tracks" were designed to cater for high speed freeway traffic and had concrete barrier walls to separate opposing traffic flows, as well as street lighting to provide a high standard of night-time visibility.

At Calga, it was also decided to provide a temporary link for southbound Pacific Highway traffic proceeding to join the Calga-Berowra freeway section. The 800 m long connection was built through bushland and it has now been removed and the area restored to its natural condition.

Brisbane Water National Park

The Calga-Somersby section of the F3 passes through the Brisbane Water National Park which is an environmentally sensitive area renowned for its extensive Aboriginal rock carvings. Nearby sites were fenced off and clearly marked so that construction equipment would not inadvertently run over them. They were also protected from damage due to blasting by placing sand bags over them. A photographic record was made of all sites that could not be saved.

Special measures were developed to keep disturbance of the natural bushland, particularly in the Park, to a minimum. Clearing was limited only to the area to be occupied by the completed freeway.

All access to the construction site was from existing roads along the road reserve and no access tracks were built within the Park. The construction of the piers and abutments of Mooney Mooney Creek Bridge involved only minimal local clearing, with no access tracks being allowed between those points.

Heavy storms during earthworks operations often cause erosion from a site and consequent siltation in downstream gullies and streams. This siltation has adverse effects on plant and animal habitats and is therefore undesirable.

In order to control these effects at all times during earthworks, temporary erosion and sediment control works such as graded contour dykes and drains, hay check dams, and inlet and outlet silt traps at culverts were used. Permanent sedimentation basins were built at the downhill end of each cutting to control sedimentation during and after completion of construction.

Animal Underpass

One of the major concerns expressed by the National Parks and Wildlife Service was that the location of the freeway would have a divisive effect on the Brisbane Water National Park near Calga, because it would prevent the north-south movement of wildlife in this area. This "barrier" effect has been reduced through the provision by the Department of a large corrugated steel plate arch underpass 10 m wide and 7 m high. This not only allows animals to pass under the freeway within the National Park, but will also provide access for firefighting vehicles during bushfire emergencies.

The underpass has been located in a natural watercourse which is a known water-hole for animals. It was built as an arch so as to avoid disturbance of the natural earth which now forms the floor of the pathway through it and it is expected that this will encourage its use by indigenous animals. To deter wildlife from crossing the freeway, a 1.5 m high "wallaby-proof" fence has been installed along the perimeter of the road reserve.

Above: Heavy rains during the construction period tested these erosion and sediment control works adjacent to Leask Creek.

Right: Shotcrete being applied to a cutting as part of treatment to stabilise seams of soft shale.

Below: Wombats are among the marsupials using their own access tunnel under the freeway.

Seam Treatment

At several places in the sandstone cuttings, thin seams of softer shale were encountered. These seams would have eroded quicker than the adjoining sandstone and caused local instability. The protective treatment adopted was to cut back the seams to a depth of 100 mm then install galvanised steel rock anchors to which steel reinforcing fabric was attached. Following completion of all earthworks in the cuttings, shotcrete was applied to fill the voids around the rock anchors. This treatment was used to protect over 2,000 m^2 of soft seams.

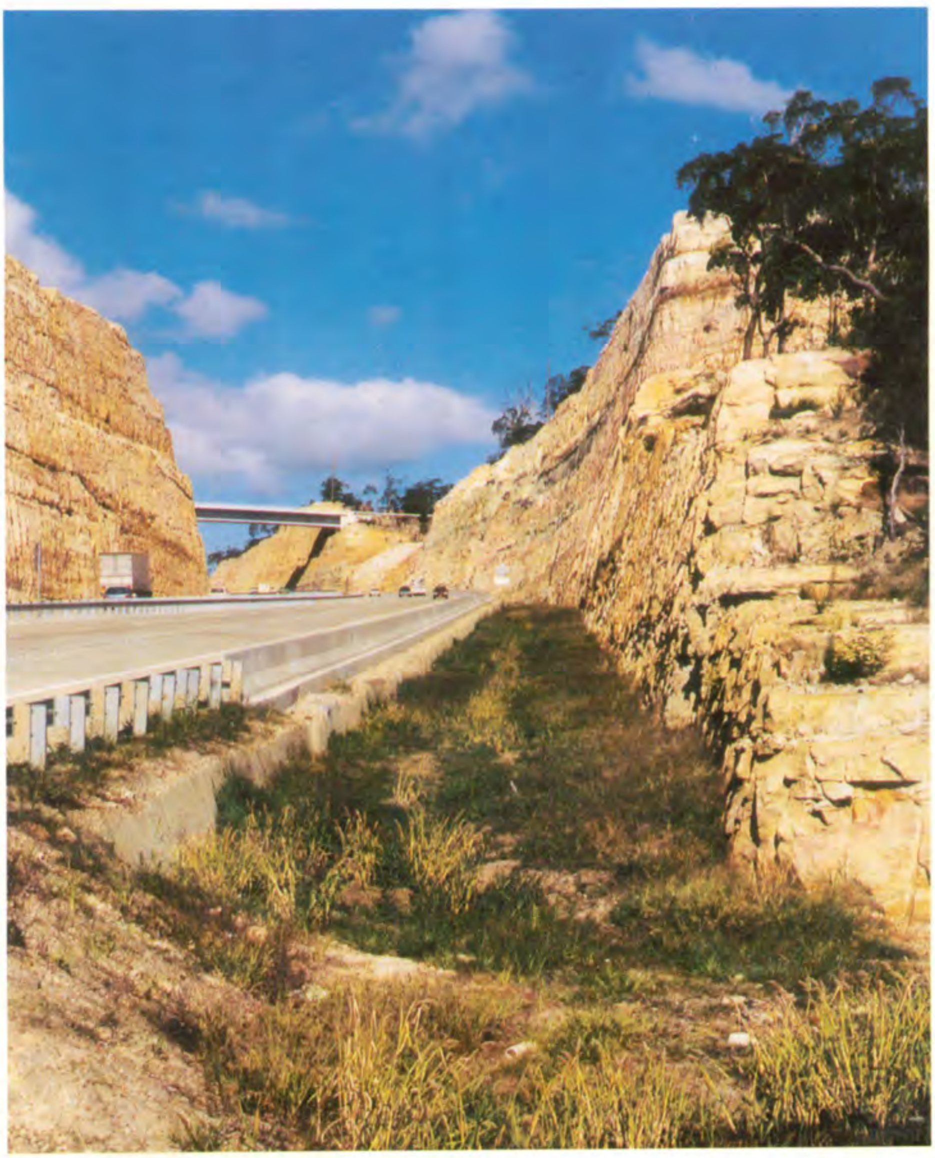
Catch Trench in Cutting

Following the completion of the cutting just north of the twin bridges over Mooney Mooney Creek, an examination of jointing pattern revealed the necessity for special treatment. It was determined that wedges of rock could fall from the face of the cutting to the roadway below.

As the removal of all these rock wedges would have required unacceptable encroachment into the National Park, the solution adopted was to widen the cutting to form a catch trench 8 m wide and 2 m deeper than the adjoining road pavement. The catch trench has a 300 mm thick loose backfill to cushion any falling rocks and thus eliminate any possible danger to vehicles on the freeway. The catch trench is partially masked from the motorists' view by a concrete barrier which also provides further protection for road-users.

Right: Visitors to the temporary construction viewing area reading the outdoor information panels.

Below: Catch trenches in this cutting saved further encroachment into the National Park by allowing steeper batters while still providing safety for road-users.



Community Viewing Areas

To cater for community interest in the project and to allow passing motorists to stop and watch construction work, a temporary viewing area was established in the vicinity of the Pacific Highway overbridge, between Mooney Mooney Creek and Kariong.

An abandoned length of the Pacific Highway was used to provide vehicular access with safe and convenient parking. Steps led up to an elevated and fenced position above a cutting and an outdoor display was set up to assist visitors to identify the types of construction equipment working nearby. Details of the project and also of the natural flora to be found close at hand were included in the display.

A permanent viewing area has been built beside the National Park and just north of the Mooney Mooney Creek Bridge. This facility comprises 250 m of two-lane road directly connected to the freeway. It has a turning circle and parking area at the far end, featuring native plants in a central landscaped plot. The "lookout" area, which is only 200 m from the bridge ("as the crow flies") and 5 m higher than its deck, allows northbound motorists to pause and enjoy pleasant views of the bridge, creek and park.

Landscaping

Prior to earthworks, the natural topsoil was removed and stockpiled, ready for re-use in the same area later. Towards the end of the work, this local topsoil was brought back and spread over medians, verges and disturbed areas, such as access tracks.

As the objective was to encourage native re-vegetation, exotic species were only used to provide an early cover over the bare topsoil. Sowing included Japanese Millet or Winter Ryecorn for immediate effect while various types of Acacias were planted for the long term effect. It is expected that this method will allow regeneration of native plants in both medians and verges. This, in turn, will eliminate the tedious and costly grass cutting which would be required if the long-standing practice of planting exotic grasses had been used.

Emergency Telephone System

An emergency telephone system has been installed along the freeway as a service to motorists who may require road service, police or ambulance assistance. The system was designed in conjunction with Telecom Australia and is regarded as the most modern development in this field.

The telephones are spaced about 1 km apart on each carriageway and when the user lifts the handpiece and presses a button, the Department's Traffic Control Centre in Sydney is dialled automatically. At the Centre (which is manned on a 24 hour roster), the location of the emergency telephone is immediately displayed to inform the operator, who then proceeds to arrange the fastest and most appropriate response available.

The phone units are so designed that the calls are only connected while the handpiece is held in the hand. The pillar is such that the handpiece cannot be placed anywhere other than back on the hook and if it is left hanging, the call is automatically cut off. A cost-saving feature is that no field repairs are required as all phone units are of the "plug out-plug in" type.

Bridge Design and Construction

An interesting constraint relating to the design of the bridges along this freeway section is the fact that the route is within a proclaimed coal mine subsidence area, the only exception being adjacent to the tidal water of Mooney Mooney Creek. While it was mandatory to provide for ground strains resulting from coal extraction below all sites other than Mooney Mooney, the Department considered it prudent to also detail this structure to cater for partial coal extraction beneath it.

During the design stage, care was taken to ensure that each of the 20 bridges would be environmentally and aesthetically compatible with its surroundings. Special pre-planning was also focussed on specifying bridge construction procedures which would co-ordinate with the earthwork activities to be undertaken at the same time. Four examples of this co-ordination are as follows.

At Calga Interchange

The freeway construction programme indicated that the twin bridges, which would eventually carry the freeway over the Pacific Highway, would need to be commenced before the abutment embankments could be placed. Furthermore, interruptions to traffic using the Pacific Highway could only be for short periods.

The solution was for single-span steel box-girder superstructures supported on piles that were extended and left exposed during construction. The relatively light girders were positioned without delaying traffic and later, on completion of the structures, backfill was compacted around the exposed piles to provide the abutment embankments.

At the Pacific Highway

On the northern side of Mooney Mooney Creek, the Pacific Highway was to cross the deepest cutting on the entire section of freeway. As the completed structure would be approximately 30 m above the freeway, access for future maintenance would be difficult. A relatively maintenance free single-span post-tensioned concrete box-girder was the most appropriate solution.

The construction of this cast-in-place structure was made possible by staging the earthworks contract. After excavation was completed to a predetermined level, the bridge contractor was given the site. This allowed shallow scaffolding of a known height to be used to support the box-girder formwork. When the scaffolding was removed, sufficient clearance was provided for earthmoving plant to continue with the excavation.

At Kariong Interchange

Here a total of four bridges were required to provide crossings of Piles Creek and another four to carry the freeway over the off-loading ramp and the Pacific Highway. These bridges are within 500 m of each other and were to be included in a single road and bridge contract. Consequently, each bridge was designed with the same type of prestressed concrete girders. This allowed the contractor to obtain all the girders from one casting yard and to more easily co-ordinate the bridge construction with the associated roadworks.

Initial work on construction of twin bridges to carry the freeway over a Pacific Highway link road at Calga.

① CALGA INTERCHANGE

Length : 58m

Construction : Steel box girder. Variable depth composite concrete deck.

② PACIFIC HIGHWAY OVERBRIDGE

Length : 58m

Construction : Post tensioned concrete box girder. Abutment located on edge of sandstone cutting.

③ KARIONG INTERCHANGE

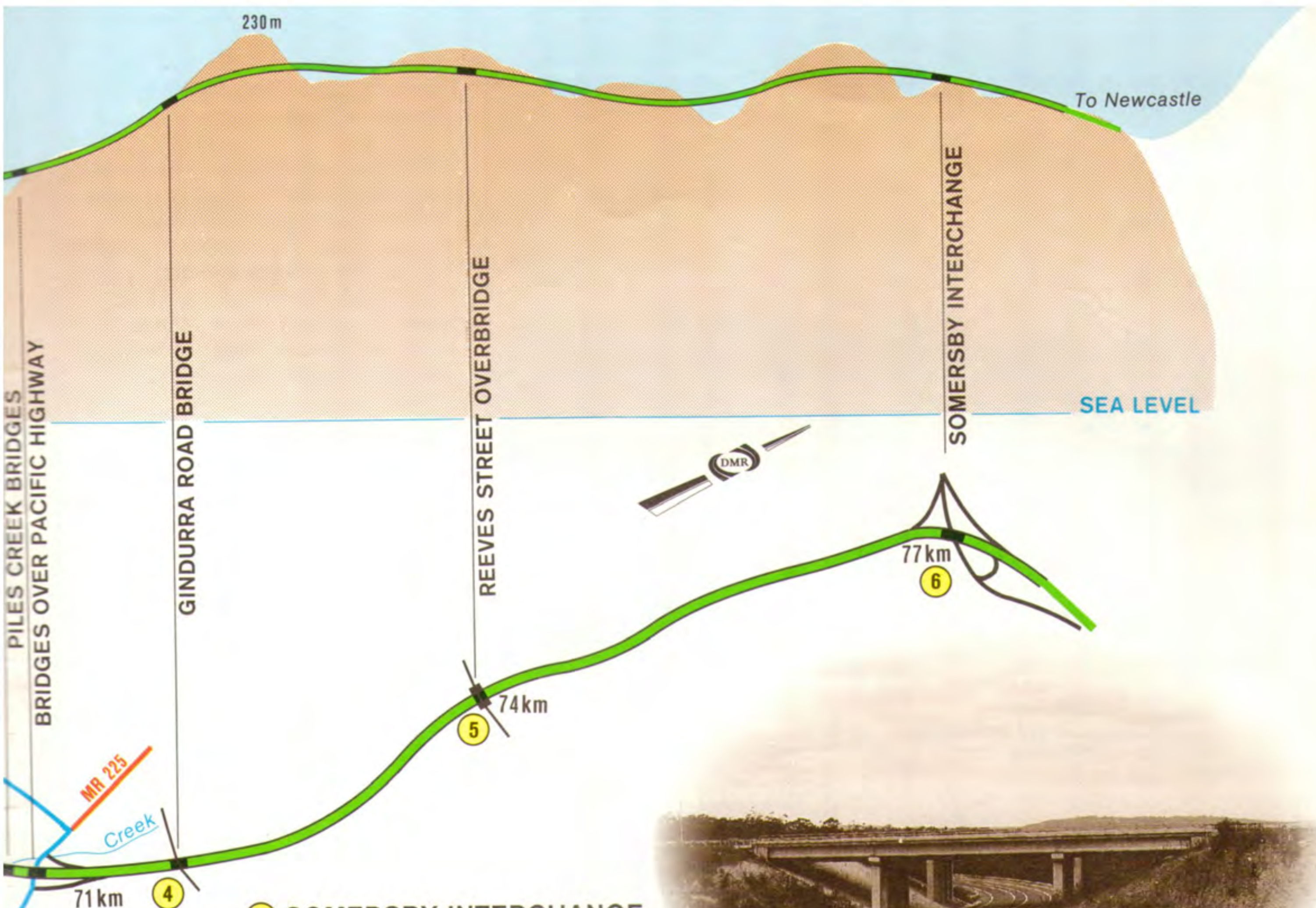
BRIDGES OVER UNLOADING RAMPS, PILES CREEK AND PACIFIC HIGHWAY

TYPICAL STRUCTURE (8 Bridges)

Lengths : 31 – 89m

Spans : 20 – 25m

Construction : Precast prestressed concrete I-girders with composite deck.



(6) SOMERSBY INTERCHANGE

Length : 48m

Span : 14 – 20 – 14m

Construction : Precast prestressed concrete I-girders with composite concrete deck.

(5) REEVES STREET

Length : 80m

Spans : 18 – 24 – 24 – 14m

Construction : Precast prestressed concrete trough girders with composite concrete deck.

(4) GINDURRA ROAD

Length : 16m

Construction : Galvanised steel I-beam girders with composite concrete deck. Reinforced earth abutments.

Pacific Highway access was maintained during the building of these bridges at Kariong Interchange.

At Gindurra Road

The twin bridges over Gindurra Road are single 16 m span structures comprising galvanised steel girders and reinforced concrete decks. The abutment headstocks are supported directly on the reinforced earth embankments.

The Reinforced Earth wall construction (with its individual concrete elements anchored by galvanised steel straps into the fill) was nominated for this site as an economical proposition, because it was possible for granular material won from the adjacent excavations to be used as suitable backfill.

In addition, the movements that can be tolerated between the reinforced earth elements are suitable to withstand any expected ground strains likely to result from mining subsidence.

Reinforced Earth walls form the abutments of the twin freeway bridges over Gindurra Road.

Twin Bridges Over Mooney Mooney Creek

One of the major natural obstacles to be overcome on the F3 Calga-Somersby section was the gorge at Mooney Mooney Creek. This is a typical gorge of Hawkesbury Sandstone initially formed by the gradual eroding action of the creek. Estuarine muds and sand have since settled in the bottom of the gorge to a depth of approximately 25 m.

Constraints influencing the bridge feasibility study included the aesthetic and environmental effects on the National Park, within which it is situated. The structures also had to absorb foundation deformations from the possible mining of a 2 m thick coal seam at a depth of 700 m.

The road grading required the deck to emerge from a sandstone cutting at the southern end, span the 480 m wide gorge at heights of up to 75 m and then blend into a road embankment on the northern side.

Feasibility

It was considered that twin three span structures straddling the creek, with the piers located away from the silted banks and in areas of convenient access, would provide a good solution environmentally while being economically viable. Preliminary designs and construction sequences were developed for alternative cable-stayed and cantilever-beam structures.

The two alternatives were developed to a stage where material quantities and estimates of cost could be determined. While both alternatives were considered as being suitable and aesthetically acceptable, estimates indicated the cable-stayed structure would be more costly than the balanced cantilever structure.

This conclusion was supported by the eminent French engineer, Jean Muller of Europe Etudes Gecti, who carried out an appraisal of the alternatives.

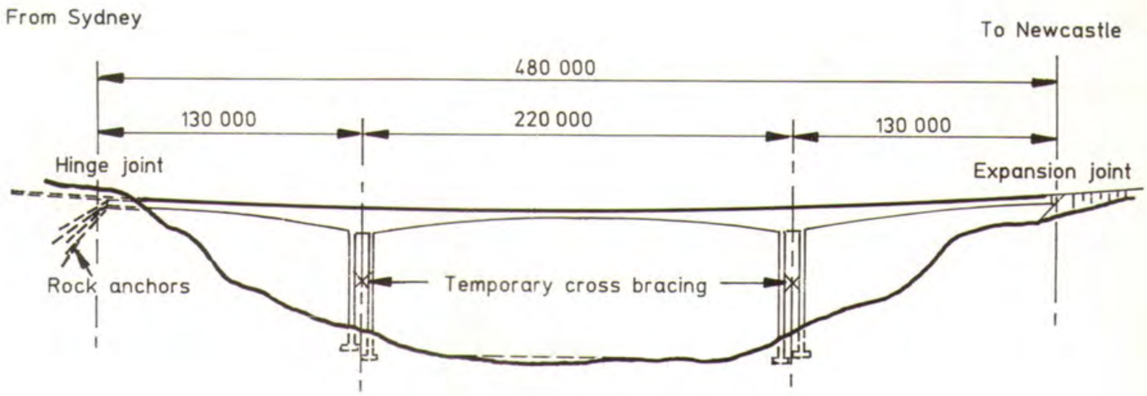
Articulation

In the final three span arrangement, the side spans are longer than half the length of the main span to eliminate uplift at the abutments.

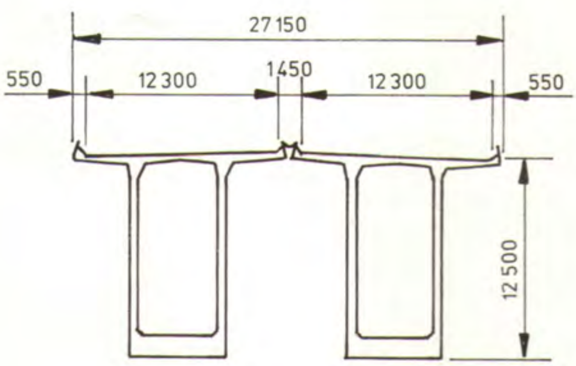
When the cantilever construction approached the abutments, temporary

Mooney Mooney Creek Bridge

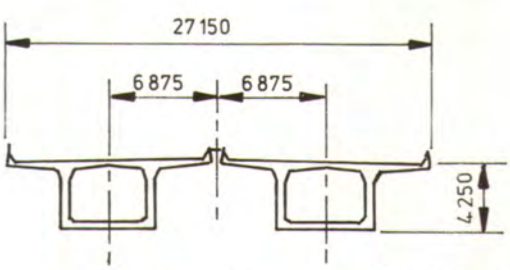
Comparison with Sydney Harbour Bridge



Elevation



Minimum Depth - over piers



Minimum Depth - midspan and abutments

Cross Section

falsework tower systems were placed behind the construction travellers to support the side spans in the out-of-balance regions near the abutments.

Each structure is anchored into sandstone at the southern abutment, with the expansion joint being provided at the northern abutment. All piers consist of twin blades with hollow concrete box columns to provide for flexibility of the completed structures.

The piers were stiffened during construction by the introduction of temporary cross bracing at approximately mid-height to resist the bending moments generated by construction and wind loads.

Transverse Wind Loads

To ensure transverse stability, the transverse wind loads are resisted by all piers through the use of vertical bearings located between the two decks.

Design Considerations

Design considerations for each bridge included:

- the installation and testing procedure for the 25 rock anchors at the fixed abutment;
- constant wall thickness in the hollow box columns. The only variable for formwork was the tapered transverse width necessary to resist wind loading;
- a reinforcement arrangement to suit 8 m high concrete lifts;
- the structural requirements of the temporary pier bracing together with times for installation and removal;
- an assymetrical pier head, being half a segment longer on one side. As segments were cast alternately about the pier, this limited the out-of-balance construction load to half a segment;
- a length of pier head which would accommodate the positioning of the two construction travellers before segmental construction commenced;
- segment lengths of 4.7 m. Although the segment masses varied, the length for the construction traveller was constant;
- constant web widths of 500 mm;
- the use of only two prestressing tendon sizes, namely 37/12.7 mm and 22/12.7 mm diameter high tensile low relaxation strands;
- the confinement of all prestress to the flanges, and a tendon pattern arrangement to enable reuse of the formwork stop ends at each segment; and
- the stressing and pouring sequence for the closing pour at midspan. During this operation the top of the pier furthest from the fixed abutment was displaced by 50 mm to minimise the bending moment induced in that pier by the long term shortening of the deck.

Abutments

The fixed abutment consists of a vertical wall and two horizontal slabs forming a Z-shaped sill, cast directly against and anchored to, the sandstone. The abutment incorporates 25 rock anchors, 24 deck-restraint tendons, 12 bearings varying in capacity from 600 t to 2000 t and a deck seal. Each rock anchor comprises 27/15.2 mm diameter high tensile low relaxation strands and each deck-restraint tendon 16/15.2 mm diameter high-tensile low relaxation strands. The bearing arrangement provides for rotation at the end of the span.

The expansion joint abutment is a relatively straightforward structure comprising a headstock supported on tapered columns and spread footings keyed into sandstone. Two sliding spherical bearings per bridge deck are provided, one being placed under each box girder web. These accommodate the total longitudinal movement of 550 mm.

Piers

The piers, ranging in height from 57 m to 64 m, are supported on spread footings. They formed a major part of the work and were constructed in about 12 months.

Birds-eye view of construction of piers as at March 1984, showing twin-blade design.

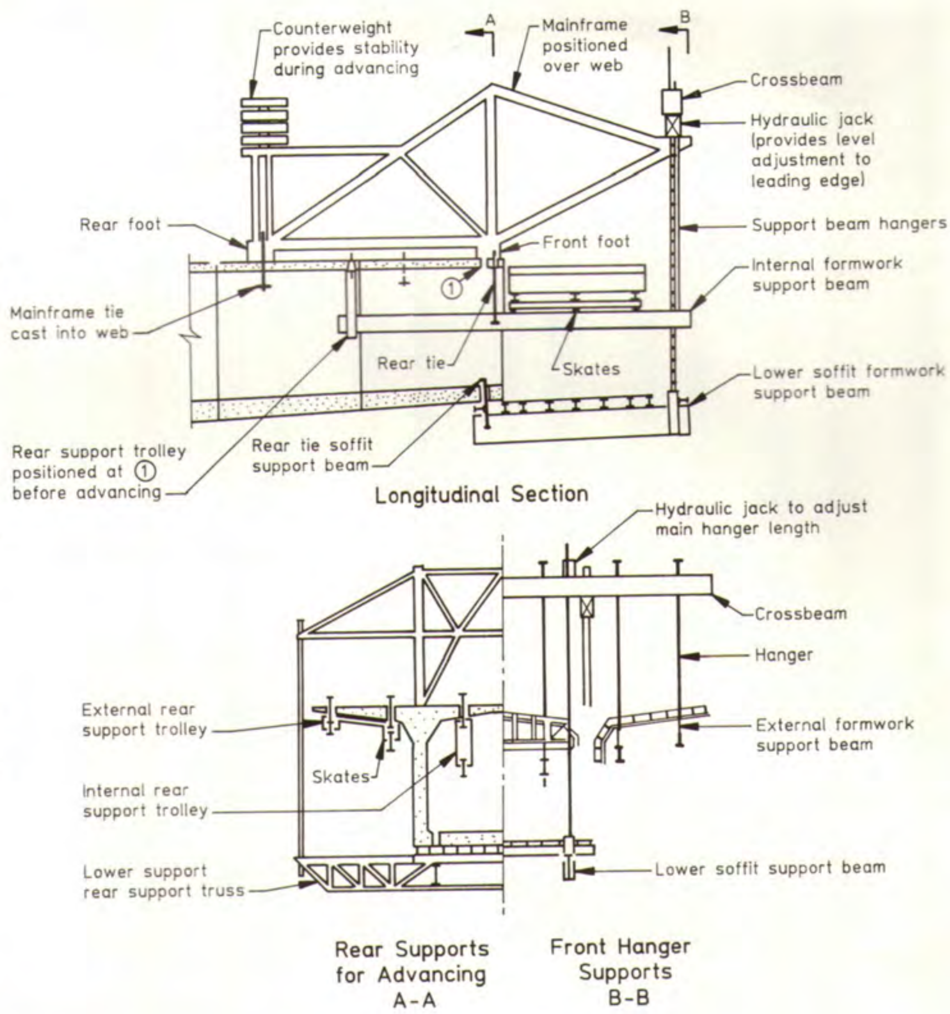
Pier Heads

The first step in the construction of the superstructure was to build the pier heads, that is, the portions of the deck directly above the piers. The falsework which supported the 1.38 m thick bottom flange was supported on sand jacks. These jacks enabled the falsework to be lowered, thus simplifying formwork removal. A precast reinforced concrete slab was used as permanent formwork to close each of the hollow concrete box columns.

The construction of the bottom flanges, diaphragms, webs and finally the top flanges of the pier heads occurred over a period of six months.

Travellers

Following the completion of the pier heads, the travellers and formwork were erected in preparation for the balanced cantilever construction of the remainder of the deck.



Traveller

Four travellers were used in the construction of the twin bridges

"Technology mirrored in nature" — cantilevering operations proceeding in placid bushland surroundings — September 1984.

The traveller is a steel cantilevered falsework structure which takes the load of the formwork, reinforcement and wet concrete for a segment and transfers it to the previously constructed sections of the bridge. When the prestressing tendons for that segment are tensioned and it becomes self-supporting, the traveller is advanced, carrying the adjustable formwork into position for the next segment.

Four travellers for the bridge construction were designed and fabricated by the contractor. The mass of each traveller, including the associated formwork and counterweights, was approximately 140 t.

The maximum segment mass for which the traveller had to be designed was 290 t. In addition to considerations of structural strength and stability, the deflections of the various components of the traveller during the casting of the concrete required due allowance.

Reaching out (above) in September 1984 and almost touching (below) in February 1985.

Decks

The decks consist of twin prestressed concrete box girders, one supporting each carriageway. Each has curved soffits with a maximum depth of 12.5 m at the piers and a minimum depth of 4.25 m at the midspan. This variable depth, coupled with span lengths of 130 m, 220 m and 130 m, provides flexibility to absorb forced displacements while having the necessary stiffness to resist the applied loads.

Balanced Cantilever Construction

Perhaps the major advantage of the balanced cantilever method of construction is the numerous repetition of identical operations. The initial turnaround time for the traveller between successive segments was 18 working days. However, after ten segments had been cast — five at the tip of each of the cantilevers which extend from the pier — a six-day cycle had been achieved.

The six-day cycle produced a total of four segments per week at the site. A separate crew at each pier head spent about 750 man-hours on the construction of a segment-pair. The operations at the opposite ends of the pier head were staggered and the workload on the construction teams was relatively evenly distributed throughout the six working days.

Segment Precamber

To achieve the design vertical profile for each bridge, all segments were built with an initial precamber to provide for all future deflections.

These deflections included:

- deformation of the formwork and traveller during casting of the segment — up to 25 mm;
- deflections of the structure resulting from the dead load of the segment being considered and every subsequent segment — up to 150 mm deflection can be caused when a segment was added;
- movement arising from the post-tensioning of the segment and every subsequent segment — generally about 15 mm per segment;

- the structure's deformation under the successive forward movements of the 140 t traveller system;
- the elastic recovery that occurred on removal of the traveller — this was a maximum of 120 mm for the main span;
- the influence of the placement and removal of equipment and material on the previously constructed section of the deck — up to 1 mm/t of load;
- deformation of the columns as the vertical load increased with deck construction — the total deformation was 17 mm;
- deflections from the addition of the traffic barriers and asphaltic concrete to the bridge — 40 mm at the centre of the main span;
- deflections from thermal effects; and
- deflection resulting from the loss of force in the prestressing tendons because of creep, shrinkage and prestress loss — 130 mm deflection predicted at the centre of the main span.

The behaviour of the bridge was continuously monitored, allowing the calculated deflections to be checked and the precamber for subsequent segments to be adjusted where necessary.

The finished profile of the bridge is not only close to the designed vertical alignment but it is also an outstanding outcome of engineering precision and technical expertise in both its design and construction.

Conclusion

Although the dimensions of Mooney Mooney Creek Bridge underline its large scale, its slender lines blend in with its bushland setting. As unavoidable construction scars heal, it illustrates how major engineering undertakings can be attractive additions to both our natural and our built environment, and part of our future heritage.

Vital Statistics
Overall length: 480 m
Spans: 130 m, 220 m, 130 m

Height above water level: 75 m
Concrete: 22,000 m³
Reinforcement: 4,000 t

Prestressing strand: 1.4 million m
Rock anchors: 810 m
Construction period: 3½ years