R T A

## Roads and Traffic Authority
## Oral History Program

# Developments in Concrete Pavements

# Summary Report

Researched and written by Frank Heimans

2002

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*Prepared by:*
Frank Heimans - Cinetel Productions Pty Ltd

*for:*
RTA Environment and Community Policy Branch
Level 6
260 Elizabeth St
SURRY HILLS NSW 2010

Telephone (02) 9218 6083
Fax: (02) 9218 6970



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**Roads and Traffic Authority**
www.rta.nsw.gov.au

## *Some comments about Oral History...*

Oral history has been described as *"a picture of the past in people's own words"*. It reveals what you often won't find in the files and the history books - the facts and the real reasons things happened. It is told by the people who were there - those who were involved, who made it happen, who were affected - in the colour, passion and inflection of their own voices.

Oral history accounts can also tell about relationships, perceptions, social and political climates, all of which are part of life and influence our actions and those of others. It often reveals the unsung heroes, the names of those actually responsible for innovations and important changes.

So, oral history provides a counterbalance to the formal written record by providing the personal, intimate, human and social account of events and why they happened.

The RTA Environment and Community Policy Branch established an Oral History Program in 1997, to investigate various topics of historical interest. *Developments in Concrete Pavements* is the sixth thematic oral history to be undertaken as part of the Program. As with previous projects, this oral history did not seek to present a definitive history of developments in this field, rather it involved a recounting of interesting stories and insights, told by those involved.

The 'Developments in Concrete Pavements' Oral History Project comprises almost 16 hours of interviews, recorded on digital audio tape with road engineers, builders and designers, RTA staff, the Oxenford brothers and a cement hand.

This Summary Report traces the historical development of concrete pavements through reference to a number of specific projects. The earliest included King Street (1880), Parramatta Road (late 1920s), Marulan (1929) and Ulmarra (1939). The use and development of concrete pavements continued through the latter half of the twentieth century with landmark projects such as the Warringah Expressway (late1960s), Lower Yarra Crossing (early 1970s), Clybucca (1975), Foreshore Rd at Botany (1978/79) and a number of improvements along the Hume Highway (1980s and 1990s).

Some of the key technical themes uncovered during the course of the project such as pavement types and characteristics, the Concrete Pavement Manual, noise reduction, international influences and future challenges are punctuated with a human dimension, the stories of those that were there.

The opinions expressed in the oral history interviews are those of the individuals concerned and do not necessarily represent in whole or in part the position of the NSW Roads and Traffic Authority.

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The Construction and Preservation of safe and commodious High-ways is a matter of great and general Importance, and tends greatly to increase Commerce, and promote Civilisation.

*- Portion of Proclamation by Governor Lachlan Macquarie in the Sydney Gazette, 6th April 1811*

In this State, with its wide spaces and widely distributed population, the road constitutes in many instances the only link the settler has with the world at large. Without good roads, industry can scarcely proceed and agriculture barely exist. Anything then that will help in solving the road problem of this State merits our warmest approbation. This attempt… to bring the work of improving the main and developmental roads… under the closer notice of the community is a valuable step in this direction and meets with my cordial endorsement.

*Lt.-Col. The Hon M.F. Bruxner, D.S.O. M.L.A. Minister for Local Government in Foreword of the first issue of the journal "Main Roads", September 1929*

# 1. Beginnings

*"The Clybucca job I think firstly gave us confidence that we could build good concrete pavements in NSW. We already had experience in the 1930s and 1950s to know that they could work, but Clybucca was different in that it was the first continuously reinforced project which has no transverse joints, and so that old bugbear with most motorists about concrete pavements where they typically say 'Oh, concrete pavements, they're the ones that go bump, bump, bump at the joints' - well, CRCP removes those joints and so you overcome one of the major obstacles that the public sees against concrete pavements. So the success of that project gave us confidence to resume building concrete pavements in areas like Sydney".*

-- Geoff Ayton: Tape RTA-CP:FH16 Side B, 33:06

Clybucca Flat, near Kempsey in northern New South Wales was one of many concrete pavements built by the then Department of Main Roads during its more than five decades as the main builder of roads and bridges in NSW. It was a milestone in the construction of concrete pavements, which, by the mid 1970s had, with one notable exception, been in serious decline for some twenty years. Clybucca provided hope for all those who believed in concrete as the medium for lasting pavements that required little maintenance, but which had been so maligned.

The history of concrete can be recorded back to ancient times. The cement used by the Egyptians was calcined gypsum and both the Greeks and Romans used calcined limestone. Roman concrete was made of broken brick embedded in a pozzolanic lime mortar. The cementious matrix of the latter consisted of lime putty, mixed with brick dust or volcanic ash. Hardening was produced by a prolonged chemical reaction between these components in the presence of moisture.

With the decline of the Roman Empire, concrete fell into disuse and it was not reintroduced until 1790 when an Englishman, J. Smeaton found that when lime containing a certain amount of clay was burnt, it would set under water. Further investigations by J. Parker in the same decade led to commercial production of natural hydraulic cement, which was widely used in England in the nineteenth century. From there it spread to France where the first concrete bridge was built in 1816 at Souillac. In 1882, William Lewis established a cement plant at Brighton, South Australia and produced a cement similar to Portland cement.

Reinforced concrete was developed in the mid nineteenth century and by 1911, probably the biggest structure of its kind in the world built from reinforced concrete was the Melbourne Public Library with a dome 35metres in diameter.

The first recorded instance of a concrete road in Australia is in King St, Sydney in 1880, where on the gradient from George Street to Macquarie Street, horses were slipping on the wooden blocks in wet weather. The wood was replaced by concrete, which, 50 years later was still in use.

> It's tragic to think about it - it was old, hardwood cedar from the forests. Whatever happened to these wooden blocks, whether they were used for fireplaces, who knows what were used. But it's quite tragic in the modern, sort of environmental sense, because it was the best wood you could get. (Hodgkinson, RTA-CP:FH 14 Side B, 44:55)

The first significant section of concrete road on a NSW highway was a five mile section of the Hume Highway at Marulan, near Goulburn, completed in May 1929. By 1991, a part of this section was still in service, although an 8km dual carriageway deviation around Marulan built in 1984 had taken the main traffic off the pavement.

The Commissioner of Main Roads, J R Kemp, noted that wear measurement over the first three years of service of the Strathpine Flats concrete road indicated a rate of wear of one inch in 2250 years and stated "an excellent illustration of the permanency and good quality of concrete roads". By 1931, Sydney City Council had constructed over 690,000 square metres of concrete as substrate for wood block and 37,600 square metres of unsurfaced concrete roads. In 1928, Marrickville Council Engineer E S Rowe declared that 'Marrickville had the finest roads in the Commonwealth' (Australian Concrete Road Training Manual, Edition 2.1, para. 1.2)

After this glowing endorsement, concrete roads in NSW took off in a big way and one of Sydney's first concrete pavements was on Canterbury Rd. A gravel pavement had been built on Parramatta Road in 1918 but it fell apart in 1921. There was another attempt at

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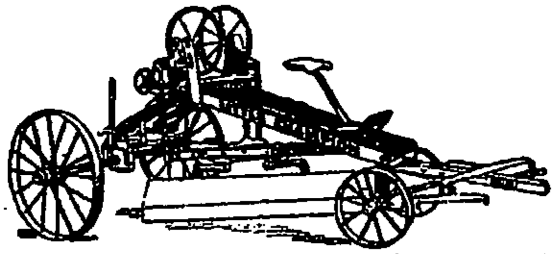

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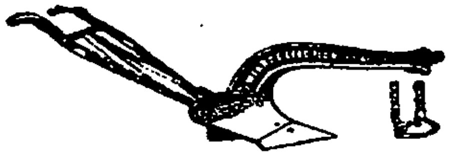

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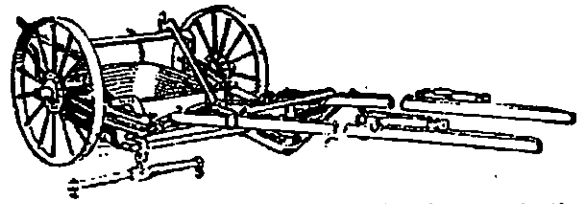

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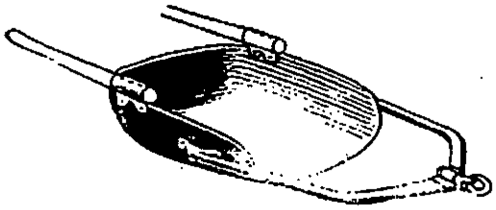

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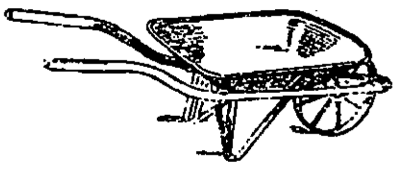

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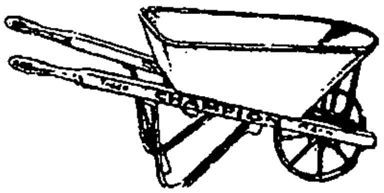


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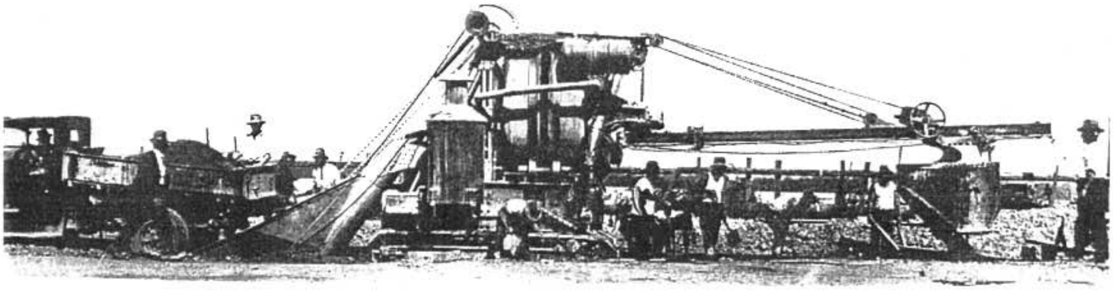
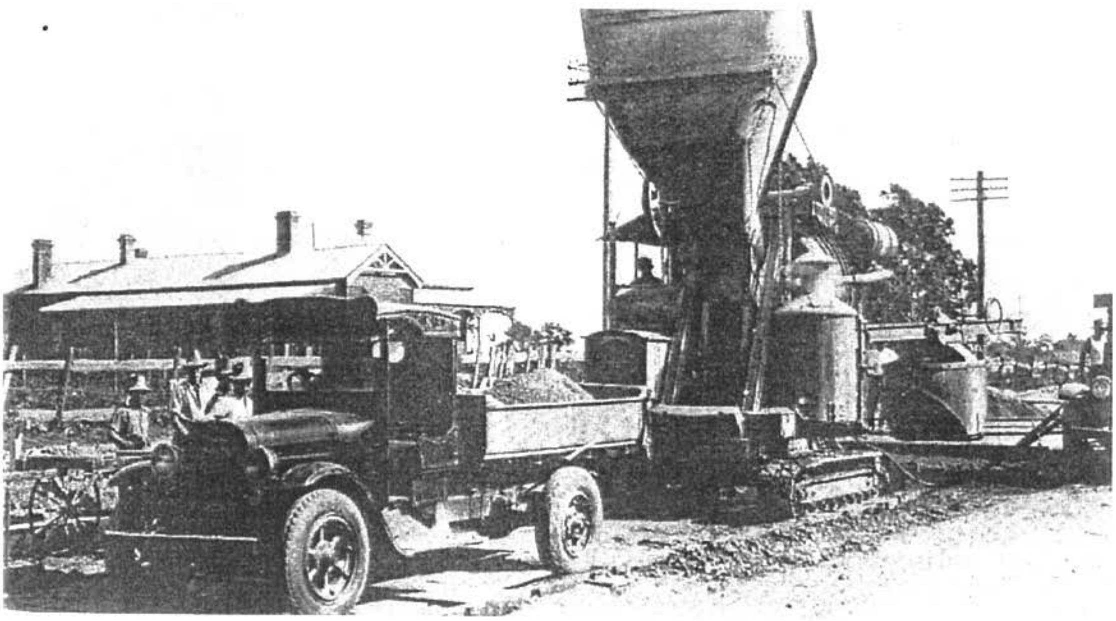
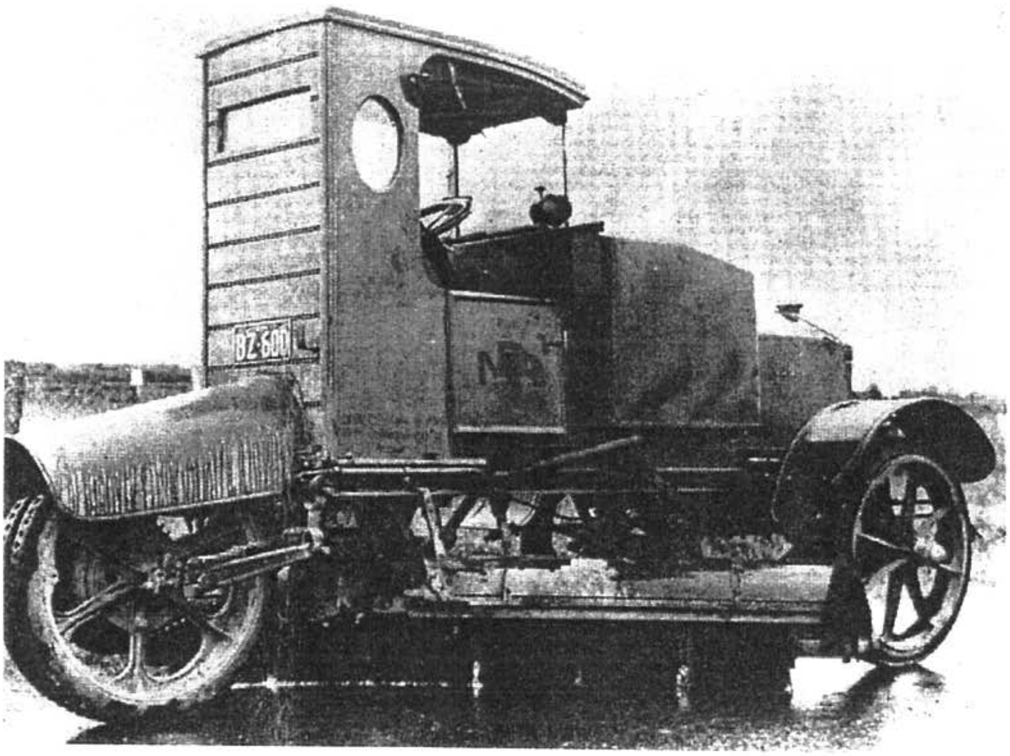
Mulgoa Road, Cabramatta in the 1920s before reconstruction



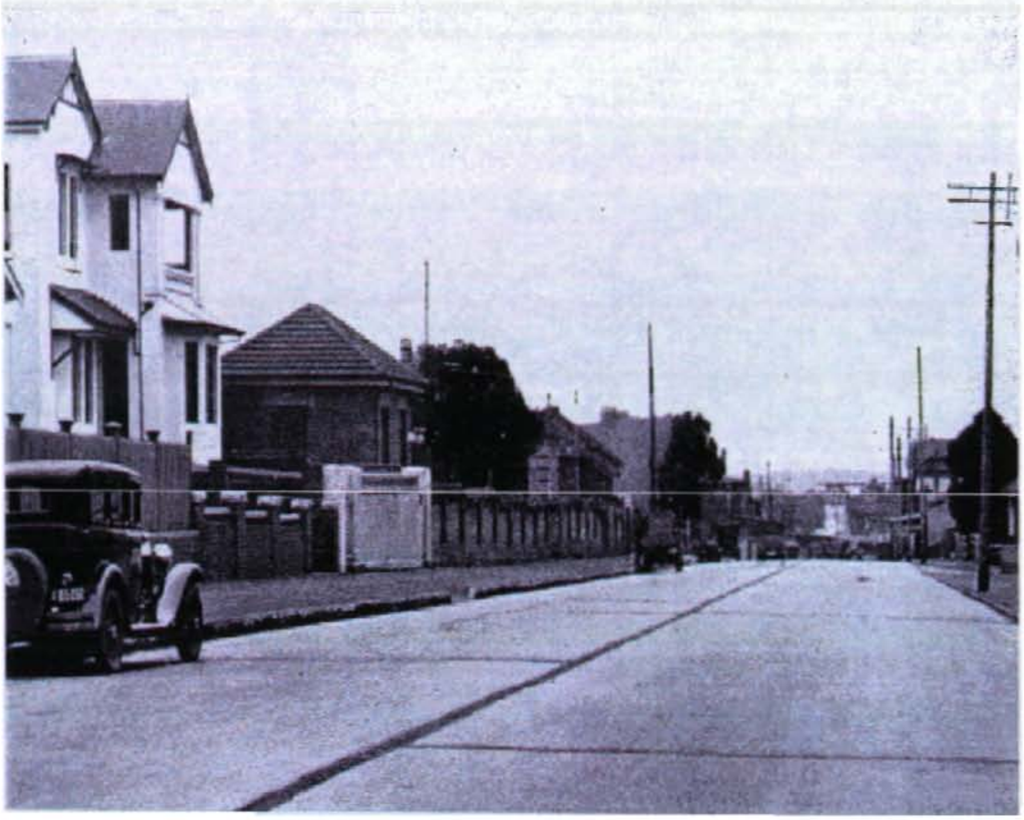
Truck loading premixed material into hopper of concrete paving machine and travelling bucket spreading concrete onto roadway, 1928



Concrete paving machine in operation near Berowra with feeding hopper raised, 1928




Three-wheeled, self-propelled road broom, 1930s



Canterbury Road, Marrickville, 1930s

Beaconsfield Rd Chatswood (70 years old).

reconstructing it in 1923, but that ended in failure two years later. By 1925, the authorities had had enough and concrete was chosen as the prime paving material.

> Now, it's 75 years old, thereabouts, and it was built what was state-of-the-art technology at the time, a lot of it was built as Depression Labour Relief Project- we would say, seventy five years later it had a lot of shortcomings, but most of it is still there. (Hodgkinson, RTA-CP:FH14 Side A, 12:39)

Subgrade preparation on Parramatta Road was minimal.

> When you pull the slab up, on the underside, you see the imprint of the grass: they literally hadn't even mowed the grass. (Hodgkinson, Tape RTA-CP:FH14 Side A, 14:06)

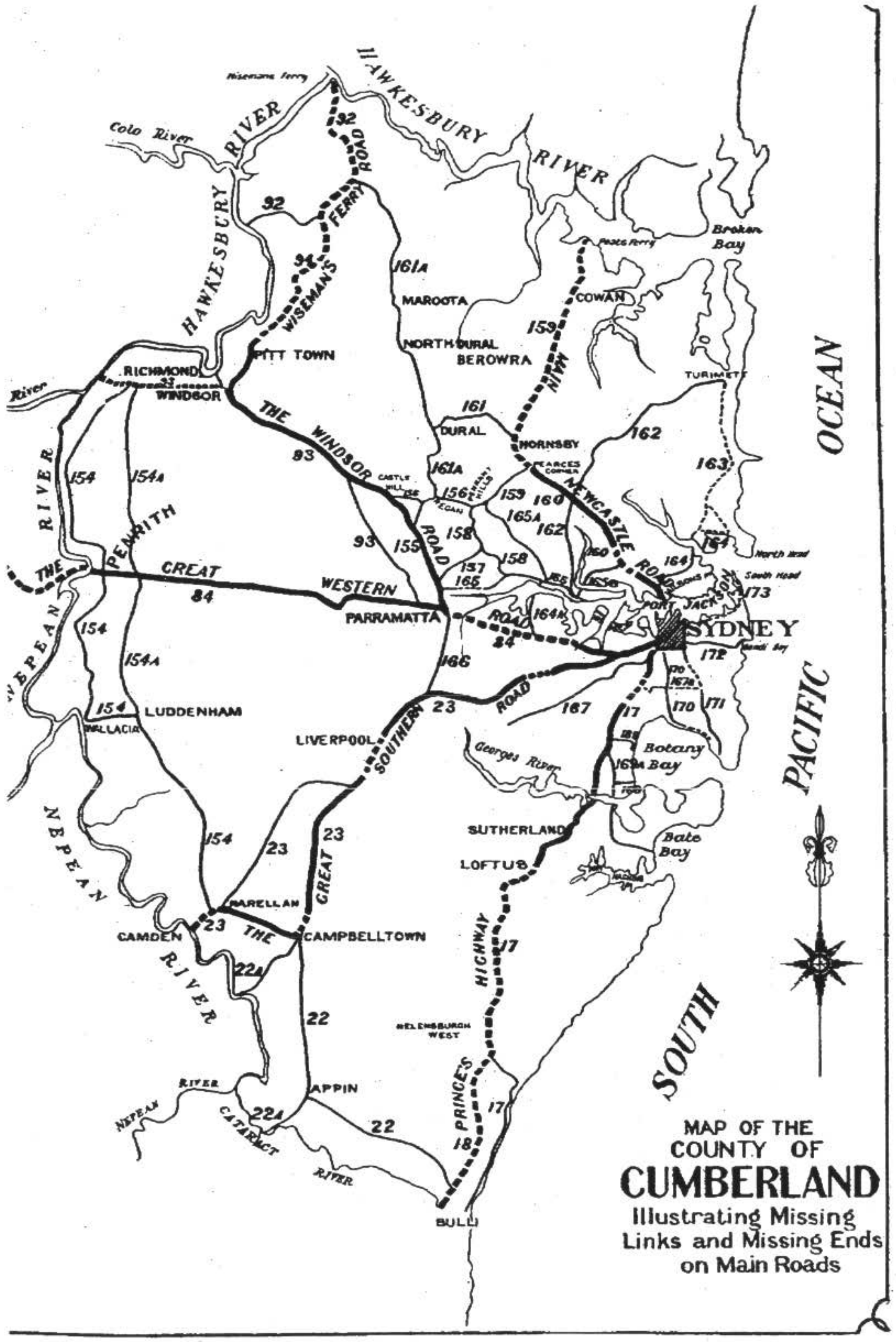
The lack of a good concrete subbase on early pavements built in the 1920s and 1930s gave rise to erosion under the joints and slabs became subject to 'pumping' as traffic loads and frequency increased. John Hodgkinson, as a DMR engineer in 1971 pioneered rapid slab replacements on Parramatta Road, placing new slabs ready for traffic in 12-15 hours, a feat that others at the time said could not be done. (Hodgkinson RTA-CP:FH14 Side A, 14:06 & 08:18)

Early concrete technology benefited by the research done by H.M. Westergard, a Professor of Civil Engineering from Illinois, whose calculations showed the stress under slabs when one wheel went over the top. He also calculated stress on different parts of the slab, such as on the edges. His design approach was followed from the 1920s until the middle of the 1980s. Westergard had a huge impact on concrete road construction worldwide. As a result of his research, many early concrete roads on Sydney's Lower North Shore and Inner West have concrete 8 inches thick at the sides and 5 inches in the middle. (Hodgkinson RTA-CP:FH14 Side A,19:39)

> They were sort of, what you'd call reinforced dowel-mesh construction and they were generally, what we'd now call 50 metres in length, with dowel joints to help transfer those loads and joints. Because they were so long, they were marked by wide joints – you know, you might talk an inch or so, full of this sort of black goo of hot coal tar or something, or hot bitumen, or rubberised bitumen to seal that joint, which became the sort of target of maintenance, but also featured when you drive over them with this sort of then familiar clackety-clack, something we endeavoured to get rid of later on. (Haber, RTA-CP:FH12 Side A, 08:30)

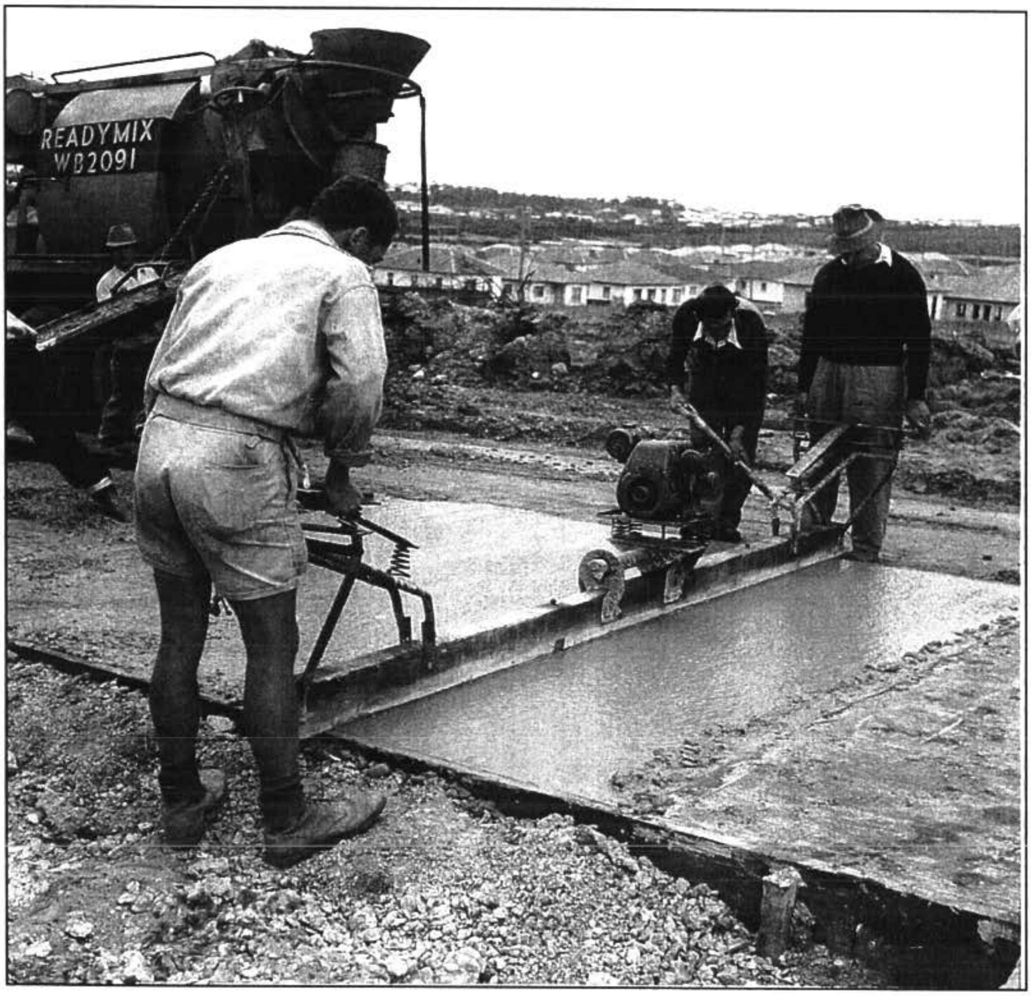
Excessive hand finishing, using gadgets such as 'jazzes' on the early pavements wore off the mortar, exposing the aggregate and making roads dangerously slippery.

> A feature I should mention is the use of much larger stone than we employ today - quite large round river gravel, alarmingly polished by modern standards; as smooth as a baby's bum (Haber, RTA-CP:FH12 Side A, 13:35)

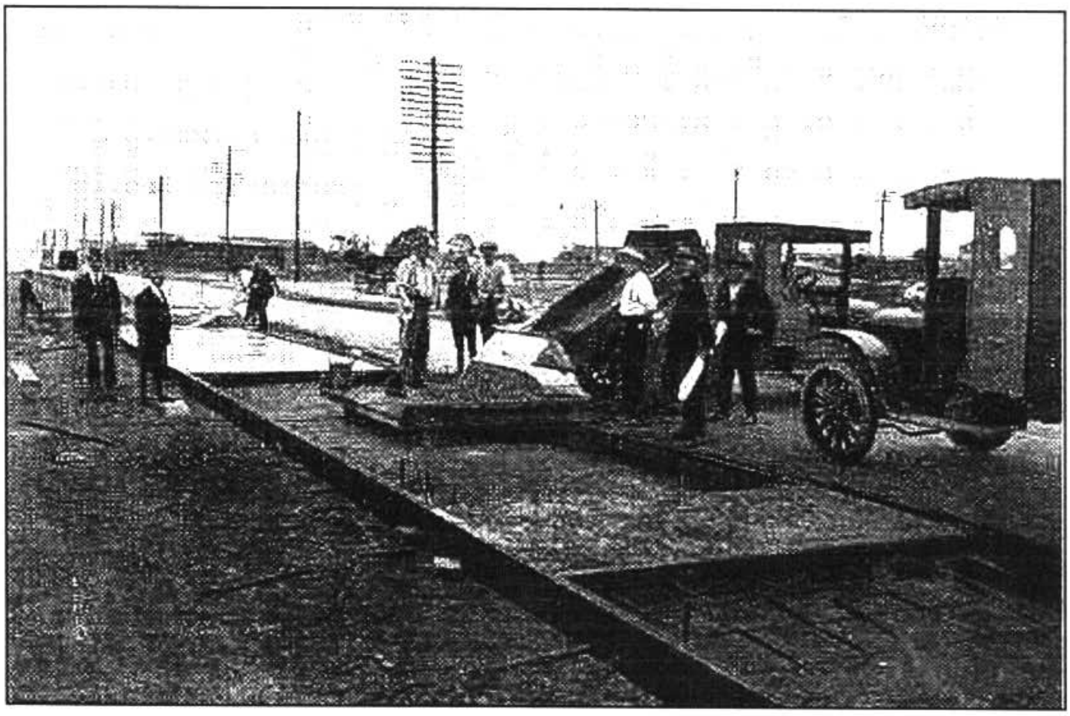



MAP OF THE COUNTY OF
CUMBERLAND
Illustrating Missing Links and Missing Ends on Main Roads

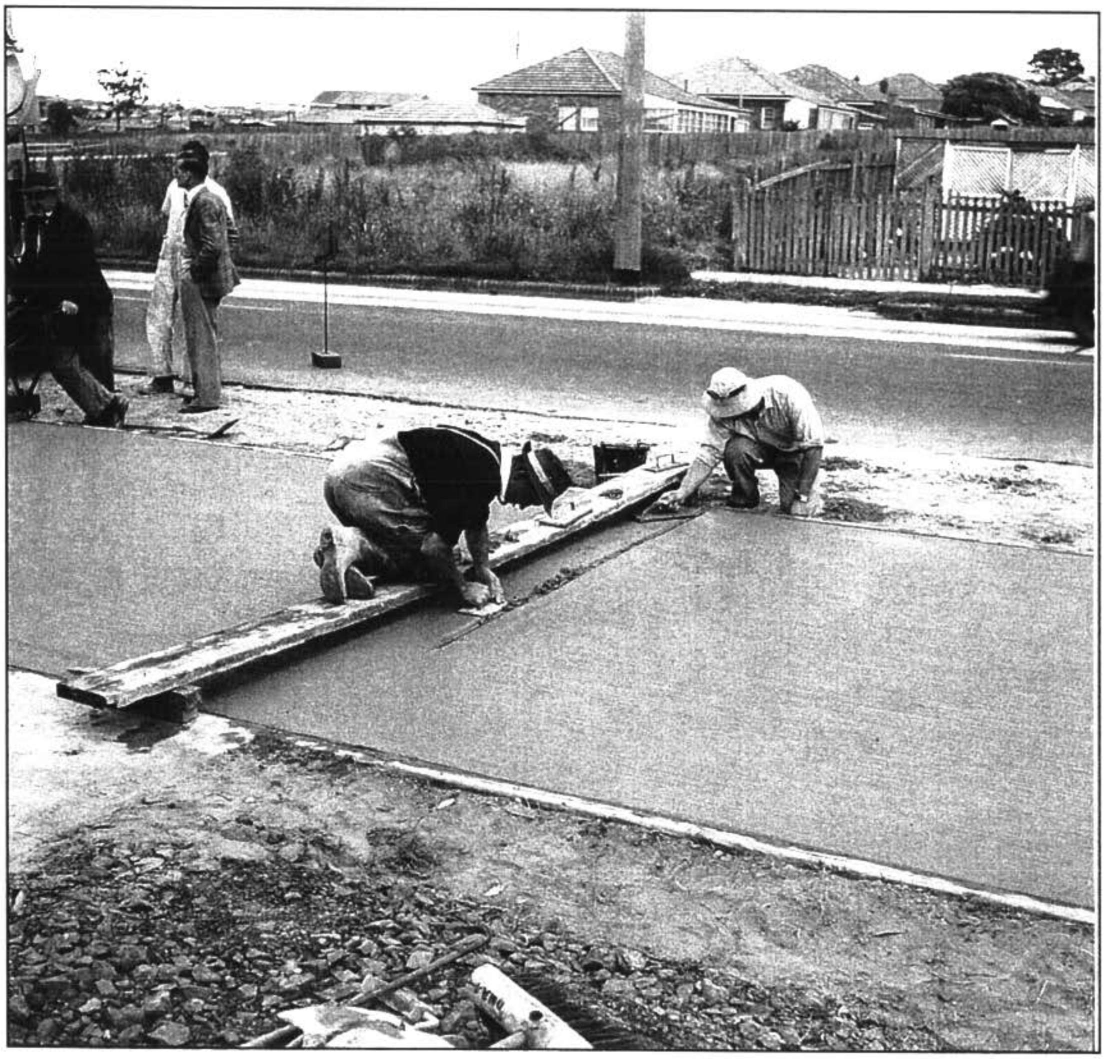
'Raising sunken concrete pavement slabs on Parramatta Road,
using the 'Mud-jacking' method, 1949




Hume Highway, Yagoona to Bass Hill, 1953



Concrete pavement construction of Parramatta Road, Lidcombe, 1953



Tooling of edges at transverse expansion joint, 1955


Delivery and spreading of concrete, 1955

## 2. Ulmarra

One of the early rural pavements built in northern NSW was a 5km long section at Ulmarra, near Grafton. The pavement was built in 1939 on a clay surface by the Oxenford Construction Company, which was awarded the contract by the Department of Main Roads for the then phenomenal sum of £40,000 (Rex Oxenford, RTA-CP:FH9 Side A, 22:10). To service the contract, Oxenfords built a wharf alongside the existing wharf at Ulmarra to unload the gravel, which came from Grafton by wooden barge. A steam-powered crane was used to lift the gravel and cement, which came in bags.

> They used to have a big old crane on the bank - a big 60 ft thing, because everything was steam – you know, they had a little old boiler, the old steam winches that they had to run it with, but they got there, they done it. The boiler was use to drive the winches, because they had no other power, no electricity, no diesel or anything, it was all steam in them days (John Oxenford, RTA-CP-FH 10 Side B, 32:35)

A screeding plant and big bins were also built on the riverbank. The gravel was one and a half inches in size, mixed at the bank, sand was added in the bins and the cement was mixed by hand and transported to the site in little open trucks. No agitators were used. This was the forerunner of what later was to become known as ready-mixed concrete plants (Rex Oxenford, RTA-CP:FH9 Side A, 5:48).

Brian Small, now 91, was a cement hand on that job. He still lives at Ulmarra on the Pacific Highway right outside the pavement he helped to build in 1939.

> Like, of a morning, I would start work – first off, I would oil meself all up with olive oil. That would stop it from chafing. I thought I'd get a bit quicker by putting sandshoes on and a pair of shorts and it bloody near crippled me. What happened, cement dust got into the shoes and set. So I soon changed that (Small, RTA-CP:FH 11 Side A, 08:03)

Brian seems to have been a phenomenal worker. He worked from 8am until 5pm, forty-eight hours a week, with only a half-hour break for lunch and no tea breaks or 'smokos'. On one day, carrying two bags, one under each arm, he emptied 1175 bags into the cement mixer. According to Brian, 1175 bags is the modern equivalent of two semi-trailers' full loads of cement. When a young 18-year fellow was brought in to replace Brian, he lasted just one hour before Brian took charge again. (Brian Small, RTA-CP:FH 11 Side A, 03:36)

Brian recalled another instance of hard work by a fellow workmate:

> One man, he stopped on that job, shovelling the sand back, when the water brought it down, shovelling it back, he stopped on that job and he wore the handle of the shovel, just above the metal, to the thickness of his finger – that little finger! Oxenford, when the job finished, he took that shovel and he said: 'I've never seen this before' he said, and he took it and I suppose it's somewhere up in their sheds there now, he took it to put it away. (Small, RTA-CP:FH 11 Side A, 22:50)

The pavement was laid in bays, in chequerboard fashion. Concrete was tipped on the reinforcing mat and the half-inch bars by labourers with shovels. Rex Oxenford's father Bert invented little stands to keep the mat off the ground before the concrete was poured. Finishing was done with a belt. The biggest pour on a single day was 26 bays, each 9ft wide. Slabs were between 25ft and 30ft long with joints, and metal dowels were used to tie the slabs. Placing the concrete was backbreaking work.

> The concrete when it was tipped out, was nearly solid from being driven, say three mile from the batching plant just in the back of a truck. Well, you know what it goes like, just sort of shimmers a bit and nearly set (John Oxenford, RTA-CP:FH 10 Side A, 16:22)

Rex Oxenford recalls the only hiccup that occurred on the Ulmarra pavement.

> I remember one incident- it wasn't funny, the only mishap that happened on the job, when it happened in the middle of Ulmarra. The story of it is that the cement used to be delivered by the North Coast Steamer and on the return trip, they used to cart sugar and this load of cement that came up.... there was some busted bags and one thing and another and it all did happen, and of course those days they didn't waste anything, they shovelled it up and put it in the bags and used it. But in the process, they got sugar got into the cement and there was about three of these bays, right in the middle of the town – and when they went back the next morning it wasn't set. They had to be dug up and redone because of the sugar that got into the cement (Rex Oxenford RTA-CP:FH9 Side A, 25:05)

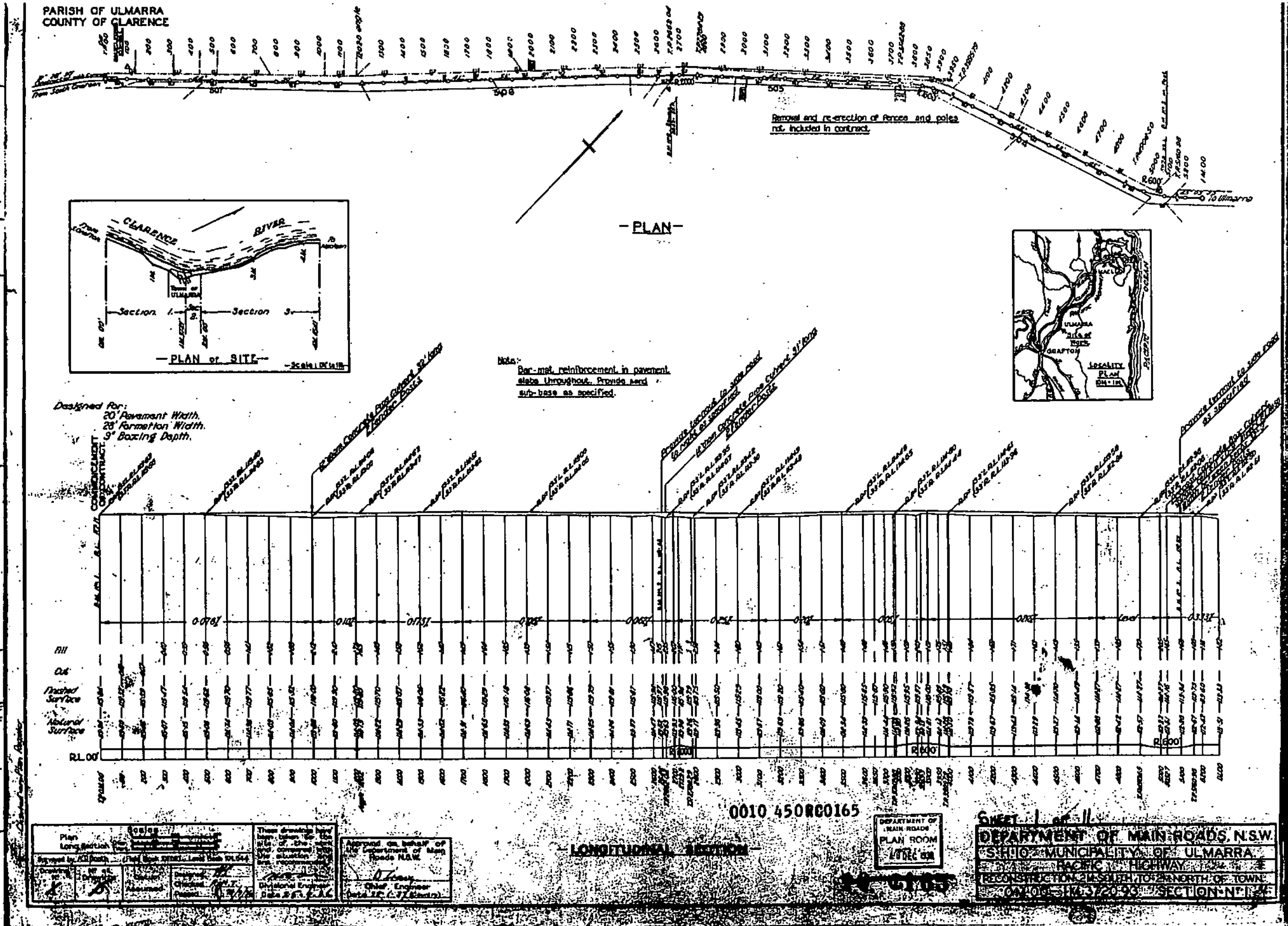
The unusable cement was dug up and thrown over the riverbank where it may still be today (Small, RTA-CP:FH11 Side A, 13:16).

The Ulmarra pavement was placed in the post-Depression era and just before the start of the Second World War. About 30 labourers worked on that contract. Through Brian Small's accounts, we get a fascinating insight into wages and living conditions at that time.

> *Q: How much was the pay on that job for you?*
>
> Oh: £4 a week – a lot of money - £4 a week. The mixer/driver got £4 a week and that's what I got to empty all that cement. It wasn't good money. I tell you what, I earned me bloody dough. You was lucky if you had a job. In those times there was not many jobs about and no money, like when you got five or six kids and mother to feed and clothe. At the time there was no houses to rent in the town. Well, we lived out in a bloke's paddock, out the back, in a tent, with five kids at one part of it, and I'll tell you what: it's no joke living in a tent with five kids. A lot of (wives) today would leave you – they wouldn't go living in tents with five kids. 'Cause that was my fault, I suppose – you had nobody worry about how many kids you had, that's your own bloody doing. (Small, RTA-CP:FH11 Side A, 24:19 and Side B, 41:20)

When the pavement was finished, Ulmarra residents loved it. It served admirably for decades and it was only when the heavy vehicles started pounding it that it showed signs of distress.

> When the road was first built, it was good, but it was never built to do what it does now … them huge semi trailers and things, and it just wore out. (John Oxenford, RTA-CP:FH10 Side A, 25:04)



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# 3. The Warringah Expressway

When the war came to Australia in 1939, the construction of road pavements, with the exception of work done for the military largely ground to a halt. All our efforts were concentrated on defending Australia from the external threat. By 1950, however, post-war demand for better roads by motorists increased in intensity.

> The growth of traffic and consequently, the use of fuelled oil had grown considerably. Bitumen was relatively cheap, because there was an abundance of it. Concrete sort of fell out of favour because they had a large asphalt plant at our central workshop at Granville and not only that, but dissatisfaction with the riding qualities [of cement roads]. Riding qualities of the asphalt were far superior (Leask, RTA-CP:FH5 Side A, 27:03)

What saved concrete roads was the decision by the DMR in 1965 to embark on its most ambitious project: the construction of an American-type freeway with exit and entry ramps through the suburbs of Milsons Point, North Sydney, Neutral Bay and Cammeray. The plan was to ultimately link the Sydney Harbour Bridge with an expressway to Newcastle. For the design, the DMR looked to America, the foremost exponents of the freeway system.

> The design was actually done by de Leeuw-Kather, which is an American firm and it was actually done in America and the presentation of the design was totally different from that we were used to in the DMR. So even that took a while to visualise what the road would eventually look like and there were so many split levels and so many ramps and the four main carriageways and especially at Falcon St. where on the southern parapet of Falcon St bridge, there are 23 traffic lanes, excluding shoulders, side by side – there are 23. And to visualise what it might look like when it was completed was a challenge in itself. (Tinni, RTA-CP:FH 18 Side A, 25:09)

> The design is for 80km/hr and it was done from aerial photography, which in those days wasn't quite as accurate as it is now and the 2.4 km of Warringah Expressway joins onto existing surface streets at 33 locations. Now it's something like 32 that we had to redesign for level or slight adjustment of line because when we came to connect, it didn't quite match the plans. But that would be expected, that was no big hassle. I think it's a pretty good design. (Tinni, RTA-CP:FH 18 Side A, 26:02)

The scope of the project meant the demolition and relocation of many residences and this posed some problems for Resident Engineer Arvo Tinni.

> Something like 404 houses were actually demolished and some 100-odd were adjusted and there was also the North Sydney red light area, Little

> Arthur St that actually got obliterated and the ladies even came with a deputation to me at one stage to relocate them, but I told them I was in a different business (Tinni, RTA-CP:FH 18 Side B, 29:32)

Arvo Tinni was so busy coming to grips with the scale of the work that he did not have time to reflect on the complexity of the task. The contractors chosen were the trusted firm of Reed and Stuart, Reed being the Reed portion of Reed and Mallik of the UK, and Stuart Brothers who, together with Reed and Mallik had built the successful Gladesville Bridge for the DMR in 1963 and 1964.

> It was the biggest thing since Noah's Ark. About 47,000 cubic metres of concrete went into that contract. (Hodgkinson RTA-CP:FH14, 02:42)

Traffic management of 140,000 cars daily during construction became a logistical nightmare. In three years, there were 15 major and 60 minor detours and traffic changes, on average one every ten days.

Excavation and blasting was on a scale never attempted before: 1.2 million cubic metres of rock had to be excavated and about half needed blasting, a difficult task in such a built-up urban area. Some residences were affected by firerock from the blasting and many houses received holes in their tiled roofs.

Environmental Impact Statements were never heard of at that time, but landscaping was extensive with over 20,000 shrubs and trees planted after completion.

The concrete pavement was designed before the time of equivalent standard axles and mechanistic designs.

> Basically the pavement consisted of 300mm of a select subgrade, which was a good quality sandstone with a plasticity index less than 12 and maximum size rock less than 100 and things like that. Then it had 150mm of dense graded gravel as the base course and 200mm of reinforced concrete. Now this reinforced concrete was actually reinforced with fabric and obviously, a lot smaller proportion of steel than is currently put into CRCP, but this fabric was continuous, with no expansion or isolation joints other than at structures, pavements are continuous and contraction joints are hand formed with a guillotine, 50mm deep and 10mm thick, filled with bitumen. The concrete is 18MPa, about half the strength of current compression strengths. It was mandatory that the concrete be overlaid with 50mm of asphalt, placed in two layers, placed with pavers in echelon so that longitudinal joints would always be hot joints. To my understanding, this was the first time this was

> done in NSW and the first time three pavers were used in echelon. There are no expansion joints, but there are induced joints for contraction and there are longitudinal joints at 3.7 metres spacing. Tiebars are 1.33 metres long and all are spaced at 750mm. (Tinni, RTA-CP:FH 18 Side B, 39:05)

It was the first time that a concrete pavement was built in Australia without expansion joints and that subsoil drains were constructed for cuttings. Kerbs and gutters were tied on as part of the concrete base, also a new experiment. The concrete was placed by a purpose-built paving train, a big advance on earlier methods of placing concrete by hand. The train ran on two steel rails and also formed the sideforms. It could place one lane, 3.7 metres wide, at a time. Concrete was being delivered at the rate of 40 cubic metres per hour by agitators. Progress was slow by current standards of 1000 cubic metres per hour, but the finish with the paving train was excellent.

As the Warringah Expressway neared its completion, Arvo Tinni recalls an amusing incident involving the Minister and the Commissioner for Main Roads.

> The Commissioner was Russell Thomas and he used to have an iridescent silver Chevrolet car, a lot of chrome and very fancy, and one weekend, Thomas and Pat Morton, the Minister, were on the job and talking about openings and things like that, and I, was standing behind them, ready to answer any questions. And the Minister says to Thomas: 'Mr Thomas, how come you have got this beautiful, iridescent silver Chevrolet and I've got the identical one, except mine's just plain white?' And Thomas looked as his car and said: 'Mr. Minister, the difference is that I'm the Commissioner.' And there wasn't a sound made by the then Minister. (Tinni, RTA-CP:FH 19 Side A, 04:58)

Unlike the Gladesville Bridge, there was no formal opening ceremony planned for the Warringah Expressway, so the engineers all contributed funds and had their own party, inviting the Police and Services people they had lent on every day as a token of appreciation.

The Warringah Expressway stands out among the DMR's achievements because of its complexity. The asphalt covering is now 33 years old and has never been replaced, a feat that Arvo Tinni regards as 'unbelievable.'

What lessons were learnt by the Warringah Expressway that the DMR could use in future projects?

I think the fact is that good jobs and good work could be done by contractors rather than just......... we kept thinking that we were the only ones who could do it. (Tinni, RTA:CP19 Side A, 08:18)


The Warringah Freeway just north of the Harbour Bridge is over 30 years old.

# 4. The birth of CRCP: The Lower Yarra Crossing Project

A milestone in the history of concrete roads in Australia – the first continuously reinforced concrete pavement - strangely enough, originated in Victoria in the early 1970s. It was strange because the CRB (Country Roads Board of Victoria, the equivalent authority to the DMR in NSW) had hardly built any roads in concrete for decades and understood little about modern concrete technology. The project was the construction of the eastern freeway approaches to the Lower Yarra Crossing Project in South Melbourne through Brady, Boundary and Montague streets. Barry Munce, an engineer with the CRB was the Assistant Project Manager for the entire project, and the continuously reinforced concrete pavement problems were predominantly left to him to solve.

> I believe a small trial (with continuously reinforced concrete) had been done in a bus depot somewhere, I think, in Sydney. It is my understanding, and I think it is widely accepted that Boundary/Brady/Montague Street was the first application of continuously reinforced concrete pavement to a public road. We sort of affectionately refer to it as CRCP. (Munce RTA-CP:FH20 Side A, 07:11)

Munce was aware that CRCP roads were being used extensively in the US and Europe, particularly Belgium, so he looked to those countries for information and inspiration. Getting reliable information by long distance was slow and difficult, so in 1973 Munce was fortunate to obtain a Churchill Fellowship and left for overseas to study concrete pavements in the US, Canada, Switzerland, Germany and the U.K. On his return, he designed the pavement. It was not an easy task, as parameters were arrived at by engineering deduction. Data on CRCP relevant to Australian conditions simply did not exist. The pavement was documented by Munce and two other CRB engineers in the Materials and Research Section and was presented to an Institution of Engineers meeting in June 1973.

The pavement was to be built on reclaimed land with high water tables and poor subgrades of fill and silt. High voltage power lines, major drains and water mains posed additional problems for conventional pavement construction. The pavement was about 200mm thick on a lean mix concrete subbase. Site conditions did not permit on-site mixing. The differences between that first CRC pavement and today's CRCP are significant.

> In terms of the modern CRCP, the steel, both longitudinal and transverse, would not be mesh. In the case of Brady/ Boundary/ Montague Street, the

> only reasonable way we had of handling the reinforcing at the time was to use very heavy commercially-available mesh and that said, mesh was available to meet the design criteria (Munce,RTA-CP:FH20 Side A, 19:16) .
>
> The Brady/ Boundary/ Montague Street job was entirely hand. The lean mix subbase was placed by hand and the CRCP itself was formed with conventional fixed forms, concrete delivered by agitator truck, more or less spread by hand, compacted by hand and then we used motor-driven vibrating screeds to do the final surface compaction and finishing. This differs hugely, of course, from the modem technique of any of these larger pavements being slipformed. (Munce RTA-CP:FH20 Side A, 19:16)

Construction was slow-going, but the contractor was thorough. The road had two elongated bends in the middle of it and Munce was quite uncertain about how the continuous action would negotiate those bends. He was also unsure about the amount of movement that would arise in the pavement where it interfaced with the existing pavement.

Munce argued the case for more CRCP roads with the CRB but never understood their resistance to concrete pavements. He went on to construct CRC pavements for airfields and has innovated new techniques for hot climate paving: the use of iced concrete at the RAAF base at Curtin,. WA.

Munce believes that a lot of his Brady/ Boundary/ Montague Street pavement has now been demolished or covered over.

> History now records that the Lower Yarra Crossing is now interfaced with a number of major urban arterials or freeways which have substantially made the Brady/ Boundary/ Montague route redundant (Munce RTA-CP:FH 20 Side B, 31:26).

The Brady/Boundary/Montague Street project remains as an early test of the effectiveness of continuously reinforced concrete pavements. It has also bestowed on Munce the honorary title of 'Father of CRCP in Australia', one he reluctantly accepts.

# 5. Clybucca: resurgence in concrete paving

In NSW, in 1975, it was decided to apply CRCP concrete technology to solve the DMR's monumental headache - the five and a half kilometre section of the Pacific Highway at Clybucca Flat, near Kempsey, where periodic flooding inundated the road surface and caused deterioration of the pavement on an almost annual basis. Clybucca Flat was the first time that a CRC pavement was constructed in NSW. Geoff Ayton, then a young engineer just out of university, was appointed as Site Engineer to the project.

> Clybucca Flat was a very challenging project because it goes through a floodplain and the then DMR was not allowed to raise the levels of the road, because that would have impeded the flow of flood waters . The Macleay River breaks its banks during floods and flows through that area, so we were forced to build that pavement at existing levels and that always introduces problems because your subgrades are very soft. Water lies beside the road for almost 12 months a year and if you took off the top layer of the existing pavement, which in some cases was probably only eight inches thick, 200mm, you could take a piece of reinforcing bar, steel bar and drive it into the subgrade with your hand under your own weight. And it is said that truck drivers, driving through that section before we reconstructed it, that the pavement was so soft that they had to change down a gear going through that section of Clybucca, because there was significant deflection under the tyres - it was almost like driving a truck across a mattress. So they were the sort of challenges we had (Ayton, RTA CP-CP:FH16 Side A, 06:25).

Clybucca's files went back to the 1930s. The DMR's Materials and Research Engineer, Alan Leask, had been invited to Melbourne to study the materials, design and construction methodology of the Brady/ Boundary/ Montague Street pavement and gained valuable insights into the new technology. Leask and his co-designer, Ed Haber, now had an opportunity to apply some of their newly-found knowledge to the Clybucca Flat problem.

> Because we knew we couldn't compact any subgrade properly, we innovated the first poured concrete subbase, which was 130mm thick, of low strength concrete, about 8MPa concrete, which could be laid straight upon this uncompacted subgrade. It was done with a machine – we had steel rails along the edge side and the machine rode on those rails and poured this subbase. That was vindicated quite early in the piece because there were several floods - I think there were three during construction - when the water came over, but immediately that receded, we were able to get back on it. Had we tried to do that with a conventional subgrade, we would probably have been there for months (Leask, RTA-CP:FH5 Side B, 45:45)

The introduction of the first lean mix concrete subbase in NSW was regarded as a technological triumph.

> Because of the success of that lean mix concrete at Clybucca, we adopted that almost straight away as a standard feature on our concrete pavements and from the early 1980s onwards, there are few projects in New South Wales in concrete pavements that don't have a lean mix concrete subbase. (Ayton, RTA-CP:FH16 Side B, 34:10).

> This first application of concrete subbase gradually permeated into the whole main roads system to the extent it is used in flexible and concrete road construction: in such situations its benefits could be seen everywhere. (Haber, RTA-CP:FH12 Side B, 31:25).

Another first on the Clybucca project was a decision by Leask that the concrete should have an upper limit strength, as well as a lower limit at 28 days. Previous to Clybucca, all of the DMR's concrete specifications called for a minimum strength limit only.

> What we were aiming for there was to limit the shrinkage, and to further that, we insisted that they use a low shrinkage cement, and we also specified shrinkage limits (Leask, RTA-CP:FH5 Side B, 52:30)

The biggest challenge at Clybucca was getting the concrete mix right.

> About 35 trial mixes were made at the DMR's Milsons Point laboratory and that would still stand as some kind of record of effort put into refining a mix. The mix included an air entraining agent and a water-reducing admixture. The subbase was a lean concrete mix with high fly-ash content, unusual in those days, but it has since become standard practice. (Ayton, RTA-CP:FH16 Side'A, 23:33)

> (Another first at Clybucca) and it has continued ever since, was to deliberately over-sand the mix.........that was the Optimun Sand Design as it was called – you worked out, by a whole series of trial mixes the optimum sand by a plot, and then you'd go slightly above optimum, because that would promote the fines to the surface and in effect, produce what I term a type of sandpaper finish (Haber, RTA-CP:FH 12 Side B, 52:55).

Engineers at Clybucca also had to come to terms with unfamiliar technology, such as the use of a vibrating wire strain gauge and electrical resistance gauges. According to Leask, from Clybucca on, all future CRCP work closely resembled that at Clybucca and had the same specifications requirements.

The concrete base was placed by manual methods, using shovels to spread the concrete into fixed forms and for the first time in NSW, a spreader/finisher, a Gamaco C-450 was used, comprising of an auger and a roller which provided a good standard of finished surface profile. Ahead of the spreader/finisher, two or three men used internal vibrators and particular attention was directed to the thorough vibration of the concrete. Geoff Ayton credits that to the success of the job and for Clybucca being one of the lowest maintenance pavements ever built in NSW, if not the lowest.

> That's probably our most successful concrete pavement. If there are better ones, I'm not aware of them ... that was constructed in 1975 and so we're approaching 25 or 26 years old and we have never spent one single dollar on the maintenance of that concrete pavement, which is a remarkable achievement, given that it is five and a half kilometres long, and when I tell those stories to overseas pavement engineers, they open their eyes and marvel at that story ..... So I'd say that that probably rates as some sort of world record (Ayton, RTA-CP:FH16 Side A, 16:40).

Despite the success of the Clybucca pavement, Barry Munce, who was seconded by the DMR to advise on aspects of the design, believes that

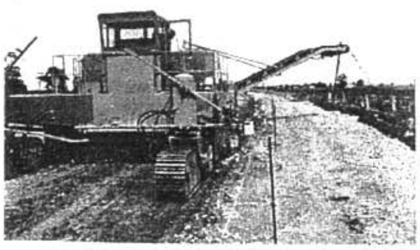
> The cement contents that the then DMR used in that mix design, I felt were too low and I am still of that view. And if you see that job now, after something like twenty five years of Pacific Highway traffic on it, when you look at it in the wet, you actually can see some wheel pass tracking, where it is my view that the weaker concrete material on the surface, where you get the laitance coming to the surface and there is an amount of hand finishing, so you get a little bit of mortar - that mortar has worn away and my recollection is that there is only 220 or 250 kilograms per cubic metre or equivalent of cement and I was always concerned that that was enough. It was well below my durability threshold and I do believe that that is one aspect where I have always differed with the DMR, and subsequently the RTA, in terms of cement content and I do believe to this day that whilst that pavement has served remarkably well, it's got some small wear in the wheel tracks, which possibly could have been lessened by using more cement (Munce, RTA-CP:FH20 Side B, 36:25).

Ed Haber maintains that there was not another concrete pavement research project that has yielded such valuable research data as Clybucca, which still is probably the most monitored road in Australia.

> Clybucca was the starting point and provided a springboard into the behaviour of concrete pavements on which we could dine out for years to come (Haber, RTA-CP:FH12, Side A, 23:45)

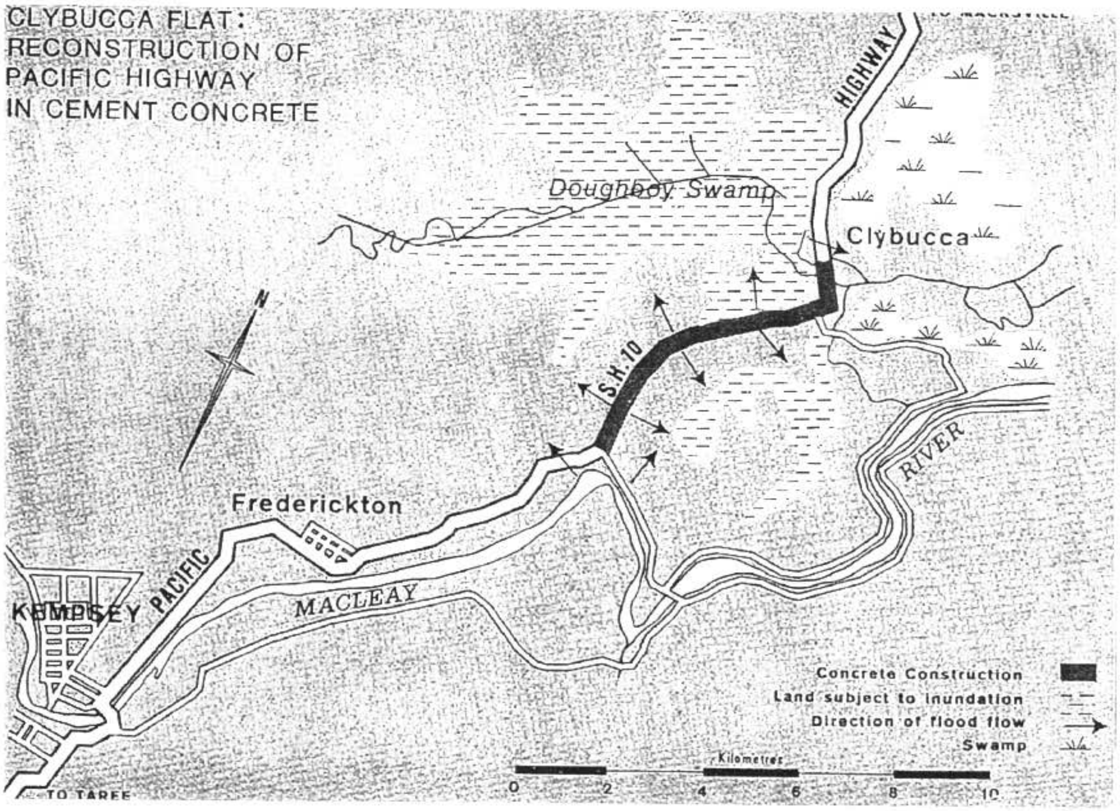
Clybucca was the pivotal pavement of the 1970s, launching the DMR into the modern era of concrete pavement construction.

*The trimmer-spreader at work. Electronic sensors activated by a surveyed stringline keep the machine accurately positioned in relation to line and grade.*

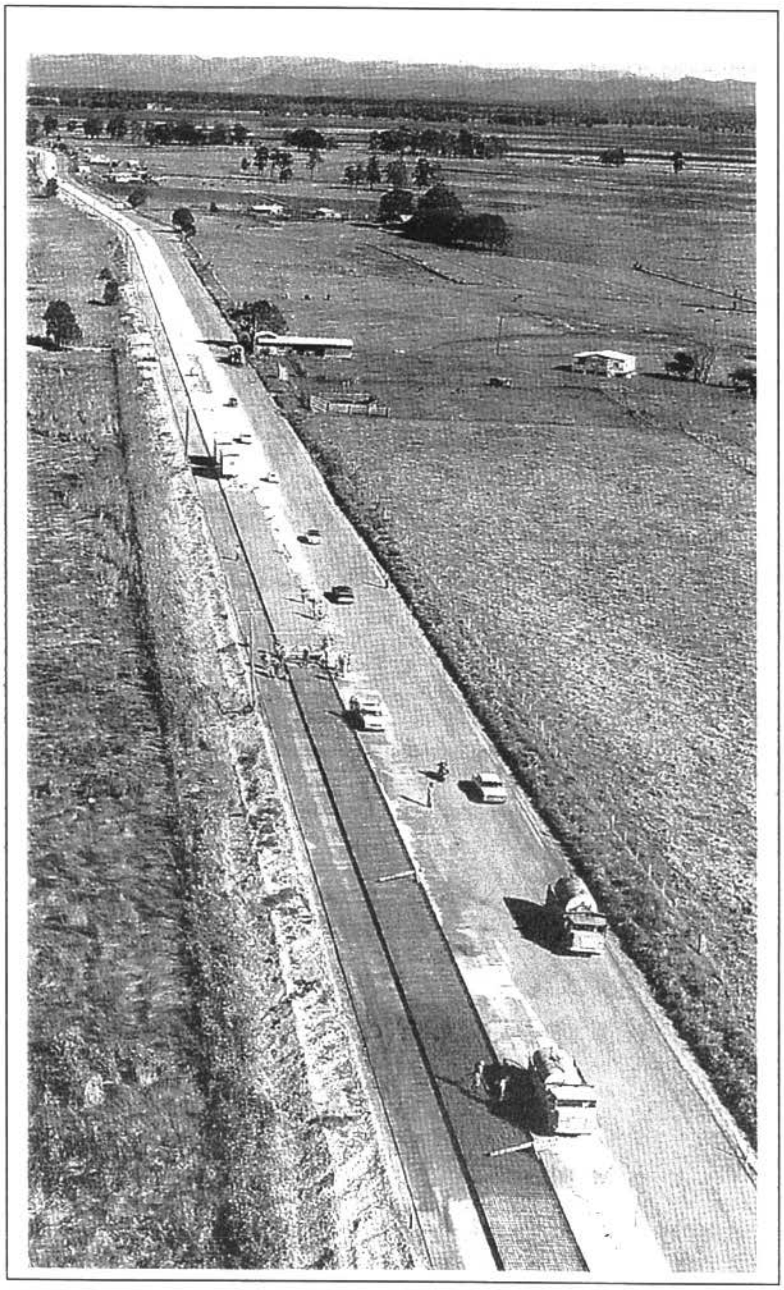


*Steel formwork rails are accurately positioned for the spreading of the mass concrete base.*

*The ready mixed concrete is tipped onto the subgrade and spread by hand ahead of the spreader-finisher (right).*



Clybucca Flat pavement nearing completion,1975



# 6. The Foreshore Road

One of the DMR's notable projects was the construction of the Foreshore Road in 1978/1979, the first continuously reinforced concrete pavement to be built in Australia using a slipform paver. The road was needed to service the new container terminal at Port Botany and was part of the government's plan to move sea freight to a second port in Sydney. The road closely follows the contour of the Botany Bay shoreline. Steve Warrell and Pat Kenny were both young engineers on that project, which became much more complex than they ever imagined.

> The reclamation would have gone, I think in the order of 100 metres from the old shore line. It was quite a complex project. It extended at the western end from General Holmes Drive where there was a great separated interchange to be built - from there it went about three kilometres long over the top of the reclaimed sand to a junction with Botany Road, which had to be reconstructed. From there it went further east to Bunnerong Rd. Now within that section between Botany Rd and Bunnerong Rd, we had two bridges to be built: one over a railway line and another over a creek and within that area there were four separate areas of reinforced earth embankment to be built. Underneath there were caustic soda lines, 24 inch water lines, some aviation fuel lines, major telecommunications cables, as well as 132,000 volt underground power lines (Warrell, RTA-CP:FH7 Side A, 21:09)

Excavation work on top of the underground power lines was about to commence, but required a demonstration of faith by Steve.

> There was one particular day when the overhead power lines had been completed and we really needed to start some excavation work in the vicinity of the old underground power lines, which were cables around 75mm in diameter, copper core cable. Now the fellows that had to do the excavation work had been told by an Electricity Commission worker that the underground cables were still live and that they shouldn't touch them, so to get things rolling, I made a phone call to the Electricity Commission to confirm the cables had actually been taken out of service and I then drove a steel spike through the cable to demonstrate to the workers that they were actually out of service and after that, it was OK (Warrell, RTA-CP:FH7 Side A, 26:12)

Putting a road on top of reclaimed beach sand posed its own set of engineering challenges.

> We formed up what we called bunded areas – areas of flat sand about 80 to 100 metres long, with a wall built out of the sand around the perimeter of each of these bunded areas – the wall would have been of the order of half a metre high. What we did then was to pump water out of Botany Bay into the bunded area and waited until we had water actually lying on the surface to a depth of the order of 150mm to 200mm. We then got an old D-9 dozer towing a 96-T smooth drum vibrating roller up and down through the water within the bunded area for a set number of passes to achieve the densification of the reclaimed sand and to ensure that we had a sound base to build the road on after that (Warrell, RTA-CP:FH7, Side A, 13:40)

The biggest problem for all was having to work with and through sand, blowing from nearby dunes.

> After a couple of problems with the sand blowing around the site, a decision was made by the Maritime Services Board, who were responsible for the reclamation to spray a stabilising product over the bulk of the reclaimed area to stabilise the surface of the sand... it formed a crust on top of the sand.........we also put up star picket fences with steel wires running between them and draped the wires with hessian between them ... and that way we formed artificial sand dunes ... (the sand) also caused concern with local residents, blowing up into the eaves of houses and at one stage, on the detour road put around the Caltex terminal, the paint on the guide posts was actually sandblasted off and there were a few issues with the workers in that area being concerned about damage to their cars..... a strike of one week occurred (over that issue). (Warrell, RTA-CP:FH7, Side A, 08:12, 09:51 & 25:21)

It seems that not everyone was happy with the work being carried out.

> There was one day when we had a small bulldozer down on the beach starting to shift around some sand and we had a few people lie down in front of it to try and prevent work. There was quite a lot of community concern about the dredging taking place in Botany Bay, but it was largely to do with the vast amount of sand need for the Port Botany works, rather than being specifically targeted at the Foreshore Rd as an individual construction project (Warrell, RTA-CP:FH7 Side A, 08:43).

Reclaimed sand was placed to a depth of three to three and a half metres or more. The subbase for the road was a layer of 125mm of lime treated fine crushed rock, placed directly on the sand subgrade, compacted and covered with a sand primer-seal. A construction road of sandstone beside the actual road was built. The most important decision to be made by the DMR was the choice of paver to be used on the project. A particularly impressive machine, a slipform paver imported from the UK by McGregor Paving Ltd had already been used by the New South Wales Railways in the construction of the Zig Zag Railway Tunnel at Lithgow. John Watkins-Wilson accompanied that paver to Australia.

> The machine we brought out we actually manufactured ourselves. It was a single-lane machine, which could lay, from memory, a lane about four metres wide. It's a two-track machine, guided by a piano wire at each side, it's got a level sensor on each corner and a steering mechanism on a steering sensor on one side. The difference between that slab and a lot of slabs laid now is that was a reinforced slab- continuously reinforced - where most of the majority of pavements today are plain concrete. So where normally with a slipform paver, the advantages – particularly with a plain concrete, you can reverse a vehicle straight in front of the paver and tip concrete in - once there's reinforcement in the way, you can't do that, so we had to side feed the concrete. At that time, because we weren't geared up concrete mixer-wise, it was fed from a standard ready-mixed concrete plant, so the concrete was fed by agitator onto a small conveyor, which fed the thing sideways. But even then, we were still getting production of over a linear metre per minute, which, as an average is pretty good, even today (Watkins-Wilson, RTA-CP:FH3, Side A, 08:31).

The paver was hired on a plant-only basis with operators. The challenge for the DMR was to get everything ready for the paver, something that had not been done before. John Watkins-Wilson still admires the people at the DMR who put their heads on the line in proposing the new paver. If it proved to be successful, the door would be opened to large-scale concrete pavement production in NSW. But early on, problems occurred.

> One thing about slipform pavers: because you haven't got edge forms to contain concrete, you want a consistency of concrete and coming through with ready-mixed concrete supply, you rely very much on the agitator/driver, because he wets the load up - on his skill to get consistency of concrete (Watkins-Wilson, RTA-CP:FH 3, Side A, 18:01)

Early loads of cement were either too wet or too dry and were rejected

> I think the subbase from my recollection went down, first pour, absolute disastrous day, as I remember in October 1978 and I think there were four runs, as in four lanes, up and down and the quality of concrete increased from the first to the fourth and by the fourth lane, typical of jobs like that, they had it down to a fine art and it looked very successful (Haber, RTA-CP:FH12 Side B, 54:20)

The DMR had concerns about the steel content in a road so close to the sea. Normal crack width tolerances for CRCP pavements was 0.3mm and this was further reduced on the Foreshore Road to 0.2mm. However, Ed Haber still had concerns about the condition of the steel reinforcement inside the concrete.

> There was some maintenance on the Foreshore Road. In my time, there were only two lengths of five metres...the truck axles will find the weak points on

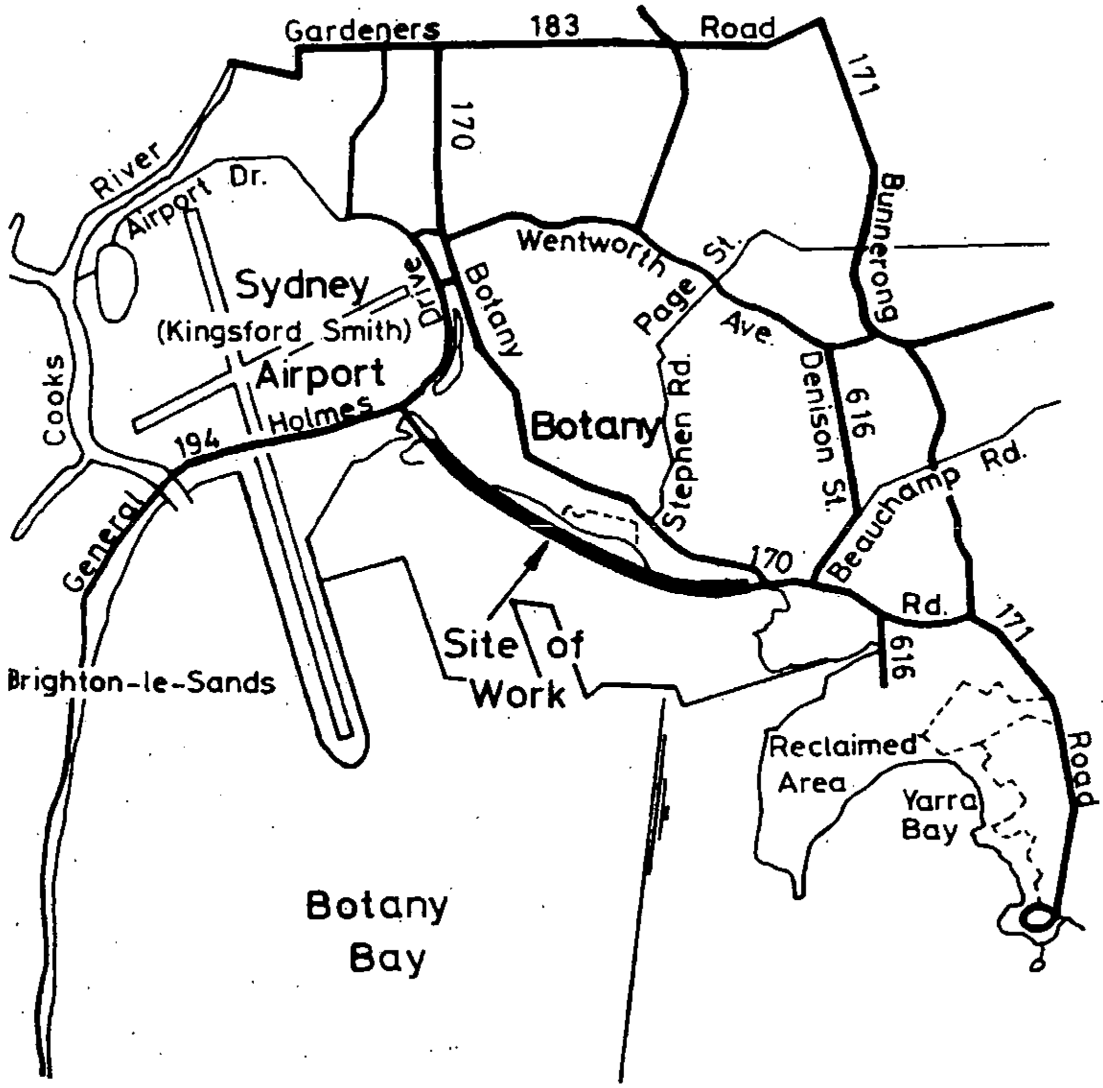
> the concrete....two repairs that were proven necessary afforded us the opportunities to open up the road, which I was quite anxious to do because of all the controversy that preceded it and have a bit of a peek-a-boo at the condition of the steel, which was found to be in mint condition, so all pre-existing fears relating to potential corrosion of the steel were expelled (Haber, RTA-CP:FH13 Side A, 00:25).

> It really was an excellent opportunity to be challenged in the engineering sense and to overcome those challenges and to create a really good team out on site. I think from the DMR/RTA's perspective it was a good project. It demonstrated the viability of concrete paving and things have really gone ahead in leaps and bounds from there (Warrell, RTA-CP:FH7 Side B, 55:50).

After the completion of the Foreshore Road, the McGregor paver was only used for a small section of the M4 Motorway, and as the anticipated boom in slipform paving would not arise for about another five years, due to lack of demand, Australia lost its only slipform paver when it was shipped off to South Africa.

The Foreshore Road exceeded all expectations, continues to carry traffic loads many times more than its designers ever imagined and has withstood the test of time.

Foreshore Road Map




The McGregor paver in use on Foreshore Road, 1978

The paver at work on Foreshore Rd, 1979

The completed Foreshore Rd, 1979

# 7. The Hume Highway

After the successes of Clybucca and the Foreshore Road, a much larger problem loomed for the DMR. Here was a highway, the main arterial route to Australia's second largest city, starved of funds by successive governments for decades. Arvo Tinni, who was posted to the Yass Works Office in 1963 recalls the state of the highway.

> The Hume Highway had had a miserable collapse and failure in the 1950s where it was actually closed to traffic for three months in the area of Tarcutta – the Hume Highway was closed to traffic for three months and so the task was to again.... well, the major task was to keep the maintenance at the stage that it can't start to break up (Tinni, RTA-CP:FH 19 Side A, 19:50).

David Dash maintains that it was frustration that forced the decision to use concrete on the Hume Highway.

> I went, I think, in '84 to Goulburn and I asked the local works engineer what sort of pavement that was and he said it was pre-mix, spray-sealed every summer (Dash, RTA-CP:FH 1, Side A, 04:46).

Some of the reasons of why the Hume Highway would benefit from a concrete pavement were heavy truck loadings, poor foundations and a readily available supply of aggregates. By the early 1980s, a review of concrete world practices had taken place in California, France and South Africa and unreinforced concrete with short slabs was reintroduced, which lent itself to slipform paver construction. This led to an ever-diminishing gap between the cost of concrete and other types of pavement construction. Life-cycle costing now became an issue and concrete was competitive again. However, lack of funding for major highway construction in Australia was holding back any development.

Finally, the breakthrough for the Hume Highway came in 1982.

> What really gave it a big acceleration despite whatever might be said was that the Fraser Government in Canberra, leading up to the Australian Bicentenary in 1988 introduced the Australian Bicentenary Road Development Program, or ABRD for short, where the Fraser Government said to the country 'Here's two and a half billion dollars, we want this spent by 1988'. But it had to go to the national highways, which were the highways that the Federal Government funded. This allowed large lengths of

pavement, including concrete pavements to be built with slipform paving, on-site concrete production, putting up to something like.........peaking at say 1500 cubic metres a day - in other words, building a carriageway of three lanes and a shoulder in about two or three days. Now this revolutionised construction and it also revolutionised economics (Hodgkinson, RTA-CP:FH14, Side A, 24:32)

The ABRD road building program allowed engineers the chance to refine design procedures. There was a great determination by roadbuilders to be successful and it was now possible to achieve a concrete paving rate of 700 cubic metres per day, using new, larger slipform paving machines. One of the first sections of the Hume Highway to benefit from the new technology was at Tumblong, in southern NSW.

The Tumblong Deviation is located just on the south side of Gundagai, between Gundagai and Tarcutta and it was built in a number of stages. Tumblong I was about 10km long, dual-carriageway, concrete. After the Wyong section on the F3, this was the second major plain unreinforced concrete pavement sections built. It had a number of firsts in it: the entire carriageway, that is three lanes and a shoulder were paved in a single pass – that was the first time it was ever done in this country. That was also a very significant aspect in its construction. A number of interesting, retrospective lessons, which are not in any way critical: these are lessons of history. In 1983, road authorities did not have any access to the data which measured the actual loads of trucks, so truck loads was a bit of an assuming factor. This changed in 1987 with a particular design manual that came out, and in retrospect – and it's very easy to say in hindsight – the pavement at Tumblong was probably under-designed, that is, it wasn't designed for as many trucks as we now know run over it and the actual axle loads assumed weren't what we now know to be, and this has perhaps led to a few problems with some slabs. ........but all things considered, this was quite an amazing demonstration piece in 1983 of what concrete highway construction in 1983 was, compared to the sort of things we saw back in the 1960s, so in that sense it was quite an historic and quite, again, a pivotal construction (Hodgkinson, RTA-CP:FH15 Side A, 00:22)

Tumblong I was the first full-carriageway slipformed pavement and the first time that tipper trucks were used to supply the paver. It was also one of the first jobs where on-site dedicated batch plants were used. In addition, Tumblong set a new level of ride quality with a roughness measurement of about 35 counts per kilometre, a very satisfactory result.

However, Arvo Tinni, Divisional Engineer at Goulburn at the time feels somewhat differently about the Tumblong I Deviation.

It's a jointed, plain concrete pavement done by contract. It was a learning curve for lots of things in construction and now it's already at 20 years old

> and already at the end of its design life, because it was underdesigned and we know the reasons - it's still OK, but it's starting to break – and we know the reasons why it's happening and never to be repeated. So it was the ground-breaking exercise. The pavement was too thin at 180mm and in those days the design wasn't refined to building safety factors and minimum thicknesses and we thought fatigue failure may be the worst case, but it's not fatigue when something breaks. In reality, it's the joints: if they are too thin and if we rely on the aggregate interlock to transfer the load from one side of the joint to the other and if they're too thin, as they move, they wear out and it's called erosion failure. The contractor did an excellent job, because they were also going through a learning curve and they had the first of these modern slipform pavers that was brought out from America which can do a whole road in one hit. We played around a lot to get the shrinkage down and we were aiming at something like 350 microstrains shrinkage and eventually we finished up at 400 which is still an excellent result. Tumblong I was still the trailblazer for the modern concrete pavement and we know that there are design shortcomings. A lot of the construction methodology was actually developed there and we've improved it dramatically since (Tinni, RTA-CP:FH19 Side A, 12:57).

Other sections produced after Tumblong I were a mixed bag of successes and failures. Competition between contractors forced prices down and quality varied, as some contractors did not come up to expectations.

> Oh, I think we had the good, the bad and the indifferent again. Maybe I should reveal some problems that occurred in the immediately adjoining section Tumblong II. In this case there was a French contractor with whom I already had experience many years earlier in Perth. They procured a machine of which no one had made a translation, an English translation of the French instructions, I think. This had huge consequences concerning the hydraulics level control of the machine, and worse still, this section, Tumblong II, abutted the existing Tumblong I, so you go from a smooth one to a rough one where the level control was lost. I guess the bicentennial funding had a downside: things started to move a bit too fast and we were spreading our resources pretty thinly and we were more and more reliant upon the contractor (Haber, RTA-CP:FH13 Side B, 30:40).

Other concrete pavements that have given the DMR/RTA high maintenance demands were at Coolac, north of Gundagai where the concrete was not compacted as well it should have been, leading to long term durability problems, and at Wyong on the Sydney-Newcastle Freeway.

> One project which would be known to most people is the Wyong Bypass – that's the famous Wyong crack – that's a longitudinal crack in the left hand lane over about 7km in both directions, and that came about as a combination of events. Firstly, we designed a subbase joint underneath that crack that's very apparent these days, but secondly, it resulted from the fact that a joint, which was supposed to form just outside the left hand lane line - the edge line of the shoulder – there was supposed to have been a joint there

> initiated by a plastic ribbon inducer, but unfortunately, that wasn't successful (Ayton, RTA-CP:FH16 Side B, 39:55)
>
> I always refer to it as the world's longest crack. It was produced with a multi-lane paver, but there were no requirements in the specifications where longitudinal joints should be. They laid 5MPa concrete in two runs and a joint ran down the centre of the lane. Movement in that joint was reflected in the base concrete above. Attempts have been made in subsequent years to stich tie bars across, with mixed success. In fairness to that job, that was a learning curve and nobody anticipated the problems at the time. Subgrade problems haven't helped – I think there have been quite a few settlement problems on that job. It's a thing we don't do any more - longitudinal joints in subbase concrete – so we don't have that problem any more (Watkins-Wilson, RTA-CP:FH3 Side B, 56:25)

Ed Haber also cites one of the reasons for the Wyong crack as inadequate supervision by the Department. He believes that it isn't possible to over-supervise a job. The crack, he believes, was due to a certain level of cockiness and over-confidence that crept in. Although concrete is very forgiving, it was, he said, utterly abused at Wyong. Mass concrete subbases shouldn't have joints. The specifications referred to the treatment of cracks and this was not picked up. The crack-inducing ribbon became curved. In addition, that particular concrete mix used basalt, which is not conducive to high tensile strength. The overall levels of tensile strength in that pavement were unsatisfactory. To him, this was proof that specifying the concrete by compressive strength alone was insufficient.

Other pavement failures, faults or maintenance demands mentioned by interviewees were subsidence in a section of the M2 Motorway (Arvo Tinni, RTA-CP:FH19 Side A, 26:25); parts on the Cumberland Highway built on the subgrade without any treatment (Vorobieff, RTA-CP:FH8 Side A, 16:05) and poor subgrade conditions and construction quality of the Hexham Bridge approaches (Ayton, RTA-CP:FH16 Side B, 41:48)

The problems that resulted from the construction rush of the 1980s led to changes in construction specifications and saw the introduction of compaction testing of concrete and of pre-qualification as the DMR/RTA moved from Quality Control to Quality Assurance. The changes, which came out of the switch from mainly in-house construction to contracting out all work also had major social repercussions as the workforce in regional towns suffered dramatic losses in employment. The ABRD program had required competitive bidding and the switch to contracting was almost complete as contractors came in with external equipment and personnel, moving from job to job. The DMR and RTA workforce shrank by more than 30% state-wide during the decade, Works Offices were scaled down and the local workforce had to find new jobs and change lifestyles to adapt to the changing times.

> Well, we moved into– and this is a different area – into what's called Quality Assurance, where the contractor does the testing, and there's still debate how effective that is, and the RTA's in-house ability to do testing has decreased quite markedly (Dash, RTA-CP:FH1 Side A, 24:06).

If the RTA found that a road had been built by a contractor below its standards, what could be done about it?

> It's extremely difficult with concrete, because once the material has gone through the paver and hardened, the only correction is to remove it, which is complete catastrophe really, and this is a political risk as well and so there's enormous pressure to retain a product that you may not be completely happy with (Dash, RTA-CP:FH1 Side A, 24:51).

> At the end of the day we can say that we have built very, very good pavements under both systems and we have also built pavements that we're not so proud of under both systems, and at the end of the day it really comes down to the site, staff and the attention and care that's taken with quality control and the overall consciousness of the staff on site, and of the company involved, or the authority involved in how much emphasis they're going to place on quality of construction (Ayton, RTA-CP:FH16 Side B, 38:27)

Hume Freeway near Yass, constructed in 1996

# 8 . Concrete in many forms

The types of concrete roads built in Australia include PCP (Plain Concrete Pavement), JRCP (Jointed Reinforced Concrete Pavement), CRCP (Continuous Reinforced Concrete Pavement), and SFRC (Steel Fibre Reinforced Concrete Pavement).

PCP is most commonly used in concrete road construction, accounting for about 80% of all concrete roads (Vorobieff, RTA-CP:FH8 Side A, 17:36).

> Plain concrete is the major type of concrete pavement. If we're in an urban area, where we have intermittent concrete supply, we have utility trenches, drainage pits, we would reinforce the pavement, purely to provide a safeguard against non-uniformity and holding any cracks ... plain concrete has no safeguards when you have cracking. Our earlier PCP pavements are cracking and are now giving us some concern because they are thin and less well-supported. We won't use plain concrete over high settlement areas where we can't give good support (Dash, RTA-CP:FH1 Side B,37:00)
>
> All concrete pavements up to the 1950s were JRCP [The reason for the decision in the 1950s to switch over to PCP is because] there are big advantages in slipform paving in not having the reinforcing - these lighter-powered machines. We had great deal of trouble in compacting around the reinforcing, as well as actually keeping the reinforcing in place. Also, you could deliver the concrete up to the paver using the formation of the road: as soon as you place steel on that formation, you have to build an access way for the trucks to deliver concrete to the paver, as well as spread the concrete in front, so you have another plant item in the train.
>
> *Q: So was it really done for reasons of cost?*
>
> It was a common practice in America and we adopted the practice and it is a less expensive type of pavement, if it works (Dash, RTA-CP:FH1 Side B, 39:10)

JRCP roads are mainly older roads with long slabs, joints and dowels, such as Canterbury Rd and Parramatta Road in Sydney's west. These roads were built during the 1920s and 1930s, which saw an expansion in the use of JRCP roads, driven by an excess of labour. Councils like Woollahra and Willoughby had up to half of their roads built in concrete. (Vorobieff, RTA-CP:FH 8 Side A, 06:47). JRCP is not often used today, but can still be used for bridge approaches and in car parks (Watkins-Wilson, RTA-CP3 Side B, 45:45)

> It's not a common pavement, but we've recently done a project in the middle of Coffs Harbour where the Council wished to have a concrete pavement on performance basis. It wasn't suitable for plain concrete because there were utilities, with agitators moving among traffic, it was one lane at a time and in that situation, you go back to the 1930s to 1950s jointed reinforced concrete. It's quite applicable, but these days we build it with a heavier mesh, we build it thicker, and shorter slabs, so we have less of the annoying 'click, click, click' at the slabs. (Dash, RTA:CP2, Side A, 05:22)

CRCP uses longitudinally-running steel and has no transverse joints, but closely spaced, controlled fine cracks.

> In CRCP we got rid of the joints altogether ..... by using 0.67 of a percent steel content, you don't need any joints and you rely upon the behaviour of the concrete – and this is the splendid part: if you got it right and your mix right, it'll become self cracking and the joints, ideally, are every metre or so, or even half a metre, provided you keep those joints tightly together and they don't intersect or converge - so if you like, it's self-cracking or self-jointing concrete and you shouldn't be aware of the joints ....... this is what we term the Rolls Royce, or gold-rolled continuously reinforced concrete pavement (Haber, RTA-CP:FH12 Side A, 16:43)

> We tend to use CRC in those areas where we want minimum maintenance, such as in tunnels. Also, another benefit of CRCP, in the cracks being quite close spaced and held together tightly by the steel is that they can be surfaced by thin asphalt for noise. Those types of pavement are performing well, but also because the moisture regime is constant within the pavement (Dash, RTA-CP:FH2 Side A, 04:13)

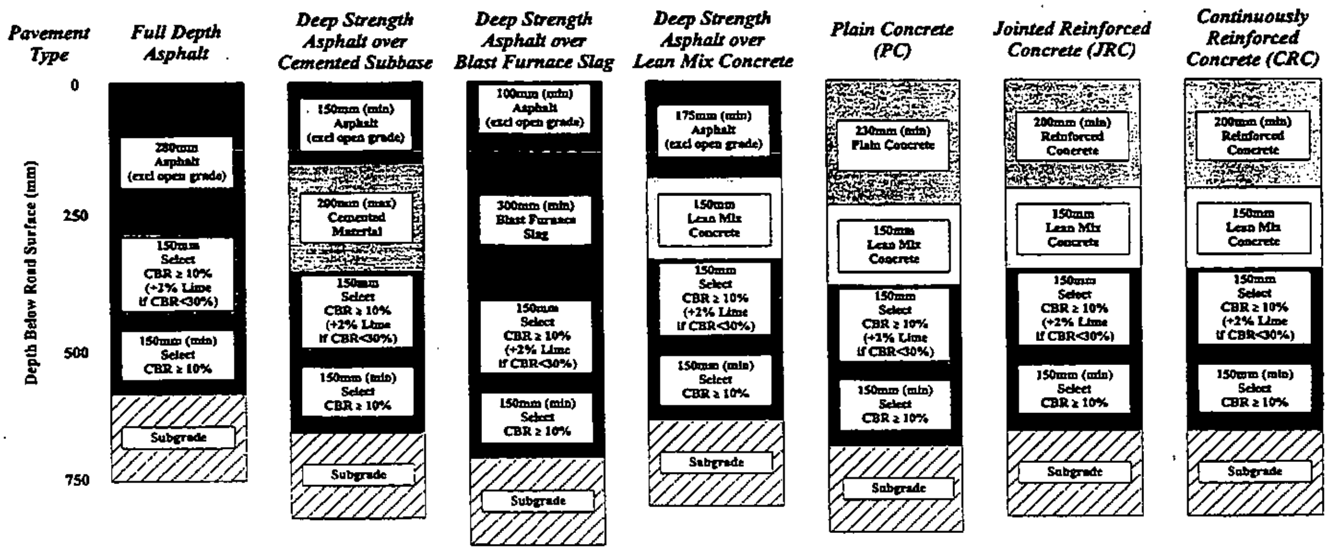
SFRC pavements date back to the UK and the 1970s. Joints are necessary with this type of road. (Watkins-Wilson, RTA-CP3 Side B, 47:47) They are now most commonly used in roundabouts.

> Steel fibre reinforced concrete pavement has been a real success story in roundabouts. The beauty about steel fibre is that we could reduce the corner angle down to about 70 degrees, which gave us much more flexibility and they're performing exceptionally well. But it's a very..... extremely unworkable concrete - it's generally hand paved, difficult to work and it's a specialised use in roundabouts (Dash, RTA-CP:FH2 Side A, 09:32)

> Speaking personally, probably the most interesting [project I've been involved with] was Australia's first slipformed steel fibre reinforced concrete pavement on the Newell Highway at a place about 40km north of West Wyalong called Marsden which consisted of two houses and a lot of cattle and the original idea was to rebuild an intersection out there. But the legs of the intersection grew arms and legs and it became 2km long. So in the middle of summer, we built a steel fibre reinforced concrete with a site

concrete plant and I still have at home photographs of the cardboard boxes: we used 9,500 cartons of steel fibre. They're short steel fibres, 25mm long and the thickness of a dressmaker's pin and you add about 40kg of these to a cubic metre of concrete, and the real trick is to mix them so that they are mixed uniformly through the concrete and when they're transport it to the site they stay uniformly through the concrete, and when you place it, spread it and work it, that it they remain evenly distributed. So the mix design of the concrete itself is quite a trick to hold these fibres uniformly and randomly distributed through the mix (Hodgkinson, RTA-CP:FH14 Side B, 37:25).

# TYPICAL HEAVY DUTY PAVEMENTS




Notes:

Full Depth Asphalt:
- 7mm seal on top of select
- Asphalt thickness variable, usually 280-350mm

Deep Strength Asphalt over Cemented Subbase:
- 7mm seals on top of select and cemented material
- Asphalt thickness variable, usually 175-225mm

Deep Strength Asphalt over Blast Furnace Slag:
- 7mm seals on top of select and slag
- Slag placed in 2 layers with variable thickness, usually 300-400mm

Deep Strength Asphalt over Lean Mix Concrete:
- 7mm seal on top of upper select
- Asphalt thickness variable, usually 175-225mm
- Bitumen emulsion curing compound on lean mix concrete

Plain Concrete (PC):
- 7mm seal on top of upper select
- Concrete thickness variable, usually 230-250mm
- Transverse sawcut joints at 4.2m

Jointed Reinforced Concrete (JRC):
- 7mm seal on top of upper select
- Reinforced Concrete thickness variable, usually 200-230mm
- F82 mesh reinforcement with dowels. Transverse sawcut joints at 8-12m

Continuously Reinforced Concrete (CRC):
- 7mm seal on top of upper select
- Reinforced Concrete thickness variable, usually 200-230mm
- Continuous 16mm dia longitudinal steel at 0.7% steel ratio

*Design:*
- *40 year design life excluding post cracking*
- *1 metre minimum cover to finished surface level above subgrade with CBR<2%*
- *Nominal thickness of pavement structure 20mm greater than design, predominantly in critical layer*

*Drainage:*
- *Subsoil drains to be designed as part of full structure drainage system with connections to slag or edge drains at upper lean mix concrete interface.*
- *Subsoil drains to be discharged at 60m max intervals.*
- *Drainage blanket to be provided in rock cuttings (500mm layer, -125mm size <5% -19mm)*

*Selection Criteria:*
- *Differential settlement*
- *Scale of works*
- *Works under traffic*
- *Surfacing*
- *Maintenance requirements*
- *Economics including life cycle costing*

*3rd February 2000*

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# 9. Influences

How much of Australia's concrete pavement technology is derived from local experience and what came from overseas? I posed this question to persons interviewed for this project.

As far back as the early 1970s, concrete designers looked to California and South Africa for leadership in concrete technology because both had concrete roads and a climate similar to that of Australia (Ayton, RTA-CP:FH17 Side A, 01:36).

According to John Hodgkinson, concrete technology in the past 20 years is a mixture of influences. The method used to calculate the thickness of slabs is basically from the United States. The technology of producing lean mix concrete subbases under slabs to avoid erosion underneath the slabs came from France from an organization called SETRA and from a particular person, Michel Ray. Jointing systems models were adopted from California when short slabs, without reinforcement were reintroduced in the 1980s. (Hodgkinson, RTA-CP:FH14 Side A, 18:10).

David Dash talked of differences and similarities between roads in Australia and the US. Californians don't seal transverse joints, but texture longitudinally, while NSW textures transversely. Joints in NSW were sealed with Neoprene, but now silicon sealers from Georgia introduced in the 1980s are used for both transverse and longitudinal sawn joints. Californians saw-cut their joints to a very narrow 3mm and maintain that unsealed joints are not a problem for them. States other than California place pavements directly on granular material, a method that Australia did not adopt. Americans are experiencing problems with concrete pavements that don't have adequate support and are finding faulting occurring at joints on shoulders. They are now switching to very thick pavements and a better quality ride. Europe has always had higher quality control and thicker pavements and Britain is retrofitting concrete roads on heavy vehicle lanes on roads such as the M25. (Dash, RTA-CP:FH1 Side B, 30:00 & RTA-CP:FH2 Side A, 16:04)

Ed Haber believes that Australian concrete roads lie somewhere between the US and Europe. American engineers have a different attitude towards road building and subjugate the quality of roads to quantity. Europeans are more concerned that the road surface matches their latest automotive technology. High-speed cars on autobahns set the standard for safety and road friction (Haber, RTA-CP:FH13 Side B, 47:20).

Geoff Ayton holds the view that it would be arrogant to state that Australia is a world leader in concrete pavements. Everyone poaches everyone else's technology. One area where Australia is at the forefront is in good, basic concrete technology and the US has taken an interest in Australia's efforts at the control of compaction. Ayton maintains that Americans seem to have largely forgotten much about the compaction of concrete. Australia has also put a lot of effort into debonding between different layers of concrete. The US asked Australia to present a paper on the subject at a conference in Indianapolis. The US is also impressed by the performance of Australian lean mix concrete subbases. (Ayton, RTA-CP:FH17 Side A, 05:27)

John Watkins-Wilson believes that some people will just never accept concrete pavements.

> A lot of people have still got prejudices against concrete roads, mainly because they're influenced by bumps, bump, bump on Parramatta Road and places like that and if you take people down a plain concrete road now, which is jointed, they'll swear that they can tell you that they're going over all the joints when they can't – if they close their eyes they can't tell them anyway. One other local development was all the joints in concrete roads: they used to be square to the road, transversely, 90 degrees to the edge of the road. For years now, the joints have always been at an angle, so that you never get two wheels hitting the joint at the same time. The joints are at random spaces – the reason they're random, they probably vary between four metres and five metres, something like that, so you always get a break up of the wheel pattern – but if you ask the average man in the street what he thought about concrete roads he would say they were awful because they go 'bump, bump, bump' which I say is just a myth. But generally, a concrete road now, built properly, is maintenance-free, cost-effective and leaves a flexible pavement for dead (Watkins-Wilson, RTA-CP:FH4 Side A, 05:48)

# 10. Flexible or rigid: that is the question!

Of the heavily-trafficked arterial routes in NSW, only about 30% of all pavements are built in concrete (Dash, RTA-CP:FH1 Side B, 32:30) So why aren't there more concrete roads?

> It is not feasible to place concrete under heavy traffic conditions. Large scale pavers and a dedicated batch plant are needed, so a big investment is required. Large scale concrete works need a minimum of 10,000 cubic metres, or 3kms of dual carriageway to make it viable for contractors (Dash, RTA-CP:FH1 Side B 35:32)

> Concrete roads are chosen on the basis of lifecycle costing [over a 40-year period]. Although concrete roads are initially more costly to construct, asphalt has a much shorter life and needs resurfacing more often. Concrete roads need less maintenance. I'm unaware of any concrete pavements being replaced due to wear. (Dash, RTA-CP:FH1 Side B, 34:58)

> The cost of building a concrete road for many years was far greater than building an equivalent asphalt road and initially, this was because the asphalt industry had very good, mechanised equipment and the concrete industry took a long time to develop the same mechanised process to get scales of economy........when you look at most of the concrete roads we're building in a rural environment, because you have to build a specialised plant to build concrete - and the same now applies to asphalt; the initial set-up costs and the mechanised systems required for both systems - we're finding that concrete pavements are of an equivalent cost to asphalt pavements in a rural environment on initial costs as well (Vorobieff, RTA-CP:FH8 Side A, 20:05).

New South Wales has the largest proportion of concrete roads in Australia. What is the record of other States in building concrete pavements?

> Queensland have had mixed views on concrete roads, on the Gold Coast they've done quite a bit, Victoria – I think they've generally been anti-concrete roads - they've done a few, but they haven't shown much interest in concrete roads, South Australia probably haven't done any worth talking about and neither have Western Australia (Watkins-Wilson, RTA-CP:FH3 Side A, 10:00)

According to Alan Leask, the best pavement for riding quality is a concrete pavement with an asphalt surface. Would this be the best of both worlds?

> In our view, it's the best of both worlds, but you can't just use any type of concrete pavement underneath, because if you use a jointed concrete

pavement and put an asphalt surfacing over the top, you'll get reflection cracking from those joints. So, the ideal combination is the continuously-reinforced concrete, which has no transverse joints and on top of that the open grade asphalt, and we've constructed several sections of that which have been very successful. Our findings and our experience in that regard are consistent with overseas experience and at international conferences, more and more during the late nineties, there has been this shift towards a compromise and an acceptance that a combination of concrete and asphalt is probably the ideal pavement to satisfy everybody's demands (Ayton, RTA-CP:FH16 Side B, 55:50).

# 11. Noise

One of the criticisms of concrete has always been that it is noisier than other pavements. This has become an environmental issue, particularly in urban areas in recent years.

George Vorobieff admits that concrete is much noisier than asphalt and after studies with the RTA, a different combination of longitudinal hessian dragging was looked at to reduce tyre noise. A longitudinal surface in combination with transverse grooves was achieved and this also had benefits in reducing aquaplaning and skidding. Noise levels were reduced by 6db (Vorobieff, RTA-CP:FH8, Side B, 40:11)

> The pitch of a noise is quite noticeable at the higher levels, although dB(A) penalises those levels and asphalt has a benefit in reducing that pitch, so exposed aggregate concrete is where you remove the mortar and you only have your cubicle aggregate on the surface, similar to stone mastic asphalt, which is where we have a stone on the surface and that is – a not particularly greatly lower noise, but a less annoying noise, and we've produced a trial length of what's called Whisper Concrete. It's an exposed aggregate surfacing. We use a maximum 10mm - not 20mm aggregate, we're now down to a 10mm aggregate size - to give a small stone. You know in a spray seal, the coarse spray seal has a much higher noise than the finer spray seal. We use a cubicle aggregate and we expose the texture on the surface (Dash, RTA-CP:FH2 Side A, 17:42).

John Watkins-Wilson points out that trials with Whisper Concrete have included putting a no fines concrete on top of existing concrete using two pavers, the second being the no fines paver, immediately following the first run. Diamond texturing is also being investigated (Watkins-Wilson, RTA-CP:FH 3 Side B, 53:09)

Geoff Ayton mentions another noise reduction technique: grinding the pavement with saw blades mounted on a rotor to produce a longitudinal, corduroy-like finish. This gives a smooth ride quality, low noise generation and a very high friction value. The only drawback is the cost and Australia does not yet have large, dedicated equipment to carry out this work at an economical level (Ayton, RTA-CP:FH16 Side B, 55:50)

John Watkins-Wilson deplores the fact that practically every concrete road in Sydney has sound barriers on it, something, he says that will create a long-term maintenance problem.

He believes that politicians have caved in on the noise problem (Watkins-Wilson, RTA-CP:FH4 Side A, 05:48)

John Hodgkinson concludes that noise is an issue that's partly technical, partly political and partly emotional (Hodgkinson, RTA-CP:FH15 Side A, 16:45).

# 12. The Manual

In 1983, the DMR produced its first-ever Concrete Pavement Manual. Alan Leask, Ed Haber and Geoff Ayton, among others, contributed their knowledge and experience to produce it.

> My biggest challenge at the DMR was to be part of the preparation of the Pavement Design Manual. Its last chapter was concerned with the evaluating pavements on a total cost basis, rather than initial cost, and that was the biggest challenge to get through. I was the chairman of the committee that did the Interim Guide to Pavement Thickness Design and I clearly recall having to front up to all the Chief Engineers to all the States and answer about a hundred questions as they were trying to torpedo this thing, and of course in a sense they were right in that a lot of the information required hadn't been researched, hadn't been discovered and the point that I was trying very forcibly to make was that unless they approved the implementation of this Interim Guide, improvements in pavement design were stone cold dead, because we put an enormous amount of effort into that and had it been knocked back, we would never have attempted it again to the detriment of the whole of Australia. So they finally conceded that and put it out as an Interim Guide, provided that it was revised within a period, of say two years, which happened, and of course everybody realised its importance (Leask, RTA-CP:FH6 Side A, 10:03).

> The Concrete Pavement Manual was first compiled in 1983..... it was reprinted in 1991 and it now really requires an update again and we hope to do that in the next 12 months. We also hope to add a set of model documents to it, showing all of our standard design procedures, and that would be a fairly substantial development. The Manual is used in various places throughout Asia for concrete pavement construction and it is even used as a reference document by some of the leading authorities in America and the FHAA for example, the Federal Highway Administration in Washington DC uses it as a reference source on various issues. Now that's not to say that it is accepted as a world-wide bible, but I think it is accurate to say that some aspects of it, and some issues that are covered in the Concrete Pavement Manual are treated as a reference source.

> *Q: Well, that's a very big plus for the RTA, isn't it, to have that accepted?*

> Yes it is, it's a great compliment. From another point of view, it's a little frustrating, because if we had the time and resources to put into that manual, I think we could turn it into probably the best concrete pavement manual in the world (Ayton, RTA-CP:FH17 Side A, 10:00).

# 13. Future challenges

What is the future for concrete roads in Australia? They've been with us for 122 years. At present, it looks positive, as concrete will play a significant role in rebuilding the Pacific Highway northwards from Newcastle. One factor that will determine concrete's future is the availability of good road building materials.

> The biggest single issue, I think, is the declining aggregate sources in Sydney – that's recognised – and being more sophisticated with use of materials. We really want to forget cement as just ordinary Portland Cement and start thinking very seriously of the widespread use of supplementary cementicious materials, both fly-ash and slag and fly-ash/slag/cements in combination with each other. Without fly-ash, lean mix concrete subbases could never have come into existence. .......There is organisational resistance to the use of new materials. I think the days of old-fashioned Portland Cement are numbered. There's a lot of scope to develop materials and develop their prudent use to the fullest, because we engineers should find a challenge in utilising these natural materials, because I think we have a social responsibility in that regard. It fits in with environmental needs and the use of by-products. Another area that is opening up is waste material out of building construction, even crushed bricks. The society sees roads as an outlet for use of these materials -we just can't continue just building up on our landfills (Haber, RTA-CP:FH13 Side B, 52:40).

> We have a lot of specialists around the world developing higher technology issues. We see a lot of work, for example, around America being done with Finite Element Modelling in order to analyse the stresses in concrete pavements and to try to define our design methods. But when you look at the performance over the past 20 or 30 years of our pavements, you keep coming back to the conclusions that one of the most important aspects is the quality of the initial construction and the quality of the maintenance work that's carried out during its life. And really, that brings you back to the basics of good, old-fashioned concrete technology, and in my opinion it's those basics, which in a lot of areas, we've lost sight of, and we have to keep refocussing on them. And by basics, I mean the principles of good mix design, the principles of good compaction of the concrete and the ideas of good, timely curing of the concrete. And unfortunately, in some areas, in different parts of the world, the focus on the high technology issues is carried out to the detriment of those old-fashioned basics (Ayton, RTA-CP:FH17 Side A, 24:41).

Are there still instances of bad roads being built by certain contractors?

> Oh, there certainly is. There's no doubt there's always, from time to time, that a contractor, for whatever reason, decides to source what we would regard as not a good material that should have gone into the concrete, and we're finding roads that should not have been built with those sort of materials (Vorobieff, RTA-CP:FH8 Side B, 49:20).

> I think, in looking at the spread of roads, you shouldn't look at either the good or the bad - the total spread. We can go to pavements that haven't had a dollar spent on them in 25 years and pavements that have caused strife from day one. We're going back to the quality of construction – it's probably even more important than the design, once we get the design principles sorted out and Cullerin Deviation on the Hume Highway is a magnificent situation, works on the Federal Highway have had no maintenance, even Clybucca 1975 has had no maintenance. Yet we have other concrete roads, Wyong, Hexham, so vigilance right across the board in surveillance, independent testing is critical when you have a thin, shell structure where any failure will exhibit itself. So the technology, both from the contractor and the RTA needs to be of the highest order and continual to ensure a product that performs (Dash, RTA-CP:FH2 Side B, 37:02).

However, Barry Munce still has reservations about the quality of present-day concrete roads.

> I do not believe that we are fully on top of the design and construction of CRCP. I offer this view, just on the basis of examining a large number of recent jobs and found that the crack spacing is highly variable, and in many cases far too closely spaced, which is already leading to some punch-outs, and no doubt we'll see a good deal more of this sort of problem in the future (Munce, RTA-CP:FH21 Side A, 09:37).

In concrete roads, as in almost everything else, the individual's skill and application is important.

> I think one of the challenges we have in Australia at the moment is: most of our good pavements are built by dedicated engineers. It's the individual that has made progress at times, rather than a particular company, and I think one of our challenges is to find younger engineers – to fully train those engineers and give them the same sort of culture and ability to progress their individual skills as well (Vorobieff, RTA-CP:FH8 Side B, 52:09).

> I would say that concrete roads now being built in Australia are as good as anywhere in the world, probably a lot better (Watkins-Wilson, RTA-CP:FH3 Side B, 32:31)

The future of concrete pavements seems assured.

# 14. Findings

Since the first concrete pavement was laid in 1880, there has been an almost exponential evolution in the design and use of paving equipment, aggregates, concrete mixes and every other conceivable aspect of concrete pavement production. What has been the course of this evolution – some would say revolution?

- Early slipform pavers were single track machines, while the new machines have four tracks, essentially a track on each corner. Texturing is now mechanised, the application for curing is better controlled, all new machines have a separate finishing beam behind the paver and now have super finishes, either an oscillating screed or a transversely operating screed cantilevered off the back of the paver, which takes out any ripples coming out of the machine.

- The other big development is the method of forming joints. On multi-lane pavers, a tape or rubber strip used to be fed in to for joints, but there were failures with this method and concrete cracking resulted, as was the case with the Wyong Bypass. Tie bars had to be inserted underneath the paver and this was a hit-and-miss affair- sometimes tie bars disappeared completely or got caught and turned longitudinal - these aspects have been vastly improved. Transverse joints are now saw-cut.

- Sealants have been improved from early neoprene to silicon. There are no hot-poured joints any more. The method of feeding the pavers has also been improved: on-site concrete plants deliver concrete to the pavers in end tippers, so better production and quality control have been the result. Mix designs are now also superior.

- Production rates using pavers have increased from about 700 cubic metres per day for subbase and 300 metres per day for base in the late 1970s to an astounding 3,500 cubic metres per day reached on the Yelgun to Chinderah section of the Murwillumbah bypass, using two pavers.

- Uniform support for the base and good drainage under the subbase is where most of the improvements of recent times have been directed to.

- In reinforcement, deformed bars and mesh with better bonding characteristics, and the use of an 8mm bar in the mesh, rather than a 7mm bar, is now used. For CRCP, 16mm deformed bars are still used.

- Concrete mixes are becoming more effective with the use of fly ash to gain long term strength rises and the use of an over-sanded mix, designed for workability, slightly at the expense of strength and shrinkage.

- In mixing equipment, most companies use a split-drum mixer, where the whole drum moves apart and the concrete drops from the drum directly into a truck. Two new types of mixers have recently come to Australia- one is a tilt-cone and the other a shaft mixer.

- Pavement slab thicknesses have increased, from the early 1920s pavements of 6-8 inches (150mm-200mm) to 250mm for modern concrete pavements.

- Compaction and curing has improved and now virtually all machines use hydraulic vibrators. Slipform pavers have a series of poker vibrators, placed horizontally and the size and effectiveness of the vibrators have improved over time. RTA is now using a 35mm slump for slipform paving which is a quite different mix design: more difficult to compact and critical in performance.

- Early concrete pavements generally used a 38mm general maximum size of aggregate which used to polish to dangerous levels - this has decreased to a general maximum of 20mm which has improved the workability of the mix.

- Concrete shoulders were adopted on concrete pavements in NSW since the 1970s and that has proven to be a wise investment. Concrete shoulders are performing extremely well.

- Subbases have been lean concrete mixes since Clybucca and as they have good support, faulting is not being experienced, contrary to the situation in some overseas countries.

- Milestones in concrete paving were King Street, Sydney in 1880- the very first concrete pavement in Australia, the reconstruction of Parramatta Road in JRCP during the 1930s, Brady/Boundary/Montague St, Clybucca, The Foreshore Road, The Warringah Expressway, Tumblong and the advent of the large, modern slipform pavers in Australia since the late 1980s.

- Even though the standard of concrete roads has risen remarkable, continued vigilance is necessary to ensure that contractors don't cut corners, rush work or compromise on the quality of roads now being planned and built. Much has been discussed in this project about the shortcomings, as well as the successes, of the past.

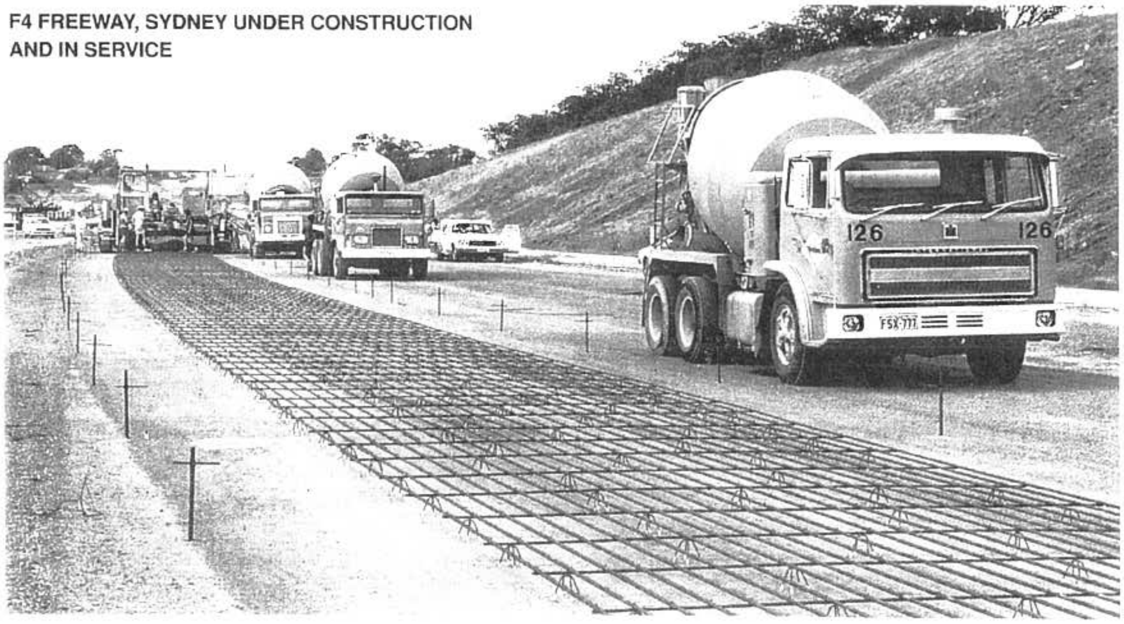
- Generally speaking, concrete roads are serving the state of NSW well and are providing a safe and reliable surface for motorists with low maintenance requirements.

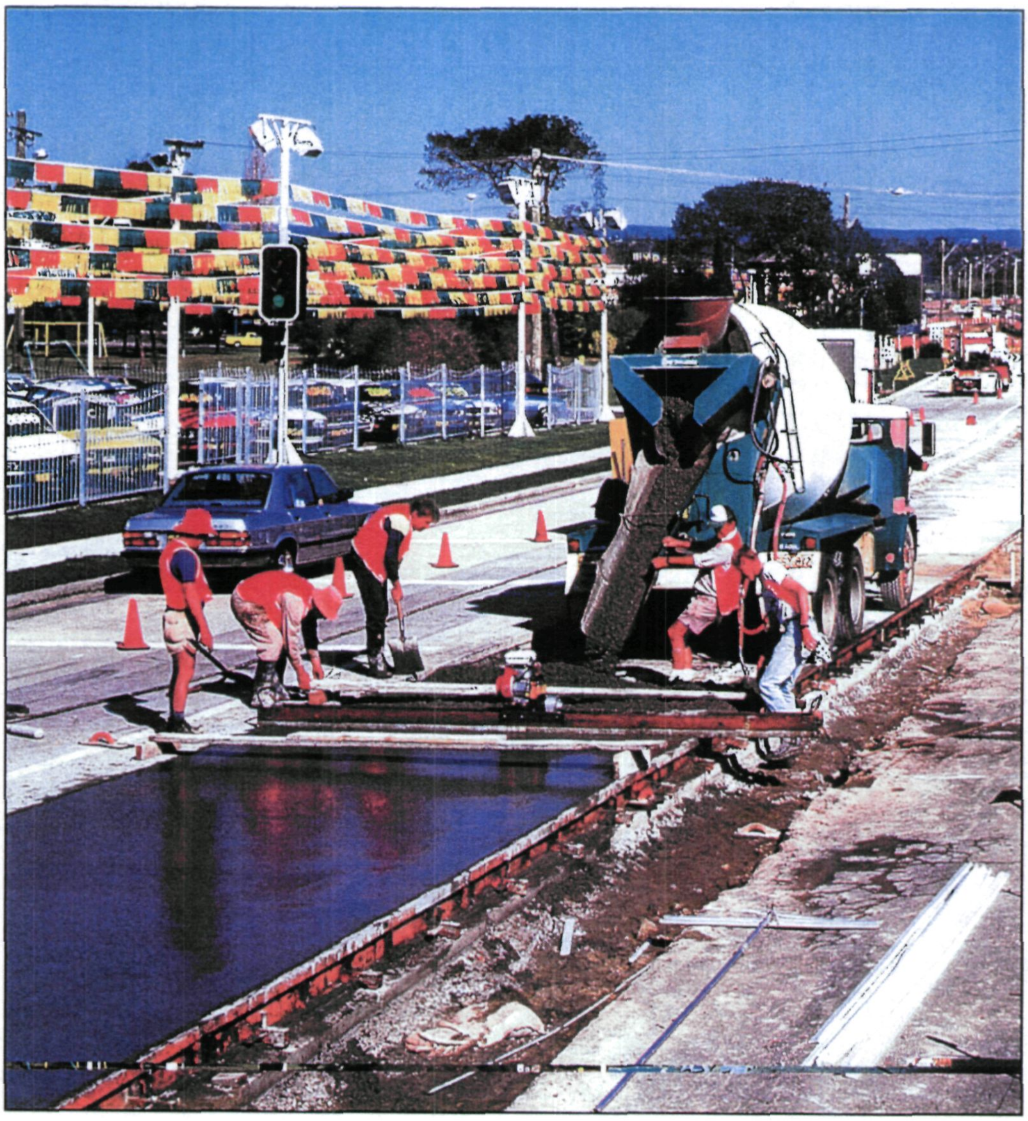
- The support and expertise provided by the DMR and RTA in its contribution to concrete roads technology in this State has been invaluable and has contributed to a very high standard of pavement being constructed.

- The dedication and enthusiasm demonstrated by former DMR and current RTA staff, and others in the world of concrete who were interviewed for this project was overwhelming. Concrete is in good hands if this enthusiasm prevails.

Mays Hill pavement under construction, 1975

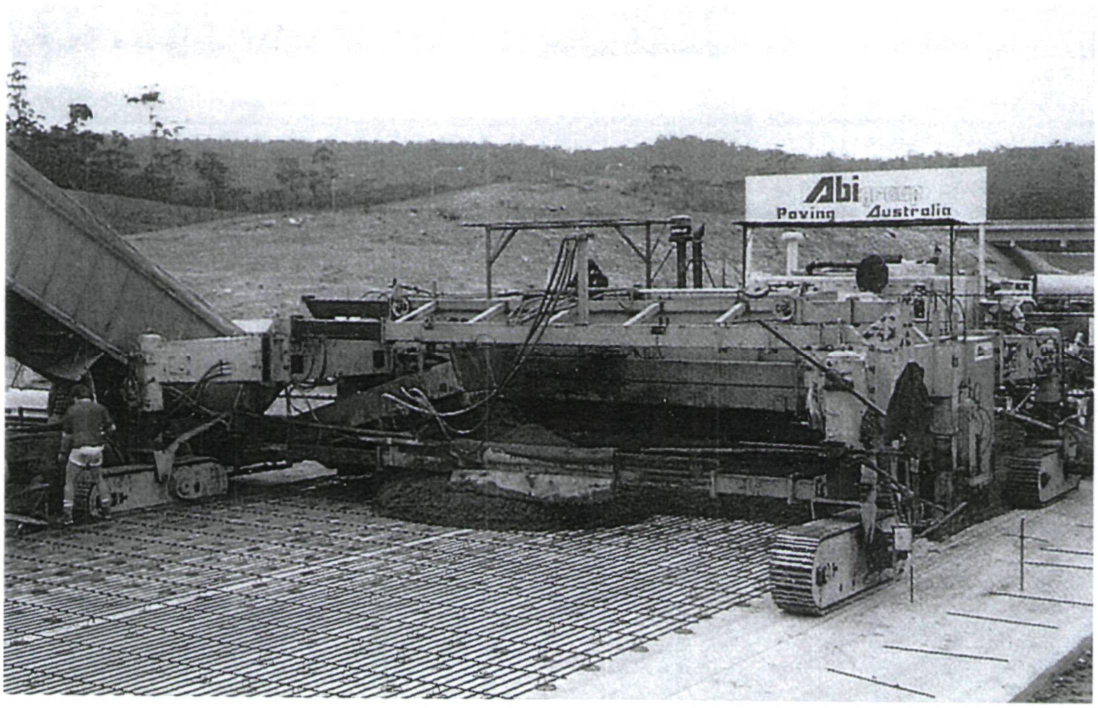
F4 FREEWAY, SYDNEY UNDER CONSTRUCTION
AND IN SERVICE



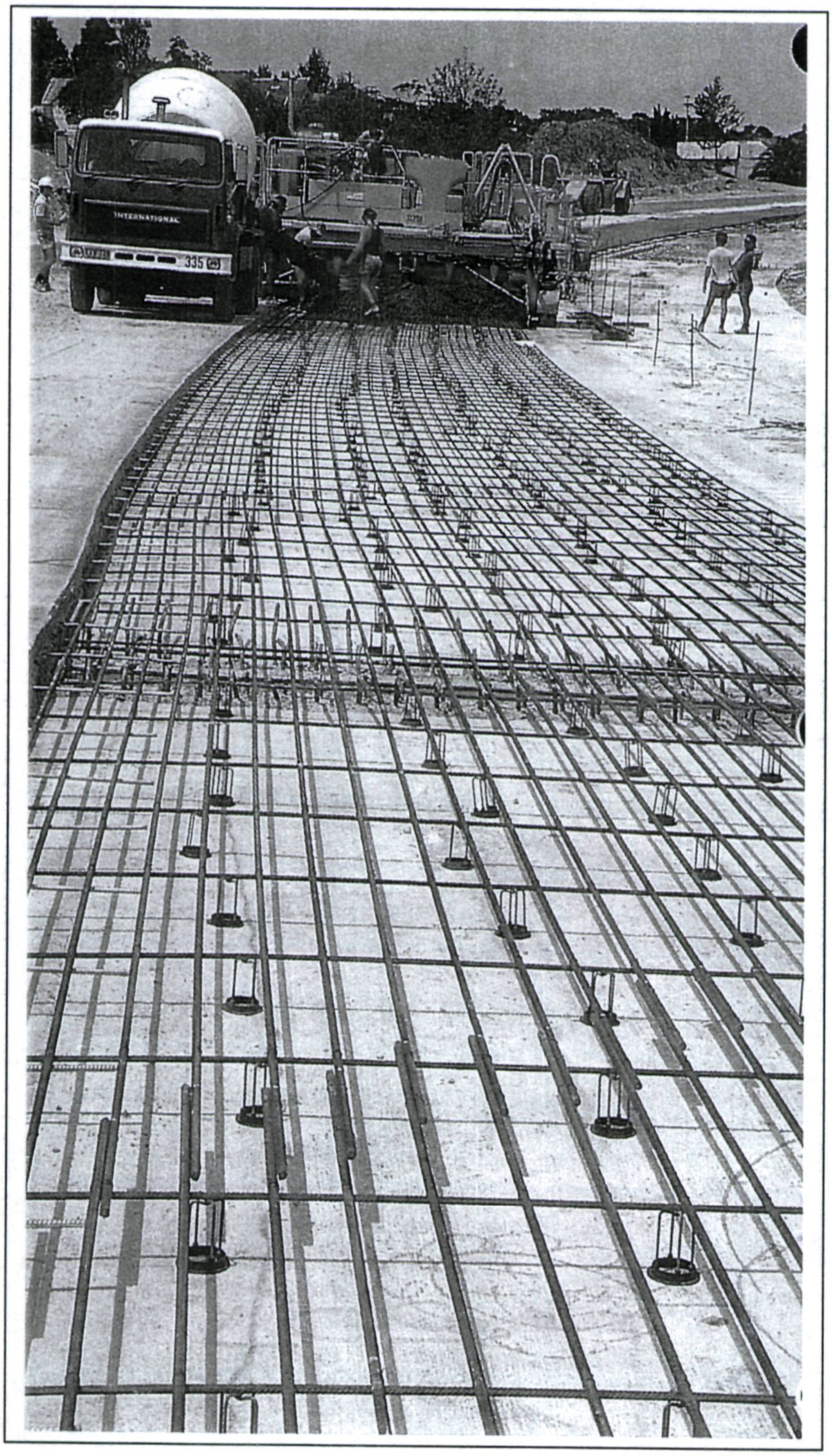
Concreting work at St Marys, 1985

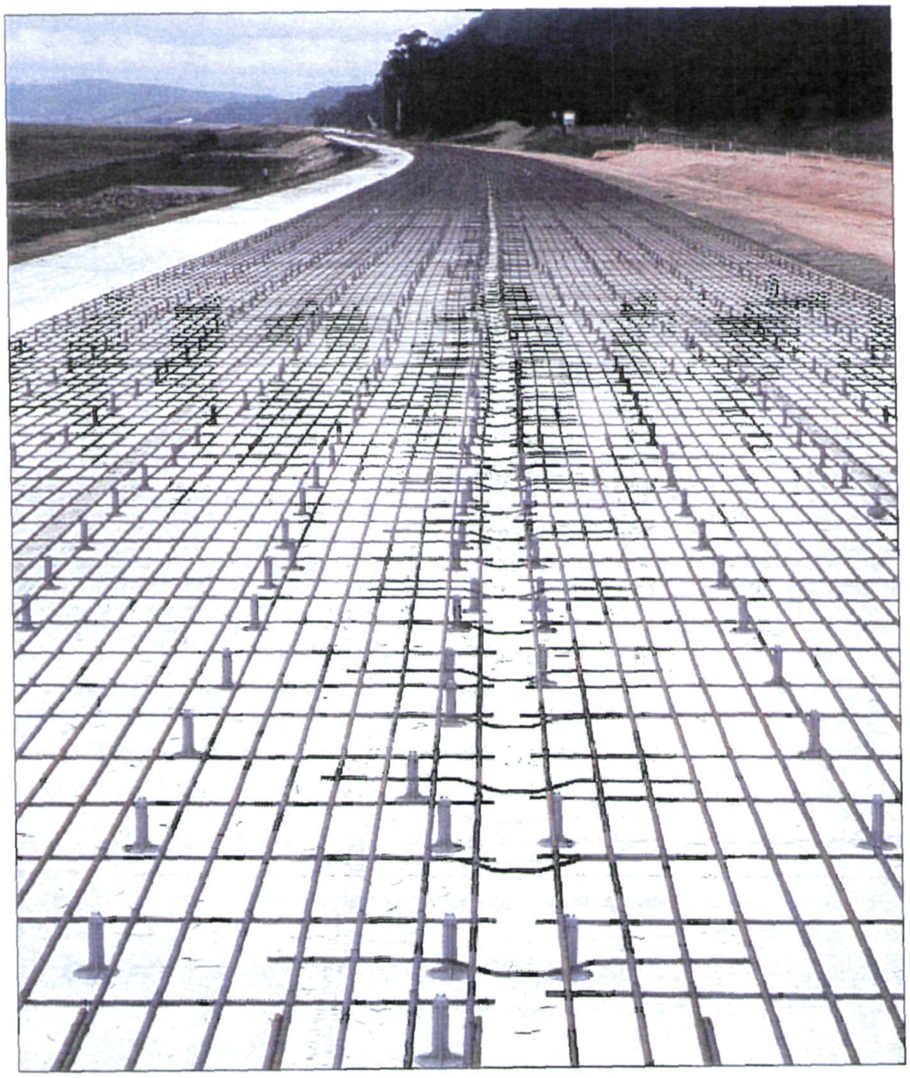
Concreting work at Bowenfels, 1990




Final stage, Sydney-Newcastle Freeway being constructed, 1992

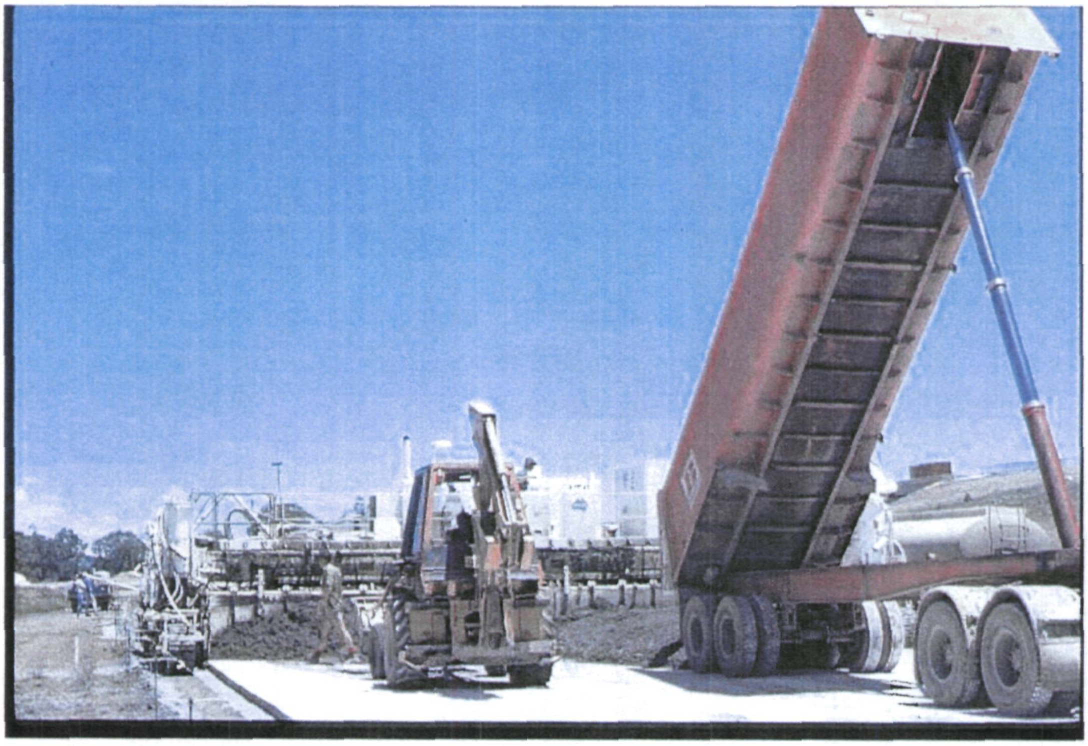
Gore Hill Freeway under construction 1992





The continuous reinforcement laid out on the construction site of the Federal Highway at Lake George (NSW) shows the extent of reinforcement in the concrete pavement.

Typical mobile rural concrete production plant



Delivering concrete to the slipform paver (Berrima Bypass)

Pacific Highway Deviation at Bulahdelah

Slump testing

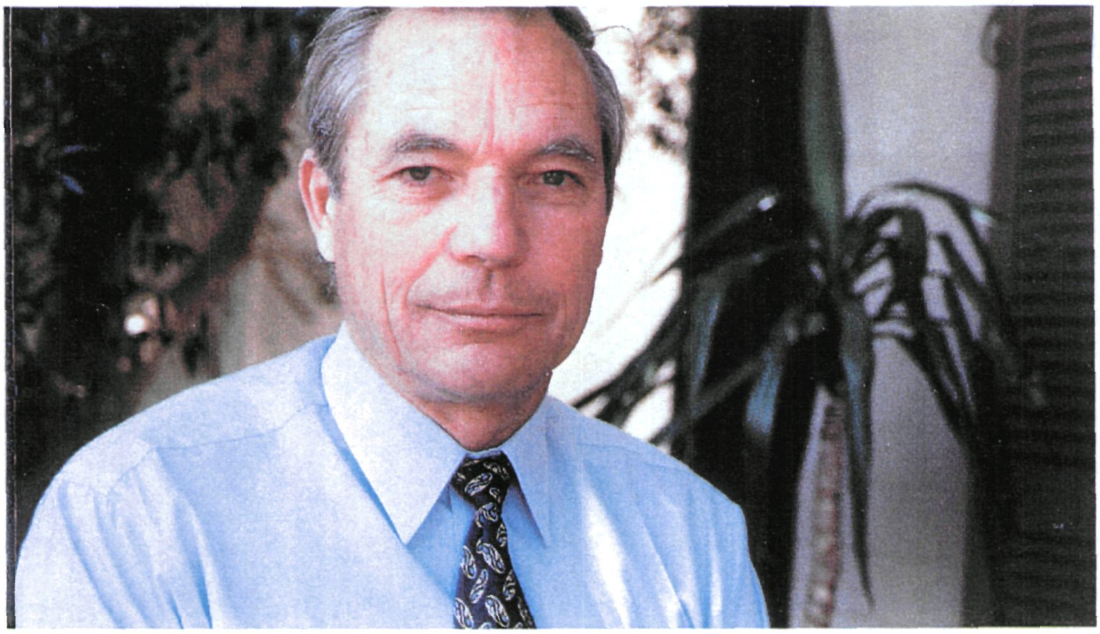
Cleaning a sawn transverse control joint with high pressure water

Inserting preformed joint sealant (Hume Highway)

# List of Interviewees

| *Name:* | *Tape Nos:* | *Place of Interview* | *Duration:* |
|---|---|---|---|
| David Dash | RTA-CP:FH1 & 2 | Cremorne NSW | 100 mins |
| John Watkins-Wilson | RTA-CP:FH3 & 4 | Prestons NSW | 75 mins |
| Alan Leask | RTA-CP:FH5 & 6 | East Lindfield NSW | 75 mins |
| Steve Warrell | RTA-CP:FH7 | Cremorne NSW | 41 mins |
| Pat Kenny | RTA-CP:FH7 | Cremorne NSW | 17 mins |
| George Vorobieff | RTA-CP:FH8 | Cremorne NSW | 54 mins |
| Rex Oxenford | RTA-CP:FH9 | Grafton NSW | 35 mins |
| John Oxenford | RTA-CP:FH10 | Grafton NSW | 40 mins |
| Brian Small | RTA-CP:FH11 | Ulmarra NSW | 42 mins |
| Ed Haber | RTA-CP:FH12 & 13 | Kirribilli NSW | 117 mins |
| John Hodgkinson | RTA-CP:FH14 & 15 | Cremorne NSW | 82 mins |
| Geoff Ayton | RTA-CP:FH16 & 17 | Cremorne NSW | 84 mins |
| Arvo Tinni | RTA-CP:FH18 & 19 | Cremorne NSW | 102 mins |
| Barry Munce | RTA-CP:FH20 & 21 | Cremorne NSW | 77 mins |

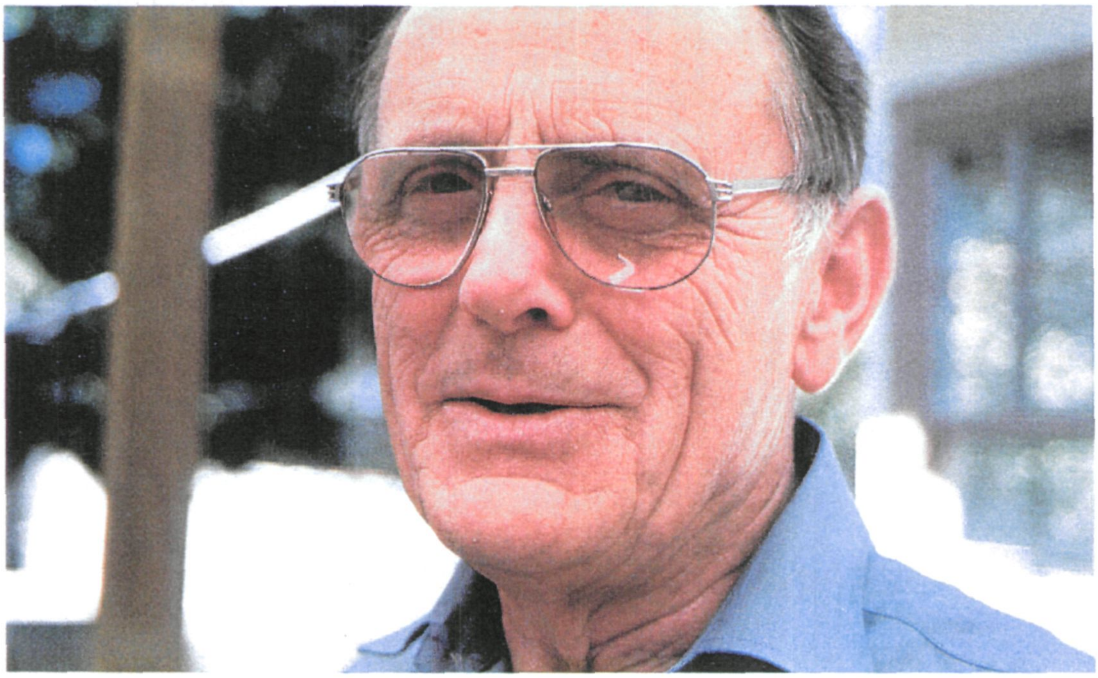
# David Dash



**David Dash** joined the Bridge Section of the DMR as a cadet in the Design Office in 1960. His first concrete paving assignment was on Old Windsor Road in 1982, using early slipform pavers. He has 30 years experience in road and bridgeworks, including design and supervision of major projects on the Hume and Federal Highways, the Sydney to Newcastle Freeway and the Pacific Highway. He also has.an extensive knowledge of technical specifications, development and performance of concrete pavements in Australia.

David is General Manager, Pavements Branch with the Roads and Traffic Authority NSW and is a member of the AUSTROADS Pavement Reference Group with responsibility for managing the AUSTROADS Pavement Rehabilitation Guide Project.

# John Watkins-Wilson

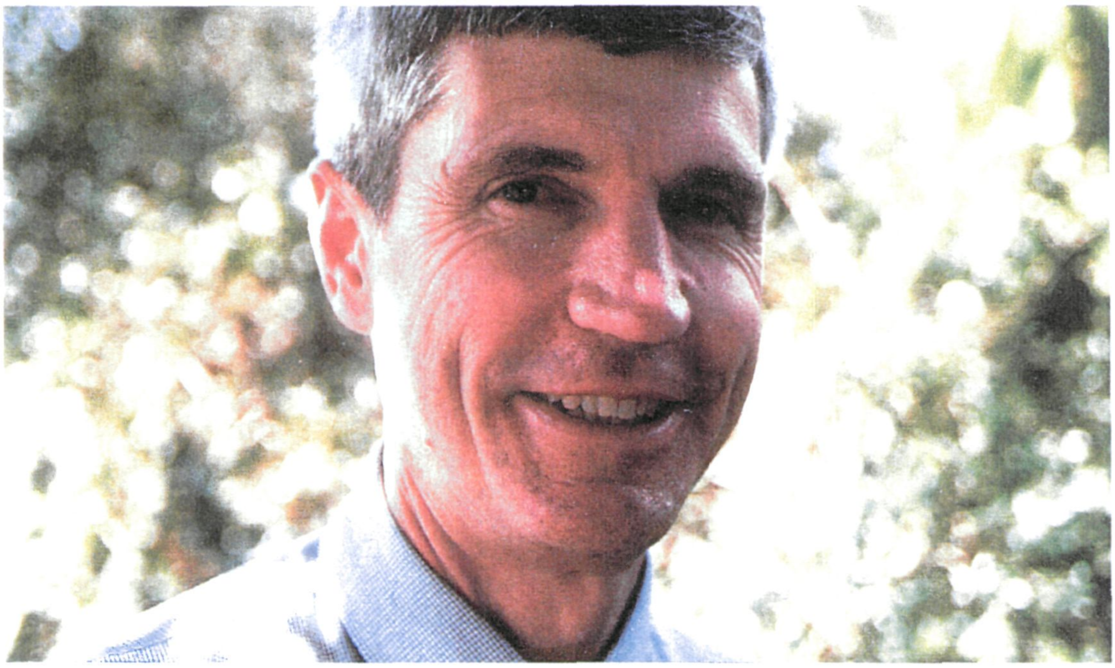


**John Watkins-Wilson** was born in Leigh, Lancashire, a cotton mills town. He worked for McGregor Construction in the UK and came to Australia in 1977 to help construct the Zig Zag tunnel for the NSW Railways with the first slipform paver, a single lane machine, imported into Australia. After that work was successfully completed, he supervised the paver during the construction of the Foreshore Road to Port Botany, Australia's first concrete pavement placed by a slipform paver. Since 1985, John has worked with NACE Civil Engineering. He has had a lifetime association with concrete and has a wide knowledge of the development of different types of concrete pavements.

# Alan Leask

**Alan Leask** was born in England on 24 August, 1924. At age two, he arrived in Sydney where his father, formerly a model maker for a shipping company, found work as a construction foreman. Leask left school at 18 and worked for a year as a junior draftsman at the DMR. He joined the RAAF as a pilot and was stationed at Morotai, flying Beaufighters in the Pacific war. In 1945, aged 21, he returned to the DMR and started his university course on a Commonwealth allowance. He graduated in Civil Engineering in 1951 and entered the Bridge Section as an engineer. His time in the DMR was interrupted by a trip to Europe. He returned to the Department in 1954 and became the DMR's Materials and Research Engineer in 1968. Alan has had a major input in the DMR's activities in concrete testing, having worked on major projects, including the construction of the Gladesville Bridge and he innovated many new procedures and techniques. He retired in 1984 and lives at East Lindfield, NSW.

# Steve Warrell



**Steve Warrell** is currently Manager Transitways RTA Sydney Client Services. He began his career with the DMR Assistant Works Engineer in 1976 and among the major projects that he was involved in was the site supervision of all construction works on the Foreshore Road at Botany. He became Works Engineer at DMR's Goulburn Office in the 1980s and supervised many maintenance and construction works on the Hume Highway. He was also Manager Infrastructure Development at RTA from 2000-2001.

# Pat Kenny

**Pat Kenny** joined the DMR as a Cadet Engineer in 1969. He was engaged on the reconstruction of Mona Vale Road at St Ives and on the maintenance of major roads in the Sydney Metropolitan region, such as Parramatta Road and the Warringah Expressway. He became Project Engineer on the construction of the Foreshore Road in 1978/79 and thereafter Works Engineer of the Nowra Bypass at the Bomaderry Works Office. He supervised construction of the William Street Tunnel, and gained the position of Supervising Engineer, Road Design, RTA in 1992. He then joined the University of Technology, Sydney where he was a senior lecturer in Road and Transport Engineering for seven years. He returned to RTA in 1999 and is currently Sydney Development Program Manager in Road Network Infrastructure.

# George Vorobieff

**George Vorobieff** was born in Australia in 1958. His parents left Russia via Shanghai and then came to Australia where George's father worked with concrete on the construction of the Gladesville Bridge. George joined the Cement and Concrete Association of Australia in 1988 where he compiled information on the history of concrete roads in Sydney. Much of this knowledge was contained in the *Australian Concrete Road Training Manual*, a project finished in 1998.

George was the project leader of the Austroads working group reviewing Chapter 9 of the 1992 *Austroads Structural Pavement Design Guide*. The new guide was a major change in thinking, as it incorporated algorithms that allowed engineers to program the design method rather than use the tedious nomographs in the 1992 guide.

George now provides training to road engineers through a two-day course and assisted the RTA in the preparation of the *R83 User Guide* and the *Maintenance Manual*. He has also researched many areas of the current RTA specifications.

George is presently a Director of Head to Head International.

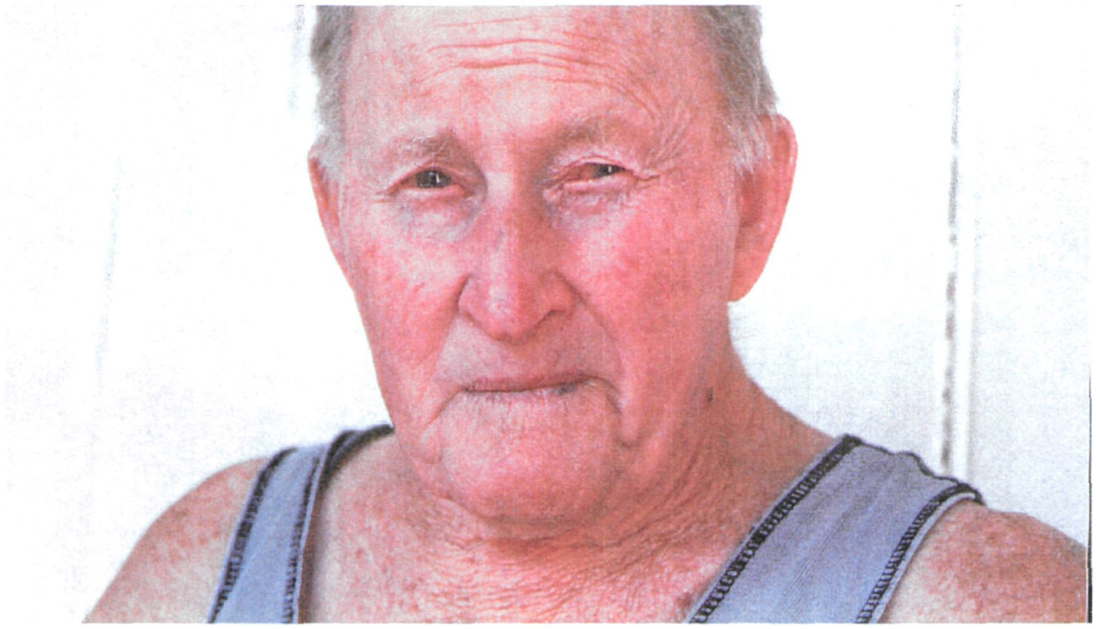
# Rex Oxenford

**Rex Oxenford** was born at Ballina in 1927. He is the son of Bert Oxenford who, with Rex's grandfather and uncle ran the Oxenford Construction Company. Having achieved a reputation for building structures that nobody else would tackle, the Oxenfords were awarded a contract by the DMR in 1938 to construct a new section of concrete pavement for the Pacific Highway at Ulmarra, near Grafton. Rex was only 11 when this work commenced and he used to light the kerosene street lanterns on the road barriers at Ulmarra. Rex gives us vivid descriptions of life in the steam-powered era in northern NSW. Rex and his brother John both joined the family company during the post-war years. The Ulmarra pavement has performed remarkably well after 62 years of unrelenting traffic, but it is was covered over by new asphaltic cement late in 2001 and has become part of Australia's road history.

# John Oxenford

**John Oxenford** was born in Forbes in 1929. He rode around with the workmen in the small trucks used by his father's company while they were constructing the Ulmarra pavement for the DMR in 1939. He recalls the steam road roller with big flywheels that took four days to drive to the construction site and the steam cranes used to lift the sand and cement from barges at the wharf built at Ulmarra. John worked in the family company after completing his education and has a good knowledge of other projects that the Oxenford Construction Company undertook in subsequent years. He now lives at Grafton, NSW.

# Brian Small



**Brian Small** was born in 1911 at Trenton, NSW, the son of a diary farm hand. He married at 22 and lived with his wife and six children in a tent at the back of a paddock during the 1930s until he was able to buy his first house on the Pacific Highway at Ulmarra for £50. Brian was a cement hand, employed by the Oxenford Construction Company during the building of the concrete pavement at Ulmarra in 1939. He recalls that on one day, he carried and emptied 1175 bags of cement, the equivalent of two semi-trailer loads full, from the wharf into the cement mixer. Brian's accounts give us a fascinating insight into life during the period following the Great Depression and of working conditions at that time.

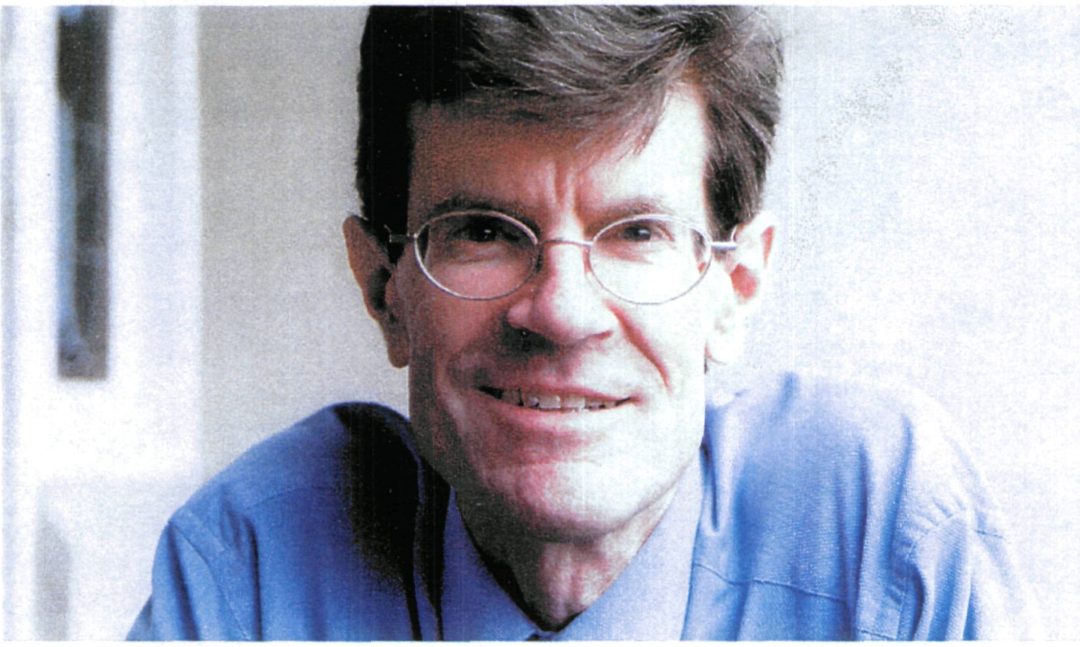
# Ed Haber

**Ed Haber** was born in Sydney in 1942. He graduated from Sydney University in Science and Civil Engineering and completed a post-graduate Diploma in Applied Science from the University of NSW. He joined the DMR in 1972 in the Materials and Research Section, working with Alan Leask. He was involved in the construction of NSW' first continuously reinforced concrete pavement on a public road in NSW across Clybucca Flat, in the introduction of slipform paving at Foreshore Road, Port Botany and in many subsequent projects. He has written historical and technical articles on the development of concrete pavements and has an extensive background in concrete design and technology. He is presently a concrete consultant and lives at Kirribilli, NSW.

# John Hodgkinson

**John Hodgkinson** was born in Sydney in 1945. He gained a traineeship with the DMR to study Civil Engineering in 1963, was conscripted during the Vietnam War and rejoined the DMR on his return in 1970. His major engineering projects with the DMR were the bridge approaches at Alfords Point, to railways lines at Bankstown and Villawood and the building of a second carriageway at Newbridge, Milperra. In 1971 he pioneered the technique of rapid slab replacement on Parramatta Rd He worked for 14 years with the Cement and Concrete Association and has written a great number of technical articles, manuals and conference papers on aspects of concrete technology. He was a member of the working party that produced the Austroads Concrete Pavement Design Guide and is currently Facilities Manager at Interlink Roads on the M5 South-West Motorway.

# Geoff Ayton



Since graduating in 1975 in Civil Engineering from the University of Newcastle, **Geoff Ayton** has worked throughout New South Wales on road and bridge works, with a special interest in concrete pavements. He was Site Engineer on the Clybucca Flat reconstruction project, a milestone in Australian concrete pavement construction. He has co-authored several RTA technical guides and served for eight years as Australia's representative on PIARC Committee TC7 for concrete roads. He is currently the Manager of the Rigid Pavements Section in Client Services Directorate at RTA.

# Arvo Tinni

**Arvo Tinni** was born in 1935 and left his native Estonia in 1944. He arrived in Australia in 1950, aged 13 as a displaced person. He was always fascinated by engineering. He signed up with the Department of Main Roads during his last year at university and his first posting was in 1960 at Ballina Works Office as Works Engineer. After a stint at Yass on the maintenance of the Hume Highway, his big break came in 1966 when he was appointed Resident Engineer on the construction of the Warringah Expressway. Arvo's recollections of the construction of the DMR's most ambitious project gives us an interesting and valuable personal account into the life of an engineer in the 1960s. Arvo is proud of the work done on the Warringah Expressway, and after its completion went on to become the DMR's Divisional Engineer at Goulburn and Chief Engineer, Roadworks, Services and Operations. In 1990 he left the RTA to take up senior positions with Statewide Roads and Abigroup, where he is General Manager of Special Projects.

# Barry Munce

**Barry Munce** was born and educated in Melbourne. He graduated with a Diploma of Civil Engineering and worked for Melbourne Metropolitan Board of Works and the Country Roads Board in Victoria. After a six-months Churchill Fellowship, studying concrete techniques overseas in 1973, he was involved in the construction of the eastern freeway approaches to the Lower Yarra Crossing Project in Brady / Boundary / Montague streets, South Melbourne in the early 1970s. This was the historic first application of a continuously reinforced concrete pavement in Australia. Work done on the Lower Yarra Crossing Project was to prove invaluable in 1975 during construction of the concrete pavement at Clybucca Flat, on which Munce was a consultant. Munce worked on airfield construction with the Dept of Housing and Construction and is currently National Technical Manager- Aviation and Chief Pavement Engineer- Airports with Sinclair Knight Merz in Canberra.