



Concrete Slab and Arch Bridges

Heritage Study of Pre-1948 Concrete Slab and Arch Road Bridges

2005

HISTORY OF CONCRETE SLAB AND ARCH BRIDGES IN NSW

I.1. Timeline of Reinforced Concrete

The following timeline summarises the history of the material now referred to as reinforced concrete. Its path to the form used in bridges in New South Wales up till 1948 represents one of the successes of the industrial age by bringing together physics, chemistry, engineering and innovation to produce a product that has given excellent service to the community. The timeline, of course, did not stop at 1900, and this report also records what has happened to the various bridges since then, and their current role in the infrastructure of the state.

REINFORCED CONCRETE TIMELINE

12,000,000 BC	Reactions between limestone and oil shale during spontaneous combustion occurred in Israel to form a natural deposit of cement compounds. The deposits were characterized by Israeli geologists in the 1960's and 70's.
3000 BC	Egyptians used mud mixed with straw to bind dried bricks. They also used gypsum mortars and mortars of lime in the pyramids.
7 th to 2 nd C BC	Chinese used cementitious materials to hold bamboo together in their boats and in the Great Wall.
800 BC	Greeks, Cretans & Cypriots used lime mortars which were much harder than later Roman mortars.
300 BC	Babylonians & Assyrians used bitumen to bind stones and bricks.
300 BC - 476 AD	Romans used pozzolana cement from Pozzuoli, Italy near Mt. Vesuvius to build the Appian Way, Roman baths, the Colosseum and Pantheon in Rome, and the Pont du Gard aqueduct in south France. They used lime as a cementitious material. Pliny reported a mortar mixture of 1 part lime to 4 parts sand. Vitruvius reported a 2 parts pozzolana to 1 part lime. Animal fat, milk, and blood were used as admixtures (substances added to cement to improve the properties.) Many structures still exist. Bronze cramps were used to reinforce masonry in the Colosseum.
1200 - 1500 The Middle Ages	The quality of cementing materials deteriorated. The use of burning lime and pozzolan (admixture) was lost, but reintroduced in the 1300's. Gothic builders in Northern France used iron ties and cramps. Damage due to rust spalling led to abandonment of the method.
17 th Century	Claude Perrault used armature of embedded iron for long span architraves in his colonnade in the Louvre.
1678	Joseph Moxon wrote about a hidden fire in heated lime that appears upon the addition of water.
1779	Bry Higgins was issued a patent for hydraulic cement (stucco) for exterior plastering use.
1780	Bry Higgins published "Experiments and Observations Made With the View of Improving the Art of Composing and Applying Calcareous Cements and of Preparing Quicklime."
1793	John Smeaton found that the calcination of limestone containing clay gave a lime which hardened under water (hydraulic lime). He used hydraulic lime to rebuild Eddystone Lighthouse in Cornwall, England which he had been commissioned to build in 1756, but had to first invent a material that would not be affected by water.
1796	James Parker of England patented a natural hydraulic cement by calcining nodules of impure limestone containing clay, called Parker's Cement or Roman Cement.

Historical Overview of Bridge Types in NSW: Extract from the Study of Heritage Significance of Heritage Study of Pre-1948 Slab and Concrete Arch Road Bridges

1802	In France, a similar Roman Cement process was used.
1812 -1813	Louis Vicat of France prepared artificial hydraulic lime by calcining synthetic mixtures of limestone and clay.
1812-1824	The world's first unreinforced concrete bridge was built at Souillac, France by Louis Vicat.
1824	Joseph Aspdin of England invented Portland cement by burning finely ground chalk with finely divided clay in a lime kiln until carbon dioxide was driven off. The sintered product was then ground and he called it Portland cement named after the high quality building stones quarried at Portland, England.
1828	I K Brunel is credited with the first engineering application of Portland cement, which was used to fill a breach in the Thames Tunnel.
1836	The first systematic tests of tensile and compressive strength took place in Germany.
1849	Pettenkofer & Fuches performed the first accurate chemical analysis of Portland cement.
1849	Joseph Monier of France commenced producing concrete tubs for orange trees using wire reinforcing.
1851	A beam consisting of brickwork reinforced with hoop iron was displayed at the Great Exhibition.
1854	Patent 2293 by W B Wilkinson of Newcastle, England for concrete floor with network of flat iron bars or wire rope sagging near centre of span. Not significantly commercialised.
1862	Blake Stonebreaker of England introduced jaw breakers to crush clinkers.
1865	Mass, unreinforced concrete used for multiple arch Grand Maitre Aquaduct to convey water to Paris
1867	Joseph Monier of France patented reinforced concrete portable containers.
1867-72	Patents issued to Monier for reinforced concrete pipes and bridges.
1875	First reinforced concrete bridge built to Monier design at Chazelet Castle, France
1884-1891	Wayss & Freitag acquired patent rights and built 320 reinforced concrete arch bridges with spans to 40m.
1887	Wayss published "Das System Monier", incorporating theory developed by K Koenen
1894	Experimental Monier arch on Parramatta Road, Burwood as culvert.
1896	Aqueducts over Johnstons and Whites Cks at Annandale by Carter Gummow & Co.
1896	Unreinforced arch bridge over Black Bobs Creek near Berrima by J W Park
1897	Windsor Bridge over the Hawkesbury River redecked using reinforced concrete beam and slab construction.
1899	The first reinforced concrete bridge built in Victoria: Anderson St Bridge, by Carter Gummow & Co
1900	The first reinforced concrete Monier arch bridge built in New south Wales: Reads Gully near Tamworth, by Carter Gummow & Co

Prime references:^{1,2}.

1.2. The Evolution of Concrete Technology – International Context.

The timeline above demonstrates the long path from the earliest uses of cementitious materials to the application of steel and concrete for the construction of bridges. Two keys were required to unlock the door: strong cements, and the means to carry tensile forces.

The Romans had used a cement sourced from the Italian town of Pozzuoli, mixed with lime, sand and water c.400BC – 476AD. This material was used as a binder in piers and arch spandrels, but also in mass footings.³ In the following centuries the use of cement was largely lost although lime mortars (made by burning seashells for example) were common.

Louis Vicat in France, an engineer (Ingenieur des Ponts et Chaussées) initiated scientific studies of natural cements to reveal for the first time an understanding of the chemical properties of hydraulic (meaning it would set under water) cement. Between 1812 and 1824 he supervised the construction of a seven span unreinforced concrete bridge over the Dordogne River. Known as Pont de Souillac or Pont Louis Vicat, it has a total length of 180 m and utilised his artificial hydraulic lime.⁴



Pont de Souillac by Louis Vicat 1812-1824



*Plaque on Pont de Souillac
(source www.structurae.de)*

In 1824 an artificial Portland cement was developed in England by Joseph Aspdin using a mixture of clay and limestone, calcined and finely ground. The use of these materials began to extend through the building industry as their utility became better appreciated. In 1828 Iseambard Kingdom Brunel was credited with the first application of hydraulic cement to repair a breach in the Thames Tunnel which his father had designed.⁵

By 1865 unreinforced concrete had been used in France to build a mass concrete arch aqueduct, continuing to use the compressive strength of the concrete in exactly the same manner as stone which has been used in arch bridges for at least two thousand years. In this instance, it was used for a multiple arch aqueduct (Grand Maître Aqueduct), conveying water from the River Vanne to Paris.⁶

However, this use still reflected the limitations of masonry, which was its inability to carry tensile loads. Even when using stones with good tensile strength, the joints between blocks would not pass any dependable tensile forces. This shortcoming of masonry had been addressed in a variety of ways over the centuries but with insufficient success to permanently change the way materials were used. China's oldest surviving bridge, of

¹ "The History of Concrete" Materials Science and Technology Teachers Workshop, University of Illinois. Website [//matse1.mse.uiuc.edu/~tw/concrete/hist.html](http://matse1.mse.uiuc.edu/~tw/concrete/hist.html)

² International Database and Gallery of Structures www.structurae.de

³ "Context of World Heritage Bridges" A Joint Publication with TICCIH, 1996 by Eric DeLony www.icomos.org/studies/bridges

⁴ International Database and Gallery of Structures www.structurae.de

⁵ "The History of Concrete" Materials Science and Technology Teachers Workshop, University of Illinois. Website [//matse1.mse.uiuc.edu/~tw/concrete/hist.html](http://matse1.mse.uiuc.edu/~tw/concrete/hist.html)

⁶ "The History of Concrete" Materials Science and Technology Teachers Workshop, University of Illinois. Website [//matse1.mse.uiuc.edu/~tw/concrete/hist.html](http://matse1.mse.uiuc.edu/~tw/concrete/hist.html)

open spandrel arch construction, is the Zhaozhou Bridge (c AD 605), attributed to Li Chun and located in Hebei Province south-west of Beijing. Its thin curved stone slabs were joined with iron dovetails so that the arch could yield without collapsing.⁷ This articulation allowed the bridge to survive the movements of abutments bearing on spongy, plastic soils, and also the effects of moving traffic loads. In Europe, bronze cramps had been used by the Romans in stone masonry in such structures as the Colosseum in Rome.⁸ From the 12th Century, gothic builders used iron ties and cramps in cathedral construction. Unfortunately, damage in the form of rust spalling led to the abandonment of the method. In the 17th Century, Claude Perrault depended on an armature of embedded iron to achieve the long span architrave of his colonnade in the Louvre, Paris. The French-born engineer and innovator Marc Isambard Brunel (1769-1849) experimented with reinforced brickwork in 1832; and a beam of hoop-iron reinforced brickwork was displayed at the Great Exhibition of 1851. However, none of these approaches addressed the problem of corrosion of iron which increases its volume by a factor of 6 (causing bursting or spalling of material around it), not to mention the loss of strength as the iron turns to iron oxide (rust).



*Joseph Monier 1823-1906
(source www.structurae.de)*

The solution to this problem came from an unexpected source. In 1867, a French gardener, Joseph Monier was granted a patent for cement flower pots strengthened by iron-wire mesh embedded in the concrete and moulded to curvilinear forms. He had begun making such pots in 1849.⁹ During this period to 1867 several other patents were granted to other innovators including: in 1848 for a reinforced concrete boat; in 1855, for the use of iron in combination with cement as a substitute for wood; and in 1854, for a concrete floor with a network of flat iron bars or wire rope. While Monier was not the first to put cement and steel together, he was the first to trigger its use in bridges. He was granted a patent in 1873 for the construction of bridges and footbridges made of iron reinforced cement. In 1875 he built the world's first reinforced concrete bridge, a four beam footbridge of 13.8m span and 4.25m width at the Castle of Chazelet, Saint-Benoit-du-Sault, Indre, France.¹⁰ (By way of context, in the same year patents were taken out for the electric

dental drill and blasting gelatin!) As he was not an engineer in a country which had a strong engineering heritage, (the Ecole Nationale Des Ponts et Chaussées was established in 1747) he was not permitted to design or build bridges for general public use. He therefore on-sold his patents in 1884 to German and Austrian contractors Wayss, Freitag and Schuster. Interestingly, the history of Wayss¹¹ suggests that they obtained the patent rights gratis, perhaps evidence of a lack of business acumen which ultimately led to Monier dying a pauper in 1906. Wayss, Freitag and Schuster built the first commercial reinforced concrete bridges in Europe: the Monierbrau footbridge of 40 m span in Bremen in Germany, and the Wildegg Bridge with a span of 37 m in Switzerland. It is reported that by 1891 they had built 320 arch bridges.¹²

As part of the process of developing reinforced concrete design, Wayss initiated strength testing of this new combined material, and had K Koenen develop a system of computation. This was published in 1887 as "Das System Monier", and incorporated the following principles:

- Steel alone took the tensile loads
- Transfer of force to the steel from the concrete took place through adhesion

⁷ "Context of World Heritage Bridges" A Joint Publication with TICCIH, 1996 by Eric DeLony
www.icomos.org/studies/bridges

⁸ "A note on the history of reinforced concrete in buildings" by S.B. Hamilton HMSO London 1956

⁹ "A note on the history of reinforced concrete in buildings" by S.B. Hamilton HMSO London 1956

¹⁰ International Database and Gallery of Structures www.structurae.de

¹¹ International Database and Gallery of Structures www.structurae.de

¹² "A note on the history of reinforced concrete in buildings" by S.B. Hamilton HMSO London 1956

- Volume changes in both materials due to temperature could be assumed to be approximately equal
- For calculations of bending, the neutral axis was assumed to be at the mid-depth of the section

In 1890, Paul Neumann, Professor at the Technical School of Brunn published a memoir on calculation using Monier construction in which he corrected the location of the neutral axis. This basically put the design of reinforced concrete into the hands of general civil engineers. This remained the theoretical basis for design until the middle of the 20th Century, when design based on ultimate strength criteria began to displace elastic design principles.



Pont Camille de Hogues (Pont de Châtelleraut) 1900 First Heritage ranked reinforced concrete bridge. (source www.structurae.de)

Whilst the bridges of Wayss et al were the first of the genre, the period saw a proliferation of patents and applications for reinforced concrete. These took advantage of improvements in available cements and delivered structures considered to have enhanced features including fire and corrosion resistance, and freedom of form. Reinforced concrete began to be widely used in construction of civil works and then for commercial buildings.

The first firm to market reinforced concrete bridges internationally was formed by Frenchman Francois Hennebique who also held various patents for improvements to the art. His bridge at Châtelleraut in 1900, an item of World Heritage significance under UNESCO's criteria, remains one of the first notable reinforced concrete arch bridges in the world, with a central span of 52m and two side spans of 40m.¹³

Outside Europe the reinforced concrete bridge began to spread, but sporadically. The first known reinforced concrete bridge in the USA was an arch built in Golden Gate Park, California in 1889.¹⁴ New Zealand built several small footbridges in the Otepunu Gardens in Invercargill in about 1899 before their first road bridge in George Street Dunedin was constructed in 1903.¹⁵ The bridge claimed to be the oldest in the UK is Chewton Glen near Milton in Hampshire, built in 1900.¹⁶



*Otepunu Gardens footbridge c1899 (source *Bridging the Gap* by G Thornton)*

¹³ "Context of World Heritage Bridges" A Joint Publication with TICCIH, 1996 by Eric DeLony
www.icomos.org/studies/bridges

¹⁴ "A Survey of Non-arched Historic Concrete Bridges in Virginia Constructed Prior to 1950" by A.B. Miller et al Virginia Transportation Research Council July 1996

¹⁵ "Bridging the Gap Early Bridges in New Zealand 1830-1939" by G. Thornton, published by Reed

¹⁶ www.hants.gov.uk/environment/bridges Bridges in Hampshire of Historic Interest

I.3. The History of Reinforced Concrete Bridges in the Context of New South Wales

I.3.1. Introduction

Bridging streams was one of the first public works carried out in the fledgling penal colony of Sydney. The Tank Stream was spanned by a bridge made from local timber, in the first year of European settlement, at the time, *“a gang of convicts were employed in rolling timber together to form a bridge over the stream at the head of the cove”*.¹⁷



*Lennox Bridge 1880s
(Source Mitchell Library scanned from Pictorial Memories Blue Mountains)*

This set a pattern which was to continue into the twentieth century – of using the strong, plentiful, straight local hardwoods for bridge construction over streams. Larger rivers were crossed by punts or ferries. Although during the 1810s Governor Macquarie set his sights higher, and triggered a period of excellence in public works, no bridges of his period remain. The oldest surviving bridges are of stone arch construction over Lapstone Creek in 1833 and over Prospect Creek at Lansdowne in 1836, both by David Lennox. However, the vast majority of bridges built over the following eighty years were of timber. These were initially simple structures using timber for piers and abutments, with round logs forming the stringers of the deck, and topped with timber planking, all connected using iron bolts and spikes.

I.3.2. The Colonial Period

During the nineteenth century the need to span larger crossings, and to avoid piers in the water which degrade quickly and form an obstruction to flood debris, led to the development and adoption by the 1850s of a range of truss designs. These were typically named after the designers who developed their geometry, immortalising Allan, Warren, McDonald, Pratt and Howe amongst others. While Percy Allan was an Australian (Chief Engineer for National and Local Government Works, Public Works Department), they were not all local engineers (Pratt was an American for example). Information on the latest bridge design tended to spread fairly rapidly through the worldwide engineering community. Adoption of new ideas was, however (and remains) a slower process, being driven by a diverse set of parameters including cost, material availability, site suitability and various pragmatic issues such as individual preferences, resistance to change, and the cost of preparing new designs.

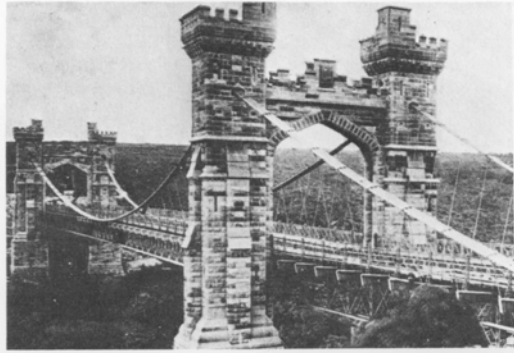
As the century wore on, iron in its various forms became more available and its use in bridges increased. Its ability to carry tensile loads led to truss forms wherein timber in the truss tension diagonals was replaced by wrought iron and then steel rods. Although complete iron bridges had been built elsewhere from the late eighteenth century (Ironbridge 1779), it was not till 1851 that an all metal superstructure was erected in New South Wales over Wallis Creek at Maitland. Subsequent bridges included the Prince Alfred Bridge over the Murrumbidgee River at Gundagai in 1865 having three continuous wrought iron spans, the Denison Bridge over the Macquarie River at Bathurst in 1870 using iron from the Fitzroy Iron Works at Mittagong, and Iron Cove and Parramatta River bridges in Sydney in 1882 and c1883 respectively. Complexity of steel structures increased rapidly, with swing, bascule and lift opening spans becoming common, with the technology

¹⁷ The Roadmakers A History of Main Roads in New South Wales, Department of Main Roads New South Wales, 1976

extending to suspension bridges (Hampden Bridge, Kangaroo Valley 1898 and Northbridge 1892).¹⁸

Concrete saw its first role in bridges in New South Wales through the "back door". It was found to be a

The completion of this suspension bridge in the 1890's led to the naming of Sydney's suburb, Northbridge.



Northbridge (source The Roadmakers)

suitable material for filling the insides of cast iron pier caissons and the like, providing a filling which was not only strong and stable but also protected the iron from corrosion due to its alkalinity. It also began to make cameo appearances in the form of mass concrete for abutments. This actually revived a role concrete had filled for the Romans two thousand years earlier.

With the dominance of German speakers in the commercialisation of reinforced concrete bridges in the late nineteenth century it is not surprising that this link brought the technology to Australia. W J Baltzer, a German immigrant working for the New South Wales

Public Works Department maintained contact with his brother in Germany, and through that link, awareness of the emerging technology. In 1890 he travelled to Germany to gather information on this new form of bridgebuilding. But on his return he was unsuccessful in interesting his superiors in the technique and ultimately joined several businessmen to obtain licences through Wayss to cover the Australian Colonies.¹⁹

Their company, Carter Gummow & Co, built several small trial structures, apparently one of these being a culvert under Parramatta Road at Burwood in 1894.²⁰ Unfortunately, it is unclear if this structure is still extant. The current main crossing has a flat soffit and the semi-arched connection to an upstream circular pipe is of rough construction unlikely of a trial structure built to impress potential users.



Entrance to culvert under Parramatta Road Burwood



Arched connection from slab culvert to circular pipe under footpath

Carter Gummow & Co subsequently obtained contracts to build two large arched sewage aqueducts over Johnstons Creek and Whites Creek in Annandale.²¹ Completed in 1896 they remain as probably the earliest reinforced concrete bridge-like structures in Australia.

¹⁸ The Roadmakers A History of Main Roads in New South Wales, Department of Main Roads New South Wales, 1976

¹⁹ John Monash Engineering Enterprise Prior to World War I Introduction of Monier concrete to Victoria, Australia <http://home.vicnet.net.au/~aholgate/welcome.html>

²⁰ Some Notes on the History of Concrete Bridges in N.S.W. by L.H. Evans Unpublished manuscript, stamped March 1986, held by RTA library, Parramatta

²¹ John Monash Engineering Enterprise Prior to World War I Introduction of Monier concrete to Victoria, Australia <http://home.vicnet.net.au/~aholgate/welcome.html>

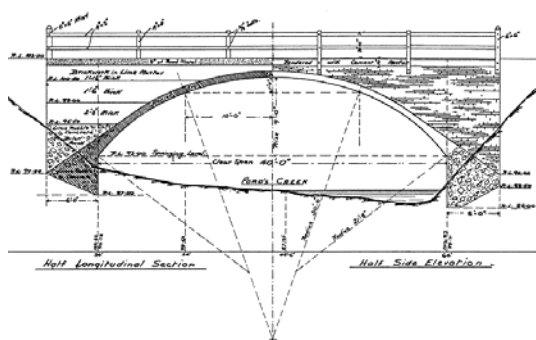


Johnstons Creek Aqueduct, Annandale



Whites Creek Aqueduct, Annandale

Baltzer became the Chief Engineer of Carter Gummow and in this role began promoting the technology. He spoke in 1897 to the Engineering Association of NSW, and the company held a stand at the Engineering and Electrical Exhibition in Sydney, gaining coverage in the Building Mining and Engineering Journal.



Monier arch, Fords Creek, Victoria (source <http://home.vicnet.net.au/~aholgate>)



Monier arch construction, Victoria. (Source: State Library of Victoria)

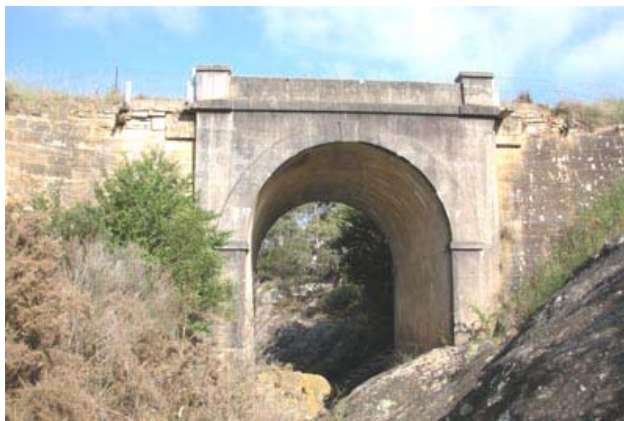
In the same year Gummow and W C Kernot, Professor of Engineering at the University of Melbourne jointly mounted an exhibition on the subject in Melbourne. The partnership of John Monash and Joshua Anderson, which had formed in 1894, obtained from Gummow sole rights to the Monier patent in Victoria. In 1899 Anderson St Bridge was built by Carter Gummow & Co and then the Monash/Anderson partnership constructed two Monier arch bridges, at Fyansford and Wheelers Creek in 1900. Several others followed. In 1901 one of their bridges, Kings Bridge at Bendigo, collapsed whilst being load tested,²² ultimately bringing the partnership down with it, but not before they had built a total of 15 bridges in the period 1899-1903. The Bendigo bridge was a heavily skewed arch. It collapsed under an unusually severe test load of a steamroller

²² John Monash Engineering Enterprise Prior to World War I Introduction of Monier concrete to Victoria, Australia History of King's Bridge Bendigo <http://home.vicnet.net.au/~aholgate/jm/texts/kingshist.html>



*Kings Bridge collapse during load test by steam and traction engines – both visible
(source <http://home.vicnet.net.au/~aholgate/jm/>)*

on the Hume Highway near Berrima.²³ Like the Pont de Souillac, it was unreinforced, having a 9.14m span and a width of 8.84m. It remained in service until the Highway was rerouted in 1971, despite the concrete having been made from low strength sandstone aggregate. It has been said in the RTA that the bridge was, in fact, detailed with exposed stone to avoid problems from those who were nervous about the new technology of concrete. Whilst this bridge is no longer in service, it remains in the hands of the RTA and there are current plans to improve its accessibility from an adjacent rest area, and install appropriate heritage signage.



*Black Bobs Creek Bridge, old Hume Highway alignment.
Unreinforced concrete arch*

escarpment of the Blue Mountains, it consists of 7 arches, reaching a height of 38m at the centre. It was designed by John Whitton, engineer-in-chief of the Railways, and referred to as his masterpiece.²⁴

back to back with a steam traction engine, killing one man. The partnership was exonerated by the coroner when Professor Kemot of the University of Melbourne showed that accepted theory (as set forth in W J M Rankine's texts) greatly underestimated the stresses in skewed arches - by a factor of as much as four. Monash went on to establish the Reinforced Concrete and Monier Pipe Company, and progressively moved into beam type bridges rather than the arch concept which had proved so troublesome.

Returning to New South Wales, the oldest existing concrete road bridge was constructed for the Public Works Department by J W Park of Gladesville in 1896 over Black Bobs Creek

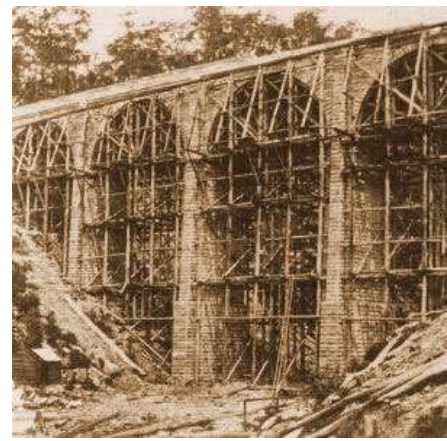
Whilst on the issue of unreinforced arches (i.e. the form leading to reinforced concrete arches) it should also be mentioned that brick and stone arches were also a very significant bridge form, not so much for road bridges as for rail. The spread of an extensive rail network throughout New South Wales saw a large number of brick arches built, ranging in size from modest culverts to large multispan structures such as those visible west of Lithgow. One of these which has come into the RTA's portfolio is the sandstone multi-span arch over Knapsack Gully at Glenbrook. Originally built in 1865 as part of the centre leg of a zig-zag rail link up the eastern

²³ Some Notes on the History of Concrete Bridges in N.S.W. by L.H. Evans Unpublished manuscript, stamped March 1986, held by RTA library, Parramatta

²⁴ The Roadmakers A History of Main Roads in New South Wales, Department of Main Roads New South Wales, 1976



*Lapstone masonry arch bridge
(Photo NPB Photographics)*



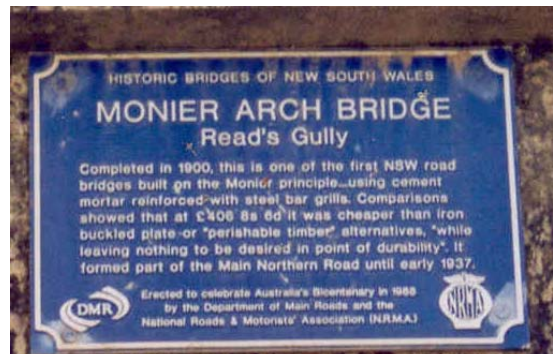
*Lapstone Bridge during construction
(source <http://info.mountains.net.au/rail/lower/lapstone.htm>)*

Abandoned in 1913 when the rail line was rerouted to avoid the delays of the zig-zag, it was widened and reopened in 1926 to carry the Great Western Highway. Another (brick) arch structure still in the RTA inventory was a brick arch built in 1840 over Duck Creek at Granville, servicing the Great Western Highway. A number of other masonry arches from the late nineteenth century are also still in service.

In 1900, six years after the trial culvert at Burwood, a Monier reinforced concrete arch was erected over Reads Gully on the Main Northern Road near Tamworth (presumably by Carter Gummow & Co who held the patent rights) at a cost of £406.8.6. The bridge served until it was replaced during a realignment of the New England Highway in 1937. It is now in the care of Parry Council. The Assistant Engineer for Bridges, Mr E M De Burgh mentioned in the Public Works Department Annual Report for 1900 that the Monier arch system would have been used more often if there had been more suitable sites.²⁵



Reads Gully Bridge, Tamworth



Plaque on Reads Gully Bridge, Tamworth

²⁵ Some Notes on the History of Concrete Bridges in N.S.W. by L.H. Evans Unpublished manuscript, stamped March 1986, held by RTA library, Parramatta

Such a site was soon found at Richmond where the existing timber bridge was prone to damage during the frequent floods which submerged it, often with heavy loads of floating debris. Professor W. H. Warren of



Bridge over Hawkesbury River at Richmond 1905 (RTA Bridge No 429)

Sydney University acted as a consultant to the Public Works Department on the design which consisted of thirteen Monier style arches, two of 15.84m span and eleven of 16.45m. With a total length of 214.6m this 1905 structure was the longest reinforced concrete bridge in New South Wales for the next 25 years.

Not far downstream from Richmond was a bridge of almost comparable proportions. Supported on cast iron caissons sunk a metre into rock, the Bridge over the Hawkesbury River at Windsor was originally opened in August 1874.

The original deck had been formed using 16 inch by 17 inch hardwood stringers topped with timber planking. In 1897 a new 143m deck of closely spaced reinforced concrete beams was opened. The new deck was apparently installed when the level of the bridge was raised by 2.4m to its present level by the addition of extra cast iron stub column pairs connected by reinforced concrete headstocks. Thus the honour of the oldest extant reinforced concrete bridge deck in New South Wales rests with a renovated bridge – but one of substantial proportions.



Bridge over Hawkesbury River at Windsor Raised and redecked 1897 (RTA Bridge No 415)

1.3.3. Developments in the Twentieth Century

In support of the move to use reinforced concrete for local structures, Professor W.H. Warren, Challis Professor of Engineering at Sydney University and President of the Royal Society of NSW undertook research into the strength and elasticity of reinforced concrete utilizing local materials. Results of these investigations were published in the Journal of the Royal Society of NSW in 1902, 1904 and 1905.²⁶ Despite this supportive work, the number and scale of concrete bridges built in New South Wales over the next decade was small. Included were a concrete beam bridge at Rockdale in 1907, the slab bridge over Muttama Creek at Cootamundra (RTA Bridge No 6438) in 1914 and the beam bridge over American Creek near Figtree in the same year (now replaced), a similar bridge over Mullet Creek, Dapto of 1916 (now replaced), a concrete beam bridge at Throsby Creek Wickham and a slab bridge over Surveyors Creek at Walcha (RTA Bridge No. 3485), both completed in 1916. The bridge described as “the first true continuous girder reinforced concrete bridge” was Fullers Bridge across Lane Cove River, completed in 1918.(RTA Bridge No. 105)²⁷



Muttama Creek Cootamundra 1914 (RTA Bridge No6438)



Surveyors Creek Walcha 1916 (RTA Bridge No 3485)

These structures, with deck geometries having either flat soffits or beams, represented a logical step forward in the use of reinforced concrete. While the first applications promoted by the Monier patents were arched, this did not in fact, fully utilise the freedom of geometry that reinforced concrete was able to offer. In the traditional masonry arch, avoidance of collapse was achieved by keeping the line of compression within the stone or brickwork. With a reinforced arch the same thinking initially applied, but with the advantage that the reinforcement could accommodate any local bending effects (such as from concentrated loads from heavy wheels) by using the tensile capability of the concrete. However, these structures were still faced with placing filling on top of the arch to build an almost level surface for traffic, and this meant an overall heavy (and thus somewhat inefficient) structure. In centuries past this difficulty had been overcome by various stratagems, including horizontal cylindrical holes through the spandrels or building arch upon arch – as used in Roman aqueducts. Once designers of reinforced concrete began to use the material in other structures such as buildings, they developed designs which allowed flat slabs of reinforced concrete to carry loads in bending. By placing the reinforcing steel predominantly in the bottom of the slab at midspan, and bending it up into the top over supports (where the bending effect is reversed) they were able to place the steel effectively where the tension forces occurred. Progressively it was realised that by thickening the concrete into beams which spanned between piers, and leaving the slab thinner in between these (i.e. having a form similar to that of the Windsor Bridge deck), that good economies could be achieved. The logic contained in these early bridges was to persist with relatively modest changes until the introduction of prestressing in the 1950s.

²⁶ W.H. Warren, 'Investigations in regard to the comparative strength and elasticity of Portland Cement Mortar and Concrete when reinforced with Steel Rods and when not reinforced'. *Journal of the Royal Society of NSW*, Vol. XXXVI, 1902, pp.290-313; 'Further Experiments on the Strength and Elasticity of Reinforced Concrete', *Journal of the Royal Society of NSW*, Vol. XXXVIII, 1904, pp.140-189; 'Reinforced Concrete, Paper III', *Journal of the Royal Society of NSW*, Vol. XXXIX, 1905, pp.49-64.

²⁷ Some Notes on the History of Concrete Bridges in N.S.W. by L.H. Evans Unpublished manuscript, stamped March 1986, held by RTA library, Parramatta

By the end of World War I there was the prospect of a substantial increase in both bridge building in general and in reinforced concrete in particular. In 1914 the Director General of Public Works stated that “*the increasing cost and difficulty in obtaining timber of suitable quality and dimensions for the large highway bridges determined me to adopt steel and ferro-concrete construction wherever practicable*”.²⁸ In contrast with timber, the raw materials for reinforced concrete bridges: coarse aggregate, sand, cement and steel bars were becoming readily available. The other driver was the explosion of private car ownership and the dramatic growth in truck transport of goods.



Mulyandry Creek Cowra (Bridge No 4282) Note curved deck with crossfall to suit

The style of roads and bridges which had sufficed during the nineteenth century, wherein the road alignment and surface was subservient to the surroundings, was no longer acceptable for the higher vehicle speeds now emerging. Road design became a science in which the design speed dictated the minimum radius of vertical curves as well as horizontal ones. These were predicated on principles of safe stopping sight distances, and on limiting the lateral forces on vehicles. Previous rules, such as that mandated by the railways, that all overbridges must be at right angles to the rail line (to minimise soot effects from steam trains) began to be overturned, as were

rules of thumb such as minimising the cost of bridges by making them straight and of minimum length (for example over rivers). Other parameters to evolve progressively during the Twentieth Century included the design weight of vehicles, the width of lanes, the provision of width to provide continuity with the shoulders of the roadway, and rules for impact resistance of railings. All of these have had their impact, not only on the design of new bridges but also on the continued appropriateness of existing structures and the need to modify them to maintain their level of service.

1.4. The Role of Government in Road and Bridge Expansion in NSW.

1.4.1. The Colonial Era

Prior to the granting of responsible government in the 1850s all authority and responsibility was exercised by the Crown's representative in the Colony of New South Wales, the Governor. Roads and bridges were constructed by decree of the Governor on the advice of his staff. These were the officers of the Colonial



David Lennox, first Superintendent of Bridges, 1833-1843

David Lennox

Architect's Branch of the Surveyor-General's Office. This system evolved at Federation into a structure containing three tiers of control: Federal, State and Local. Interfacing with this hierarchy was free enterprise, the entrepreneurial companies of which variously built roads and bridges for contracted amounts or were licensed to carry out works and collect tolls. The course of change through this process has been well documented in such works as *The Roadmakers*, and *Vital Connections*. During the period of interest for this current study, viz 1905 to 1948, many changes occurred. Leading to the period in question (and covering some of the earliest reinforced concrete works), the Department of Public Works (created in 1859) was put under the control of R Hickson as Commissioner in 1889 who separated the State into six divisions, each with its own Resident Engineer who reported to Divisional

²⁸ Some Notes on the History of Concrete Bridges in N.S.W. by L.H. Evans Unpublished manuscript, stamped March 1986, held by RTA library, Parramatta

Engineers operating from Sydney. In 1895 the Roads, Bridges, Harbours and River Branches were placed under the control of one officer with the title of Engineer-in-Chief for Public Works, and Hickson was appointed to this position. In the following year he was also made Under Secretary for Public Works.

1.4.2. Key Bridge Design Personnel

The following table identifies many of the key engineers involved with the design or design management of bridges in NSW, with particular reference to the period under study. The list is provided to help readers understand the flow of engineers and managers who drove the design processes of the road bridge network. Where information has been available to link individuals to bridges, this has been identified. Unfortunately, in the majority of the bridges under study, little remains in the RTA files to identify the actual designers. Where original drawings (or copies thereof) are on file, the initials of designers are sometimes discernable and these have been acknowledged in the inventory.. However, the practice of not including the designer's full name on the drawings, and giving him recognition on the bridge itself, all conspire to hide the identity of the individuals who created the original designs.

Having said that, it should be recognised that bridge design, like many other areas of human endeavour, is generally not the work of one person alone, but the compilation of inputs from those who have gone before in developing earlier designs, of field personnel who gather data necessary for proper assessment of foundations, waterways etc, of peers carrying out design checking and drafting, and of management who ensure that all aspects are orchestrated efficiently and within overall budget constraints.

In the instance of slab and beam bridges in particular, the modest scale of most crossings has meant that designs became more or less standardised, with individual bridges being created by use of standard spans, piers and abutments. These standard designs tended to stay in use for some years until the march of progress, in the form of increased traffic design loads or improved material properties (such as concrete strength) meant that revision was warranted, leading to another standard design.

KEY NAMES IN BRIDGE DESIGN, NSW

Title	Name	Start Date	End Date	Significant Work
<i>First Superintendent of Bridges</i>	David Lennox	June 1833	1843	Lennox Bridge Lansdowne Bridge
<i>Commissioner and Engineer-in Chief for Roads</i>	W.C. Bennett	1862	1889	
<i>Engineer-in-Chief for Public Works</i>	R. Hickson	1889	1901	
<i>Professor of Engineering, Sydney University</i>	Prof W.H. Warren	1883	1925	Northbridge suspension bridge, Richmond Bridge
<i>Bridge Modeller & Bridge Computer</i>	H.H. Dare			Richmond Bridge
<i>PWD Engineer</i>	John A. MacDonald			MacDonald truss bridges
<i>Chief Engineer for National and Local Government Works</i>	Percy Allen	??	46 years	Allen truss bridges; Associated with more than 550 bridges
<i>Chief Engineer, Sydney</i>	Dr J.J.C. Bradfield	1891		Sydney Harbour

<i>Harbour Bridge and Metropolitan Railway Construction, PWD</i>	1867-1943	(Started with PWD) 1912	1932	Bridge
<i>Supervising Bridge Engineer</i>	E.M. De Burgh	1891 (?)	1900?	De Burghs Bridge, Lane Cove
<i>Bridge Engineer (Transferred from Public Works)</i>	Spencer Dennis	1928	1951	Promoted use of Reinforced concrete
<i>Bridge and Designing Engineer</i>	H.M. Sherrard	1926	1928	
<i>Assistant Bridge Engineer</i>	F.W. Laws	1935	1942	
<i>Assistant Bridge Engineer</i>	C.A.M. Hawkins	1944	1946	
<i>Assistant Bridge Engineer</i>	R.A.J. Thompson	January 1946	November 1946	
<i>Assistant Bridge Engineer</i>	A.J.Clinch	1946	1953	
<i>Bridge design engineer</i>	Vladimir Karmalsky	1930s	1950s	Bow-string arches
<i>Bridge design engineer</i>	A.T. (Sandy) Britton	1930s	1950s	Shark Ck, Hillas Ck (bow-string arches)
<i>Bridge design engineer</i>	A Halvorseth	1930s	1950s	Tuena River (through girder) Galston Gorge Bridge and others

Prime reference²⁹

1.4.3. The Twentieth Century

With the turn of the century, significant political change occurred. The States combined (with the blessing of the Crown) to form a new country, the Commonwealth of Australia, in 1901. The increase in population also led to further pressure for decentralisation of power, and the 1906 Local Government Act transferred to shires and municipalities the responsibility for care and maintenance of local roads and other public works. This was funded partly by council rates which were based on the unimproved capital value of land, and topped up by grants from the State and Federal governments under a variety of funding arrangements. As a result of the handover, the greater part of the state's 48,500 miles of roads and bridges were passed over to the care of local government, and in 1907 the position of Commissioner for Roads was discontinued. Unfortunately, this change led to a decline in the amount of money actually spent on roads in general, and main roads in particular although a proportion of roads and bridges were declared National Works and were maintained by the Department of Public Works.

By the end of the First World War, the NSW roads were in a poor state with even national roads badly underfunded. In 1924, after years of haggling and politicking, the Main Roads Bill was introduced into the New South Wales Parliament and subsequently the Main Roads Board of New South Wales was created in 1925 with the powers to function as a State road authority, and with 12,840 miles of roads to care for. Within a year the Board was swamped with requests from councils eager to offload their road responsibilities, the cost of which had been escalating. Early planning reviews not only allocated funding to established roads, but also set in train plans for a dozen new roads linking areas of the state not well connected by the road system

²⁹ The Roadmakers A History of Main Roads in New South Wales, Department of Main Roads New South Wales, 1976

which, until then, had grown like the proverbial Topsy. These new roads required new bridges, a number of which form part of the present study.

It was not until 1927, after almost three years of wrangling between the Main Roads Board and the Department of Public Works that a clear definition of the lines of responsibility was achieved. The Department of Public Works took charge of roads and bridges in the Western Division, and the Main Roads Board took responsibility for Main and Developmental Roads in the Eastern and Central divisions of the State. Matters relating to other roads, including interfaces with the councils, were placed with the Department of Public Works.

To rationalise the system of road classifications, all roads were reviewed in 1928 and new classifications of State Highways, Trunk Roads and Ordinary Main Roads were introduced. These changes had substantial implications for funding of the various roads, and thus of the councils who carried out much of the work. In the same year the Main Roads Board decentralised its road design and construction activities to regional headquarters in Glen Innes, Tamworth, Parkes, Queanbeyan, Wagga Wagga and Sydney. While it was feasible to set up road design teams in these offices, the high level of professional skill required for bridge design (and the more peaky nature of the workload) was seen as justification for keeping the bridge design team together in Sydney, at the Board's offices in Castlereagh Street.

More political machinations and funding skirmishes saw the Main Roads Board dismantled in 1932 and replaced by the Highway and Roads Transportation Branch of the Department of Transport. In the aftermath of a dogfight between the State and Federal governments (during which the funds of the State were garnisheed by the Commonwealth), the Department of Main Roads was created in 1933, a bureaucratic arrangement which lasted until 1989. These organisational changes occurred during (and perhaps because of) confronting times of economic depression and high unemployment.

From 1932, motor vehicle registrations grew at the astonishing annual rate of 48% in a period of 4% population growth and with a depressed economy. As the motor vehicle moved from being an unreliable and relatively slow contrivance to an essential high speed means of transport, new concepts for roads began to emerge, including multilane roads, grade separated intersections, speed limits, removal of level crossings, and, in the country, separation of roads from stock routes. Thus the focus changed from making the roads passable to making them safe and efficient. By 1938 the total length of roads covered by the Department was 24,643 miles. This was a boom period for the construction of simple, functional concrete bridges which embodied the new standards, to replace decrepit timber structures or flood prone open crossings on roads controlled by the Department. (Whilst not part of this study, the same pressures were also being felt at the local government level with respect to bridges on local roads. However, with lower levels of funding their inventory of bridges typically lagged behind).

With World War II looming, and then running from 1939-1945, external drivers impacted the development of roads and bridges over the final 10 years of the period under study. The decisions regarding which roads would be built and which bridges built or upgraded were made on defence criteria ahead of general traffic management issues. Key issues included the ability to move troops and military hardware rapidly from military facilities to strategic defensive locations. North-south lines of communication were seen as particularly important, with potential invasion expected from the north. Further downsides of the war included the diversion of funds and personnel away from non-strategic infrastructure. Contractors with bridges already committed to construction found difficulty getting tradesmen and materials to complete their works, and the Department was asked for extensions of contract times in many cases.

Coming out of the War, there was another hiatus as the community and bureaucracies refocussed. This meant another difficult period of limited access to equipment, materials and personnel even for urgent works, some of which had been held over from prior to commencement of hostilities. The War had seen a further jump in motor vehicle technologies and with it a new era of road planning began to implement more of the ideas regarding traffic management conceived in the 1930s, but not brought to fruition. The late 1940s thus closed out an era, to be replaced by a new world of freeways and prestressed concrete.

1.5. The Reinforced Concrete Bridge as an Element of Public Infrastructure – Social and Historical Significance

1.5.1. Introduction

Despite the arduous process required of Baltzer and others to get reinforced concrete bridges accepted as a valid medium, the social impact of these bridges during the twentieth century has been immense. From a standing start at the turn of the century, they achieved the status of preferred bridge form for small to medium spans, and were looked to to provide the flexibility that would allow greatest spans to be contemplated. They are now a ubiquitous part of the landscape, generally providing many years of troublefree service to the community and representing a substantial part of the bridge infrastructure of the state.

1.5.2. Bridges as Infrastructure



Bridge over the Dawson River at Cundletown (RTA Bridge No 1803)

Only two of the bridges in the study group are over major waterways – the Dawson and Hawkesbury Rivers. Here the bridges have played a major part in the development of important routes, replacing punts and less reliable lower level bridges. In doing so they have also become dominant features in the landscape and are perceived as important infrastructure items by the community. Most of the remaining bridges in the study group are more modest structures which cross minor waterways, many of which, especially in the western half of the study area, are dry for much of the year. However, their value as infrastructure should not be underestimated. These

sites are characterised typically by various combinations of steep gullies, bogging sands, rapidly rising freshes or persistent flooding. These smaller bridges replaced open crossings, causeways, culverts or more maintenance-intensive and dilapidated timber bridges to create, along with road improvements, reliable, safe, comfortable and speedy transport which revolutionised motor transport in local areas, regions and, cumulatively, the state as a whole.

Bridges in the study group were built in a number of different infrastructural contexts. Several of the bridges were constructed due to local needs, and at times under the pressure of energetic community lobbying. The reliable carriage of goods is what the community looks for in its road and bridge system. The bridge over Swanbrook Creek near Glen Innes was finally built after years of transport hold ups whilst waiting for freshes to subside. (*Inverell Times*, 21st June 1921). Similarly, the *Lithgow Mercury*, 19th Nov, 1928 notes the opening of the Marrangaroo Creek bridge with some relief: 'There will ... be no need in future for cars to wade through the river, the Bugbear of many local drivers...'. Safe pedestrian use of bridges, particularly those providing access to schools has also been a significant issue in the planning of bridges, with decisions as to whether to provide a footway (and who should pay) and retrofitting of footways being well represented in the correspondence. In several cases, the concrete bridges in this study were constructed to replace timber structures which were on the point of collapse, or which had done so already, having served sixty years or more. The historical value of some of the bridges in the study group is enhanced by physical evidence of these older structures.



Old footing and headstock,



Previous pier timbers, Tyagong



Log protruding from

*Eastern Creek Riverstone
(RTA Bridge No 535)*

*Creek Cowra (RTA Bridge No
4080)*

*abutment fill, Jeir Creek No 1,
Yass (RTA Bridge No 6341)*

For the majority of bridges in the study group, their construction was associated with upgrades of state-managed roads under the Department of Public Works and subsequently the DMR. In some instances this involved the construction of deviations or new routes and necessitated the modernisation of a number of crossings. For example, slab bridges were constructed over Ugumjil, Bundara and Rays Creeks, within several kilometres of each other, in 1938/9 in conjunction with the improvement of the Newell Highway south of Dubbo. Such programmes often involved the combining of the construction of two or three bridges in a single contract.

Different times produce different priorities, and during World War II, this was manifested in providing and upgrading links seen as strategically significant for military purposes. The bridges on Heathcote Road (Williams Creek, and Deadmans Creek) were constructed under this imperative.

1.5.3. Visual Impact in the Landscape

The bulk of the bridges in this study are, by the nature of their design, inconspicuous and unobtrusive. Many are only discernable to the passing motorist by the presence of a signpost identifying the waterway, and a length of guardrail protecting the drop on either side.



Jeir Creek Bridges 1 and 2 suggest little to the motorist

This is in contrast to the steel, timber and truss bridges which enclose the motorist and declare their structural form above deck level. For most bridges in this study it is necessary to leave the car and in some instances climb fences before the actual structure of the bridge can be seen. Even then, the bulk of bridges are the outcome of a process which has maximised function by minimising the complexity of form, resulting in simple clean construction lines with little to attract attention. They may thus be summarised generally as successful infrastructure, providing community service for a minimum of capital cost and upkeep. Failures, particularly in the area of ongoing maintenance requirements, have

also been identified in the study group, among them being the simply supported slabs which in many instances have cracked and been repaired repeatedly, yet are still carrying out their function.

Another subset within the study group are those bridges which have settings facilitating views of the bridgeworks. These include bridges with picnic grounds such as those at Swanbrook Creek west of Glen Innes and Deep Creek at Narrabeen Lake. Incidentally, both this bridge and the Bridge No 3 over Middle Creek were designed with the expectation that boaters would row under them as part of the recreational uses of the Narrabeen Lake. Two bridges (Belubula River flood Channel at Canowindra and Dawson River at Cundletown) are also sited adjacent to caravan parks, affording views of their structures, whilst others (Lagoon Creek at Narrabri, Peachtree Creek at Penrith and Crookwell River at Crookwell) cross flood plains or overflow channels in towns which have consequently been kept free of development, and thus affording some public access. The Stringybark Creek Bridge at Lane Cove, once a dominant arch in the landscape, has all but disappeared due to widening and regrowth of bushland, but its sweeping arches can still be viewed to advantage from beneath on a signposted bush track. A bridge now by-passed by its old highway but,



*Spring Creek Bathurst (RTA Bridge No 1002)
showing headstock and slab distress*

along with its twin sister, known for its visual impact, is Hillas Creek Bridge at Tarcutta. So significant was its bowstring arch form that it was (and still is) referred to as "The Little Sydney Harbour Bridge".

Despite the generally modest set of bridges in the study group, it also contains some gems of public works. The Hawkesbury crossing at Richmond is a bold and noble example of bridge construction, providing a strong visual statement about its ability to both span the river and to resist the scourge of inundating floodwaters with their attacking loads of floating debris.



Hillas Creek Bridge on old Hume Highway, Tarcutta



Bridge over Berowra Creek Galston (RTA Bridge No 389)

The arch bridge at Galston is a crossing where not only the scenery is dramatic, but the elegant sweep of the open arches is visible from the twisting roadway, encouraging visitors to stop at the parking area and use the walking track to inspect the bridge from below and enjoy the power of its lines.

The king of the study in terms of visual impact is undoubtedly the Northbridge crossing. At once an arch of substantial span and height, and also carrying the heritage of its gothic styled suspension bridge past, it is impressive from every angle. The reinforced concrete elements, designed in mixed Norman and gothic styles incorporate

approach arches and a main span with twin ribs and soaring piers supporting a deck with detailing embellishments to match the sandstone towers.



Northbridge southern abutment and tower (RTA Bridge No 172)



Oaky Creek Cobbadah (RTA Bridge No 3670)

Perhaps the unsung hero of the set is the barrel vaulted ribbon arch over Oak Creek at Cobbadah, a modest rural road. The crossing appears to be no more than a culvert, with tree covered fill batters topped by an old chain wire and timber post fence, yet the structure when seen from stream level has beautiful lines as the arch widens towards its springings to support the width of the batters.

1.5.4. Visual Evidence of the Construction Process in the Fabric of the Bridges

All of the bridges in the group bear evidence of the construction processes characteristic of their period. One of the earliest bridges (Muttama Creek at Cootamundra) used corrugated iron as formwork. The fact that the earliest section of crossing at Peach Tree Creek Penrith was also constructed using corrugated iron formwork is seen as evidential of an early construction date. Later bridges used timber formwork which was eventually phased out by large sheets of formply. These developments left their imprint on the finished work.



Corrugated iron formwork



Timber formwork



Formply

Falsework used to support the formwork was originally made from timber, with concrete footing pads for this still visible under some bridges. (While this timber falsework was eventually replaced by standardised steel frames, there is no evidence of the transition). Within the concrete, the reinforcing steel had to be supported above the formwork to provide sufficient cover of concrete to prevent corrosion of the steel. This has been achieved by a variety of means over the years, with most work of the period being supported on small cubes of concrete referred to as Aspros. The marks of many of these can be seen on the undersides of bridges in the study group. Later, bar chairs were made from steel wire, then tipped with plastic, and finally made completely from plastic. These changes have reflected sometimes poor performance of these systems which, when they allowed the ingress of moisture to the steel, triggered corrosion.



*Bridge over Eucumbene River (No 6049)
Freeze/thaw damage to kerb*

The concrete itself in some cases bears testimony to its origins. At Tuena the rounded local quartz pebbles are visible. The bridges on the Summit Road near Charlottes Pass and Eucumbene River, Kiandra show the coarse finish of locally sourced aggregates, and all also bear the scars of 60 winters which has resulted in freeze/thaw damage to upper surfaces. On other bridges the spalling has been caused by insufficient cover to the reinforcement, reminding us that quality control has always been important, and its absence will finally betray itself. These individualities of texture, and particular material failures, are absent from the pre-stressed, trucked-in components which characterise most modest concrete bridges built since the late 1960s.

1.5.5. Relationships with Communities

The cohort of bridges comprising the study group have a diverse set of relationships with the community. Some are in Sydney, others in country towns and some on long stretches of highway joining regional centres. As evidenced by replies from local historical societies, some bridges have been created and satisfactorily performed a function while remaining almost totally unnoticed, or have been simply experienced as part of general road improvements. Others provided much relief to locals at the time of construction, (although now are generally taken for granted) alleviating the stress of being stranded (or washed away eg Yaminba Ck, Mullaley) in floods or having part of the town cut off (Cootamundra, and Riverstone), some connected to a community's sense of pride or identity (Cundletown called by *The Wingham Chronicle* of 3rd Nov 1933 'a grand sample of modern architecture'). Some were involved with local events, the most spectacular story being Northbridge, where the arch was constructed in the face of potential collapse of the suspension bridge. The most enduringly controversial has perhaps been the bridge over the Hawkesbury at Richmond where, despite being higher than its predecessor, the bridge is still subject to immersion during floods. The need to lower the railings on the bridge for such events meant that for many years the bridge had a caretaker, a role normally restricted to bridges with opening spans. Complaints, defences, demands for a yet newer and more reliable structure, have flooded the DMR and the RTA over the years in relation to this bridge.

As discussed above, in many instances local communities have not just been passive recipients of the structures but have played an active role in lobbying for (and debate over) bridge construction or improvements another

example is the bridge over Yaminba Creek on the Oxley Highway where local residents as well as the Borah Creek Branch of the Agricultural Bureau had made applications to the DMR for a bridge³⁰.

1.5.6. Interface of the Bridge Design and Construction Process with the Community

As noted above, many communities were in the forefront of exerting pressure on government departments to improve the local infrastructure. Many roads in the first decades of the Twentieth Century were susceptible to quick degradation during rain, and stream crossings were even more vulnerable. Community action was therefore directed to achieving all-weather roads and bridges on main routes. This action usually took the form of written dialogue with the local representative of the Department of Main Roads (or its predecessors), and in some cases, via members of parliament.

Once the need for a new crossing was established, the site was surveyed, soil investigations undertaken and the catchment area measured. This work was typically undertaken by DMR personnel or contractors working for them. Bridges were typically designed by the Bridge Section in Sydney, with construction being undertaken through divisional offices. Construction was either by the Department's own work force (so-called day labour) or let out by tender to private contractors. Many local contractors were engaged. Irrespective of contractual arrangements, the majority of input was labour and the supply of materials, much of which was available locally – all assisting the local economy. This can be quite a tight loop as in the case of the Kosciusko Hotel which agitated for bridges on its access road (Summit Road) and then had the senior members of the construction team as guests during the building, and also assisted in evacuating the construction sites when bad weather hit.

Bridge building is a specialised and highly skilled trade. Several generations of bridge builders were involved in the construction of the bridges in the study group. Construction in the period under study had certain salient features that made the builders a particular kind of community in an unusual workplace. The workers were often accommodated in camps due to the on-site pouring process which, when concrete was mixed by hand, was a slow, labour-intensive activity, and one which could not be suspended at convenience but which had to reach pre-designed construction joints. The study period saw an increasing mechanisation of the road and bridge construction process with petrol driven mixers replacing hand mixing of concrete for example.



Concrete mixer 1947 – Cockle Creek railway bridge (Photo Max Broadbent)

For some of the bridges the RTA files contain quite rich detail on this early labour intensive style of construction. For the construction of the bridge over Spring Creek, Bathurst, for example, a camp for approximately twelve men was constructed on an adjacent reserve used by travelling stock. The gang moved from Coxs River and work commenced on 25th November 1946. The work was closed for the Christmas Holidays and Foreman Spence, who lived at Wagga, who arranged for his wife and family to spend part of the school holidays with him there, renting part of a cottage overlooking the work. Construction work had finished by 23 September 1947 when the Divisional Engineer asked the district telephone office at Bathurst to disconnect the telephone service at the Construction Office. The construction team were complimented by the Department's Assistant Bridge Engineer on the high quality of their work and the efficiency with which it was carried out. (RTA Bridge File 6.177;1)

Within the RTA's files is evidence that the design and construction of bridges did not proceed in-vacuo. Examples include delays to the bridges on the Wakehurst Parkway (Middle Creek No 3 and Deep Creek) because the Second World War led to a shortage of skilled manpower. Conversely, the bridges on the Heathcote Road (over Williams and Deadmans Creek) were deemed to be of military strategic importance and hence accelerated.

³⁰ RTA Survey, Design & Construction File, 11/98.152;1



Middle Creek No 3 (RTA Bridge No 148) – delayed by War



Williams Creek (RTA Bridge No 499) – Brought forward by War

Entire routes were constructed in the aftermath of the Depression in order to stimulate the economy and generate employment. Unfortunately, even the Board was affected by the economic woes in the depths of the Depression and unemployment relief works which carried 2000 people in 1929 (out of a total workforce of 4000) was curtailed completely by 1931, leaving only 1000 in jobs. By 1933 the number employed by the Board was back up to 3000, and in the mid 1930s relief works aimed directly at using unemployed labour included sections of the Princes Highway including the Cockwhy Range deviation, which contains the bridge over Higgins Creek (RTA Bridge No 740).³¹

1.5.7. Significance of Bridge Set to Today's Communities

Bridges represent a substantial and an essential part of the assets of the community. Of the bridges in the current study, the majority are on routes carrying high levels of goods and services, and their disappearance would bring much of the State to a halt. The growth in vehicle weights and increases in lane and shoulder widths have meant that many bridges built of reinforced concrete in the 1905-1948 period have already been replaced. It is therefore testimony to the success and resilience of the subject bridges that they still exist. That many have been widened and/or lengthened is a reflection of their flexibility to be incorporated in upgrades. Of those which have not been changed in width, many have had their original pipe or concrete railings replaced with guardrailing which has a better safety record in redirecting impacting vehicles. The bridges with all original features intact have thus become a minority, and one that is under pressure, particularly those outside urban areas where high transit speeds and narrow bridges compromise road safety.



Endpost damage – Spring Creek (RTA Bridge No 1002) Bathurst

In fact, quite a few of the bridges in the study have been widened only as a result of fatalities. Those not widened already have, in many instances, been investigated for upgrades in the interests of safety (quite apart from any issues of alignment etc)

In summary, the current situation is a reflection of a state of dynamic equilibrium between the competing demands on the infrastructure.

On a more socially significant level, the set of bridges has a wide range of linkages with their communities. This ranges from childhood memories of rambling along creeks, picnics and bushwalks to matters of life and death including

crossing bridges to escape floodwaters and the like. Each local bridge fits within its own microcosm, tying farms together, linking families to schools, transporting goods and services. Some are known as gateways to towns or, as in the case of Northbridge, give their naming to the suburb. Even the bridges themselves provide a habitat, with most bearing the musings of tenants past ranging from political exhortations to advice how far upstream

³¹ The Roadmakers A History of Main Roads in New South Wales, Department of Main Roads NSW, 1976 pp160-161

the nearest waterhole is, and providing large canvasses for unofficial public artwork. Each bridge, no matter how modest, is thus worthy of careful investigation before decisions are made which affect its future.