John Monash & His Innovative Bridge Designs

Eight Bendigo Bridges Establish the Era of Monier Reinforced Concrete in Victoria

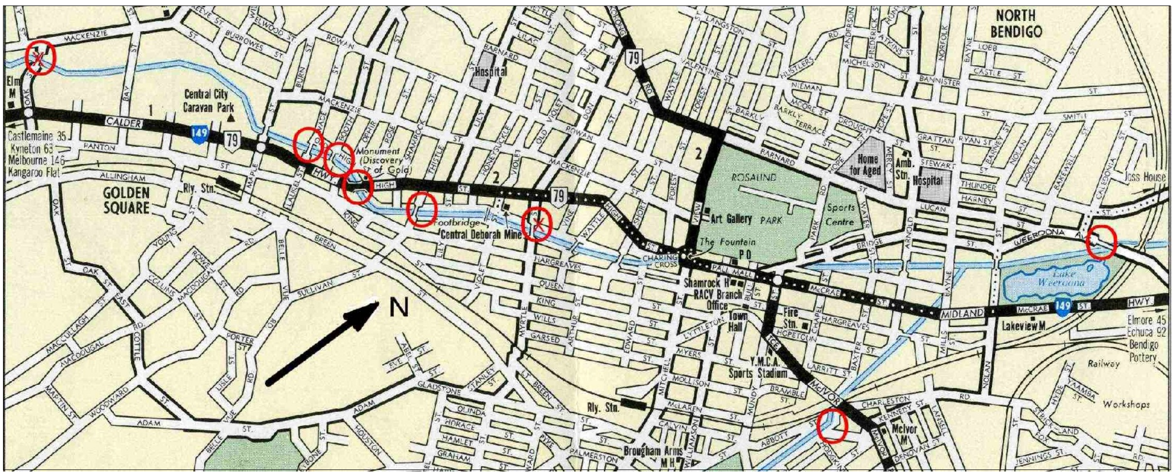
Joseph Monier (1823 - 1906) was a French gardener and one of the principal inventors of reinforced concrete. He was looking for a way to produce unbreakable planter troughs. He experimented with concrete embedded with iron mesh and got his first patent for these in 1867 and another for bridges made with iron reinforced concrete in 1873. He built the first reinforced concrete arch bridge over the moat of the chateau de Chazelet in 1875. It had a span of about 15 metres. The first reinforced concrete arch bridge in America was built in 1889. It is still extant in San Francisco's Golden Gate Park (American Society of Civil Engineers).

In Victoria the engineering firm of John Monash (later General Sir John Monash) & Joshua Anderson obtained rights for the use of the Monier patent in Victoria and South Australia, and built many bridges using the method. The Fyansford Bridge near Geelong was their first Monier arch bridge to go into service, in late 1899. Next was Wheeler's Bridge, near Creswick in Victoria, completed in 1900. The eight Bendigo Bridges – the subject of this story – were next.

Abbott St Bridge Bendigo Photo Owen Peake

In what became a major innovation in bridge and concrete design in Victoria, in 1901-02 Monash and Anderson were contracted to build seven single span reinforced concrete arch bridges over Bendigo Creek plus one over a tributary of Bendigo Creek called Back Creek. The contract was let by the Bendigo Council as part of a project to control flooding and silting after Bendigo Creek had been subject to gold-winning operations. The creek was to be controlled by building a concrete-lined channel right through the City, and this required the replacement of a number of bridges. The eight bridges designed by Monash and Anderson were (from North to South):

1. King's Bridge carrying what is now called Weeroona Avenue over Bendigo Creek. This bridge had a span of 93 feet (28.5 metres) and was designed to be skewed at an acute angle to the creek bed. The design computations did not allow effectively for the increase in span and reduction in strength of the concrete caused by the skewed shape of the deck. The bridge failed under extreme testing on 14 May 1901, causing the death of a bystander. It was subsequently rebuilt as a two span bridge which remains in service today. The bridge was widened to four lanes in 2004, by adding a new bridge of similar appearance alongside the original King's Bridge.
2. Abbott Street Bridge (over Back Creek), still in service.
3. Myrtle Street Bridge has been replaced by a new bridge. It is thought that the motive for the replacement was the need for greater width rather than any failure of the original bridge.
4. Thistle Street Bridge. This bridge shows a little more "flattening" at the crown of the arch than the other bridges.
5. High Street Bridge. This carries what is now the Calder Highway over Bendigo Creek. It was always regarded as a highway bridge and is wider than the other bridges in the group, carrying four traffic lanes. It had a span of 55 feet in a shallow arch, and a width of 99 feet.
6. Booth Street Bridge, still in service.
7. Wade Street Bridge. Curiously this bridge no longer has its bluestone coping stones on the top of the parapet walls. It is not known why. Were the walls rebuilt at some time or was the bridge originally constructed with the simple concrete coping slab present today?
8. Oak Street Bridge has been replaced by a new bridge, for the same reason as the Myrtle Street Bridge was replaced.



Map of Bendigo showing the 8 Monash bridges, from 1 (R) to 8 (L) in red circles. Adapted from an old RACV map

King's Bridge, Bendigo. Photo Owen Peake

Thistle Street Bridge, Bendigo. Photo Owen Peake

Except for the rebuilt King's Bridge, with its two spans and metal parapet fences, and the High Street (Calder Highway) Bridge with its four-lane highway width, all the bridges were very similar to each other. In the references used, it is noted that the High Street Bridge was designed with a 55ft (about 17metres) span, but no other bridge spans are recorded in references seen. It is probable that all the bridges (except King's Bridge) had similar spans – they certainly look similar, with elegantly simple appearing shallow arches, such as could never be obtained with unreinforced concrete. The arches and spandrel walls of all the bridges are reinforced concrete. All the parapet walls (except King's Bridge) are brick with a row of bluestone blocks at the base of the parapet wall and as a coping, except for Wade Street as mentioned above.

John Monash Overcomes Problems & Develops His Design Skills

Some of the engineering heritage we study is particularly important in that it incorporates innovations in engineering which were quite new at the time of construction. In some cases the new concepts changed almost everything in construction design which followed. The eight reinforced concrete bridges in Bendigo represent such a case. We should take note of the engineers who invented or used these new engineering concepts. They are an important part of our engineering heritage. Some were giants whose innovations literally changed the world. The eight bridges in Bendigo may look somewhat modest now but the men behind them were visionaries who were prepared to take great risks to implement innovative technology.

The key individuals in this case were business partners John Monash and Joshua Anderson. They made a huge contribution to the modern Australian engineering world. Before Monash & Anderson started to use the Monier reinforced concrete patents there were very few concrete bridges in this part of the world. They took risks, sold the new innovations with great vigour and, after much heartache, successfully demonstrated reinforced concrete technologies which remain familiar today.

Until the Monier patents were applied most bridges in Australia were built of masonry, wrought iron or timber. Masonry could only be used for arch bridges where it was in compression. Wrought iron had to be imported and was expensive and took a long time to deliver from the United Kingdom. Timber lacked durability and was terribly vulnerable to bush fire and flood damage. Concrete, before Monier, was good in compression but poor in tensile strength. Monier added wrought iron (or later steel) to the structure to give concrete structures tensile strength. Now we can build soaring structures of reinforced concrete. These structures are not only strong but have a very long life. The early Monier arch bridges mark the beginning of the use of reinforced concrete for structures such as bridges. That makes them very important milestones in the history of engineering.

King's Bridge under test before failure Melb. Uni. Archives

The Bendigo project was not without problems. The King's Bridge failed under test when the Council engineer increased the test loadings and one man was killed. Monash & Anderson rebuilt the bridge as a two-span structure at their own expense.

They also engaged Professor William Charles Kernot, first Professor of Engineering at Melbourne University and a highly respected academic of the era, to try to understand the cause of the failure. It became clear that the failure did not stem from material deficiencies, construction errors or problems with the design calculations. Rather the investigation revealed that the informal design standards of the day were deficient in dealing with highly skewed bridges.

King's Bridge after testing failure. Melb. Uni. Archives

So where did concrete bridge development go after the early Monier bridges? We only need to look at where concrete bridges now stand to see something of what happened. Monash cut his teeth on the Monier patent arch bridges but he was an innovator and soon moved on. It is said that Monash led in reinforced concrete girder bridge design and construction in Australia after Anderson left the partnership. The impressive Janevale Bridge on the Loddon River at Laanecoorie just 40 km to the west of Bendigo, built in 1910-11 shows just how quickly the fertile mind of Monash moved. To the casual observer the Janevale Bridge looks very little different to modern "T" beam bridges.

Janevale Bridge under Test c1911 — Melb. Uni. Archives

Janevale Bridge c1997 — Photo Lesley Alves

During almost every journey by road or rail we cross reinforced concrete bridges in large numbers. Most are small, standard designs, built to the standard drawings of road and rail authorities, and we cross them without much thought. Now and again we cross a big concrete bridge such as the mighty Gladesville Bridge in Sydney Harbour, which held the "longest span for a concrete arch bridge" record for 16 years. Whilst modern "T" beam bridges incorporate off-site fabrication of the beams and pre-stressing techniques they look much the same. The use of modern trucks and large mobile cranes has also contributed to the capability of modern bridge engineers to build impressive bridges quickly.

General Sir John Monash GCMG, KCB, DEng., wasn't just a Soldier

We tend to think of General Sir John Monash more as a soldier than as an engineer. We should remember that John Monash was as much an innovator on the battlefield as he was on the bridge sites of Bendigo. He planned his battles with a level of detail and precision which confounded the enemy but which would be familiar to engineers. He grasped and applied the concept of "integrated force" – using infantry, artillery, tanks and aircraft in close co-ordination to reinforce his attacks in such a way that he literally terrified the enemy into submission. Perhaps he regarded the battle plan as an engineering challenge? It is certainly true that he captured vast amounts of ground on the Western Front and brought World War I to an end much more quickly than had he not been involved. However that is another story. We in the engineering profession can do worse that remember that this giant of his time was first and foremost an engineer.

Engineering Heritage Victoria (EHV) has had a sub-program within its Heritage Recognition work to recognise structures designed or built by General Sir John Monash, the firm Monash and Anderson or later iterations of companies with which Monash was associated, as a contribution towards the celebration of the centenary of the ANZAC Campaign in 2015. Heritage recognition ceremonies so far accomplished for Monash works include bridges mentioned above and the Yallourn Power Station in the Latrobe Valley, built while Monash was Chairman of the State Electricity Commission of Victoria in the 1920s. The EHV ceremony for the eight bridges in Bendigo was held on 9 August 2014 with partners City of Greater Bendigo and VicRoads. The marker and interpretation panel are erected between the High Street and Booth Street Bridges on the bank of Bendigo Creek within a few metres of the point where the first gold was found in Bendigo. Bendigo made a huge economic contribution to the development of Victoria during its incredible Gold Rush but perhaps the emergence of the reinforced concrete bridge was an even richer treasure.

Owen Peake
Engineering Heritage Victoria

References and more information

The nomination document for engineering heritage recognition of the Bendigo Monier Bridges should be available for downloading from the Engineers Australia website in due course. In the meantime, Alan Holgate's website on the Engineering Enterprise of (Sir) John Monash prior to WW1 has an extensive section on the Bendigo Monier Arch Bridges – contract acquisition, planning, design & construction. This can be found at:
http://www.aholgate.com/texts/bgobrshist.html
Meanwhile, typing *Bendigo Monier arch bridges* into a search engine, brings up a number of information sources and images. Find a biographical article about Monash from the ADB at: http://adb.anu.edu.au/biography/monash-sir-john-7618