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Historic Bridges in New Zealand: Five Case Studies

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SUMMARY: The many fast flowing rivers in New Zealand have presented challenges to the early engineers. Prevailing bridge types are discussed. Five short case studies of different forms of bridge design are presented. All have been assessed, researched, preserved and presented to the public as nationally significant historic structures. The value of cooperation between the Engineering Heritage Committee of the Institution of Professional Engineers New Zealand and the New Zealand Historic Places Trust is acknowledged.

1 INTRODUCTION

New Zealand is a land of rivers and streams, many fast flowing. From deep chasms to broad meanders they presented challenges to the early engineer. So great was their number and so meagre the resources in skilled men, permanent materials and money that often their construction was delayed for many years. Either ferry punts were used or in desperation a minimal bridge was erected, soon to be swept away in the all too frequent floods.

Many districts had copious supplies of timber so this became the predominant material. Few areas had good stone, brick was rarely used, and occasionally iron bridges were built before steel became available. From the first decade of the twentieth century the virtues of reinforced concrete were soon appreciated. Some pioneer examples of the latter are still in use.

Early timber bridges frequently lasted but a few years - built of indigenous softwoods from trees nearest to hand and often of inferior species they suffered from decay and structural failure.

This was aggravated by the very wet climate in some areas. Nevertheless there were some suitable timbers available, especially in the north where the splendid kauri was both plentiful and durable. Totara and rimu were also used but towards the end of the nineteenth century there was considerable reliance on imported Australian hardwoods.

The very widespread prevalence of timber truss bridges, usually painted in red oxide, produced a vernacular form in the New Zealand countryside. Today there are only a few examples remaining.

Wrought iron and cast iron were in use for bridges and some can be seen today. They were superseded by steel in trusses and plate girders, especially for railway bridges and viaducts.

2 TYPES OF BRIDGES

For quite short single or multiple spans the timber beam or stringer predominated for vehicular bridges. For larger spans various forms of truss were used including the simple king post, Warren, Whipple, Howe and Pratt. One of the best examples of the latter was demolished in early 1972. It spanned the Manawatu River at Ballance and consisted of a 61m timber double intersection main truss with a smaller conventional Pratt truss at the south end. Although derived from very early European examples the truss owes its development both in timber and iron (later steel) to U.S. engineers. New Zealand looked to America for truss design rather than Britain.

Masonry arch bridges were not common and quite unknown in many regions where suitable stone was unavailable. Brick arch construction was even rarer.

The suspension bridge was used extensively, especially across rivers in deep gorges where a single span was desirable. The narrow swing bridge, limited to foot traffic only, was common and today this type is still being erected in rugged bush country as an aid to trampers.

After some early use of timber trestles in railway viaducts the steel trestle was favoured for railway construction and tall viaducts were built between the 1880s and the 1930s. The largest is the Mohaka Viaduct in Northern Hawkes Bay with a height of 95 metres - the fourth highest in the world when completed in 1939.

The development of reinforced concrete construction by the turn of the century saw a big interest in this material for bridges. It became popular because of its permanence, avoidance of rot and rust, use of mainly local materials and no maintenance. The reinforced concrete arch was in use from the first decade with a spectacular extant example opened in 1910. This is the Grafton Bridge in Auckland having a main span of 97.6m with a height of 44.8m. When built it was the largest r.c. arch bridge in the world. Reinforced concrete was favoured by some engineers for bowstring arch bridges with several fine structures resulting. The earliest built in 1917 is still in use.

3 WAIANAKARUA NORTH BRANCH BRIDGE

This fine bridge, located 26 kilometres south of Oamaru on S.H.1, was opened in 1874. The designer was John Turnbull Thomson, who had been Provincial Engineer and Chief Surveyor of Otago and later the first Surveyor-General for

New Zealand. Born in Northumberland, England, he came to Otago in 1856 after 18 years of service in the former Straits Settlements. His design for the Waianakarua North Branch Bridge is said to have been inspired by the picturesque Twizel Bridge over the Till near his birthplace. Thomson became noted for his paintings made during his explorations of Otago as a surveyor as well as other parts of New Zealand, England and the Far East.

The Waianakarua River was once known as the Rookery because of the numerous shags in the area.It has two branches, both having masonry bridges replacing fords that were prone to treacherous floods. The North Branch structure has twin skew arches of 18.28m with a 4.57m rise. Built of Kakanui limestone with sandstone foundations the bridge has a length of 50 metres. As was common with stone bridges there is a vertical rise giving a modest hump.

By today's standards it is rather narrow being only 6.4m between the solid stone balustrades. The mason's skill can be appreciated in the ashlar (dressed stone laid in regular courses) and in the voussoirs to the arches which are reticulated, that is, cut into regular sinkings to give a pattern. In addition the setting out of the masonry for the skew arches called for craftsmanship of a high order. The central pier has rusticated blocks showing the bold and characteristic effect of ridges and hollows. It projects to give cutwaters ca ped by a plastered semi-dome.

This bridge is the second oldest on a State highway and in 1975 it nearly followed the fate of the South Branch bridge a kilometre away. Also designed by Thomson in masonry this was built in 1869, but has been modified by a reinforced concrete deck cantilevered over the sides. The North Branch bridge gains considerably in a setting enhanced by its close proximity to the former Waianakarua Flour Mill built of stone in 1879 and now a motel with attractive grounds.

The New Zealand Historic Places Trust has classified the bridge as one of national importance and it also has a plaque awarded in the IPENZ Engineering to 1990 Project.

4 CLIFDEN BRIDGE

Replacing a ferry punt on the formerly turbulent Waiau River this suspension bridge was designed in 1896 by C.H.Howorth, Engineer to the Southland County Council. The opening took place in April 1899.

It has a clear span of 110m with totara deck and stiffening truss of Australian hardwood. The concrete towers, founded on limestone, have a decided taper and are plastered and lined out to simulate ashlar (dressed and coursed stone). The main cables passing over saddles in openings below the tower caps have 28 hangers on each side to support ne deck. Anchorages are provided by large limestone blocks.

On the upstream east tower a World War 1 Roll of Honour tablet was added giving the names of the fallen from the Clifden district. There are several memorial bridges in New Zealand but others were specifically designed as such.

Generally speaking the Waiau River has less flow since the completion of the Lake Manapouri Power Scheme. In 1978 a replacement bridge in reinforced concrete was built some 180 metres downstream. Because suspension bridges, once very common, were becoming comparatively rare the New Zealand Historic Places Trust decided to take over the Clifden Bridge and maintain it in a small reserve with pedestrian use only. It was already classified as a structure of national importance and its retention has had strong local support, especially for its War Memorial function. The bridge records of design and construction were available for research when it was offered to the Trust facilitating the proposal for retention.

The design engineer, C.H.Howorth, had his engineering training in Dunedin and in 1880 he was appointed Engineer to the Southland County remaining in that position until 1906. He had some talent as an artist with his works being held in galleries throughout New Zealand and Australia.

As responsibility for the bridge was a national one at that time the design was delegated to him with the contract supervision being under E.R.Ussher, District Engineer of the Public Works Department in Dunedin.

5 MAKOHINE VIADUCT

Although a railway link between Wellington and Auckland had been considered in 1870 it was 38 years before the dream of a Main Trunk Railway was realised. The central North Island at that time consisted of heavy bush with many fast flowing streams in deep gorges in a mountainous plateau. Even to the south of this region the country was rugged with only a few scattered farms until the railway was in operation.

The first major bridge in this latter area was the Makohine Viaduct 13 kilometres north of Hunterville. Construction began in 1897. The design was that of Peter Seton Hay who later became Engineer-in-Chief of the Public Works Department. Born in 1852 in Glasgow he died in 1907 from pneumonia contracted while inspecting progress on the Main Trunk Railway.

The viaduct is a steel lattice girder structure 72m above the Makohine Stream. There are two spans of 75m, a central span of 53m and two end spans of 12 metres. The limitation to two main piers, also of lattice construction, increased the spans. Abutments and pier bases are concrete.

Tenders called in 1895 were so high the Government authorised the PWD to build the viaduct using the cooperative contract system. This entailed the employment of groups of about 10 workmen under an elected headman who received extra pay. Materials and equipment were provided by the department whose engineers and overseers supervised the work. This system had been introduced by Prime Minister R.J.Seddon as a means of overcoming the poor work done by many contractors at that time. Governments had tended to accept the lowest bids regardless of the competence and integrity of the tenderer.

Work began on site in June 1896 but the project had many delays with work being discontinuous. Landslides from torrential rain delayed work for one winter. Floods caused more holdups followed by a lengthy strike in England delaying an order for steel and machinery. Furthermore the pier foundations proved costly in the poor ground.

All steelwork was taken to the site and fabricated in a temporary workshop operating 16 hours a day. To speed

progress electric light was installed at the bridge site thus extending the hours of work. It was the first such occasion on a construction site in New Zealand.

This was the only viaduct site on the Main Trunk where staging was used. The actual steel erection took only two years but the bridge was not opened until 17 June 1902. Originally the south approach had a tunnel del ouching directly onto the viaduct, however this has been turned into an open cut in more recent times. With the introduction of the much heavier K and KA locomotives from the mid 1930s the trusses had to be strengthened with vertical struts. Recent electrification of the line has modified the viaduct silhouette.

It is worthy of note that before the opening of the viaduct a scenic reserve of 22 hectares of the Makohine Gorge was gazetted. Today this is a pleasant picnic spot for motorists as No 1 State Highway passes nearby over a low level concrete bridge.

The New Zealand Historic Places Trust has given its highest classification to the Makohine Viaduct as a structure meriting permanent preservation. It was the forerunner of several splendid steel lattice viaducts built in the first decade of this century for the Main Trunk Line, although regrettably one of the most accessible has been demolished after a major deviation was constructed.

6 EDITH CAVELL BRIDGE

Of the many bridges spanning deep gorges in New Zealand that over the Shotover River at Arthurs Point 5 kilometres from Queenstown is one of the best known. It was designed by F.W.Furkert to replace an 1875 timber deck truss. Opening in 1919 it was built in record time.

The turbulent gold bearing Shotover river narrows considerably at this point. Being the most suitable site for a bridge it was logical to use the same position and so the existing schist stone abutments were retained. The timber truss served as centering for the new bridge which is a two hinged parabolic reinforced concrete arch having a span of 30.48m with a height above water level of 27.4 metres.

The length is 42.6m and the roadway is 4.26m wide - considered adequate for the sparse light traffic on a rural road at the time.

The deck is immediately above the crown of the arch which has horizontal ties to the vertical struts. The balustrade is open having concrete posts with wire ropes strung between.

The name comes from the persistence of a local miner, Jack Clark who lived nearby in a tiny sod hut. He had asked the Lakes County Council to name the bridge in honour of the British nurse shot by the Germans in 1915 for helping Allied prisoners to escape. When refused he painted her name on a rocky bank near the bridge to coincide with the formal opening. Subsequently he painted her name on the side of the bridge and after many years the public have adopted it instead of the official version of the Upper Shotover Bridge.

Frederick William Furkert(1876-1949) became Engineer-in-Chief and Under-Secretary of the Public Works Department from 1920-1932. He was the author of the only study of early engineers in New Zealand and was an outstanding engineer of all round ability. The completion on time of the North Island Main Trunk Railway was due largely to his superior management skills.

The Edith Cavell Bridge was identified, assessed and classified as a structure of national importance by the New Zealand Historic Places Trust. Today it has a high profile in the public's appreciation for it overlooks the assembly point for a commercial jet boat service providing spectacular views of the craft shooting through the gorge. Likewise it has considerable aesthetic quality in a spectacular setting.

7 MANGANUKU BRIDGE

Although there are still considerably larger and more impressive timber truss bridges in New Zealand the single span Manganuku Bridge has the virtue of being in a splendid bush environment. No longer in use and therefore untrammelled by vehicular traffic it can be appreciated by the picnicker and tramper in a more leisurely way.

The bridge was built in 1928 by the Public Works Department at the end of the timber truss period. It is located in the Waioeka Gorge section of S.H.2 about 25 kilometres northeast of Matawai. This was a new road to avoid the even more winding and narrower hilly route to Motu further to the east. It was in use until 1964 when a reinforced concrete bridge was built.

The original bridge has concrete abutments and a single pier near the right bank with a shore span of 9.5m RSJs. The single truss is a modified six panel Howe type with vertical rods and a span of 24.8 metres. The width is 4.74m between truss centrelines. Decking, transoms, joists, wheelguards, braces and handrails are Australian hardwood with the deck having had bitumen sealing at some later stage.

Since its replacement in 1964 there has been deterioration through lack of maintenance and this has been aggravated by the very heavy rainfall in this forested area. Structural failure of the downstream truss has occurred in the bottom chord through timber decay. A full engineer's report was made and the Department of Conservation, guardians of the bridge on behalf of the Opotiki District Council, apportioned funds to repair the damage and do other deferred maintenance work to prolong the life of the structure.

As the focal point of a most attractive picnic area only 200 metres from the highway and at the start of a tramping track it is worthy of retention. The New Zealand Historic Places Trust has classified the bridge on the basis of its comparative rarity as a formerly commonplace, indeed vernacular form of bridge design and construction. Its continuing use for pedestrians in a public reserve in a most delightful bush and stream setting enhances its value and demonstrates the importance of presentation for public enjoyment.

8 AWARENESS

An awareness of bridges as structures exciting interest through their form and an aesthetic appreciation of their visual qualities has been slow to develop. Indeed the civil engineer has been loath to appreciate the historical importance of technology in bridge design; also the need to both preserve and conserve worthy examples as an ongoing

record of achievement in transport and communication.

Industrial heritage (industrial archaeology) has not been given its due regard in New Zealand and the general public is only now beginning to take an interest in such aspects as early bridge engineering.The New Zealand Historic Places Trust has been at the forefront through its statutory role of identification, research, assessment, recording, preservation and presentation. Nevertheless, very little has been written on the history of bridges in this country and there has been no comprehensive work published.

9 COOPERATION

Until two or three years ago the Institution of Professional Engineers of New Zealand Engineering Heritage Committee and the New Zealand Historic Places Trust steered separate courses with little or no appreciation of the value of joint participation.

In 1989 the Engineering Heritage Committee offered a place for a representative from the Trust and the writer was appointed. This has brought the philosophy and operations of the Trust before the Committee as well as 18 years of experience in identification, research, assessment, recording, preservation and presentation.

The Trust is the proud owner of a number of engineering structures which it has acquired as the only means of preserving them at the time. It has had to go through all these steps for each project. As the Committee is Christchurch based (except for the writer) a local member was appointed to the Canterbury District Committee of the Trust and this has proved to be mutually beneficial.

New Zealand is a small country with limited resources in many areas so that close cooperation between such bodies is essential if real progress is to be achieved. There is a tremendous amount of work to be done in a rich field of early engineering endeavour.

10 CONCLUSION

Bridges were of the utmost importance in the development of New Zealand. Early engineers had many challenges in their design and construction and were conspicuously successful in many instances. All manner of bridge types were built although masonry arch bridges were rare. The five case studies indicate bridges being retained for their evidence as examples of engineering technology and therefore historic merit. The timber truss was a vernacular design made familiar by its usual red oxide treatment. Close cooperation is being developed between IPENZ and NZHPT but there is a great deal to be done in bridge conservation and public awareness.

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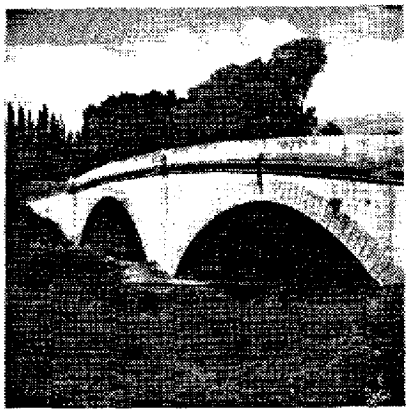

Figure 1 Waianakarua North Branch Bridge opened in 1874.

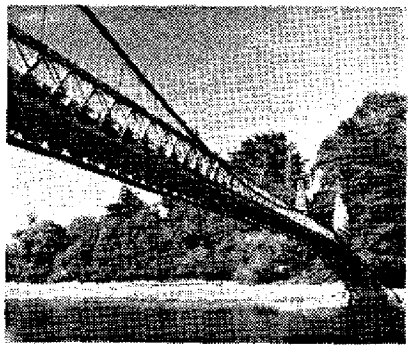

Figure 2 Spanning 110m the Clifden Bridge over the Waiau River is a war memorial.

Figure 3 Edith Cavell Bridge spans the turbulent gold bearing Shotover River.

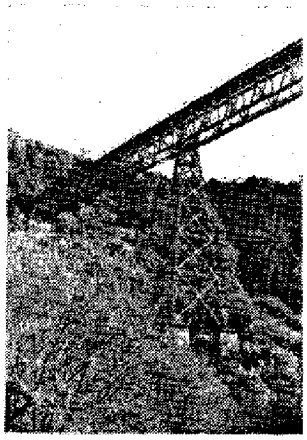

Figure 4 Makohine Viaduct, 72m high, opened in 1902.

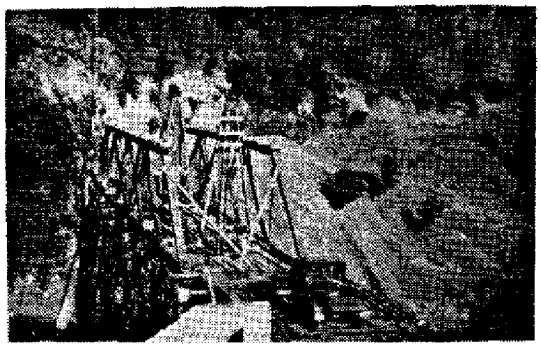

Figure 5 The Howe truss was a common form in timber bridges. Manganuku Bridge was completed in 1928.