A large timber arch bridge once crossed the wild Waikato River at Ongaroto, six kilometres west of Atiamuri on State Highway One (Figure 1). The Ongaroto bridge carried the Taupo Totara Timber Company’s trains from the sawmills near Mokai to the timber-yard and government railway at Putaruru. Designed in 1904 by Wellington civil engineer James Fulton and built by John McLean and Sons, it was reputedly the Southern Hemisphere’s longest single-span timber bridge, with an effective span of 61 metres and an overall length of 79 metres.

The Taupo Totara Timber Company (TTT) was founded in 1901 by a group of Wellington businessmen led by solicitor and entrepreneur Tudor Atkinson, who had been persuaded by local chief Hitiri te Paerata to commercialise several isolated podocarp forests northwest of Taupo. These forests were considered among New Zealand’s finest remaining stands of totara and matai.

James Fulton was a founding director and shareholder of the TTT, and a close associate of Tudor Atkinson. In March 1903, he and the contracting firm of John McLean and Sons signed a construction contract with the TTT to build the railway. By then, a survey party had laid out the proposed route from the sawmill site at Mokai, 23 km northwest of Taupo, to the government railway at Putaruru. From Mokai to the Waikato River, the route traversed a large block of freehold land owned by the company. The railway crossed the river at a narrow gorge near the downstream boundary of this freehold land, and then climbed a valley toward the Wawa saddle, the most practical route over the Maungaiti Range and across the Tokoroa Plains to Putaruru [1].
The contractors built a temporary suspension bridge across the river. This was designed to carry a load of 63 tonnes [2], adequate for construction traffic, but not strong enough for the railway. It became the construction platform for the timber arch bridge.

The arch bridge was built entirely of heart totara from the company’s forests (Figure 2). The railway ran between two pairs of timber arches, each built of seven laminations bolted together. The arches leaned inwards at about eight degrees (Figure 3). On each side of the bridge, the vertical timbers of a cross-braced truss were sandwiched between the two arches. These trusses were connected, top and bottom, by transverse timbers and cross-bracing, and their ends were attached to the timber columns that originally supported the suspension bridge cables. These trusses distributed the train-wheel load along the length of the arches, which provided the bridge’s primary strength (Refer to Table 1 for sizes of principal members).

The northern bank comprised rhyolite rock. On this side, the ends of the arch timbers were notched into a heavy transverse timber, with totara packing timbers spreading the load into the rock.

The softer river deposits on the southern bank required more complex foundations. Here, the uphill side of a trench was lined with close-spaced timber piles, and then partly filled with rammed stone grouted with concrete. The timber piles were propped to a second row of piles further back from the river. The arches were notched into large transverse timbers laid in the trench [3].

### Table 1. Size of principal members (2 Arches and one through-truss per side).

<table>
<thead>
<tr>
<th>Member</th>
<th>Size (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arch</td>
<td>2/375 x 700</td>
</tr>
<tr>
<td>Truss top chord</td>
<td>2/150 x 300</td>
</tr>
<tr>
<td>Truss bottom chord</td>
<td>2/150 x 300</td>
</tr>
<tr>
<td>Truss vertical tension</td>
<td>2/275 x 250</td>
</tr>
<tr>
<td>Truss diagonal (compression)</td>
<td>200 x 250</td>
</tr>
<tr>
<td>Truss diagonal (tension)</td>
<td>2/230 x 130</td>
</tr>
<tr>
<td>Transom beam</td>
<td>2/150 x 675</td>
</tr>
<tr>
<td>Rail Beam</td>
<td>2/150 x 450</td>
</tr>
<tr>
<td>Sleepers</td>
<td>185 x 125</td>
</tr>
</tbody>
</table>

The bridge’s strength depended on the shape of the arches, which were designed as circular arcs. Stanley Jones, a member of Mr. Fulton’s staff, later described how the contractors achieved the correct shape. The bridge was assembled with the arch timbers temporarily held together. Upstream of the bridge, there was a bend in the river, where Mr. Jones set up the lid of a large billy. Loaded railway wagons were moved on to the bridge from each end. Meanwhile, sighting over the billy lid, Mr. Jones checked the shape of the arches. When the curve matched the shape of the billy lid, the laminations were bolted firmly together [4].

The bridge was designed to carry trains weighing about 1.7 tonnes per metre of length, hauled by a 24 tonne six- wheeled locomotive [5]. Mr. Fulton’s design shows how engineers of the Victorian era transferred loads through a timber structure. The track was mounted on longitudinal rail beams on top of transverse transom beams. Vertical truss members carried the load from the transoms into the arches and the longitudinal truss chords. Critical load-bearing joints were notched and through-bolted. The hangers were notched over the transoms, and into short bearers on top of the arches, and into cross-ties above the upper truss chord timbers (Figure 4). The bearers were notched into the top arch lamination. At the intersections between the arches and longitudinal truss chords, the chords were spliced across the joints with bolted “iron” (probably steel) plates. Many bracing timbers were also notched into structural members.

James Fulton was born in Outram, Otago, in 1854. He was educated by private tutors. In his late teens he worked at local engineering workshops and a large flaxmill before joining the Public Works Department as an engineering cadet in 1874. After completing his training, he worked on various surveys before going into private practice in 1880. In late 1882 he joined the Wellington and Manawatu Railway Company, and was later promoted to Traffic Manager and Locomotive Superintendent. Back in private practice from the beginning of 1897, he designed the Wellington cable car,
James Fulton and Tudor Atkinson arrived in Putaruru to begin the project, Mr. Atkinson wrote: "We are bustling here now and there’s joy to me in the steady movement... three bullock teams of eight bullocks each and a dozen men collected and horse teams etc. - We are getting the engine off today from here and it is expected to take a week to get it into the bush as hay for the bullocks and food for the men have all to go in together: it’s like a small convoy [9]." The "engine" was a small sawmill.

Apart from the Atiamuri Hotel, there was no shelter. Stanley Jones wrote that the pumice soil would not hold tent pegs during winter gales, and surveyors would sleep in trenches cut at right angles to the wind, covering themselves with tarpaulins.

The bridge stood for more than twenty years. Timber trains would take about eight hours to make the journey from Mokai to Putaruru, though lightly-loaded special trains could make the journey in four hours. A train usually consisted of five or six flat-top timber wagons with a small van for passengers, mail, and freight. An eight-wheel "Heisler" locomotive would haul a loaded timber train to Koporahi, near the present-day Tokoroa golf course, where it was met by a conventional locomotive from Putaruru hauling empty timber wagons. The locomotives swapped trains and returned to their home bases. The line seldom carried more than one train per day.

Originally the TTT used 20 tonne eight wheel Heisler locomotives. These were replaced on the main line in 1921 by larger eight wheel Heislers, weighing 32 tonnes. The timber wagons usually carried about 14 tonnes of timber. All up, the trains were slightly heavier than the bridge's design load. Several independent engineers reported on the TTT railway during the life of the timber arch bridge. Public Works Department engineer John Coom wrote in 1911: "I have calculated the strengths of the principal parts, and find they are fully strong even for the loads it was originally proposed to carry.. [10]." According to Stanley Jones, Mr. Fulton intentionally made the arches considerably stronger than necessary [11]. However, F.W. MacLean, Chief Engineer of the New Zealand Railways, wrote in 1920: "To counteract some movements in the structure some heavy struts have been introduced, but the bridge shows very considerable deflection under load [12]" (See Figure 5). These assessments would have assumed the laminated arches acted as a unit. However, with a pair of 22 mm bolts every 1.1 metres, the bolts could not provide enough friction to prevent the laminations sliding relative to one another.

By the late 1920s the bridge was showing its age. By then, Mr. Fulton had retired and the TTT consulted Stanley Jones’s firm, Jones and Adams. The engineers were concerned that the bridge had become distorted horizontally, and the arches were sagging at one end. The laminations had moved. Jones and Adams re-adjusted the arches to their proper shape. During that project, they noticed decay in one of the transoms. It was

Figure 4. Sketch showing connection of members between the transoms and arches and the notches which transferred the loads. All members held together by bolts (not shown). Through-truss chords and cross-brace members not shown for clarity. G D Honey sketch.
the beginning of the end. In late 1929 they inspected the bridge again, finding decay in many parts, including the critical arch timbers. For most of its life, the bridge had been hosed down with fresh water before each train to reduce the fire risk from sparks pouring out of the locomotive’s exhaust. Jones and Adams speculated that this, together with the fact that the timber was not seasoned before being made into a bridge, may have sealed the structure’s fate. The timber was rotting from the inside, and it was impossible to distinguish good timber from bad without boring into the timbers [13].

The TTT imposed a six kilometre per hour speed limit and forbade anyone from riding the train across the bridge. The train would stop and wait while the fireman walked across. Then the driver would start the engine and jump off, leaving the train to cross the bridge at a very slow walking speed. When it reached the other side, the fireman would hop into the cab and stop the train, while the driver, guard, and any passengers crossed the bridge on foot [14].

In 1931 timber arch bridge was replaced with a two-span steel truss bridge. The timber bridge was dismantled.

The TTT was taken over in the 1970s by NZ Forest Products, which eventually became part of Carter Holt Harvey. Little remains of the TTT railway or the Mokai sawmill. Only an occasional piece of sawn totara, or faint disappearing earthworks, testify to its former existence. The bridge site is about three metres below the surface of Lake Whakamaru. A concrete bridge spans the lake at this point, part of a private forestry road along the approximate route of the TTT railway.

REFERENCES


Figure 5. Photograph of bridge showing additional strengthening members (dark coloured). Date of photograph not known. Suspension cables from the temporary bridge have been removed. National Library of New Zealand
He transferred to Wellington in 1971 and maintained an interest in timber engineering, representing MWD on Standards Committees related to timber and chaired NZ3603, NZS 3604 and NZS 3606 committees for a time and sat on NZS 3616, NZS 3618 and NZS 3631. Also during this time he was a committee member of the FRI Protestion Forestry Advisory Committee.

During the early 1970s a group of engineers in Wellington with an interest in timber decided to set up a technical group under the auspices of IPENZ called the Timber Design Society and Trevor was its founding president and later became a Fellow.

As he became increasingly involved with management in MWD and the change from a government department to a commercial enterprise, his involvement with timber diminished.

It was after Trevor retired in 1994 that he came across a blueprint of the Ongaroto Bridge over the Waikato River in the Putaruru Timber Museum. Subsequently he found copies of the original plans of the bridge and its forerunner, a suspension bridge on the same site. The sheer magnitude of the work interested and amazed him, unaware of any other timber structure in New Zealand that can equal its load carrying capacity over such a span. Trevor felt details of the structure should be recorded in a place where Timber Engineers can become aware of it and where it can become part of our heritage record.

Kevin Cudby has assisted Trevor in providing much of the background information and assistance in the writing of this paper. Trevor would like to acknowledge his input and is deeply indebted to him for this.

Kevin is a freelance writer specialising in technical and scientific subjects. He regularly contributes to Engineering Insight and Boating New Zealand. Before he became a full-time writer, he was an electronics manufacturing engineer at AWA New Zealand, and later, Tait Electronics. His book about the Taupo Totara Timber Company, “Men Of Pluck”, was published in 2001. His latest book, “From Smoke to Mirrors”, surveys New Zealand’s options for climate neutral alternatives to conventional petrol, diesel, and jet fuel.