Cairns to Kuranda Bridge QLD

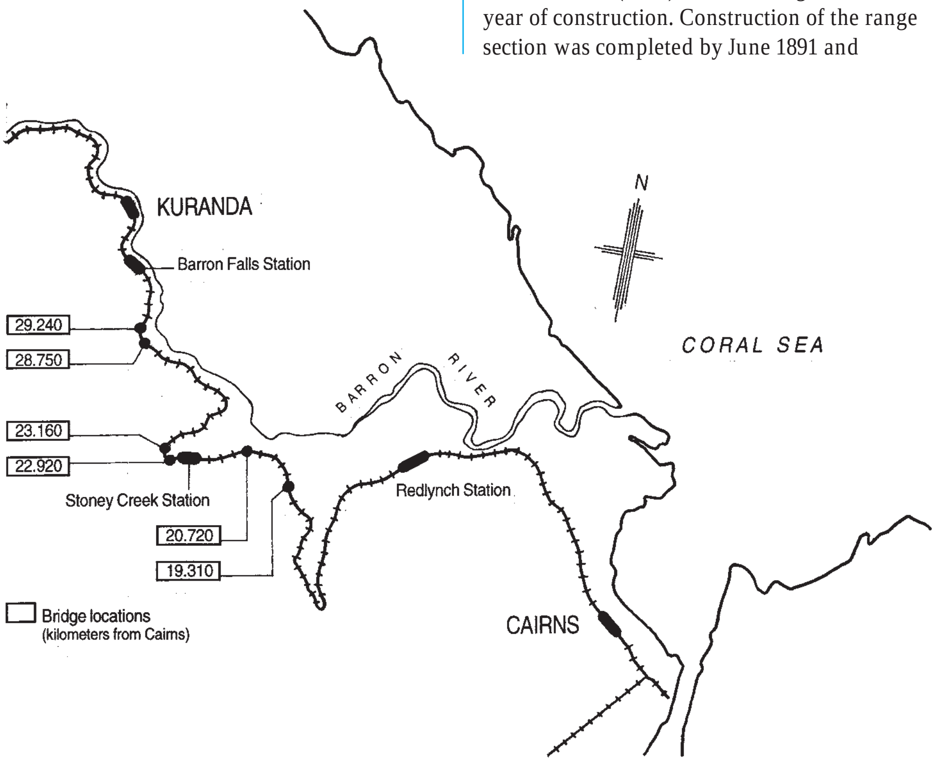
July 2001

This case study was written at the time when InfraBuild (formerly Liberty OneSteel) was part of BHP. In that context, in some instances within this case study reference may be made to BHP.

Rail Link to the Past

Versatile, cost-effective structural steel enabled six of Australia's most inaccessible and remote railway bridges to be upgraded with minimal disruption to rail traffic.

Thirsty work – Irish and Italian navvies roll 300 beer kegs up the track.



Australia's most breathtaking scenic railway route, the Cairns to Kuranda line, had its origins back in the 1870's. With the opening up of the goldfields and pastoral districts around Cairns and to the west, the need for a railway became obvious.

In March 1886 construction commenced on the Herberton to Cairns line. Engineer John Robb successfully tendered the sum of £290,094 to build the intimidating fifteen-mile long range section of the line, from Redlynch to Myola, three kilometres past Kuranda. The major challenge facing Robb was to negotiate the ascent of the face of the tableland, which rises from a height above sea level of 5.5m at Redlynch Station to 327m at the summit of the ascent, Barron Falls Station, which lies 19 km inland.

Materials, plant, tools and explosives were transported by mule, from base camps at Kamerunga and Stoney Creek, up tracks that were cut along the leading spurs of the mountain. Excavation for cuttings was particularly difficult, especially in the Barron Gorge section, where the average ground slope was about 45^0, and comprised loose rock, rotting vegetation and soft soil in depths varying between 4.6m and 7.6m.

Up to 1500 men, mostly labourers from Ireland and Italy, worked on the line. Fatalities were common due to malaria, scrub typhus and dysentery, snake bite and scrub ticks. Tunnel cave-ins, falls, carelessness and mishandled dynamite also contributed to the horrific casualty rate, which exceeded 30 lives lost.

The weather was a constant threat, with almost 15 feet (4.6m) of rain falling in the first year of construction. Construction of the range section was completed by June 1891 and included 6 steel bridges, fifteen tunnels, and 98 curves, and had an average grade of 1 in 68. John Robb was paid £901,213, a cost three times the initial contract price due to the difficulties and hazards experienced during construction, especially damage caused by landslides during the wet seasons.

Original Bridge Construction

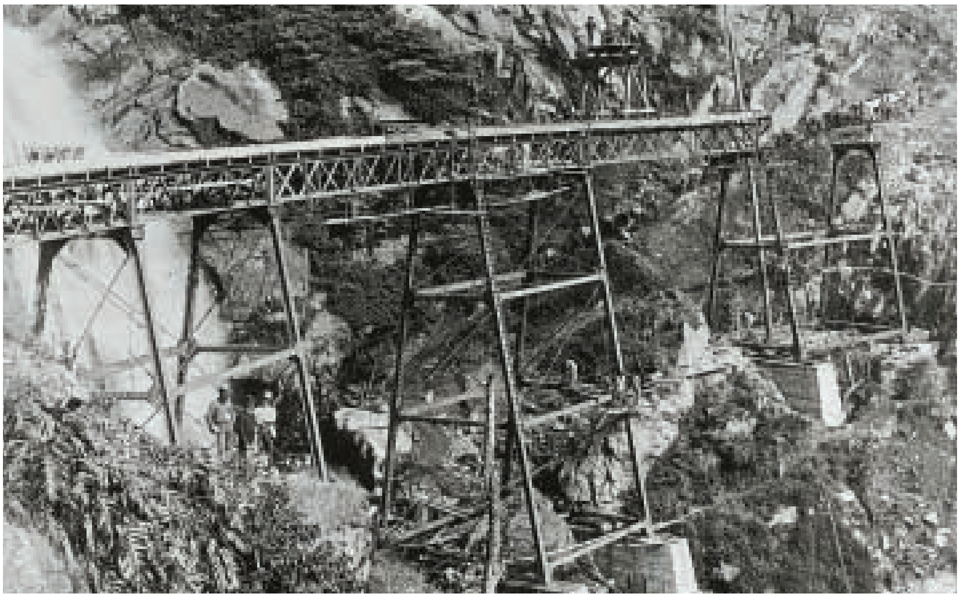
Six riveted steel lattice-girder bridges were constructed, each designed to carry locomotives having a maximum axle load of 8 tons (8 tonnes). The total length of steel bridges constructed was 800 feet (244m). Messrs Walkers Limited, of Maryborough, cut, fitted, and partly riveted up a total of 339 tons of steelwork for the project. The riveted girders were transported in sections convenient for handling by steamers and railway, and when landed at the bridge site, the riveting was completed and the girders launched into place by means of derricks.

Two classes of locomotive were originally used on the line, Queensland Railways 'B13' (combined engine and tender weight 46 tons) or 'B15' (combined weight 51 tons). From Redlynch to Kuranda, the 'B13' engine hauled a payload of about 80 tons and the 'B15' engine hauled 120 tons.

1998 Bridge Strengthening Design

The Cairns to Mareeba bridge improvement work is part of the general infrastructure upgrading associated with the development of the Atherton Tableland sugar industry. This article is concerned with the Cairns to Kuranda section of the line, however a separate contract is presently under way to upgrade the Kuranda to Mareeba portion.

The entire Cairns to Kuranda line, including bridges, is listed on the Queensland Heritage Register. Much of the land surrounding the line forms part of the world heritage wet tropics, hence access is extremely limited and can only be practically achieved by rail transport.



Stoney Creek bridge under construction, 1890. (Pics courtesy Queensland Railways historical collection)

Pruning of vegetation during construction was therefore restricted to a maximum distance of five metres from the extremities of the existing structure. A design solution was required that would increase the load carrying capacity of the bridges from 8 ton to 15.75 tonne axle loads, whilst observing heritage principles. This meant that any additional structure must be clearly identifiable as new (although not too obvious), and must be removable.

The superstructure of most of the existing bridges comprises two trusses, spaced 3200mm apart. The exception is the bridge at 20.720km which has trusses spaced at 2100mm centres. This necessitated a change in construction technique, as discussed later. The truss top chord is raked to suit the track grade on some of the bridges.

The engineering solution developed by Queensland Rail's Engineering Services Division was to add a truss of matching depth, midway between the existing trusses. Apart from increasing the load carrying capacity of the bridge, this has the beneficial effect of reducing the load on the existing outer trusses, thereby reducing the stress levels in the members and extending their service fatigue life. The addition of a truss also eliminated the need to strengthen the cross girders. All timber longitudinal beams have been replaced by steel and in some cases additional steel longitudinal beams have been added. Some existing trusses have been strengthened. Typically, existing top and bottom truss chords are steel whilst the web members are either wrought iron or steel.

The new centre trusses are braced both vertically and horizontally (at bottom chord level) to the existing outer trusses. Bracing members are connected to the new truss through a bolted gusset plate connection. The top chord of new trusses in the bridges at 19.310 km and 22.920 km is stepped to avoid the existing end cross girders.

All steel sections are OneSteel 300PLUS® in accordance with ASNZS3679.1 and steel plates are Grade 250 in accordance with ASNZS3678.

Truss segments were spliced, in place, in the field using bolted connections incorporating web and flange plates. The splice detail varies between the different bridges. The Stoney Creek bridge splice detail for the 15.2m span consisted of the following:

Truss chord splice	(350WC258):
Top Flange -	1 / 400x32x1320 plate with 40 / M24 8.8TF bolts
Bottom Flange -	1 / 400x32x960 plate with 40 / M24 8.8TF bolts
Web -	2 / 180x32x1410 plates with 28 / M24 8.8TF bolts.

Construction

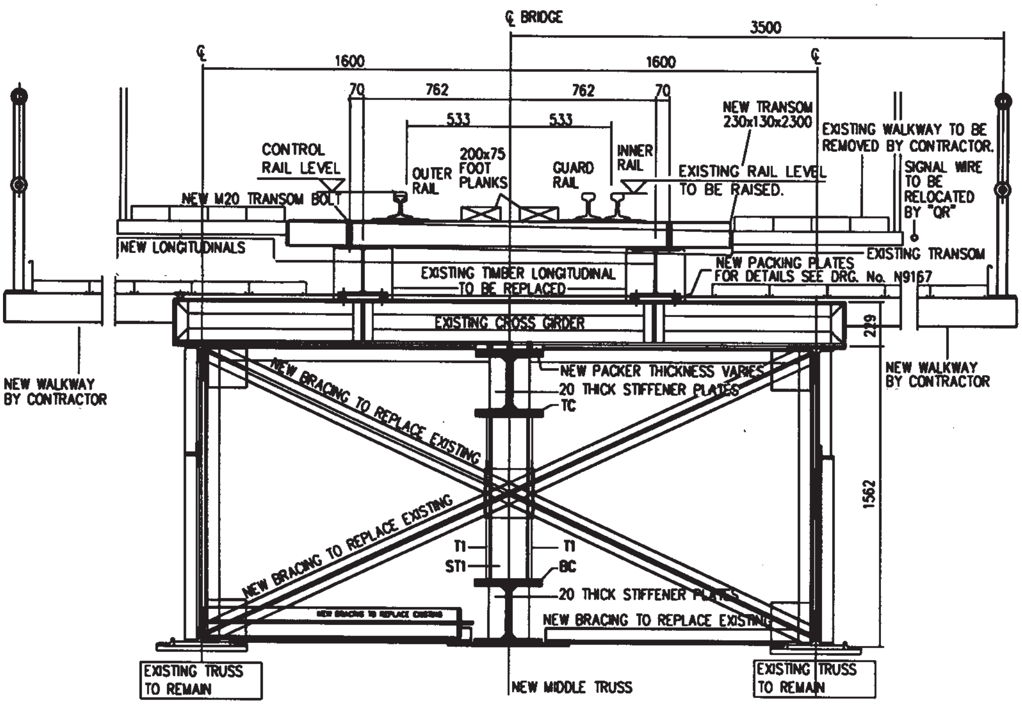
Following in the footsteps of Robb and his army of navvies is Brisbane based civil engineers and contractors, CANSTRUCT, with a construction team of twelve. Whereas Robb relied on the herculean efforts of his manual workers, CANSTRUCT are applying modern engineering, state-of-the-art technology, and safety techniques to this hazardous work. Examples of the technology include a specially designed self-propelling bogey, built by Dawson Engineering in Cairns, which transports a lightweight mobile crane along the track. The 8 tonne Komatsu crane was imported from Japan specifically for the project.

A total of 320 tonnes of steelwork was used in the project, including up to 200 tonnes of OneSteel Welded Column sections. The new trusses were field spliced as follows:

Bridge Location	Span Length (m)	No. of Field Splices
19.310 km, 22.920 km	30	5
20.720 km	21	See Note 1 below
23.160 km	15.2	2
29.240 km	9.1	1
28.750 km	21	2
	30	5

Note 1: Since this bridge was much narrower than the others, and consequently the spread between crane outriggers was much less, the weight lifted by the crane had to be reduced. The components of the truss segments were therefore installed individually.

The installation procedure for the additional truss to the Bridge at 19.310 km was typical of most bridges, and is as follows:



Cross section through bridge at mid span

Prior to Rail Closure

1. Transport truss segments to site and arrange in order of need
2. Remove rivets, as necessary, from existing structure and replace with bolts
3. Install and tighten countersunk bolts
4. Survey, check and drill connection points between new truss and existing cross girders
5. Install static line for entire bridge
6. Position two mobile gantries under bridge
7. Install two fixed chains, supported above the transoms, in the appropriate position for the particular truss segment
8. Remove all bracing, other than key bracing

During Rail Closure

(typically 10.30am to 7.00pm on Day 1; 7.00am to 2.30pm Day 2. Total 16 hours):

1. Establish crane on track, load truss segment on truck, drive crane on to bridge and reverse truck to crane position
2. Remove key bracing at truss position, working from the gantry
3. Lift truss segment off truck, using lifting beams and beam clamps, and lower over side of bridge
4. Connect independent lifting chains and continue lowering until truss swings in under bridge to centre position
5. Disconnect crane from truss, hoist lifting beam and chains, and lower lifting beam chains through centre of bridge. Reattach crane to truss segment
6. Lift truss to underside of cross girders, partially bolt to cross girders (move truss longitudinally using girder trolleys attached to the top chord, if necessary)
7. Install new or temporary key bracing. Install remaining bolts to cross girder connection
8. Repeat above process for remaining truss segments
9. Complete bracing for bridge
10. Return track for use.

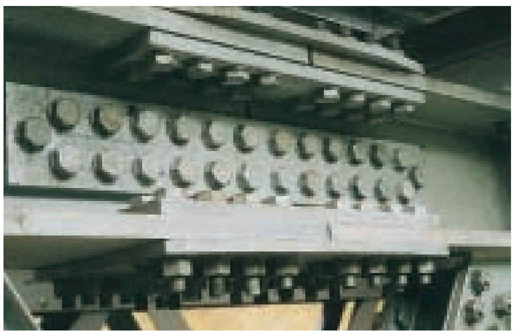
CANSTRUCT also prepared a detailed set of safety procedures which controlled the movement of workers and equipment whilst on the bridge.

Interestingly, the contractor experienced some difficulty in drilling holes through the existing wrought iron truss web members. The hardness of the wrought iron appeared to vary, possibly due to hard slag inclusions in the iron, however perseverance overcame the problem. All lattice towers are strengthened by plating the legs with 200x25 OneSteel 300PLUS

Bridge Location (see Locality Plan)	Track Long'l Grade	Span(s)(m)	Overall Truss Depth (mm)/ Substructure	New Truss Details
19.310 km	1 in 60	30	2800 at midspan[1] WI cylindrical piers, 1067mm diam.	Top & bottom chords vary - 310UC137 (ends); 350WC280 (midspan); 350WC230 (elsewhere) Web members vary - 150UC37 & 2/150PFC typical at ends
20.720 km	1 in 60	21	2000 at midspan[1] Concrete piers	Top & bottom chords - 350WC197 Web members vary - 150UC30 & 2/150PFC typical at ends
22.920 km	1 in 60	30	2800 at midspan[1] Concrete abutments	Similar to bridge at 19.310 km
23.160 km (Stoney Creek)	1 in 99	4 x 15.2	1560 typical[2] WI lattice towers	Top & bottom chords - 350WC258 Web members vary - 200UC46 & 2/150x16 Flat typical at ends
Horiz. curve radius 80 m		3 x 9.1	1560 typical[2] WI lattice towers	Top & bottom chords - 200UC59 Web members – 150UC30 & 2/130x12
28.750 km (Surprise Creek)	1 in 60	1 x 21 end span (Cairns end)	2860 typical[2] Concrete piers	Top & bottom chords –310UC96 Web members vary - 200UC46 typical at ends
		1 x 21 end span (Kuranda end)	2860 typical[2] Concrete piers	Top & bottom chords – 310UC158 Web members vary – 250UC72 & 200UC59 typical at ends
		1 x 30 centre span	2800 at midspan[1]	Similar to bridge at 19.310 km
29.240 km (Christmas Creek)	1 in 60	2 x 15.2 end spans	1410 typical[2] Concrete abutments	Top & bottom chords – 350WC280 Web members vary – 200UC59 & 2/150x20 Flat typical at ends
Horiz. curve radius 100 m		1 x 9.1 centre span	1410 typical[2] WI lattice tower	Top & bottom chords – 310UC137 Web members vary – 150UC23 & 2/100x16 Flat typical at ends

Note 1: top chord rakes to suit track grade.
Note 2: top & bottom chords parallel.
Note 3: WI is wrought iron

All sections to OneSteel 300PLUS



flats, each side. A total of 30 tonnes of flat is being used. The tower headstocks are also being stiffened.

Steel fabrication was carried out by Dawson Engineering of Cairns, and HC Mobile Welding and Universal Fabrications, both of Brisbane. Pollards in Cairns did all the hot dip galvanising.

Conclusion

The strengthening of the steel bridge spans in the scenic Cairns to Kuranda railway line demonstrates the versatility and cost effectiveness of structural steel in rail bridge construction. Steel construction enabled six of Australia's most inaccessible and remote bridges to be simply upgraded, whilst at the same time satisfying the requirements of State heritage legislation and preserving the world heritage listed wet tropics. A magnificent example of this is the upgraded Stoney Creek bridge, which traverses the majestic Stoney Creek Falls.

Extensive use of OneSteel's Welded Column sections, as truss chord members, provided a cost effective and compact section which enabled the overall truss depth to be reduced in order to match the depth of the existing trusses. Further benefits of steel construction in this project were:

- fast speed of construction leading to short rail closure periods
- easy transport and on-site handling in difficult conditions
- maximum shop fabrication of components, effectively reducing site occupancy time and simplifying erection on site.

Above: Upgraded Stoney Creek bridge.

Opposite:
(1) Positioning new truss segment on bridge.
(2) Lowering truss over side of bridge, using bogey-mounted crane.
(3) Positioning truss under bridge, using winches.
(4) Bolting new truss segments at splice joint.

Project Team

Client:	Queensland Rail
Structural Engineer:	Queensland Rail, Engineering Services
Contractor:	CANSTRUCT
Steel Fabrication:	Dawson Engineering, HC Mobile Welding, Universal Fabrications
Galvanising:	Pollards