Department of Transport and Main Roads

Technical Note 54

Fibre Composite Projects

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Queensland Government

Feedback: Please send your feedback regarding this document to: mr.techdocs@tmr.qld.gov.au

1 Definitions

ACQ	Ammoniacal Copper Quaternary
AS/NZS	Australian Standards/New Zealand Standards
BCC	Brisbane City Council
CFT	Composite Fibre Technology
FCDD	Fibre Composite Design and Development unit
FRPC	Fibre Reinforced Polymer Composite
H3	Hazard Level 3
NSW	New South Wales
RTA	Road Traffic Authority
SME	Small to medium enterprises
TUMA	Timber Utilisation and Marketing Act
USQ	University of Southern Queensland
Wagners	Wagners Composite Fibre Technology

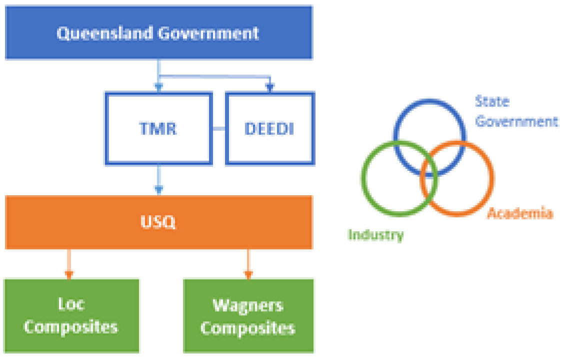
2 Purpose

The Queensland Department of Transport and Main Roads has 317 timber bridges. In order to keep these bridges in service, it is necessary to periodically replace timber girders when their condition has deteriorated below predetermined limits. Originally, the timber girders were replaced by like timber girders. However, due to a combination of environmental restraints limiting the number of logs available from state forests and the reduced number of mature trees of desirable hardwood types, insufficient supply of timber girders is occurring. When a timber bridge is replaced, the existing bridge is demolished and the timber recycled.

In 1997, the department commenced working with the fibre composite industry to develop structural engineering concepts for timber girder replacement, as well as new bridge construction and underwater bridge pile repair applications.

In 2002, with the aim to develop a fledgling fibre composite industry, the Queensland Government approved funding for a joint research and development program with the University of South Queensland's (USQ) Fibre Composite Design and Development unit (FCDD). This initiative (formerly called Bridging the Gap and established jointly with the former Department of Employment, Economic Development and Innovation (DEEDI)) enabled industry consultation through a concurrent collaborative relationship with Toowoomba firms, Wagners Composite Fibre Technology (Wagners) (CFT) and Loc Composites (Loc). Figure 2 below illustrates the interaction of Government-academia-industry from this program.

Figure 2 - Government-academia-industry interaction in the fibre composite industry



This program has enabled the department to investigate the use of fibre composites in two main areas:

a) Construction of fibre composite bridge decks (superstructure) for new structures on standard concrete foundation (substructure), and

b) Construction of a fibre composite girders as an alternative to hardwood girders in timber bridges.

Transport and Main Roads involvement with the fibre composite industry, described above, has paved the way for cross fertilisation of concepts from a range of industry players undertaking their own research projects. These include investigations of fibre composite applications to railway sleepers, railway over-bridge beams, power pole cross-arms, portable bridge structures, floating river walkways, ‘no-rust’ structures and building panels.

The department aims to increase industry understanding of fibre composite technology in public infrastructure by providing an infrastructure owner’s perspective. The purpose of this technical note is to provide:

a) a general overview of fibre composite technology to date, and

b) details of fibre composite technology projects undertaken through the abovementioned Government-academia-industry collaboration program.

3 What is a fibre composite?

Fibre composites consist of polymers (plastics) reinforced with carbon, glass and/or aramid (Kevlar) fibres. These materials are four to six times stronger than steel and concrete, but are only a fraction of the weight. They are non-corroding and non-magnetic. They can be designed to place strength and stiffness where it is needed. They have significant potential whole of life cost benefits, however, these costs will need to be monitored into the future to ensure they can be realised.

4 History of fibre composites

Fibre composites were originally developed for the aerospace industry and have found their way into a much wider range of applications, including transportation (automotive, railway, boats), sports (squash, tennis, golf, skiing, bicycles), medical science (prosthetic devices, wheelchairs), and more recently the building and construction industries (bridges, structural frames, offshore structures, and architectural products).

The application of fibre composites in the construction industry creates the opportunity for a new and innovative approach to structures which have undergone little change over the past 100 years. The unique mechanical and chemical characteristics of fibre composites combine to challenge the supremacy of conventional materials such as steel, timber and concrete, particularly in areas that are weight and/or corrosion sensitive.

5 Advantages of fibre composite materials

Fibre composites are meeting an increasing demand for construction materials that are robust, strong, economical, easy to assemble and durable. They are often directly competitive on initial installation and less expensive to maintain. The whole of life cost is often less than for traditional construction materials.

Fibre composite structures are commonly smaller and more slender than traditional construction materials. This characteristic highlights its high strength and low weight advantages of excellent design flexibility qualities which blend with their environment.

Figure 5a below shows an example of Wagners CFT supplying power pole cross-arms to Energex. These fibre composite power poles replace the timber equivalent previously used. The beneficial properties fibre composites offer in this example are desirable in bridge members, being lightweight, corrosion resistant, inert, easy and fast to install.

Environmental benefits of fibre composites include no need for additional or ongoing chemical treatment or protection maintenance. With the development of bio-polymers, future potential environmental benefits may include manufacturing fibre composites from renewable resources.

Figure 5a - Wagners CFT cross-arm installation

In certain circumstances, the corrosion resistance properties of fibre composites are particularly important. It was this benefit which prompted the Brisbane City Council (BCC) to approach FCDD in late 2001 to ascertain whether this innovative fibre composite technology could be utilised in the construction of the floating walkway project for the Brisbane River.

The 800 m long structure required a new type of structural beam system to tie the individual pontoons of the walkway to a unified structure. Traditional hardwood timber and steel solutions were projected to deteriorate in the aggressive salt water environment within 10–15 years post-construction, resulting in unsustainably high maintenance costs. Having developed a new polymer concrete technology, FCDD created a unique ‘waler beam’ concept (as shown in Figure 5b). The waler beam could accommodate the high structural loads of the walkway whilst still meeting the 100 year design life imposed by the BCC.

Figure 5b - FCDD’s fibre composite waler beam used in the BCC River Walk Project

6 Challenges of the fibre composite industry

Fibre composites are an emerging market. Academic research is being undertaken whilst manufacturers are refining their product. Manufacturers are typically small to medium enterprises (SME), safeguarding their manufacturing methods through intellectual property law. Specialist boutique design offices typically undertake the design.

The fragmentation and limited transparency pose challenges in a commercial context, because arrangements between industry and academia are frustrated by intellectual property law restrictions limiting the openness of information shared and available for publication. Market failure in limited information mean issues, such as brittle material and the effect of normal outside temperature, impact the reliability of strength and stiffness qualities of fibre composite products being produced.

Further, some large consulting firms have indicated the high risk of professional indemnity issues prohibit them from entering the fibre composites market due to a lack of standards.

7 Risks of fibre composites

The abovementioned government academia industry program seeks to provide expertise and understanding through research to assess the materials, properties and manufacturing of fibre composites. In order to minimise and address potential risks, a series of test programs and trial projects have been implemented to date. The tests described in the trial projects at Sections 9 and 10 included a proof load test for each girder manufactured, with one in twenty girders subjected to an ultimate load test. This provided valuable information about the statistical variability of the fibre composite girders. The tests identified one girder in twenty was brittle.

Bridges are based on the assumption of ductile failure, because there is warning of collapse. To date, brittle collapse is an issue that remains unresolved. It needs to be resolved for the fibre composite industry to develop.

Short term and long term structural health monitoring is being implemented on selected bridge girders to compare design behaviour with in-field response. Long term monitoring is to determine changes in performance over time. Structure health monitoring is a prudent risk measurement essential to infrastructure owners to be aware of any changes in material or stiffness characteristics early in the useful life of alternate fibre composite girders so any necessary intervention can be proactive rather than reactive.

The whole of life costing of fibre composites is an economic risk for infrastructure owners. The long term behaviour of fibre composites is part of asset management of this product, and an undeveloped area of knowledge requiring further applied research.

8 Standards and specifications

Standards and specifications are the methods that infrastructure owners use to establish the technical criteria for a project.

8.1 Australian Standards

Australian Standards is the preferred method for the supply of materials and products in Australia. The lack of an Australian Standard on fibre composites means there is no recognized basis for infrastructure owners to:

a) compare different proposals from suppliers

b) define suitable material for various environmental conditions

c) provide a level playing field for all suppliers

d) benchmark an acceptable criteria

e) determine acceptable ‘Product Conformity’ criteria for suppliers and independent ‘Conformity Assessment’ for third party certification.

Consultants rely on standards criteria as a basis for defining an accepted standard. If there is no accepted standard, there is risk. Hence, companies may elect not to work in this field.

The lack of Australian Standards is hampering the development of fibre composites for civil engineering infrastructure, because the industry is based on standards.

8.2 Transport and Main Roads specifications

Due to the internal demand for alternative products and no relevant Australian Standards, Transport and Main Roads has developed specifications to embed fibre composites within the industry. Significant resources have been drawn on to develop these specifications. The suite of documents being developed are:

- *Design Criteria for Bridges and Other Structures*
- *MRTS59 Manufacture of Fibre Reinforced Polymer (FRP) Composite Girders*
- *MRTS60 Installation of Fibre Composite Girders*.

9 Typical engineering properties

A simplified comparison is set out in Table 9 below showing typical engineering properties of a glass composite fibre girder (V_f = 0.5) to steel, concrete, timber (hardwood) and softwood (pine). Materials are listed from heaviest to lightest, as indicated by the density column.

Table 9 - Comparison of engineering properties (typical)

Material	Engineering Property			
	Stiffness E (GPa)	Tensile Strength (MPa)	Comprehensive Strength (MPa)	Density (kg/m^3)
Steel	200	300	300	7650
Concrete	28	5	50	2500
Glass Composite (V_f = 0.5)	90	900	800	1300
Timber (F27 seasoned hardwood)	18	50	60	1100
Softwood (pine)	10	5–10	5–10	800

Structural design using a mixture of these materials enable the construction of bridge beams (for example) to fit a range of desired bending strengths and deflection limits (stiffness criteria).

A combination of steel, glass fibre and concrete on a bridge beam application can be designed with the following properties:

a) Concrete is the cheapest compression material and can be used in the compression zone of a beam.

b) Steel is stiffer than glass and carries most of the initial tensile forces. When the steel yields, the beam becomes less stiff as the extra load is now carried by the glass fibres in tension.

c) 'Softening' of one beam under increasing load transfers the load to adjacent beams, so the full load capacity of all beams can be used to carry the applied loads in extreme overloading conditions. This behaviour ensures adequate safety, while minimising material costs.

Whilst many corrosive materials used in light weight infrastructure would use a high proportion of fibre composites in their design, it is a fair assumption that alternative non-corrosive infrastructure from a combination of materials, including fibre composites, would produce a more economical solution. In this regard, fibre composites are very flexible.

10 Fibre composite alternative to hardwood timber girders

10.1 Transport and Main Roads investigations

The goal of this project was to investigate viable cost effective alternatives to timber girders, which are becoming increasingly scarce and expensive. Harvesting timber from old growth hardwood forests of sufficient diameter, length and quality is becoming increasingly difficult. Hence, the supply of hardwood timber girders are not environmentally sustainable in the long term. Indeed, it is feasible future government policies will markedly limit the use of these timbers.

Transport and Main Roads has approximately 317 timber bridges to maintain and it will take some years before the fibre composite bridge replacement programs can eliminate this timber bridge stock. It is estimated there are around 20,000 timber bridges across Australia's road and rail network. Numerous other old timber structures, such as wharfs, warehouses and buildings are also subject to deterioration. The department's investigations of fibre composites in bridge infrastructure could result in potential spill over benefits to the construction industry nationwide.

Generally, it is not economically feasible to replace a whole timber bridge when only some components have deteriorated. Therefore, replacement timber components are required. Concrete and steel beams are generally not suitable to interchange with timber girders as they have markedly different properties. Most significantly is the difference in stiffness properties. Current engineered timber products generally struggle to perform ‘like an old ironbark girder’, while maintaining similar geometrics and flexibility of installation. Transport and Main Roads found fibre composites are a suitable alternative, because they offer the following benefits:

a) Flexible designs to exhibit strength and stiffness properties similar to good quality timber girders whilst maintaining geometric constraints

b) Weighs around 700 kg–800 kg, which is around 50%–60% of an existing timber girder’s weight

c) Ability to be cut and drilled onsite, so bridge carpenters can fit the product using traditional techniques

d) Product uniformity has proven far superior to that of a naturally grown timber girder

e) Girders which are generally inert, do not rot in wet and/or moist environments and are termite-proof

f) Fibre resistance equivalent to current material options.

As at 2005, trial fibre composite girders cost an estimated $7,000–$7,500 each, which is approximately two to three times more expensive than current timber girders. However, the whole of life cost for fibre composite girders is expected to be less due to the abovementioned benefits found. Hence, Transport and Main Roads anticipates the cost of hardwood timber girders will rise substantially in the future as more forests become restricted from commercial use. It is also expected fibre composite girders will reduce in price as economies of scale are realised with increased supply and proliferation within the market, enabling higher manufacture rates. Prices are expected to decrease and settle to a range of $4,500–$5,500 (2005 prices).

10.2 Transport and Main Roads engineering criteria

In 2005, timber girder research allowed Transport and Main Roads to define the engineering properties of a typical high quality ironbark timber girder. This work was used to develop the engineering performance criteria required to assess the fibre composite alternative girder. Details are shown below in Table 10.2.

Table 10.2: Fibre composite properties (tested 2005)

Parameter	Value
Stiffness	4.95 x 1013 Nmm^2
Design load	42.5 tonne semi-trailer
Target M*	599 KNM
Target V*	273 kN

Other criteria assessed included weight, durability, appearance, coatings, cappings, dimensional stability, handling, compatibility of installation with traditional girder installation techniques and resistance to impact chemicals and fibre. Full scale destructive and fatigue testing was undertaken to prove the design theory of the two distinctly different alternatives from Wagners CFT and Loc.

10.3 Wagners CFT fibre composite girder installation at Horse Trough Creek bridge

The Wagners fibre composite girder is predominantly made up of glass reinforced pultrusions, made by a process of introducing resin while pulling fibres through a heated die. It incorporates some steel to meet the stiffness requirements. Two 9.7 m long girders weighing around 700 kg were installed as inner and outer girders by Transport and Main Roads RoadTek on an existing timber bridge. The bridge crossing was over Horse Trough Creek on the Gatton-Clifton Road in the department's Toowoomba district. Works were completed on 10 May 2005.

The Wagners girder met the performance criteria in all respects with the following results noted:

- It is expected to have excellent durability because of the inert materials used. The steel component is well protected by fibre composites and no timber components are used. Therefore, it is not susceptible to termite, fungal attack, weathering or corrosion.
- It is compatible with conventional trimming, bolting and fixing methods. However, diamond cutting tips were required on quickcut blades and drill bits. There were also some minor installation issues that require improvement, but overall the installation was compatible with timber bridge processes.

A comprehensive testing program to ensure the performance of the proposed girder in bending, shear and fatigue was successfully performed. Destructive testing proved a 'soft' or 'pseudo ductile' ultimate failure, with the results shown in Figure 10.3a. Photos of installation are provided in Figure 10.3b.

Figure 10.3a - Beam load testing (170 mm maximum deflection) (left), Load/deflection graph (right)

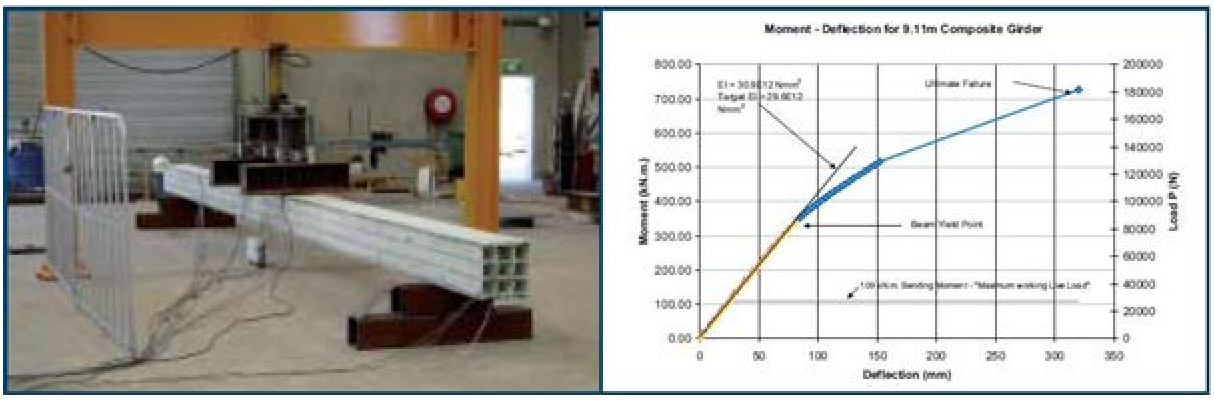


Figure 10.3b - Beam installation and working under load

The cost of the trial fibre composite girder was $7,500 (plus freight), which was approximately three times the cost of timber (2005 prices). It is expected larger production runs will reduce this cost to approximately $5,000 (plus freight) (2005 prices). This project demonstrated the whole of life costs of fibre composite girders could be lower than the timber equivalent due to its anti-rot and termite-proof benefits. Hence, it is expected the product should remain in good condition and surpass the useful life of a timber girder.

10.4 FCDD's Laminated Veneer Lumber (LVL) fibre composite girder installation at Heifer Creek No. 5 bridge

FCDD's fibre composite girder is made up of chemically treated plantation softwood Laminated Veneer Lumber (LVL) with several glass pultrusion/steel modules incorporated to meet the strength and stiffness requirements. Importantly, the softwood plantation timber is a renewable resource. Three girders (2 x 9.1 m, 1 x 9.7 m) weighing around 800 kg each were installed at inner and outer girder locations by RoadTek on an existing timber bridge. The bridge crossing was over Heifer Creek No. 5 on the Gatton-Clifton Road in the department's Toowoomba district. Works were completed on 13 April 2005.

FCDD's girders met the performance criteria in all respects with the following results noted:

a) The LVL is Ammoniacal Copper Quaternary (ACQ) treated to Hazard Level 3, (as specified by the Timber Utilisation and Marketing Act (TUMA)) (outside, above ground) in accordance with Australian Standards/New Zealand Standards (AS/NZS) 1604.5 to resist rot and termites. The 3 mm veneers, which make up the LVL, are impregnated with the H3 treatment. Although it is expected that the product will meet the minimum 30 year design life, rot and termite activity will need to be monitored.

b) The installation is 100% compatible with conventional trimming, bolting and fixing methods.

A comprehensive testing program to ensure the performance of the proposed girder in bending, shear and fatigue was successfully performed. Destructive testing proved a 'soft' ultimate failure with details shown in Figure 10.4a. Figure 10.4b shows the girder being placed insitu.

Figure 10.4a - Beam load testing (deflection 230 mm) (left), Load deflection graph (right)

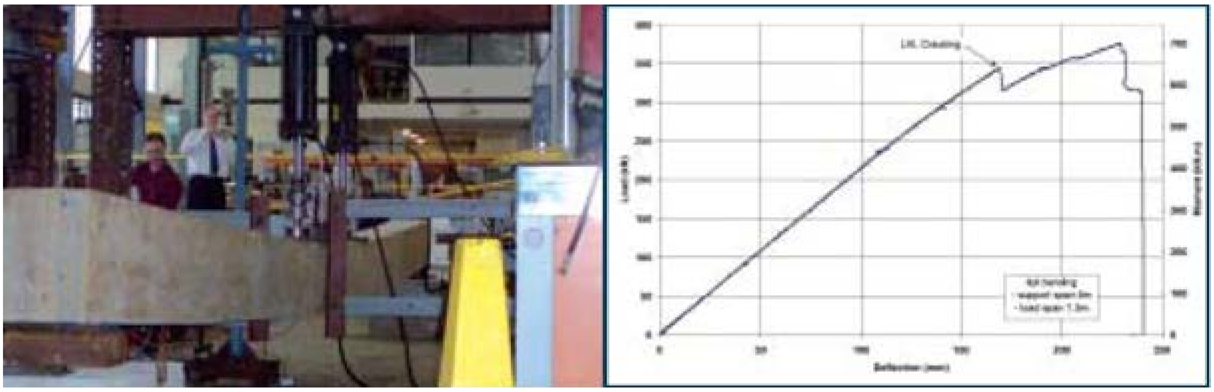


Figure 10.4b - Installation of FCDD girder

The cost of the trial fibre composite girder was $7,250 (plus freight), which is approximately three times the cost of timber (2005 prices). Larger production runs are expected to reduce this cost to approximately $5,000 (plus freight) (2005 prices).

10.5 Loc's Fibre Reinforced Polymer Composite (FRPC) installation at Coulson Creek bridge: Trial 1

Between 2007 and 2012, Transport and Main Roads undertook a comparative serviceability load testing with USQ on a batch of Loc's FRPC girders and a batch of Wagners equivalent. The performance criteria of glass resin in FRPC girders was assessed, and subsequently informed the decision to engage a manufacturer for the timber girder replacement project at Coulson Creek bridge. It was found one girder per batch tested for fatigue loading and ultimate loads. Test results conformed and were deemed satisfactory. In 2014, the department engaged Loc to manufacture a FRPC girder to replace a deteriorated timber girder at Coulson Creek bridge.

Loc's FRPC rectangular beam is a combined mixture of glass fibres with polyester, epoxy, vinyl ester and phenolic resins. These fibres allow for a high degree of tensile stress, providing high strength and stiffness properties. The resin matrix allows for a high degree of strain, transmitting the load to and from the fibres where needed.

A number of bridge factors were considered before installation commenced, including:

a) structural modelling of the timber bridge

b) load path and design actions

c) connections and restrains

d) existing geometry.

Installation methodology included variability considerations, including:

a) load classes

b) member sizes

c) snipe

d) bolt locations

e) skew, grade and crossfall

f) deterioration and previous repair work

g) hogging, sagging and warping.

The installation was completed successfully, and subject to structural health monitoring. Figures 10.5a and 10.5b below show the installation process and end result. Lessons learned from this trial highlight that difficulty may arise due to the tendency for timber structures to skew and shift over time. Specifically, this trial encountered issues fitting the restraint bracket due to differing girder height and skew; the lateral restraint bracket was heavy and added a further degree of difficulty to install. Additionally, the top plate assembly was not rigid enough. It was found to be advantageous if existing bolt holes were utilised, where possible.

Figure 10.5a - Loc's FRPC girder lifted under bridge (left) and positioned beside faulty timber girder (right)

Figure 10.5b - Completed FRPC girder installed on Coulson Creek bridge

11 Fibre composite bridge decks (FC superstructure)

11.1 Transport and Main Roads investigations

Fibre composites have a number of features which make them attractive for use in bridge structures, including low weight, high strength, excellent corrosion resistance, durability, ease of transportation and lower energy consumption[1] during manufacture.

The purpose of the projects described in sections 11.2 and 11.3 below were to allow a thorough evaluation of fibre composite bridge technology for Queensland's future bridge needs, as follows:

a) Evaluate state of the art fibre composite bridge technologies from engineering and manufacturing perspectives

b) Develop an understanding of the economics of fibre composite bridges in the Australian context

c) Identify niche applications of fibre composite bridge technology that may allow such technologies to be nurtured and developed until they become more applicable to general bridge applications, such as remote or island based projects

d) More fully understand the current nature of the fibre composite industry in Australia, and identify growth needs of the industry such that this emerging industry is compatible with the department's requirements

e) Identify issues associated with combining fibre composite superstructure technologies with conventional bridge technologies.

Subsequent investigations beyond these projects is expected to evaluate the long term performance of fibre composite bridge structures.

It is often the case the square metre cost of a given bridge varies little with different span lengths because sub-structure cost saved by using longer spans is re-distributed into increased super-structure cost resulting from the longer spans. The relationship between span length and the cost of superstructures and substructures is well understood for conventional structures.

The relationship between these parameters has not previously been investigated for fibre composite structures. This project provided an opportunity to evaluate this relationship. Fibre composite materials are generally lighter and more expensive than traditional materials. It is assumed that maximum advantage can be gained by combining these attributes with long span solutions, thereby off-setting the greater material expense of composites by reducing sub-structure requirements. There is an inherent assumption in this proposal the viability of fibre composite bridges will improve with increasing span. This following projects sought to evaluate that assumption.

11.2 Wagners' CFT fibre composite bridge deck installation at Taromeo Creek bridge

Wagners CFT have designed, manufactured, tested and installed several fibre composite bridge decks in Australia and the United States of America from 2002 to 2005. Construction costs within the three years have been reduced tenfold. Wagners aim is to bring the installed price of composite fibre bridge decks in line with concrete and steel. The cost of the trial fibre composite superstructure for this

[1] *Environmental Considerations to Structural Material Selection for a Bridge* R. A. Daniel, European Bridge Engineering Conference Light Weight Bridge Decks, Rotterdam, March 2003.

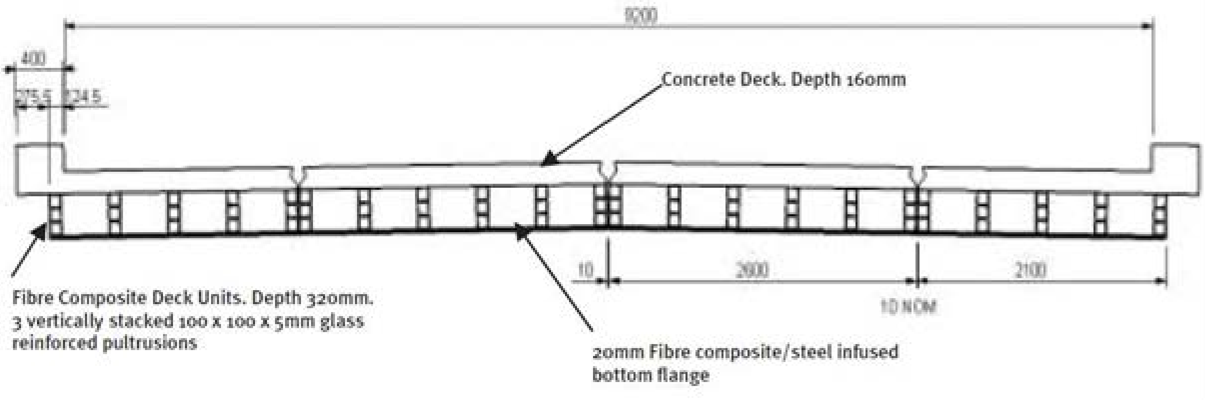
project was $1,500/m^2$ (2005 prices), including transport to site and installation. This cost is between two to three times more than the cost of a standard concrete deck unit bridge superstructure used in Queensland. However, it is expected that with the knowledge gained from this trial, fibre composite bridge costs will be further reduced in the future.

The Taromeo Creek bridge shown in Figure 11.2 is Wagners CFT's first bridge for Transport and Main Roads and the largest fibre composite bridge to date. The Taromeo Creek bridge is located on the D'Aguilar Highway at Blackbutt in Queensland. The traffic volume is around 2,500 vehicles per day with approximately 400 (16%) heavy vehicles per day (as at 2005). The new bridge replaced an old timber bridge with a new two span bridge (10 m + 12 m spans) using a traditional concrete substructure and fibre composite bridge deck. Bridge construction works were completed on 1 June 2005, with approach roadworks finished in or around mid-August 2005.

Figure 11.2a - Wagners CFT bridge installation

Wagners CFT 'Generation 4' design used four prefabricated units of 2.1 m and 2.6 m width as illustrated in Figure 11. All eight deck units for the two spans were placed on the substructure within one day. Longitudinal joints were cast insitu using a high strength grout. The weight of these deck units is almost 50% of the standard Transport and Main Roads concrete deck unit bridge. By way of example, the 12 m span fibre composite bridge deck weighed around 70 tonne, as opposed to an equivalent departmental standard 12 m span concrete deck unit system which weighs around 155 tonne including asphalt.

Figure 11.2b - Taromeo Creek bridge deck cross section



There were many challenges in ensuring the design met all of the bridge requirements. Some of the design challenges which required innovative solutions included:

a) bonding concrete slab to fibre composite webs

b) design of pre-camber in decks to allow for concrete shrinkage

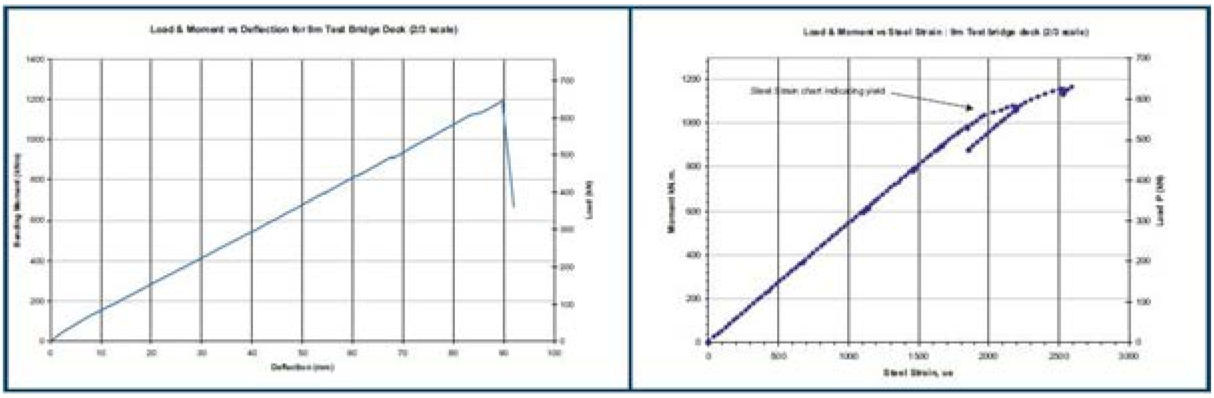
c) mechanical connection of adjacent decks

d) provision of a ductile failure mode.

Stringent load testing required life size models to be load tested to destruction in bending and shear. Fatigue testing to two million cycles was also undertaken, with no signs of deterioration shown. The actual load testing results correlated exceptionally well with theoretical finite element models. Load testing is illustrated at Figure 11.2c and detailed at Figure 11.2d below.

Figure 11.2c - 2/3 scale bridge deck load testing

Figure 11.2d -2/3 scale bridge deck load/deflection graph (left), Steel load/strain graph (right)



Overall, the trial was a success and has led to a greater understanding of fibre composite technology in the application of bridge infrastructure. The performance of the current bridge design will continue to be monitored and key lessons are fed back into new design models.

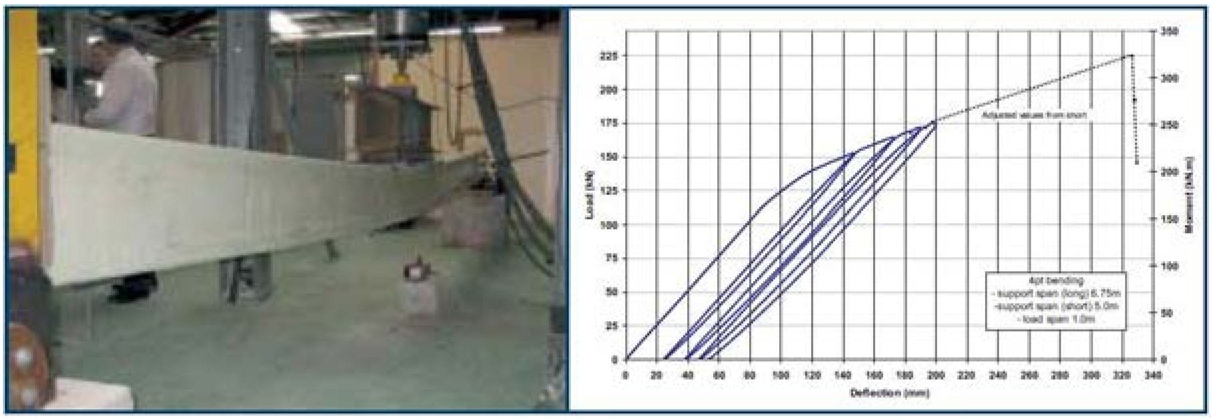
11.3 Loc's fibre composite bridge deck installation at Sandy Creek footbridge

Transport and Main Roads worked with the Darling Downs region to deliver a fibre composite pedestrian bridge at Sandy Creek Nanango. The concept and design stage were conducted by AECOM Technology Corporation and the department conducted an independent design check.

11.4 Testing

To date, the performance of the structural system has been demonstrated by testing a number of trial beams to failure as shown in Figure 11.4. The results of this testing has been encouraging. Further testing is planned to verify the connection details planned for the bridge concept.

Figure 11.4 - Load testing of FC trial bridge beam (left), load/deflection graph (right)



12 Future direction

The fibre composite industry is an emerging industry in Australia. The full potential of the industry is not well appreciated by the civil infrastructure industry. The success of this product is hampered due to market failure from restricted intellectual property inhibiting openness and transparency of information. To benefit from fibre composites now and into the future, infrastructure owners and other parties need to participate jointly and collaboratively towards a common goal. The development of recognized standards for design, manufacture and installation are fundamental to the longevity and success of fibre composite industry. The introduction of fibre composites into the Australian Standards is an essential first step for wider acceptance and positive spillover effects into similar industries.

Transport and Main Roads embraces innovation and new technology. Collaboration between all interested parties will guarantee the future of the fibre composite industry.

Contacts

For further information on this technical note, please contact:

Department of Transport and Main Roads	USQ FCDD
Dr Ross Pritchard	Professor Hao Wang
(07) 3066 8599	(07) 4631 1336
ross.w.pritchard@tmr.qld.gov.au	hau.wang@usq.edu.au