ENGINEERED TIMBER BRIDGES FOR HIGHWAYS IN NEW ZEALAND

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ABSTRACT

New Zealand has ideal growing conditions for Pinus radiata (Radiata Pine), a suitable species when treated for creating strong and durable laminated beams. Timber is a store of carbon and utilising it in construction can make a huge contribution to reducing carbon on our projects. Our transport system accounts for nearly 20% of the country's greenhouse gas emissions. Towards achieving the target of zero carbon by 2050, the New Zealand government has set an interim target of 50% reductions by 2030. To this end, in late 2021 Waka Kotahi NZ Transport Agency launched a transformative initiative to make glulam timber the preferred material choice for highways bridges of up to 30m span. This initiative began with a series of focus groups including design consultants, contractors, academics, suppliers and clients. The feedback gathered from these sessions provided input into the design of a plan and a programme to implement the challenging mission statement:

"That every highway bridge that is constructed today in New Zealand using standard concrete hollowcore or super tee beams will instead be constructed using modern, engineered timber". The plan, implemented in January 2022 consists of three complementary objectives running in parallel:

1. Development of design guidelines for timber bridges
2. Identification and curation of pilot projects to build using glulam timber
3. Liaison and involvement with timber product suppliers in New Zealand

The paper covers the challenges of developing a technical standard using international guidance. This includes the assumptions made, philosophical approach to design and analysis and a summary of technical considerations made. Key issues addressed will include durability, seismic performance, design-life, performance monitoring and asset management.

Keywords: Timber, Glulam, Bridges, Sustainable, Durability, Resilience

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1 INTRODUCTION

The use of engineered timber in construction is currently undergoing a worldwide renaissance as more and more organisations and individuals are rediscovering the benefits of wood and how it can be incorporated into a modern structural system. Significant timber buildings and bridges have been appearing all over the world in response to a sustainability and architectural challenge from government, the construction industry and the wider community. Forest and Wood Products Australia (FWPA) have recently and successfully challenged the Building Code requirements to facilitate the building of mid-rise structures in modern engineered timber in Australia. Scion, (formerly known as the New Zealand Forest Research Institute) a Crown research institute in New Zealand opened its new three storey LVL (laminated veneer lumber) timber HQ building in Rotorua last year. The year 2022 saw the formation of the New Zealand Timber Design Centre sponsored by MPI (Ministry for Primary Industries) to promote the use of timber and support the development of a sustainable construction sector. The Timber Design Centre is a not-for-profit, non-commercial collaboration of the Wood Processers and Manufacturing Association (WPMA), New Zealand Timber Design Society (TDS), BRANZ and Scion (formerly the Forest Research Institute).

Since Waka Kotahi New Zealand Transport Agency began its initiative in 2021 to promote and champion modern engineered timber highway bridges, there has been a lot of interest and support from across the industry, this paper will chart the journey and progress of that initiative to date.

2 BACKGROUND

New Zealand has a long history of working with timber as a building material. Native timbers were used extensively for making waka and for the construction of dwellings and other infrastructure prior to European settlement. During this era, material connections were made using woven fibres rather than metallic fixings which weren't available to the builders. After European settlement, timber use was intensified to build larger and more complex buildings (Salmond, 2010). Initially migrants built using their traditional methods of stone and clay until the benefits of timber were realised in terms of its availability, workability and strength to weight. Timber as a construction material also proved to be resilient to the forces of nature, something that was discovered by the recently arrived inhabitants of Wellington in 1848 and again in 1855 following earthquakes centred in Marlborough and Wairarapa respectively (McSaveney, 2017). Timber-derived structures were noted to have performed better than the more rigid and brittle structures built from brick and stone. Kauri quickly became the preferred source material due to its quality, appearance and durability although by 1900, kauri had been mostly depleted. Other native timbers such as mataī and rimu were used instead with imported north American species to provide the growth in demand as the population grew and New Zealand rapidly developed its infrastructure to cope. The birth of the railway in the early 1860's led to new railways systems initially on the West Coast of the South Island and between Christchurch and Lyttleton, but grew rapidly over the next two decades to include new major connections between towns in both islands so that by 1880 there were 1900km of railway line in New Zealand. One of these was a great project to begin surveying and constructing a rail link between Auckland and Wellington. This terrain was wild and treacherous and required a great degree of skill and engineering endeavour to cross the many obstacles often using sawn timber bridges (KiwiRail, 2022).

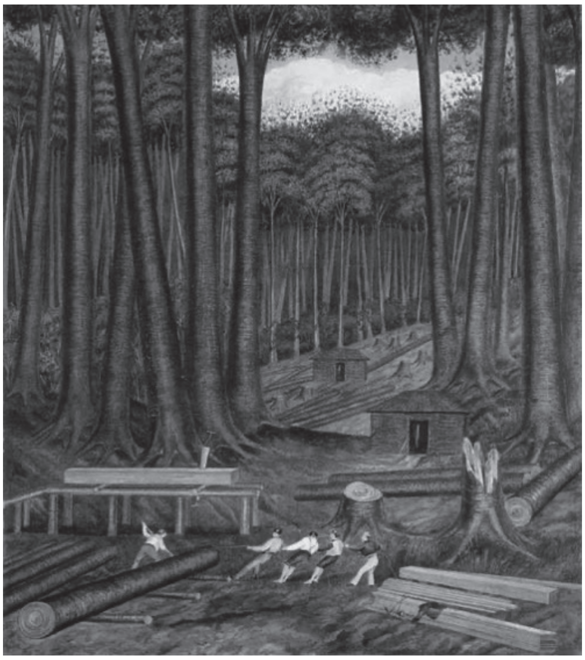

Figure 1 - Heaphy, Charles 1820-1881 :Kauri forest, Wairoa River, Kaipara. [1839] – Reproduced with permission from the Alexander Turnbull Library, Wellington, New Zealand.

Following the Kaikōura earthquake in 2016, inspections made by KiwiRail engineers on the Main North Line (MNL) discovered that although many bridges had sustained damage, the worst of the permanent damage had occurred to the concrete structures. Timber bridges on the MNL were observed through inspection and assessment to have been remarkably resilient despite the large ground accelerations and displacements that had occurred between Cheviot and Picton in the South Island on 14th November 2016 (Netley, 2016).

Figure 2 - First Ormondville railway viaduct in southern Hawke's Bay (Williams, 1891-1983)

Moving forward in time, our transport system today accounts for nearly 20% of the country's greenhouse gas (GHG) emissions. Towards achieving the target of net zero emissions of all GHG (other than biogenic methane) by 2050, the New Zealand government has set an interim target (NDC1) of 50% reductions by 2030 (Ministry for the Environment, 2022).

As a minimum, Waka Kotahi is aiming for a 10% reduction in embodied carbon across all our projects, with a stretch-goal of greater than 20% embodied carbon reduction for projects across the New Zealand Upgrade Programme of works (NZUP).

As a result, Waka Kotahi is stepping up its commitment to create a more sustainable future. This will be achieved through ongoing work to identify opportunities across our business and portfolio of work to increase efficiency, reduce material usage and make use of technologies and innovative products that lessen our impact on the environment.

Engineered Timber is one of those products that we are working to normalise as a primary material in the construction of new highway bridges. Although sourced from similar raw material, engineered timber bridge systems have the advantage of providing additional strength, utility and durability over traditional sawn timber bridges.

3 ADVANTAGES OF ENGINEERED TIMBER

There are a variety of benefits to using engineered timber for building bridges and together they provide a compelling background for including this material as a primary structural material.

Carbon

With a focus on climate change in governmental strategy, the carbon footprint of not just construction, but the whole lifecycle of an asset has become an important metric for choosing a bridging solution. The construction industry is transforming itself in response to the carbon reduction demands from clients, including attempts to decarbonise aspects of cement production and steel fabrication. Timber has some serious benefits for achieving carbon reduction targets although the savings are not as clear cut as one might imagine. The whole of life carbon budget for engineered timber is complicated due to the way forestry is managed and the context in which forestry exists with unmanaged forests. Essentially though, despite the emissions from the production process of glulam beams, carbon is stored from the moment the lumber source tree is replaced by new growth. The Pinus radiata trees are generally harvested in New Zealand after 30 to 40 years, subsequently regrowth can begin. By comparison we expect the beams to remain in service for at least 100 years, during which time there is a slow release of CO_2 as the beam ages. The majority of CO_2 will eventually release into the atmosphere as the redundant beam rots down, however there is the potential for an accumulation in carbon storage over time (Hawkins, 2021). Waka Kotahi will employ carbon calculations for new bridge projects but at this stage, the assumption is that an engineered timber bridge will be roughly carbon neutral during its design life. In addition, there will be reductions in the 'construction miles' consumed on a project through having a locally sourced supply of timber, reduced foundation demands and reduced demands on cranage and other plant.

Social and Environmental

Engineered timber structures can help to bring an enormous social premium to a project. Waka Kotahi staff have anecdotally witnessed stakeholders getting excited when presented with a timber bridge concept and on completion a well-designed timber structure has the potential to contribute to an improvement in the overall satisfaction across the community (Duchesnay Bridge, 2021). Using timber in this way also contributes to supporting the local forestry and lumber industry.

Low impact

A timber bridge being relatively lightweight and with a natural appearance, 'treads lightly' on the environment – this aligns with Waka Kotahi's social and environmental policy and frameworks such as Arataki – Our 30-Year Plan, and Toitū Te Taiao – our sustainability action plan.

Modular construction

Engineered timber is fabricated into pre-assembled parts with dedicated fixings which can be designed to be easily demountable. These characteristics make it a potentially suitable deck system for modular maintenance and replacement, with lightweight components for ease of jacking. It can also be applied to a modern methods of construction philosophy to reduce time on site for construction.

Seismic and strength

Glulam timber has around twice the strength to weight ratio of structural steel which provides significant benefits for weight reduction. The weight reduction provides many advantages of its own but for seismic resilience it means less mass and therefore less momentum to be absorbed by the structure. Seismic resilience is covered in more detail in Section 4.

Aesthetics

The natural look and tactile feel of a timber structure is a key benefit. A glulam timber form can not only look great but can be an inspiring piece of architecture in its own right.

4 ENGINEERED TIMBER BRIDGE INITIATIVE

In 2021, the Chief Engineer of Waka Kotahi instigated a new initiative to make a transformative step-change in the way we design and construct state highway bridges in New Zealand. A team was assembled to consider how we might achieve this aim and developed a mission statement:

"That every highway bridge that is constructed today in New Zealand using standard concrete hollowcore or super tee beams will instead be constructed using modern, engineered timber".

The team began with some early high-level studies into what other countries were doing to enable the design of engineered timber bridges. They then moved to establishing a focus group of approximately 20 experienced industry professionals including timber suppliers, clients, consultancy, researchers and contractors. The focus groups provided a receptive audience and sounding board to promote the initiative and gain some perspective, insight and feedback.

Having hosted two workshops with members of the focus group, it became clear that one of the key themes was to develop a comprehensive and sound approach to durability. In addition, it became apparent that providing some initial and longer-term guidance around how to design and maintain an engineered timber highway bridge in New Zealand was necessary.

Design

International studies

Studies into international timber design codes provided some interesting context for the Waka Kotahi design development project. One of the key differences between using timber as a structural material and other more established modern materials is the variability in the source lumber. Engineered timber is reliant on a quality sourced raw material, lathed and appropriately treated, use of appropriate glue and finally the processing into a coherent structural member.

Unlike steel, concrete and even FRP, timber hails from a living organism. The initial base material properties are not only variable from tree to tree but also dependent on the species, age and environmental conditions during growth. Tree species can be divided crudely into hardwoods and softwoods which provides some limited amount of information about strength, durability and seasonal growth. In the past, builders made use of slow growing hardwood species such as Kauri, which provided great advantages for the final product, but sadly neglected to conserve the supply of the dwindling resource. More recently we have adopted a sustainable practice of managed forestry; fast-growing softwood species are more suitable for this practice and less expensive to produce. Softwoods have a range of natural durability with Larch being just durable enough to use untreated in the outdoors and Pinus radiata having almost no natural durability. In Europe, Larch and Spruce are commonly used species for producing glulam beams, in North America Douglas Fir, Spruce and Jack Pine are common (Bonfacio et al, 2022).

Environmental conditions for growth and species availability are fairly unique from region-to-region and New Zealand of course is typically unique in that respect. New Zealand has ideal growing conditions for Pinus radiata which has become the dominant forestry grown species accounting for 90% of forestry stock. New Zealand's net stocked planted production forest covered an estimated 1.66 million hectares as of 1 April 2020, making up around a third of global Pinus radiata stock (Ministry for Primary Industries, 2022).

Radiata Pine has minimal natural durability, but it does have an advantage with excellent permeability for treatment uptake. This means that sawn and graded lengths of timber can absorb a water-based treatment very effectively prior to lamination build-up. This process ensures full penetration of a water-based treatment such as Copper-Chrome-Arsenic (CCA).

Learning from international experience has been undertaken using a nuanced approach. Understanding that the locally sourced lumber species needs to be matched with an appropriate glue and treatment strategy to maximise efficiency and durability. North American experience suggests that using an oil-based treatment such as copper naphthenate provides the best long-term durability when matched with a Douglas Fir source lumber. From a report commissioned by Waka Kotahi from Wood Research & Development (Tingley, 2022), a typical methodology for creating a structural bridge glulam member in North America may start with an untreated Douglas Fir or Western Larch laminated beam glued with a phenol-resorcinol-formaldehyde adhesive. Following layup and manufacture to the correct dimensions, the glulam beam will be machined with any fixing rebates, holes and any other details required for erection and assembly. The next step in the fabrication process is to incise penetrations of up to 10mm to all faces of the beam to facilitate uptake of the preservative treatment, a pressure treated oil-borne preservative. The incisions are required because the source lumber permeability does allow a ready take-up of the preservative, incisions help to improve the depth of penetration. However, unlike CCA matched with Pinus radiata, the Douglas Fir / Copper Naphthenate does not provide a full penetration of protective treatment. This means that any additional mechanical fixings into the treated Douglas Fir member must be avoided at all costs to prevent moisture ingress into the rot-vulnerable beam core. Nonetheless, it is good design practice to avoid any vertical fixings from the top face in any outdoor timber structure to enhance longevity and durability.

Design guidelines

Waka Kotahi is the largest road controlling authority in New Zealand and with a national team of subject matter experts, we undertake the authoring and revision of technical guidelines, standards and specifications. To facilitate the introduction of engineered timber bridges, we have embarked on a project to provide design guidance on this topic.

One of the key shifts required to enable timber highway bridge design in New Zealand will be an update to the guidance in the Waka Kotahi Bridge Manual (Waka Kotahi, 2022a). As a temporary measure, 2022 Waka Kotahi issued TAN #22-02 for interim guidance on recommended technical standards for timber bridge design (Waka Kotahi, 2022b). A project is currently underway to redefine and publish design guidelines, the development of which is taking place in tandem with ongoing design work for pilot projects. The expectation is that each will inform the other. One of the aims of the updates is to facilitate the transition to a standardised timber design philosophy. International standards currently available for engineered timber bridge design include Eurocode 5 - Part 2 (CEN, 2004a), AS 5100.9 (Standards Australia, 2017), Canada's S6-14 (CSA, 2014) and AASHTO LRFD (AASHTO, 2020). They all have advantages and disadvantages, but they have all coalesced around a 100-year design life which is the minimum requirement for bridge design in the Bridge Manual.

Initially the design guidance is based upon a simple implementation of a glulam beam and timber deck system (see figure 3). This deck system utilises a series of discrete glulam beams running longitudinally from end to end with glulam transom beams providing transverse restraint and mechanically (but not compositely) fixed to a series of laminated deck panels. The deck is intended to be simply supported on plain pad or elastomeric bearings with hold down bolts to secure the bridge superstructure to the abutments.

This system, chosen for simplicity and to achieve a standardised bridge span up to 30m in length, will form the basis of the first version of the Waka Kotahi engineered timber bridge design guidelines. We anticipate that in the future, the guideline will be expanded to include additional products and configurations to enhance span length, articulation and innovative solutions.

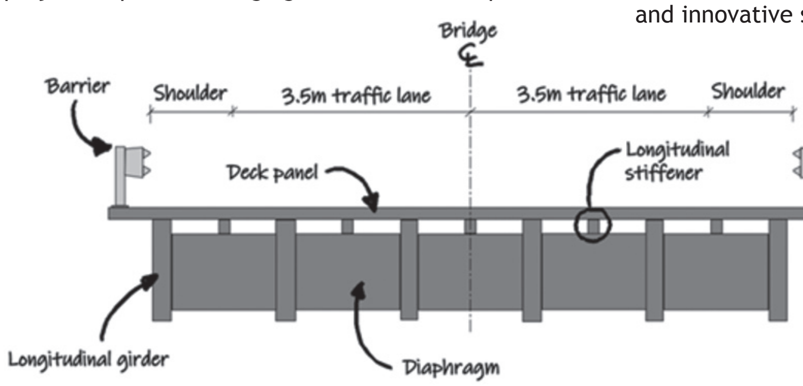

Figure 3 - An illustration of a simple engineered timber beam and deck system (Holmes Consulting, 2022)

Pre-implementation

In parallel with design guidance, Waka Kotahi is championing the development of timber alternatives for bridge renewal via the existing business case process. When the entry point for a bridge renewal is triggered, a Structural Performance Team engineer will liaise with the Business Case Advisory team to promote an option selection process which will include consideration of an engineered timber material option.

Key criteria in determining whether an engineered timber bridge is appropriate include the following:

- Level of service
- Span length
- Structural depth
- Environmental exposure
- Impacts
- Seismic demands
- Fire
- Durability

Level of Service

The level of service required for either a new build or a replacement highway bridge is usually linked to the importance of the route, the expected traffic volume and type, the geometry of the road alignment and the current and future expected speed limit. In theory, there is no reason why we might not consider an engineered timber bridge for all levels of service but in practice, particularly when introducing a novel construction material to highway bridging, we must be pragmatic. Although timber has the potential to cater to all levels of service, we might pause to take account of the demands from a heavily trafficked road with more than three or four loaded lanes. The first pilot projects will be implemented on lower volume, two lane bridges with a straightforward alignment in order for us to assess the results of the performance from instrumentation data and visual inspection. We are interested in assessing the serviceability performance such as deflection, vibration, moisture content and surfacings, as well as performance criteria around fixings, joints and barriers. As we gather more information, from initial implementation of engineered timber bridges we can update our guidance based on the quantitative and qualitative data gathered.

Span Length

For a replacement bridge project, the span length will be either a like-for-like with the existing structure or an improved configuration to provide a better outcome in terms of performance or cost efficiency. Assuming a simple beam and deck configuration as shown in figure 3, individual simply supported spans can range from 4m to 30m with a total span limited only by the engineering constraints on a given project.

Using additional timber technology to create a tied network arch, spans can be designed up to 50m. There are many international examples of timber-steel and timber-concrete composites used for both arch and truss bridge forms (Ostrycharczyk et al, 2022).

Structural Depth

For spans of up to 30m in length, the simple beam and deck arrangement will likely generate a construction depth in excess of 2.4m. This depth has implications for clearance to traffic below or for establishing an acceptable freeboard soffit level for flood return periods. This requires careful consideration during optioneering and the business case phase. However, there are potential structural solutions to reduce construction depth such as using a block laminated deck, a fibre composite lamination layer, providing additional transverse deck redistribution or through making the deck panel composite with the glulam beams.

Environmental Exposure

Exposure considerations include ultraviolet (UV), rain and flooding. With rain and flooding comes moisture ingress and buoyancy concerns. The bridge can be detailed to reduce rain exposure to the edge beams using vertical fascia panels fixed to the barriers at the sides of bridge. The bridge deck should be designed to allow the free flow of air around the end grain of glulam beams to assist with drying, following raised levels of atmospheric moisture with moisture content meters placed to effectively assess against the design moisture range. If moisture in the pine rises above 20%, the conditions for fungal attack become favourable and so for durability this is to be avoided.

In New Zealand, UV exposure has the potential to cause some surface degradation of the wood. Guidance provided by local specialists in timber design believe that due to the relatively small, exposed surface area of adhesive that is directly presented to the sunlight isn’t enough to cause any major long term durability issues and is not of structural concern. Fascia panels used to prevent rain exposure will also provide some additional UV protection. There have been several case studies in New Zealand, most notably Bridge 11 on the old alignment of State Highway 2 at Te Puke, in Waikato District. This glulam beam bridge was installed in 1965 and removed in 1993. The glulam beams remained in good condition throughout the 28 years with no signs of UV damage when the bridge was eventually dismantled for the new alignment.

Impacts

Vehicle impacts due to low clearance could become an issue for a timber bridge. The risk to an engineered timber deck is not currently known, but with a lower mass there is the potential for greater damage occurring. If the risk is significant, then an impact beam may be required, or a concrete bridge might be a better option. Impacts on the bridge itself will require an appropriate barrier system. At present, the simple bridge system being developed will include a test level 4 barrier (TL4) in the form of a Thrie beam or proprietary timber solution. TL5 barriers have not yet been considered because of the size and demands from the loading of such a barrier.

For short and medium spans, Waka Kotahi will consider using a tensioned barrier system anchored behind the abutments, which will remove the requirement for posts attached to the bridge deck.

Seismic Demands

Waka Kotahi has a new section in amendment 3.4 of the Bridge Manual relating to low-damage design for seismic limit states. Section 5.9 of the manual recognises the need for the inclusion of enhanced resilience in all new highway structures. Waka Kotahi now expects all new designs of importance level 3 and above to implement low-damage features in the design with a full justification as to why not if that cannot be achieved.

Low-damage design can be achieved through many different approaches such as including low-damage joints to dissipate energy during an event, base isolation, designing the structure to remain elastic or allowing the bridge to slide safely. Timber bridges include a number of low-damage features by design.
Wood is an anisotropic material with cellulose fibres running parallel to each other within a resinous matrix of natural lignin. It could be described in structural terms as a, naturally composite material. The wood fibres arranged and bound in a matrix provide an innate resilience to dynamic forces which helps to dissipate energy elastically at the micro and macro structure level (Ansell, 2015).

The strength to weight ratio of timber means a much lighter mass for a given span than for an equivalent steel or concrete bridge deck. This reduced lumped mass translates to a lower seismic force generated by the peak ground acceleration (PGA) generated during an earthquake.

Fire

Large timber section sizes, such as a standard glulam beam are generally resilient to fire. The initial heat from a fire will cause charring to the surface of the beam which insulates and protects the interior structural core. Design will include a charring allowance as explained in AS NZS 1720.4 (Standards Australia, 2019) or Eurocode 5 - Part 1-2 (CEN, 2014b),

Durability

From the early stages of consultation, the question of durability has been one of the most popular aspects of timber bridges raised by contributors and potential stakeholders. Therefore, Waka Kotahi has been working on a robust strategy to ensure durability is considered from the outset and incorporated into guidance for designers, constructors and maintainers of engineered timber structures.

Pilot Projects - Onetai Stream Bridge, Coromandel SH26

Waka Kotahi is currently progressing with a project to replace an end-of-life state highway bridge with a glulam timber bridge;14 km north of Paeroa in the Coromandel District of the North Island. This is the first highway bridge to be designed as Glulam in New Zealand since a trial was conducted in 1960's at Te Puke by Scion. The timber superstructure for Onetai Stream has been designed by specialist timber consultancy PTL Structural Consultants in Christchurch, with the remainder of the civils work designed by Beca. The bridge will be a simply supported, 10m single span supported by concrete abutments on shallow foundations.

The deck is comprised 22 No. glulam beams at 500mm centres connected to a bridge ply decking system. Surfacing on the bridge deck will include an epoxy binder seal coat to the timber deck, an attenuator inter layer with a stone mastic asphalt (SMA) wearing course.

Although this is the first glulam bridge of its type in the modern era in NZ, there are plans to begin a series of new timber highway bridge designs for capital works schemes as part of New Zealand Upgrade Programme, NZUP. Waka Kotahi are also working with the regions to identify suitable candidates for replacement with engineered timber.

5 DURABILITY CONSIDERATIONS FOR TIMBER BRIDGES

The Waka Kotahi approach for ensuring a long service life for engineered timber bridges is through defining requirements for durability and making these requirements the central tenets in our guidance.

Quality

Waka Kotahi has been working with engineered timber suppliers in New Zealand to help provide assurance on quality products. There are several large laminators across the country who can provide a GL10 grade beam of up to 30m long and in excess of 2m deep, accelerate delamination testing is currently done in-house using steam under pressure to simulate the effects of moisture penetration over 50 years.

Research

Waka Kotahi commissioned Scion to produce a durability report for CCA treated glulam timber bridges within a New Zealand context (Page et al, 2022). This report recommends that glulam bridges can be used in highway bridges and will remain serviceable provided good design and suitable asset management are employed. The report also refers to case studies in New Zealand of glulam bridges that have been in service for over 60 years and remain in good to fair condition.

Adhesives

There are a range of glues and adhesives that can be used for engineered timber. The recommendation from both Scion and BRANZ is that Resorcinol-formaldehyde is used for outdoor applications to ensure a durable product.

Species & Protective Treatment

Waka Kotahi have determined through investigations and research that the most appropriate species for New Zealand glulam bridge beams is locally sourced Pinus radiata, matched with a CCA Hazard Level 5 treatment as per NZS 3640 (Standards New Zealand, 2003).

Design detailing

Knowledge of electrochemistry applied to a combination of metallic bridge fixings and timber treatment types indicates that at higher water-soluble copper concentrations, mild steel and galvanised steel connections are more likely to corrode rapidly than austenitic stainless steel (Li et al, 2011). Therefore, fixings are to be stainless steel when used with CCA treated timber elements.

With the benefit of international experience, we recommend avoiding drilling into timber elements where possible to avoid moisture traps, clamping and straps should be investigated as an alternative connection detail. Top-down, vertical holes shall not be used unless agreed with Waka Kotahi.

Rain exposure can be reduced through the use of sacrificial side fascia panels or through recessing beams under a waterproofed deck.

Asset Management

Waka Kotahi are developing an in-house maintenance guide for timber structures to help enhance the expected service life. This will be based on international experience, New Zealand experience of timber exposure and good asset management practice from experienced practitioners. Key aspects will include an inspection schedule and checklist, cleaning and other routine maintenance tasks, information on hidden defects and vulnerabilities, appropriate data collection, capacity assessment and understanding of engineered timber through appropriate training.

Instrumentation

As a novel bridge construction type in New Zealand, it is important that asset engineers and designers understand how these bridges are performing in the real world. Waka Kotahi proposes to ensure all new timber bridges will incorporate moisture content sensors in several locations including near, or on an edge girder and on an internal girder as a minimum. This will help to monitor the range of moisture and trigger an alert if the range rises above a threshold setting of, say 20%. Above this level, sustained moisture can cause fungal decay to develop in the wood. Active moisture content monitoring will also be a useful tool for establishing a response plan, in case of flood.

Waka Kotahi recommends that additional sensors are included on the bridge, this may include accelerometers, tiltmeters and strain gauges to monitor performance, they will be useful for calibrating structural models and for verifying assumptions made during design.

6 CONCLUSION

Engineered timber bridges can provide an excellent structural solution for replacement and new build highway bridges. However, there are some important considerations to take into account at the feasibility and/or business case stage. Concrete and steel still have an important place in bridge engineering and for some situations they will be the preferred option, the enduring requirement for robust and heavy engineering will always be required where necessary. Engineered timber as a material is rapidly becoming another tool in the armoury of the road controlling authority and the structural engineer, which if used adeptly can provide a great outcome for customers and will deliver a long-life asset that treads lightly on the environment.

Specifying engineered timber may mean a small shift in mind-set and philosophy, particularly for professionals not accustomed to designing or working with the material. Despite this, timber is gaining support across the world with new products, innovations and technology being developed to provide sustainable solutions to engineering problems previously resolved using either steel or concrete.

Normalising engineered timber highway bridges in New Zealand is a step change for the industry and for customers and stakeholders. To date, it has been a challenging but also a rewarding journey for all those involved in making it happen. There are several key benefits to be had from making this transformative shift in policy and those benefits are all compelling reasons for having embarked on this journey, particularly with all the challenges we face both socially and environmentally this decade and beyond.

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